RESOURCE MANAGEMENT AGENCY

THREE RIVER LIONS CLUB
MEMORANDUM
2-24-16
AGENDA ITEM # 6B

MEMORANDUM

February 24, 2016

TO: Planning Commission

FROM: Dana Mettlen, Planner III

SUBJECT: Special Use Permit No. 14-034 for Three Rivers Lions Club
Response to Comments to Mitigated Negative Declaration

The Mitigated Negative Declaration for this project was released for 30-day public review on September 4, 2015, scheduled to end on October 5, 2015. The County extended the review period for an additional 15 days, ending on October 20, 2015, in order to accommodate a request. The RMA has continued to receive comments up until this public hearing.

Eight comments were received:

1) Mary Anne Vandergrift commented on road deterioration, speed of vehicular traffic on the private road, trash control, air pollution, garbage service, light pollution, and non-amplified event activities;

2) 01/19/2016 - May Ricci commented on the definition of "event" and enforcement for noise compliance;

3) 09/25/2015 - Caltrans commented the impacts would be less than significant; and

4) 10/18/2015 - Maya Ricci and Vincent Andrus commented on land-use guidelines, the Three Rivers Community Plan Update, the Notice of Hearing being provided to parcels within 300 feet, events need not be amplified, traffic control, road maintenance, dust control, noise attenuation, noise study, compliance monitoring, cumulative impacts, definition of "event".

Email Attachment on 02/16/2016

5) 02/14/2016 - Michael C Cannarozzi commented on noise

6) 01/20/2016 - Julie Doctor commented on noise and traffic

7) 02/12/2016 – Brad and Maggie Bloetscher commented on noise

8) 01/18/2016 – Juanita Tolle commented on traffic, traffic, define "event"

All of the comments have been appropriately responded to in the Response to Comments section. Conditions of Approval have been added where necessary in order to mitigate a potential environmental impact. For example, the Lions Club will contribute to road maintenance; the Lions Club will pick up trash after events; the Lions Club will self-monitor at every amplified event; the Lions Club will post a "15 mph" speed limit sign at the entrance to the private road; the Lions Club will provide security at events; and the Lions Club will consult with those persons on the notification list when scheduling amplified events.

Staff received fifty-one letters in support of the project (See Attachment 14 of Agenda packet).

Response to Comments Regarding

Mitigated Negative Declaration for
Special Use Permit No. PSP 14-034
February 10, 2016

<u>Exhibit "A" - Comments Submitted by Mary Anne Vandergrift</u>

[1] Road Deterioration: The access road, North Kaweah River Drive, is privately owned and maintained. Additional usage will lead to additional deterioration of this private drive. The Lions Club should share the responsibility of road maintenance. The commenter would like the Lions Club to pave the road up to the last encroachment point of the facility.

Staff Response: The Lions Club Board Members have volunteered to contribute to the maintenance of the private drive. Condition of Approval (COA) #15 requires that this access road be surfaced for all-weather conditions to a width of 20 feet and for a distance equal to that of the northerly property line.

[2] Speed of Patrons: Some attendees to the Lions Club events travel at a high rate of speed along North Kaweah River Drive. The commenter would like speed bumps to be installed and speed limit signs posted.

Staff Response: COA #49 has been added to the project requiring the applicant to post a 15 mph speed limit sign.

[3] Trash Control: The Lions do not adequately pick up trash that originates on their property.

Staff Response: COA #33 has been added requiring the Lions to remove litter along North Kaweah River Road for a distance of 2,000 feet by 10:00 a.m. on the morning following each event.

[4] Air Pollution: Dust inundation during events. Drafting water from the Kaweah River without a permit to be utilized on the roads to control dust.

Staff Response: As previously mentioned, COA #15 requires both the parking areas and driveways, including the easement, to be properly maintained to control dust. In addition, COA #19 requires that the arena areas be watered down as necessary to control dust. The Regional Water Quality Control Board should be informed of illegal drafting of water from the Kaweah River. In addition, it is possible that the San Joaquin Valley Air Pollution Control District may also have jurisdiction in regards to dust/dust control requirement as fugitive dust is regulated by the Air District. The Air District can be contacted at (559) 230-6000.

[5] Garbage Service: The Lions property is being used as a storage facility for a garbage service provider. Noise, dust, and road deterioration are amplified. Ms. Vandergrift would like the garbage service to find another location for storage.

Staff Response: The garbage trucks are not being stored on the Lions property. They are on the property adjacent to the Lions Club. Staff will send out a Code Enforcement Officer to investigate.

[6] Light Pollution: During events, lights shine directly into the house.

Staff Response: Standard COA #3 requires that all lighting be cast downward.

[7] Non-Amplified Event Activities: The Lions lease a portion of their property to contractors such as Southern California Edison. This increases dust, noise, and road deterioration.

Staff Response: The Lions do not own the property that is being leased to contractors. A Code Enforcement Officer will investigate.

Exhibit "B" - Comments Submitted by Maya Ricci

[1] The definition of "event" is imprecise.

Staff Response: Ordinance No. 3416 amended the Assemblage of People Ordinance and defines Special Event as being, "Any temporary use, generally lasting from a few hours to a few days, conducted or sponsored by an organization, entity, association, or group involving a display, demonstration, performance, exhibition, or amusement which includes, but is not limited to, festivals, concerts, carnivals, arts and craft shows, fireworks displays, sporting events, socials, parties, parades, rallies, and other similar uses." This definition has been duplicated in the resolution as Finding #4.

[2] The enforcement method of noise level compliance is weak.

Staff Response: A Noise Study Report was conducted for the project site. In addition, staff visited the site and the Ricci residence during an amplified event. The decibel (dB) readings on both occasions indicate that the measured noise level did not exceed 60 dB at the property line. In addition, COA #26 requires that a Lions Club member be present at all amplified events in order to monitor the noise level for compliance with the 60 dB at the property line requirement.

Exhibit "C" - Comments Submitted by the Department of Transportation

Caltrans concurs that the Traffic Management Plan submitted as mitigation for section 16, the Transportation/Transit analysis portion of the MND, is valid and will minimize project impacts to less than significant.

Exhibit "D" - Comments Submitted by Maya Ricci and Vincent Andrus on October 20, 2015

[1] The intention of our comments are 2-fold – to respond to the document and discuss other relevant considerations or omissions. I fully realize that your department is constrained to some extent with the out-dated land use guidelines for our area as well as the fact that the County of Tulare does not have a speeific Noise Ordinance.

Staff Response: Tulare County utilizes the existing Three Rivers Community Plan (adopted by the Board of Supervisors in 1980) for guidance in decision-making and land use entitlement. The County's Noise Level Criteria is consistent with the recommendations of the California Office of Noise Control (Tulare County General Plan 2030: Section 10-8.6, Health and Safety: Noise Level Criteria which were adopted in August 2012).

[2] However, we do have improved standards and guidelines that illustrate the desired character that are pending for the Three Rivers area within a reasonable time frame that will be more useful in guiding this project in the future.

Staff Response: An Update to the Three Rivers Community Plan is currently under review. Until such time, the existing standards/guidelines, by law, must be applied.

[3] To that end we would ask the RMA to stay the decision for eause pending the completion of the Three Rivers Community Plan update with it various accompanying environmental doeuments.

Staff Response: The County has determined that the Project will not have a significant effect on the environment and that the Mitigated Negative Declaration (MND) and Mitigation Monitoring Reporting Program (MMRP) for said Special Use Permit reflects the independent judgment of the County. Further, the IS/MND and MMRP have been completed in compliance with the California Environmental Quality Act and the State Guidelines for the Implementation of the California Environmental Quality Act of 1970.

[4] There is a neighborhood surrounding this project location. We cannot be penalized by the 300 foot rule as parcels are large, thus spread out by definition, but are related by the transmission of light, sound and/or inadequate roadways.

Staff Response: Government Code Section 65091(4) requires that "Notice of the hearing shall be mailed or delivered at least 10 days prior to the hearing to all owners of real property as shown on the latest equalized assessment roll within 300 feet of the real property that is the subject of the hearing." Further, a public Notice of Availability was published in the recognized newspaper of General Circulation, the Visalia Times-Delta. A Notice of Public Hearing was published on the County's website page dedicated to the Community of Three Rivers. The Lions Arena Use Permit Proposal was also noticed on the Three Rivers Village Foundation Town Hall Meeting of February 2, 2015. As such, all required noticing was conducted per state law.

[5] Additionally we would like to point out that the manner in which citizens have to participate in this particular process is essentially a lousy deal. It exists in a vacuum when those affected do not get notified objectively. It is a bad deal when others are intimidated by the potential of "getting on the bad side" of the project proponent and are afraid to speak out. It is also a bad deal to make it a competitive popularity contest. A number of folks who appreciate the Lion's Club donations to their causes never thought about the impact a "community group" has on the neighborhood – the community spirit intent of the Lion's Club becomes a bit of an oxymoron. For example if one scours the Internet to see what other Lion's Club's do for fundraising they do not stand out in needing amplifies events. Yes, I understand the nature of the property, but a little creativity can go a long, different way.

Staff Response: The public hearing process allows all persons to comment on the proposed project, in favor of or in opposition to; and the Planning Commission takes all comments into consideration prior to making an informed decision. Also, a Notice of Public Hearing was published on the County's website page dedicated to the Community of Three Rivers. In addition, members of the Lions Club presented their proposal to the community during a Town Hall meeting on February 2, 2015.

[6] The current, most active members on this project told us at different times that the Lion's Club makes its money predominantly on alcohol sales and with the ability to have more amplified events they hope to attract large numbers of people to meet this goal. It is fairly obvious whom they will have to appeal to and what kind of sound will be needed... This is per Lion Dean Stryd and Lion Tom Sparks.

Staff Response: The inference is that alcohol will attract an unruly element to the event and that additional events will be to the detriment of the community. The Sheriff's Department was sent a consultation notice of this Project amendment in 2014 and no correspondence was received regarding disturbances or nuisance calls to the existing facility. Staff contacted the Sheriff's Department on February 16, 2016 regarding incidents at the subject site. There had not been any incidents pertaining to noise during the previous three years.

[7] This process pits neighbor against neighbor and threatens friendships. There are two neighbors in the area, not happy about the sound, but will not speak up because they are afraid of being polarized by members of the community.

Staff Response: The public hearing process allows all persons to comment on the proposed project, in favor of or in opposition to; and the Planning Commission takes all comments into consideration prior to making an informed decision.

[8] There are 7 new houses in this neighborhood since the original permit was granted. This area is a neighborhood.

Staff Response: The subject site is zoned Exclusive Agriculture – 20 acre minimum and the surrounding properties are zoned for rural residential use – one acre minimum. This is an example of new development infringing on an existing use. As such, the owners of the seven new residences should have been made aware of (that is, disclosure of) the Three Rivers Lions Club facility prior to closing escrow.

new residences should have been made aware of (that is, disclosure of) the Three Rivers Lions Club facility prior to closing escrow.

[9] None of the Lion's Club Board members live in sound vicinity of the project site nor do the majority of the people in the two organizations who sent in letters of support. I asked Lion Tom Sparks this year what he thought of one of the events – he smiled and said "oh I don't know, I wasn't there ... I don't like that kind of music!" (He has a house on the coast he can escape to...)

Staff Response: The Lions Club rents the facility out to other organizations in order to collect funds for their community service activities and contributions. The manner of event is not exclusively determined by the Lions Club. Attendance by Lions Club members is a personal decision regardless of location of their residence.

[10] In a recent community plan meeting Eric Coyne admonished us (Three Rivers residents) for not taking more of a business advantage of the number of tourists passing through our town. Well many of us are trying and with our small businesses –we are marketing nature and the beauty and serenity of the area.

Staff Response: The Three Rivers Lions Club facility has been in existence at this site and utilized for a roping arena since at least 1949. The "rodeo" culture is part of the heritage/legacy of this Three Rivers area. Neighboring businesses rely on pass-by or destination oriented traffic during the course of a year, whereas events at Lions Club facility occur on an infrequent basis resulting in a temporary and short-term influx of persons interested in the events. It is also likely that persons attending these events utilize dining, lodging, shopping, and fueling within the area which contributes to businesses in the Three Rivers area.

A. RESPONSE TO DOCUMENT

[11] a. Traffic control was required with the original special use permit/ Event Management Plan –was not monitored for compliance

Staff Response: Applicant is responsible for following and adhering to the conditions of approval. If a complaint is filed, standard procedure requires Code Enforcement to address the complaint.

b. Why no mention of the private road which has areas of only 8 feet of pavement in places with sandy shoulders (picture stock trailer and emergency vehicle having to pass) not mentioned for proper and safe roadway compliance. The road along the project site is inadequate for safe and proper two-way transit.

Staff Response: The access road to the subject site is a privately-maintained private road. Condition of Approval No. 15 states, "Both the parking area and driveways, including the easement from North Kaweah River Drive to the northerly property line of the subject site to a width of 20 feet, shall be surfaced for all-weather conditions and be maintained so that dust and mud do not create conditions detrimental to surrounding roadways."

c. No mention of dust control along the road during dry periods.

Staff Response: Condition of Approval No. 15 states, "Both the parking area and driveways, including the easement from North Kaweah River Drive to the northerly property line of the subject site to a width of 20 feet, shall be surfaced for all-weather conditions and be maintained so that dust and mud do not create conditions detrimental to surrounding roadways." Also, it is possible that the San Joaquin Valley Air Pollution Control District may also have jurisdiction in regards to dust/dust control requirement as fugitive dust is regulated by the Air District. The Air District can be contacted at (559) 230-6000.

[12] **a. Three Rivers has not yet defined itself to be the County location for outdoor amplified entertainment – although there have been many attempts to make it so ...There are plenty objections to this trend and no doubt will be a large point of contention if this addition of 5 more events starts precedence.**

Staff Response: Three Rivers is the gateway to Sequoia National Park and approximately 1 million park visitors traverse Highway 198 annually. As noted in Response No. 10, neighboring businesses rely on pass-by or destination oriented traffic during the course of a year, whereas events at Lions Club facility occur on an infrequent basis resulting in a temporary and short-term influx of persons interested in the events. It is also likely that persons attending these events utilize dining, lodging, shopping, and fueling within the area which contributes to businesses in the Three Rivers area.

b. Weighted dB average over 24 hours is irrelevant to the surrounding neighborhood - and grossly unfair!

Staff Response: The CNEL (Community Noise Exposure Levels) threshold of 60 dB is consistent with the recommendations of the California Office of Noise Control and per the adopted Tulare County General Plan 2030: Section 10-8.6, Health and Safety: Noise Level Criteria which were adopted in August 2012.

c. Sound transmission as it relates to environmental conditions should be taken into account, i.e. transmission along waterways, with elevation changes, in regard to the presence and direction of the wind, and with the ambient temperature.

Staff Response: The Noise Study was conducted in accordance with the current standards of the industry. It should also be noted that the precise equipment used to conduct the Noise Study were calibrated to account for existing noise conditions, wind and ambient temperatures, and conducted over a 24-hour period using an Extech Type 2 sound level meter datalogger.

d. Vegetation grown in this area cannot attenuate sound nor can the right type of plants if they exist, be grown in this plant climate zone – otherwise the extensive riparian habitat between the project site and the North Fork Drive would have done so already.

Staff Response: Vegetation provides some limited sound attenuation. Also, as concluded in the Noise Study (at page 13), even the nearest sound receptor (at a distance of approximately 450 feet) did not exceed Tulare County's noise standards. Therefore, distance, rather than vegetation, determined level of impact. Lastly, the farthest receptor (located approximately 1,900 feet away) resulted in a noise level of 51.4 dBA. As such, it is not possible for any receptor greater than 1,900 feet away to experience a noise level higher than the nearest source as sound attenuates (that is, reduces) at a rate between 3.0 and 4.5 dBA per doubling of distance (see Noise Study, page 6).

e. Please note that the letter of support enclosed in the 'county' package of the household that lives down the road from the project site failed to mention the reason she does not hear the amplified music is that there is a large burm separating her from the site.

Staff Response: Berms, because their soil compaction results in a dense object, do effectively attenuate noise. The commenter failed to identify the specific location of the person she is referring to; however, RMA staff found only one letter specifically indicating their residence is approximately 1,200 feet from the events ground. As noted in Response 12 d., distance, rather than an actual physical barrier, would diminish noise to less than the noise level measured at the receptor located only 450 feet away. Which, as noted in the Noise Study, is below Tulare County's noise standards.

f. The "Noise Study" commissioned by the Lion's Club was extremely disingenuous and ill-timed. The event tested was the lowest and least amount of sound that particular event generated in a number of years (by their own admission – I spoke to the wife of the main organizer) ... thus the Lion's sadly wasted resources on that event. A PROPER SOUND STUDY IF NEEDED SHOULD BE DONE AT THEIR LOUDEST EVENT. (POSSIBLY ALSO AT THE QUIETEST AMPLIFIED EVENT INORDER TO MAKE A JUDGMENT ON ALLOWABLE SOUND)

Staff Response: The Noise Study Report was prepared by VRPA Technologies, Inc. and took place on Friday, May 16 and Saturday, May 17, 2014 during the Blues Fest, an annual event at the facility. As indicated in Response No. 12 c, the precise equipment used to conduct the Noise Study were calibrated to account for existing noise conditions, wind and ambient temperatures, and conducted over a 24-hour period using an Extech Type 2 sound level meter datalogger. As noted in the Noise Study, non-amplified and amplified events were both measured. The source of the sound, regardless of event type, did not exceed Tulare County's noise thresholds.

g. Unfortunately, the RMA chose one of the least loud events to measure and observe, in which the Lion's club members made sure with great care that the decibel level was adhered to, if not reduced as compared to the previous year for that event.

Staff Response: RMA staff visited the subject site and Ms. Ricci's residence on October 3, 2015 during the Performing Arts Film Festival, the last such event for the calendar year.

Using hand-held noise measuring devices, the noise levels were consistent with the noise levels measured during the Noise Study using a more precise instrument. That is, the readings did not exceed Tulare County's noise standards.

h. The lack of mention or intention to provide real-time noise reduction/attenuation measures is a glaring error of omission. *(See enclosed example of access to necessary materials and evidence of what noise reducing walls and vegetation really means)* i.e. noise absorbing material to insulate the pavilion, plexiglass placed in key areas, etc.

Staff Response: The musical entertainment and film projection occurred within an open-sided enclosure with curtains on the west-facing side that can be raised and lowered. As noted earlier in Response 12 d., distance, rather than an actual physical barrier, would diminish noise to less than the noise level measured at the receptor located only 450 feet away. As noise levels do not exceed Tulare County noise stands, no sound attenuation is necessary or required.

i. SEE ENCLOSED PAPERS ON SOUND AND NOISE MITIGATION AS EVIDENCE OF WHAT IT TAKES TO MITIGATE SOUND REDUCTION AND VALIDATE THE SIGNIFICANCE OF THE LACK OF VEGETATION AS BEING A MITIGATION MEASURE.

Staff Response: The cost of a sound wall and/or other permanent acoustical soundproofing materials does not correspond to the temporary and occasional nature of the sound originating at the subject site. As noted earlier, as noise levels do not exceed Tulare County noise stands, no sound attenuation is necessary or required.

[j] FYI - NOTE: ***Nuisance Standard:***
"Any use found to be objectionable or incompatible with the character of the city and its environs due to noise, dust, odors or other undesirable characteristics may be prohibited" (Snow v. City of Garden Grove (1961) Cal.App.2d 496).

Staff Response: This is the Nuisance Standard specific to the City of Garden Grove. Further, the citation does not explicitly prohibit the objectionable or incompatible sources, it merely indicates that such sources <u>may</u> be prohibited. As noted earlier, Tulare County General Plan 2030: Section 10-8.6, Health and Safety: Noise Level Criteria which were adopted in August 2012.

B. COMPLIANCE ISSUES

[13] a. The Lion's events have violated their authority every year since the special use permit was invoked – all the way up to this last event that was the 6th out of 5 allowable

Staff Response: Code Enforcement issued Violation No. V508-032 on the property for failure to comply with the conditions of approval of Special Use Permit No. PSP 02-013. This

Project amendment to the special use permit, if approved, will satisfy the requirements of Code Enforcement and the violation will be closed.

b. See enclosed letter from a past president as a sample of verification.

Staff Response: The Three Rivers Lions Club President at that time explained that the entity which had rented the facility for that particular event was not supposed to amplify the event and was in violation of the contract. The Three Rivers Lions Club is not limited in the number of non-amplified events.

c. There appears to be no mention of monitoring and enforcement measures that <u>must be</u> a part of this projects' plan.

Staff Response: The Mitigation Monitoring Reporting Program, if approved, will be the enforcement tool for RMA.

d. A list of violations can be provided if necessary

Staff Response: The County does not object to receiving the list of violations being provided.

C. <u>CUMULATIVE IMPACT</u>

[14] a. Cumulative impact evidence was not required or reported in this document.

Staff Response: The Initial Study that was performed for the project determined that the addition of five amplified events would be Less Than Significant With Mitigation Incorporated. Cumulative impacts are not required to be analyzed as part of a Mitigated Negative Declaration.

b. The cumulative impact of the RIVER VIEW RESTAURANT every Sunday afternoon during the same time period of spring, summer and fall, along with the periodic amplified music from the periodic wedding celebrations of the WHITE HORSE INN are an obvious error of omission and must be taken into account.

Staff Response: The comment is unclear. We are uncertain if the commenter is suggesting that noise generated by the River View Restaurant and "periodic amplified music from periodic wedding celebrations" at the Whitehorse Inn should be accounted when both are occurring on Sundays; or if the above noted sources should be accounted with the Lion's Club proposal? We are unsure if the River View Restaurant is, in the opinion of the commenter, also contributing amplified music. Further, "periodic" is undefined.

c. For example: it is Sunday almost Bpm and I can hear the RIVER VIEW RESTAURANT AND BAR that has live, amplified music on their outside deck every Sunday afternoon from May – to October in my house. This restaurant has a special use permit as well and by far does not adhere to the 65dB restriction at their property edge. Their address is 42323 Sierra Drive. We just took a sound reading and got 57dBs outside our sliding glass dining room door. As the crow flies they are located up and across the river approximately .6 miles from our location.

Staff Response: The reading, at 57 dB's, is less than the County of Tulare standard of 60 dB's. A distance of 0.6 miles is approximately 3,168 feet. The commenter indicates the distance "as the crow flies"; which we interpret to mean a straight-line distance versus actual ground (that is, travelled) distance. However, their property has intervening curves, hills, and vegetation which would attenuate sound. Importantly, as noted earlier, sound attenuates between 3 to 4.5 dBA with doubling of distance from a source to a receptor. Therefore, Mrs. Ricci reading is within an estimated reduction between 6-9 dBAs. As such, a 65 dBA at the property line of the River View Restaurant minus a reduction of 6 dBAs because of the 3,168 foot distance to the Ricci's residence results in 59 dBAs; while a 9 dBA reduction would result in 56 dBAs...both are below County of Tulare standard of 60 dB's.

D. <u>OMMISSIONS</u>

[15] a. There is a glaring lack of needing to know a definition of what constitutes an event. Is an event defined by the number of days or the number of weekends, ex: a festival or a dinner?

Staff Response: As stated in the Agenda and Resolution, Ordinance No. 3416 amended the Assemblage of People Ordinance and defines Special Event as being, "Any temporary use, generally lasting from a few hours to a few days, conducted or sponsored by an organization, entity, association, or group involving a display, demonstration, performance, exhibition, or amusement which includes, but is not limited to, festivals, concerts, carnivals, arts and craft shows, fireworks displays, sporting events, socials, parties, parades, rallies, and other similar uses." "For the purposes of this special use permit, the definition of an "Amplified Event" shall be: "A display, demonstration, performance, exhibition, or amusement which includes, but is not limited to, festivals, concerts, carnivals, arts and craft shows, fireworks displays, sporting events, socials, parties, parades, rallies, and other similar uses whose sound is made louder through the use of mechanical or electronic means." To be clear, non-amplified events are not the issue regarding the proposal and would not be counted as an amplified event.

b. How will event dates be notified AHEAD OF TIME to the community at large? And will that be required?

Staff Response: Condition of Approval #31 and MMRP #12.3 states: "The applicant shall give one week's notice before each amplified event to all property owners within 300' of the subject property and any other person who requests special notice. Applicant shall provide the same notice to TCRMA before each amplified event occurs."

D. <u>CONCLUSION</u>

[16] Taking all this into consideration it leaves us very few weekends free of undesired sound on my private property, especially during the prime time for enjoying nature. IT ESSENTIALLY IS VIOLATING OUR PRIVATE PROPERTY RIGHTS.

AS WE HAVE MENTIONED BEFORE WE ACCEPT AND HONOR THE HISTORICAL EVENTS THAT TAKE PLACE ON THE PROJECT GROUNDS ONE WOULD HAVE TO WONDER WHY IF THE PLANNING COMMISSION SAW FIT TO APPROVED 5 EVENTS IN 2004 WHEN 10 EVENTS WERE REQUESTED, WHY WOULD MORE BE COMPATIBLE WITH THE CONDITIONS AS PREVIOUSLY DESCRIBED?

This will continue to promote a slow expansion of a characteristic that is not what most residents want THREE RIVERS to be known for - an entertainment bowl for valley residents.

Instead we have a lovely area that services a national park and promotes and allows outsiders to benefit and enjoy the open space and peacefulness not available in urban settings. THIS IS GOOD BUSINESS PRACTICES.

Up and beyond the three original, historic events the addition of more amplified events requested by this project does not contribute to the intent to "preserve the unique character of Three Rivers."

Again, we request that RMA delays further action on this application until the Three Rivers Community Plan and its environmental documents are completed and implemented.

Staff Response: Mitigation Measures have been incorporated into the Project to ensure that the 5 additional amplified events will not have a significant effect on the environment. Refer to Mitigation Measures.

We appreciate Ms. Ricci's comments and her perspective of the Three Rivers area. Approximately 1 million people travel through the Three Rivers area on their way to

Sequoia National Park each year. Many of the services in Three Rivers cater toward the traveling tourist. The Lions Club arena is a facility that provides a service to local residents, a facility that raises money which is donated to local charitable organizations. As there are 52 weekends (the typical occurrence during the week of an event) each year, if a maximum of 10 amplified events were to occur, there would still be 42 weekends without amplified events (which represents almost 81% of weekends within a year). Currently, the 5 allowed amplified events (again, assumed to occur during weekends) would leave 90% of weekends (that is 47 weekends) without amplified events. As noted in Response No. 12. a; it is also likely that persons attending these events utilize dining, lodging, shopping, and fueling within the area which contributes to businesses in the Three Rivers area.

Exhibit "E" - Comments Submitted by Michael L. Cannarozzi:

[1] Noise: Through the past 25 years I have patiently listened to the drone of the PA systems, heard various bands all weekend whether I wanted to or not, and have been woken up as late as 3AM by amplified announcements.

Staff Response: A Noise Study Report was conducted for the project site. In addition, staff visited the site and the Ricci residence during an amplified event. The decibel (dB) readings on both occasions indicate that the measured noise level did not exceed 60 dB at the property line. In addition, COA #26 requires that a Lions Club member be present at all amplified events in order to monitor the noise level for compliance with the 60 dB at the property line requirement. COA #20 states, "The hours of operation for events shall be limited to 7:00 a.m. to 11:00 p.m. with clean-up activities completed by 12:00 midnight." In addition, COA #30 states, "All amplified noise associated with events held on-site shall not be permitted between the hours of 11:00 p.m. and 9:00 a.m"

[2] Disputes validity of sound study: I formally dispute the validity of the sound study commissioned by the Lions Club by VRPA Technologies….

Staff Response: The Noise Study Report was prepared by VRPA Technologies, Inc. and took place on Friday, May 16 and Saturday, May 17, 2014 during the Blues Fest, an annual event at the facility. As indicated in Response No. 12 c, the precise equipment used to conduct the Noise Study were calibrated to account for existing noise conditions, wind and ambient temperatures, and conducted over a 24-hour period using an Extech Type 2 sound level meter datalogger. As noted in the Noise Study, non-amplified and amplified events were both measured. The source of the sound, regardless of event type, did not exceed Tulare County's noise thresholds.

Exhibit "F" - Comments Submitted by Julie Doctor:

[1] Noise and traffic: Adding one or two [events] maximum might be ok, but as an adjacent resident directly across the river from the extended parking area, I am concerned about the noise and traffic. I support the community events and noise restrictions, but events like the Sober Biker and Blues fest are extremely annoying and not really supportive of our residents. The roping, Jazz Affair, Western Film Festival, Red Bud, and EAA music festivals are good for our residents, but beyond that, I am not supportive of adding more events.

Staff Response: A Noise Study Report was conducted for the project site. In addition, staff visited the site and the Ricci residence during an amplified event. The decibel (dB) readings on both occasions indicate that the measured noise level did not exceed 60 dB at the property line. In addition, COA #26 requires that a Lions Club member be present at all amplified events in order to monitor the noise level for compliance with the 60 dB at the property line requirement.

A Traffic Management Plan (TMP) was submitted to, and approved by Caltrans. The TMP details the actions that will be taken in order to control traffic at all of the public events being hosted at the project site, if they have the potential to impact State Route 198. Parking at the facility will be monitored by the Lions Members and directional signage is designed to avoid traffic backups onto SR 198. Attendees at these events arrive and depart in random patterns and do not meet the threshold of 50 peak hour trips (for Caltrans) that would indicate that a traffic study should be completed.

[2] Helicopter traffic is fairly unpleasant…

Staff Response: The property that is utilized by the helicopters is not owned by the Lions Club, but is located on the adjacent property. County staff will send Code Enforcement to investigate.

Exhibit "G" - Comments submitted by Brad and Maggie Bloetscher:
[1] Noise: Over the last decade or so we have experienced an accumulation of disturbing and annoying noise in our neighborhood of the North Fork. The Lions Club facility events are not the only contributor. Mid Valley Disposal uses the facility…. Southern California Edison uses the facility as a heliport…and the Riverview Restaurant outside music venue occurs late into the night….

Staff Response: A Noise Study Report was conducted for the project site. In addition, staff visited the site and the Ricci residence during an amplified event. The decibel (dB) readings on both occasions indicate that the measured noise level did not exceed 60 dB at the property line. In addition, COA #26 requires that a Lions Club member be present at all amplified events in order to monitor the noise level for compliance with the 60 dB at the property line requirement. Also, COA # 30 states, "All amplified noise associated with events held on-site shall not be permitted between the hours of 11:00 p.m. and 9:00 a.m."

The property that is utilized by Mid Valley Disposal and Southern California Edison is not owned by the Lions Club, but is located on the adjacent property. County staff will send Code Enforcement to investigate.

[2] Cumulative Impacts: To all of this noise you add the Lions Club amplified events and the quiet, country experience we had is slowly being eroded away.

Staff Response: The Initial Study that was performed for the project determined that the addition of five amplified events would be Less Than Significant With Mitigation Incorporated. Cumulative impacts are not required to be analyzed as part of a Mitigated Negative Declaration.

Exhibit "H" - Comments submitted by Juanita Tolle:

[1] Noise: Musical events occurring at the airport reverberate around the North Fork canyon. Evening noise definitely disturbs the peace.

Staff Response: A Noise Study Report was conducted for the project site. In addition, staff visited the site and the Ricci residence during an amplified event. The decibel (dB) readings on both occasions indicate that the measured noise level did not exceed 60 dB at the property line. In addition, COA #26 requires that a Lions Club member be present at all amplified events in order to monitor the noise level for compliance with the 60 dB at the property line requirement. Also, COA # 30 states, "All amplified noise associated with events held on-site shall not be permitted between the hours of 11:00 p.m. and 9:00 a.m."

[2] Cumulative Impacts: My family has complained about the evening noise from Riverview, and a second venue in the adjoining area would compound this problem.

Staff Response: The Initial Study that was performed for the project determined that the addition of five amplified events would be Less Than Significant With Mitigation Incorporated. Cumulative impacts are not required to be analyzed as part of a Mitigated Negative Declaration.

[3] Traffic: Will increase locally with each event.

A Traffic Management Plan (TMP) was submitted to, and approved by Caltrans. The TMP details the actions that will be taken in order to control traffic at all of the public events being hosted at the project site, if they have the potential to impact State Route 198. Parking at the facility will be monitored by the Lions Members and directional signage is designed to avoid traffic backups onto SR 198. Attendees at these events arrive and depart in random patterns and do not meet the threshold of 50 peak hour trips (for Caltrans) that would indicate that a traffic study should be completed.

[4] Definition of Event: The community needs to spell out the limitation of days for each event and consider alternative locations for some of the events – not all in one place.

Staff Response: Ordinance No. 3416 amended the Assemblage of People Ordinance and defines Special Event as being, "Any temporary use, generally lasting from a few hours to a few days, conducted or sponsored by an organization, entity, association, or group involving a display, demonstration, performance, exhibition, or amusement which includes, but is not limited to, festivals, concerts, carnivals, arts and craft shows, *fireworks displays, sporting events, socials, parties, parades, rallies, and other similar uses." This definition has been duplicated in the resolution as Finding #4.*

[5]Time Limits: The community should designate time limits for opening and closing events each day. Musical events should not play loud music during evening hours.

Staff Response: Condition of Approval No. 30 requires that "All amplified noise associated with events held on-site shall not be permitted between the hours of 11:00 p.m. and 9:00 a.m."

EXHIBIT NO. A

Negative Declaration

Project Title: Special Use Permit No. PSP 14-034

Doubling events from 5 annual to 10 annual event per year

The Lions organization on North Kaweah River Drive, in Three Rivers California, is attempting to double their permitted amplified events. This letter is intended to address some concerns that some of the affected community has. Since we are affected the most, due to proximity, we believe we have valuable observations and insight about the activities that occur on the Lions property. The Lions organization has grown accustomed to exploiting the resources of our community while diverting responsibilities to community members. The following outlines the major concerns we have that should be mitigated before a permit is issued to the Lions organization.

1. **Road deterioration:** The Lions facility is only accessible by a private road known as North Kaweah River Drive. The Lions organization currently does not maintain or repair the damage to the road caused by the activities that occur at their facility. The road is in a state of constant degradation with numerous potholes, bumps, uneven surfaces, and pooling water. The current maintenance is conducted by my family and one other member of our neighborhood that lives on North Kaweah River Drive. Doubling the traffic will inevitably lead to further deterioration and degradation of this non-county maintained PRIVATE DRIVE. The responsibility to maintain the road should also fall upon the Lions organization, due to their high volume of use. ***Resolution:*** Pave the road, with speed bumps, and keep up the maintenance, up to the last encroachment point of the Lions property. This can be paid for by the revenues generated through the events held on the Lions Property.
2. **Speed of Patrons:** Some Patrons of the Lions property events travel at unsafe velocities on the PRIVATE ROAD of North Kaweah River drive, upwards of 50-60 miles per hour, sometimes higher. For this reason, we feel that it has become dangerous for our active community. This road was a safe-haven for walkers, runners, children on bikes, etc. The owners of this road wish to restore its reputation as a safe place to teach a child to learn to ride a bike, or stay fit, or enjoy the wildlife and landscape, without fear of unsafe drivers. Doubling the events would increase the probability for speeders. ***Resolution:*** Insert speed bumps with speed limit signs to be followed by drivers.
3. **Trash control:** After every event, there is veritable cornucopia of trash all over the Lion's property. This garbage is blown onto adjacent properties, which is left to neighbors and caring locals who walk up and down North Kaweah River Drive, to pick up. The Lions do not adequately pick up trash that originates on their property. Resolution: Encourage their patrons to use trash receptacles. Create a method for complete clean up, either by budgeting to hire for the service, or create a process within their group that ensures this to occur.
4. **Air pollution:** The dust for most events is unbearable. For some events, such as the roping event, they attempt to water down the roads. However, the attempt is not adequate enough to mitigate the dust pollution. My property is inundated by dust for the duration of every event. Whenever they do use water for dust control, they are drafting water from the North Fork of the Kaweah River without a drafting permit from Fish and Wildlife. This is being done even when the river has stopped flowing, and the water is being pulled from the small

residual pools just downstream from my house. The water extraction point is not on their land. Adequate dust control is mandatory in accordance with the valley air district dust prohibition guidelines. ***Resolution:*** Pave the road. Follow the legal avenues established and apply for a drafting permit through The Department of Fish and Wildlife.

5. **Garbage Service:** Aside from the noise created from the events held on the Lions property, the garbage trucks are our major concern. EVERY MORNING, at 5:00am, we are awakened by the sound of airbrakes, revving motors, and slamming mechanisms on garbage trucks! Our gate is in the same location as the Lions access gate, so we get the full effect of a continual, industrial operation. The garbage service provider has recently, in the last year, signed a new contract with the county of Tulare. The contract has mandated the trash servicer to supply recycle and green waste cans to each of their customers. For this reason, the company has hired another truck driver, therefore doubling the noise, dust, road deterioration, etc. The Lions property is used as a storage facility for trash bins of all sizes that are not currently being used. This attracts bears and makes the property look like a county yard. ***Resolution:*** Require the garbage service to move to another location that has appropriate zoning and permits.
6. **Light Pollution:** For every event, lights from the Lions arena shine directly into our house. The lights often remain on for the duration of the night. ***Resolution:*** Change the current lights to directional, downward lights. Turn them off when not in use.
7. **Non-amplified event Activities:** The Lions lease out sections of their property to contractors who work for companies such as Southern California Edison. Currently they are occupying space to work on the flumes, which need necessary maintenance. This has increased the quantity of heavy work trucks coming and going on the road, light pollution as they leave their work lights on 24/7, dust pollution, noise pollution as they are flying helicopters in and out to move payload of materials. They are projected to be on site for 2-3 months more. We recognize this location as ideal for staging large projects, as well as helicopter flights; however, those who benefit from these activities should have responsibilities to the affected members of the community. ***Resolution:*** Inform the neighbors of intended projects and duration. Pave the Road from the proceeds generated and apply for permits as necessary.

In conclusion, increased activity at the Lions facility on North Kaweah River Drive should require increased responsibilities to the Lions organization. The garbage service needs to move to another location as the daily activities have changed the Lions into a county yard. The road needs to be paved and maintained. The lighting should be replaced with modern lights that minimize light pollution. The neighbors of the Lions facility need to be informed of when intended events and other activities will occur, as well as duration. As a permanent resident on North Kaweah River Drive, adjacent from the gate of the Lions facility, all activities directly affect my property and family. If there are any questions or need for clarification feel free to contact me.

Sincerely,

Mary Anne Vandegrift

PO Box 499

42801 North Kaweah River Drive

Three Rivers Ca, 93271

559-802-0862

maryannevandegrift@gmail.com

EXHIBIT NO. B

January 19, 2016

Mike Washam
Assistant Director
Economic Development and Planning
Tulare County Resource Management Agency

Mr. Washam,

We apologize for the delay in communications – had a computer issues, etc. Regarding the revised SUP document, while it helps some some, there are still two points that did not get clarified.

As you recall the meeting that we had in an effort to come to a compromise degenerated a bit and at the time couldn't be continued in that climate.

[1] First of all, in order to continue the potential compromise process, and having read the revised SUP we still need to come to some agreement and definition as to what constitutes and event by definition, i.e. how many night/days of actual amplified music will be allowed.

Again as was pointed out the definition as it stands, or appears to be is a fluctuating definition as best.

<u>Example</u>: The Jazz Affair has now become a 4-day event as noted by the Lion's Club members at this meeting, where it had been a three (3) days event in the past for years. With the roping as a 3 amplified event, the Blues Fest being 2 days, etc. you can see how actual days' can covertly build.

The potential exists by verbal discussions only, to produce maximally 30 days/nights of amplified sound during the annual season. That is a lot.

You will need to realize the Lion's Club organization is entirely made up volunteers and the leadership fluctuates. Clarification of all points needs to clear and detailed.

[2] Additionally, please realize that the compliance guidelines for decibel adherence are weak. If the Tulare County Sheriffs office is to be the definer and enforcer it is summarily improbable that they will not be able to respond in a timely manner to discern the violation in progress. We cannot get a quick emergency response for a criminal or medical emergency in under 10-20 minutes. It would seem to be in order to define how this will be objectively done. Could transmission of data to an off site objective local be an adequate mitigation measure?

Thank you for taking this into consideration,

Maya Ricci
Vincent Andrus
42669 North Fork Drive
Three Rivers

Cc: Dana Mettlen, Planner III
Project Processing
Economic Development and Planning Branch
Tulare County Resource Management Agency

John Elliot
Tulare County Planning Commission

DEPARTMENT OF TRANSPORTATION
DISTRICT 6
1352 WEST OLIVE AVENUE
P.O. BOX 12616
FRESNO, CA 93778-2616
PHONE (559) 455-5868
FAX (559) 488-4088
TTY 711
www.dot.ca.gov

EXHIBIT NO. C

Serious drought.
Help save water!

September 25, 2015

6-TUL-198-38.49 +/-
2135-IGR/CEQA
PSP 14-034 (2)
MITIGATED NEGATIVE DECLARATION
THREE RIVERS LIONS CLUB

Mr. Dana Mettlen, Project Planner
Tulare County - Resource Management Agency
5961 S. Mooney Blvd.
Visalia, CA93277

Dear Mr. Mettlen:

Thank you for the opportunity to review the Mitigated Negative Declaration (MND) for PSP 14-034 proposing to increase the number of *amplified outdoor events* from 5 to 10 annually for the Three Rivers Lions Club. The non-profit facility operates from April to October each year. Typical events include rodeos, music festivals and art display exhibitions on the 5.78 acre site. The project is located at 42390 N. Kaweah River Drive, approximately 1,800 feet northwest of the State Route (SR) 198 / North Fork Drive intersection in the Community of Three Rivers. Caltrans has the following comments:

On 4/23/2015, Caltrans approved and submitted to the County, the Traffic Management Plan (TMP) provided by the applicant for PSP 14-034.

As listed on page 27 & 28 of the Initial Study (section 16 "Transportation/Transit"), the MND for the project will incorporate the conditions of the approved TMP.

Caltrans concurs that the TMP is still valid as mitigation to minimize project impacts to less than significant.

If you have any other questions, please call David Deel at (559) 488-7396.

Sincerely,

MICHAEL NAVARRO, Chief
Planning North Branch

C: Hector Guerra – Tulare County RMA

Exhibit "D"

Maya Ricci Comments of October 18, 2015

October 18, 2015

To: Tulare County Resources Management

From: Maya Ricci
Vincent Andrus
42669 North Fork Drive
P.O. Box 636
Three Rivers, CA

Re: Special Use Permit No. 14-034, amending Special Use Permit No. PSP--02-013, approved on May 12, 2004

INTRODUCTION:

The intention of our comments are 2-fold – to respond to the document and discuss other relevant considerations or omissions. I fully realize that your department is constrained to some extent with the out-dated land use guidelines for our area as well as the fact that the County of Tulare does not have a specific Noise Ordinance.

However, we do have improved standards and guidelines that illustrate the desired character that are pending for the Three Rivers area within a reasonable time frame that will be more useful in guiding this project in the future.

To that end we would ask the RMA to stay the decision for cause pending the completion of the THREE RIVERS COMMUNITY PLAN update with it various accompanying environmental documents.

There is a neighborhood surrounding this project location. We cannot be penalized by the 300 foot rule as parcels are large, thus spread out by definition, but are related by the transmission of light, sound and/or inadequate roadways.

Additionally we would like to point out that the manner in which citizens have to participate in this particular process is essentially a lousy deal. It exists in a vacuum when those affected do not get notified objectively. It is a bad deal when others are intimidated by the potential of "getting on the bad side" of the project proponent and are afraid to speak out. It is also a bad deal to make it a competitive popularity contest. A number of folks who appreciate the Lion's Club donations to their causes never thought about the impact a "community group" has on the neighborhood – the community spirit intent of the Lion's Club becomes a bit of an oxymoron. For example if one scours the Internet to see what other Lion's Club's do for fundraising they do not stand out in needing amplifies events. Yes, I understand the nature of the property, but a little creativity can go a long, different way.

The current, most active members on this project told us at different times that the Lion's Club makes it money predominantly on alcohol sales and with the ability to have more amplified events they hope to attract large numbers of people to met this goal. It is fairly obvious whom they will have to appeal to and what kind of sound will be needed... This is per Lion Dean Stryd and Lion Tom Sparks.

This process pits neighbor against neighbor and threatens friendships. There are two neighbors in the area, not happy about the sound, but will not speak up because they are afraid of being polarized by members of the community.

There are 7 new houses in this neighborhood since the original permit was granted. This area is a neighborhood.

None of the Lion's Club Board members live in sound vicinity of the project site nor do the majority of the people in the two organizations who sent in letters of support. I asked Lion Tom Sparks this year what he thought of one of the events – he smiled and said "oh I don't know, I wasn't there ... I don't like that kind of music!" (He has a house on the coast he can escape to...)

In a recent community plan meeting Eric Coyne admonished us (Three Rivers residents) for not taking more of a business advantage of the number of tourists passing through our town. Well many of us are trying and with our small businesses – we are marketing nature and the beauty and serenity of the area.

A. RESPONSE TO DOCUMENT
B. COMPLIANCE ISSUES ARE NOT ADDRESSED
C. CUMULATIVE IMPACT IS NOT ADDRESSED
D. OMISSIONS

A. DOCUMENT:

Comments regarding the TRANSPORTATION ISSUES:

a) Traffic control was required with the original special use permit/ Event Management Plan – was not monitored for compliance

b) Why no mention of the private road which has areas of only 8 feet of pavement in places with sandy shoulders (picture stock trailer and emergency vehicle having to pass) not mentioned for proper and safe roadway compliance.

The road along the project site is inadequate for safe and proper two-way transit.

c) No mention of dust control along the road during dry periods.

Comments regarding NOISE:

Three Rivers has not yet defined itself to be the County location for outdoor amplified entertainment – although there have been many attempts to make it so ... There are plenty objections to this trend and no doubt will be a large point of contention if this addition of 5 more events starts precedence.

Weighted dB average over 24 hours is irrelevant to the surrounding neighborhood – and grossly unfair!

Sound transmission as it relates to environmental conditions should be taken into account, i.e. transmission along waterways, with elevation changes, in regard to the presence and direction of the wind, and with the ambient temperature.

Vegetation grown in this area cannot attenuate sound nor can the right type of plants if they exist, be grown in this plant climate zone – otherwise the extensive riparian habitat between the project site and the North Fork Drive would have done so already.

Please note that the letter of support enclosed in the 'county' package of the household that lives down the road from the project site failed to mention the reason she does not hear the amplified music is that there is a large burm separating her from the site.

The "Noise Study" commissioned by the Lion's Club was extremely disingenuous and ill-timed. The event tested was the lowest and least amount of sound that particular event generated in a number of years (by their own admission – I spoke to the wife of the main organizer) ... thus the Lion's sadly wasted resources on that event. A PROPER SOUND STUDY IF NEEDED SHOULD BE DONE AT THEIR LOUDEST EVENT. (POSSIBLY ALSO AT THE QUIETEST AMPLIFIED EVENT IN ORDER TO MAKE A JUDGMENT ON ALLOWABLE SOUND)

Unfortunately, then RMA chose on of the least loud events to measure and observe, in which the Lion's club members made sure with great care that the decibel level was adhered to, if not reduced as compared to the previous year for that event.

The lack of mention or intention to provide real-time noise reduction/attenuation measures is a glaring error of omission. (*See enclosed example of access to necessary materials and evidence of what noise reducing walls and vegetation really means)* i.e. noise absorbing material to insulate the pavilion, plexiglass placed in key areas, etc.

SEE ENCLOSED PAPERS ON SOUND AND NOISE MITIGATION AS EVIDENCE OF WHAT IT TAKES TO MITIGATE SOUND REDUCTION AND VALIDATE THE SIGNIFICANCE OF THE LACK OF VEGETATION AS BEING A MITIGATION MEASURE.

FYI - NOTE: ***Nuisance Standard:***

"Any use found to be objectionable or incompatible with the character of the city and its environs due to noise, dust, odors or other undesirable characteristics may be prohibited" (Snow v. City of Garden Grove (1961) Cal.App.2d 496).

B. COMPLIANCE ISSUES

The Lion's events have violated their authority every year since the special use permit was invoked – all the way up to this last event that was the 6th out of 5 allowable

See enclosed letter from a past president as a sample of verification.

There appears to be no mention of monitoring and enforcement measures that must be a part of this projects' plan.

A list of violations can be provided if necessary.

C. CUMULATIVE IMPACT

Cumulative impact evidence was not required or reported in this document.

The cumulative impact of the RIVER VIEW RESTAURANT every Sunday afternoon during the same time period of spring, summer and fall, along with the periodic amplified music from the periodic wedding celebrations of the WHITE HORSE INN are an obvious error of omission and must be taken into account.

For example: it is Sunday almost 8pm and I can hear the RIVER VIEW RESTAURANT AND BAR that has live, amplified music on their outside deck ***every Sunday afternoon from May – to October*** *in my house. This restaurant has a special use permit as well and by far does not adhere to the 65dB restriction at their property edge. Their address is 42323 Sierra Drive. We just took a sound reading* *and got 57dBs outside our sliding glass dining room door. As the crow flies they are located up and across the river approximately .6 miles from our location.*

D. OMISSIONS

There is a glaring lack of needing to know a definition of what constitutes an event.

- Is an event defined by the number of days or the number of weekends, ex: a festival or a dinner?

- How will event dates be notified AHEAD OF TIME to the community at large? And will that be required?

CONCLUSION:

Taking all this into consideration it leaves us very few weekends free of undesired sound on my private property, especially during the prime time for enjoying nature. IT ESSENTIALLY IS VIOLATING OUR PRIVATE PROPERTY RIGHTS.

AS WE HAVE MENTIONED BEFORE WE ACCEPT AND HONOR THE HISTORICAL EVENTS THAT TAKE PLACE ON THE PROJECT GROUNDS ONE WOULD HAVE TO WONDER WHY IF THE PLANNING COMMISSION SAW FIT TO APPROVED 5 EVENTS IN 2004 WHEN 10 EVENTS WERE REQUESTED, WHY WOULD MORE BE COMPATIBLE WITH THE CONDITIONS AS PREVIOUSLY DESCRIBED?

This will continue to promote a slow expansion of a characteristic that is not what most residents want THREE RIVERS to be known for – an entertainment bowl for valley residents.

Instead we have a lovely area that services a national park and promotes and allows outsiders to benefit and enjoy the open space and peacefulness not available in urban settings. THIS IS GOOD BUSINESS PRACTICES.

Up and beyond the three original, historic events the addition of more amplified events requested by this project does not contribute to the intent to "preserve the unique character of Three Rivers."

Again, we request that RMA delays further action on this application until the Three Rivers Community Plan and its environmental documents are completed and implemented.

Thank you,

Maya Ricci
Vincent Andrus
42669 North Fork Dr.
Three Rivers

MATERIAL INCLUDED WITH LETTER:

PAGE OF AN INTERNET SOURCE FOR AFFORDABLE SOUNDPROOFING AND ACOUSTIC PANELS

SOUND SMART - CITY OF VANCOUVER NOISE CONTROL MANUAL

RESEARCH INVENTRY: INTERNATIONAL JOURNAL OF ENGINEERING AND SCIENCE
ESTIMATION OF NOISE REDUCTION BY DIFFERENT VEGETATION TYPE AS A NOISE BARRIER: A SURVEY IN HIGHWAY ALONG WARU – SIDOARJO IN EAST JAVE, INDONESIA

PUBLICATION FROM NOISE/NEWS INTERNATIONAL
FINAL REPORT – TECHNICAL ASSESSMENT OF THE EFFECTIVENESS OF NOISE WALLS

LETTER: LETTER FROM THE LION'S CLUB PRESIDENT – 09/18/2012

NW NetWell NOISE CONTROL

Affordable Soundproofing and Acoustic Panels

Call 1-800-638-9355 for a FREE QUOTE

HELP

Get Your Questions Answered.

1-800-638-9355

Soundproofing Treatments

- Soundproofing a Auditorium
- Soundproofing a Bar
- Soundproofing a Broadcast Studio
- Soundproofing a Cafeteria
- Soundproofing a Call Center
- Soundproofing a Ceiling
- Soundproofing a Church
- Soundproofing a Classroom
- Soundproofing a Computer Room
- Soundproofing a Conference Room
- Soundproofing a Fellowship Hall
- Soundproofing a Floor

Affordable Soundproofing Services, Acoustic Panels & Soundproofing Products

Free Soundproofing Advice | Five Minutes | Call 1-800-638-9355

Our mission at NetWell Noise Control is to make your space sound better. We provide free soundproofing consutling services designed around the full array of acoustical sound panels and related soundproofing products you will discover right here on our website. With more than 22 years of industry experience, and more than 15,000 client spaces that we have succeeded in soundproofing, we welcome the opportunity to replicate for you what we know has worked for countless others before you.

Click Here to Get Started!

We start with the advice, then package the framework for your treatment around your budget, and deliver the most cost effective soundproofing products on the market to your door step. There are steps you can take to save money on your treatment, including tapping the free consulting we provide upfront, and the ease with which our sound panels and related acoustical materials can be self installed. We have just one request to get started, and that's asking that you simply call us for help. With just a five minute phone conversation, you will recognize we know our stuff, and will welcome the opportunity to deliver the value you are seeking.

Yes! Our customers experience up to a 90% collapse in their noise. You can to!

Acoustic Foam Soundproofing Panels & Acoustic Panels

Acoustiblok All Weather Sound Panels®

(New "Hurricane" Version tested to withstand <u>270 MPH / 434 KPH</u> wind load)

SPECIFICATIONS | HURRICANE MODEL | INSTALLATION METHODS | HVAC/CHILLER NOISE | INDUSTRIAL APPLICATIONS | RESIDENTIAL HEATPUMPS / AC / GENERATORS | ROAD NOISE | POWER PLANTS | PUMPING STATIONS | POOL & GYMNASIUM | MARINE APPLICATIONS | RAIL & MASS TRANSIT

THIS IS A TYPICAL IMAGE BORDER TABLE Modified on 11-2-10 to stagger images and text to shorten page PICTURE: GENERATOR IN A BOX

For years, **acoustical sound absorbing panels** have been used successfully to control problems with noise and sound in all types of indoor environments. They reduce tension, make music sound better, allow people to speak and hear better and provide a safer work environment.

But, because they are all made of fragile indoor materials, they can in no way withstand any other environment but the clean climate controlled indoors.

Click on Image to see Gallery

http://www.acoustiblok.com/images/cat3.gif

"Acoustiblok All Weather Sound Panels" are engineered specifically to withstand the most rigorous outdoor and industrial environments. Water, moisture, humid salt air or salt water, dirt, dust, constant ultraviolet light, chlorine air, grease, corrosion, and most harsh chemicals are not a problem for this product. Encased by all welded aluminum also prohibits vermin problems. Acoustiblok's **outdoor sound panels** are washable with a hose, very durable, long lasting and usable in hundreds of areas and applications. The panel has an

NRC **(Noise Reduction Coefficient) of 1.00 (highest level possible)**, Riverbank Acoustical Laboratories test results.
Extreme dust conditons can disable conventional sound absorbing systems. The Industrial & Hurricane model All Weather Sound Panels® are available with an acoustically transparent stainless steel dust filter (as much as 5 to 10 microns), which solves this problem for the mining industry, outdoor use in desert areas of the Middle East, and other applications where dust is a concern. Acoustiblok Panels are extremely durable and are currently in use by the United States Army in the Middle East.
In addition, these panels are not just **"sound absorbing"** but also **"sound blocking."** This allows one to not only absorb sound but also stop the sound from penetrating through the panel, a very meaningful advantage over conventional "sound absorbing" panels which stop sound reflections but are poor sound barriers. The panels have an extraordinarily high STC of 30 **(Sound Transmission Class)**, as the panels contain large amounts of the Acoustiblok material.
The most difficult sound blocking problems are the low frequencies (30 to 100 HZ). The annoying bass in music is predominately 40 to 80 HZ. Conventional sound barriers do dramatically less sound blocking below 100 HZ. However because of the "Acoustiblok" barrier material built into each of the "All weather panels" they actually increase in sound blocking from 100 HZ down (see test results) and are beneficial for difficult sound proofing*.
These panels are rigid and self-supporting. They can be used like building blocks to permanently or temporarily enclose a noise source, i.e., chillers and machinery. (Allow for required cooling).
Easily movable, they need not be permanent and may be stored in harsh environments without harm from the elements.
These entirely welded panels use only the highest in quality material and craftsmanship. Strain hardened 0.040" (1.016mm) corrosion resistant perforated aluminum front is resistant to abuse and sharp objects. New heavy duty frames have 18 flush eyelets free from any protrusions or screw heads thus allowing flush stacking and storage: Easily stack 50 panels in only 10 feet of height.

An optional Panel Carriage™ allows easy mounting and mobility in industrial environments.

Other Applications

Here are just a few of the many applications of the Acoustiblok All Weather Sound Panels:

LIST OF APPLICATIONS:

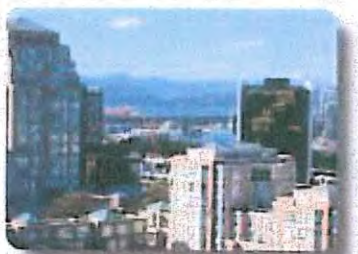
- Highway Road Noise
- Mass Transit
- Railroad Yards
- Residential Air Conditioner / Heat Pumps
- Gymnasiums
- Offshore Drilling Rigs
- Marine Vessels
- Auditoriums
- Industrial Machinery Areas
- Schools
- Hospitals
- Stadiums
- Churches
- Kitchens
- Kennels
- Engine Noise
- Transportation Barriers
- Engine Test Cells
- Shooting Ranges
- Zoos
- Recording Studios
- Racetracks
- Power Plants
- Subways
- Mining Operations
- Airports
- Community Noise Control
- Correctional Facilities
- Childcare Centers
- Swimming Pool Areas
- Construction Sites
- Commercial Vehicles

Restaurants

www.acoustiblok.com

SoundSmart

City of Vancouver
Noise Control Manual



Prepared for:
Engineering Services
City of Vancouver

Prepared by:
Wakefield Acoustics Ltd.
Victoria, B.C.

Wakefield (Acoustics)

Section 4 THE "ABC'S" OF NOISE CONTROL

- *Natural noise control*
- *Noise control at source, along the path and at the receiver*
- *Blocking the sound path – what makes a good noise barrier?*
- *Soaking up noise – sound absorption materials*
- *Controlling noise by controlling vibration – damping materials*
- *Common misconceptions about noise and noise control materials*

4.1 Natural noise control

As sound waves move out from the source, their intensity (loudness) steadily decreases due to several natural phenomena. Two of these (geometric wave spreading and air absorption) are always present to some degree, while three others (ground effect and wind and temperature gradient effects) occur only under certain, fairly common conditions. These phenomena are described below.

4.1.1 Sound wave spreading with distance

In the same way that a balloon is stretched thinner and thinner as it is blown up, sound waves become weaker and weaker as they travel outward from their source and their energy is spread over larger and larger areas. This concept is illustrated in Figure 2. For ***"point" sources of sound*** (that is, sources that are physically small compared to the listener's distance from them) such as an aircraft in the sky or an ambulance siren, this spreading is spherical (think of an expanding round balloon) and causes sound levels to decrease at a rate of ***6 dB per doubling of distance.*** Due to this spherical spreading, noise from point sources becomes at least 35% quieter with each doubling of distance. When the sound source region is large compared to the distance to the listener's position, sound levels decrease more gradually. For example, traffic on a busy roadway represents a ***"line source" of sound*** from which sound waves spread out cylindrically (think of the expansion of a long, thin "party" balloon). Sound levels from a line source decrease at ***3 dB per doubling of distance*** – or half the rate of point sources. In typical urban settings where setback distances are limited, geometric spreading generally accounts for most of the natural sound attenuation between noise sources and receivers.

4.1.2 Absorption of sound by the atmosphere

As sound waves pass through the atmosphere, they lose energy as they "jostle" the air molecules. This is a gradual process that depends on air temperature and humidity. Over the limited source-to-receiver distances typically experienced in the city, atmospheric absorption has very little effect. Over larger distances (100 m or more), it can begin to reduce overall noise levels as well as alter the character of complex sounds (such as traffic noise). This is because air absorption attenuates high-frequency components much more rapidly than low-frequency ones and this is why the noises from distant traffic, trains, industries or jet aircraft tend to have a low, "rumbling" character.

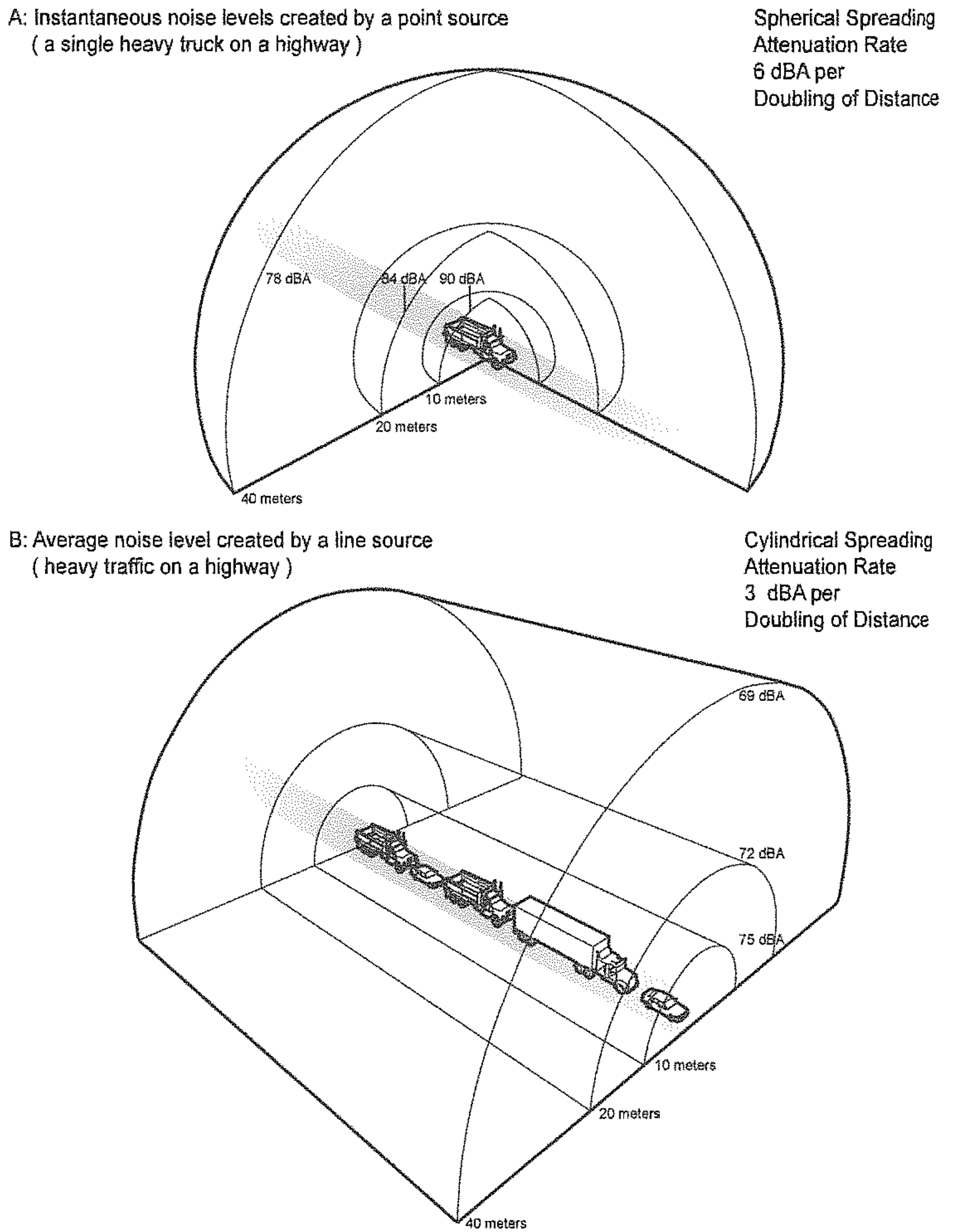


Figure 2: Spreading of sound waves from point and line sources

4.1.3 Ground effect

A third source of natural noise attenuation called ***"ground effect"*** occurs when sound waves pass close to soft, porous ground surfaces (lawns, fields, forest floors) on their way from the source to the receiver. This effect (which is caused by the local cancellation of direct and ground-reflected sound waves) can be large, particularly at distances of more than 100 m or so and when both the noise source and receiver (listener) are located close to the ground. In extreme cases where the listener is separated from a busy roadway by a wide, flat stretch of soft terrain, the ground effect can render noise from this roadway virtually inaudible over other contributors to urban hum. Even at typical smaller distances (10 to 15 m) across urban lawns or boulevards, the effect can be significant for receivers near ground level. There is then some benefit to be obtained from retaining or installing soft surfaces (e.g., lawns, gardens or flower beds) between a roadway, or other noise source, and one's residence. Figure 3 illustrates the typical effects which setback distance has on the average noise levels created by traffic on a long straight roadway.

4.1.4 Wind and temperature gradient effects

When wind blows against the direction of sound travel (i.e. from the noise receiver location towards the noise source location) it causes sound waves to bend upwards away from the earth's surface (see Figure 4A). This can create a ***"sound shadow"*** (i.e., a zone of quiet) at large distances. When the wind blows in the same direction as the sound (i.e., from the noise source towards the receiver), sound waves are bent down towards the earth (see Figure 4B). Where the intervening ground is "soft" so that ground effect is possible, or where some sort of noise barrier is present, this downward bending of sound waves can substantially increase the level of noise reaching distant receivers. However, at the short setback distances typical of most urban noise situations, the most significant effect of wind is to raise background noise levels, thereby potentially masking intrusive noises.

Strong air temperature gradients can cause similar sound-bending effects. In particular, during clear, calm nights, the air is often colder near the ground than higher up. Under such *"temperature inversion"* conditions, sound waves bend downwards towards the ground giving rise to the common perception that distance sound sources are louder at night, a perception that may also occur because "background noise" levels from common noise sources such as traffic tend to be reduced at night. During normal daytime "temperature lapse" conditions (i.e., when air is warmer near the ground), sound is bent upwards, away from the ground so that, under calm conditions, sound shadows may occur in all directions from the source.

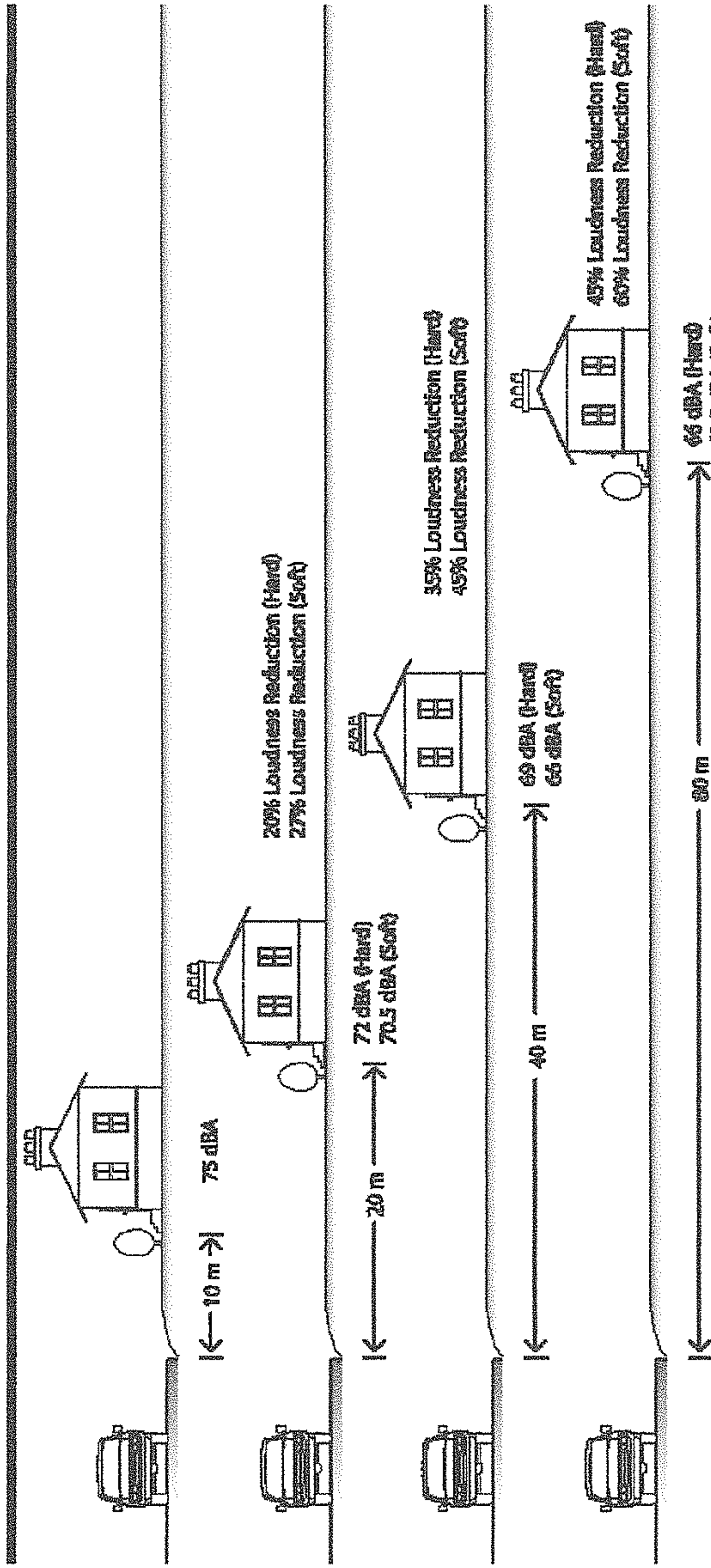


Figure 3: Decrease in the average level and perceived loudness of traffic noise with distance over hard and soft ground

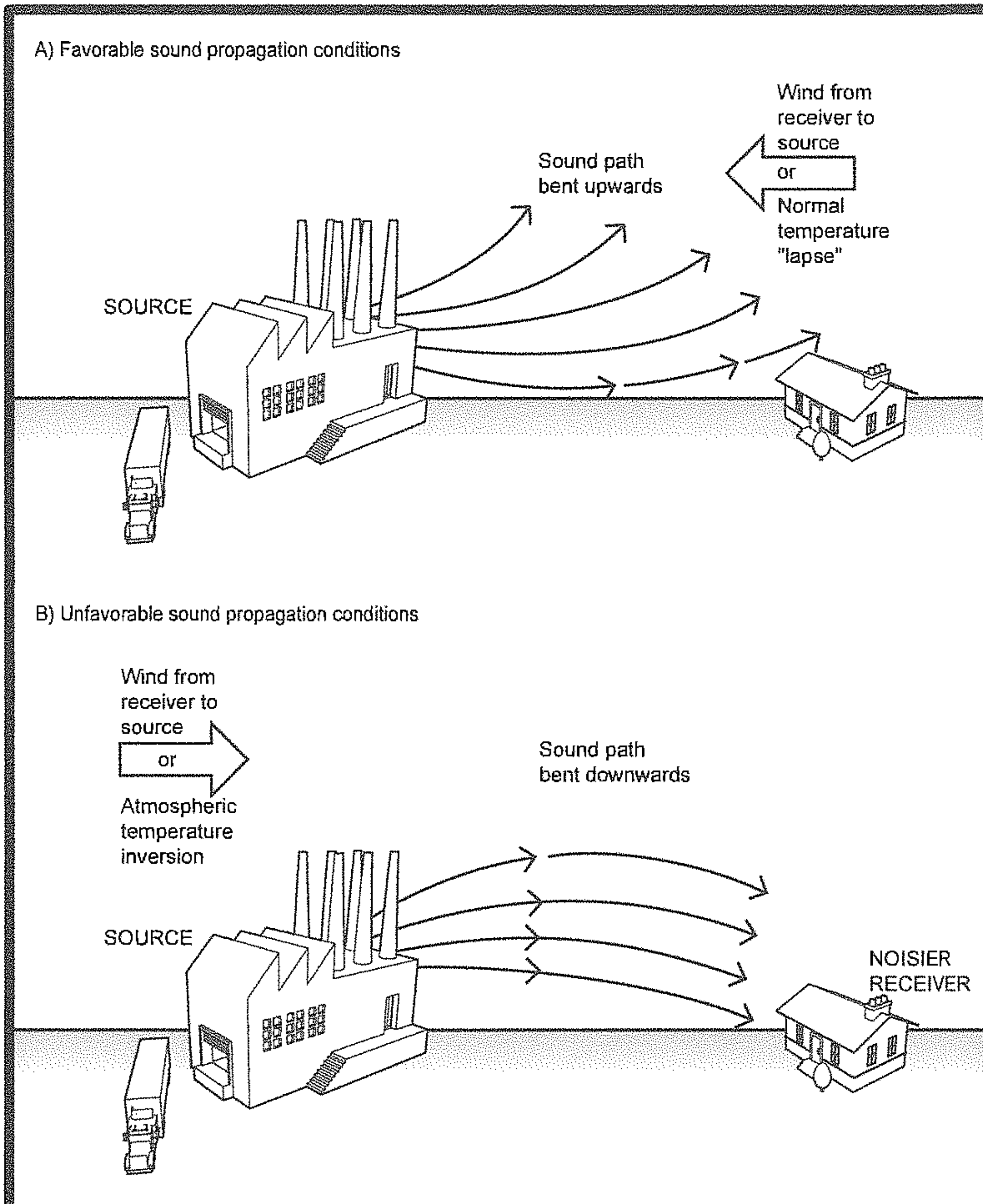


Figure 4: Effects of wind and air temperature gradients on sound propagation

4.2 Noise control at the source, along the path and at the receiver

All community noise situations involve one or more noise sources, one or more noise paths and one or more noise receivers. In planning for effective noise control, it is then useful to consider opportunities that may exist to control noise at each of these three stages of its transmission. Figure 5 illustrates the opportunities that generally exist to control noise at these three stages in the context of a residence located near a busy road.

4.2.1 Noise control at the source

Noise control at the source typically involves avoiding generation of excess noise through selection of inherently quieter equipment, regular maintenance and sensible operation. Examples of inherently quieter equipment are busses manufactured in some European countries under stricter noise emission regulations than apply to local buses and leaf blowers designed to meet a noise limit of 65 dBA at 15 m. Source control may also involve preventing noise from escaping from the source by adding appropriate control devices such as mufflers, covers or enclosures. For many prominent urban noise sources, such as arterial traffic, railways, aircraft and industry, source control measures are not in the hands of individual residents. However, at the time of this writing, the City is investigating the prominence of various urban noise sources in more detail to determine where noise control efforts should be concentrated. In addition, as may be seen in Section 5.3, there are many things Vancouverites can do to limit their personal contributions to urban noise.

4.2.2 Noise control along the sound path

Once noise has been created and has escaped from the source, there are various ways to prevent it from reaching noise sensitive areas. These may include noise barriers located close to the noise source (e.g., screens or partial enclosures around localized sources such as heat pumps, and walls, earth berms or non-sensitive buildings along a highway) or close to the noise receiver (e.g., a solid fence, earth berm or outbuilding on the noisy side of a residence to shield sensitive indoor spaces or a solid fence or screen to protect outdoor recreation areas).

4.2.3 Noise control at the receiver

Noise control at the receiver (here, the residence) may involve the upgrading of windows, doors, walls and, in some cases, roofs to better exclude noise from sensitive interior spaces (see Section 6.5 and Appendix B). It may also include the optimal location and configuration of the residence on the property to minimize noise exposure (see Figures 3 and 5) and/or the design of the floor plan (see Figure 7) which places less sensitive spaces closest to the noise source thereby creating a "buffer zone" to reduce noise exposures within the more sensitive spaces such as living rooms, bedrooms and dens.

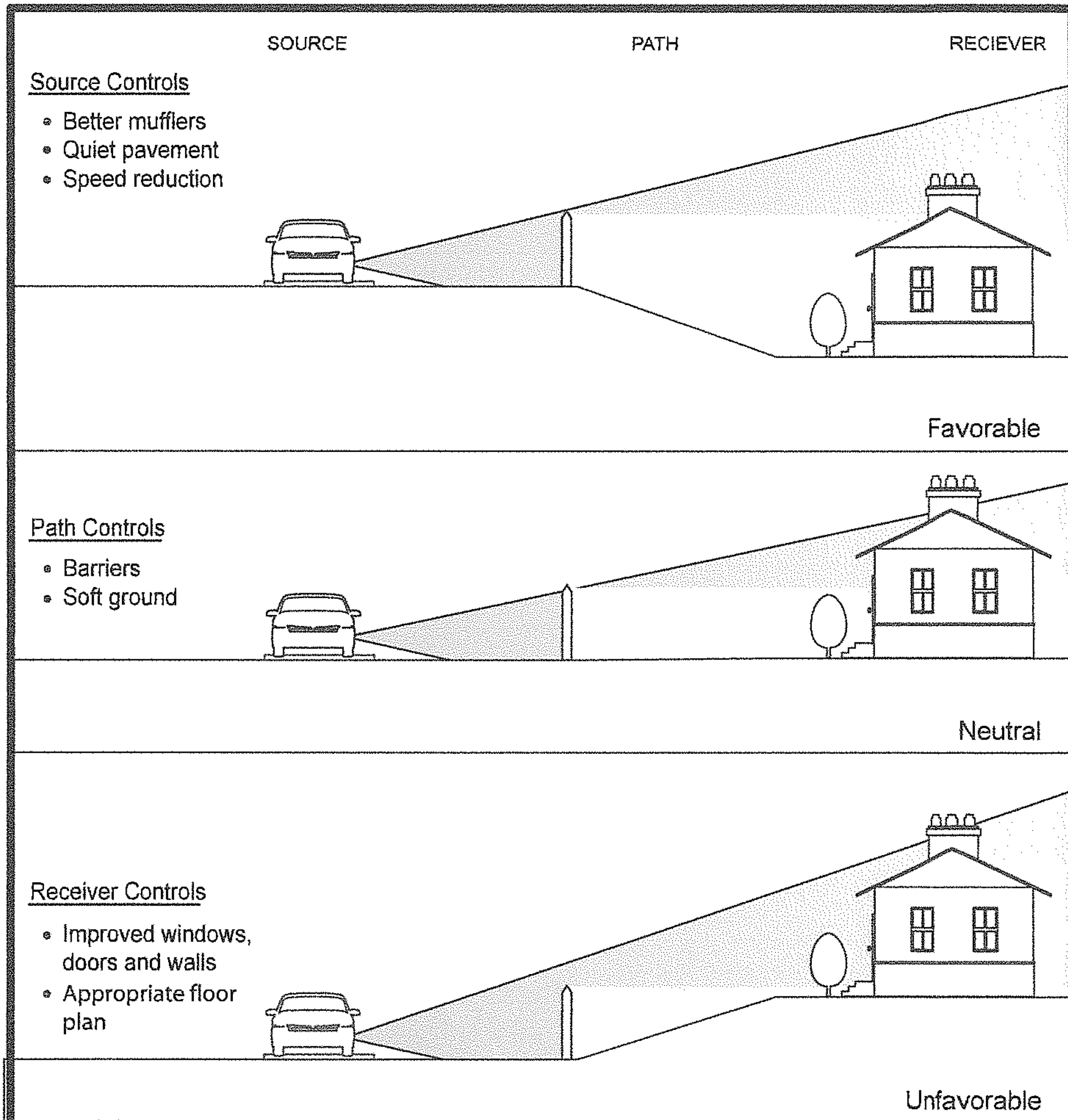


FIGURE 5 : Traffic noise control options at the noise source, along the path and at the receiver

4.3 Blocking the sound path - noise barriers

4.3.1 What makes a good noise barrier?

The most familiar means of reducing residential exposures to noise from road traffic or industrial sources is to erect a noise barrier of some sort between the sound source and the receiver. Noise barriers most often take the form of vertical walls, but other types (such as earth berms, berm/wall combinations and buildings) are also used. An effective noise barrier must meet the following three requirements:

1. It must be tall enough and long enough to clearly block the line of sight from the noise receiver to the noise source zone. For free-flowing arterial traffic, tires are the dominant noise source, so that the source zone is close to the pavement where it can often be shielded by barriers of moderate height. Where average speeds are lower, and particularly where the heavy truck mix is high, engine and exhaust noise are also important and, to be effective, noise barriers must be higher,

2. It must be dense (heavy) enough and be free from gaps and cracks so that there is no significant transmission of sound through it,

3. It must be continuous throughout the noise source zone. For example, a traffic noise barrier will not be effective if it must be frequently interrupted to accommodate walkways or driveways.

Figure 6 introduces basic noise barrier concepts. Shown are the three paths by which sound can reach a receiver located behind the barrier (here a vertical wall).

1. The first path, and often the most challenging to deal with, is associated with sound that diffracts (bends) over the top, and potentially around the ends, of a noise barrier. Low-frequency sounds (e.g. boom car noise or exhaust noise from heavy trucks) bend around barriers and other objects much more readily than do high-frequency ones (such as the "swishing" noise created by ordinary vehicle tires).

2. The second possible path is through gaps or cracks in the barrier. High-frequency sounds "leak" though these small openings much more easily than low-frequency ones.

3. The third path is directly through the barrier material itself. Low-frequency sounds are transmitted through solid noise barriers materials much more efficiently than are high-frequency sounds. It is to limit such low-frequency sound transmission that noise barriers must be made of a relatively heavy material, so that they weigh at least 10 kg/m^2 (2 lb/ft^2) and so that sound passing through the barrier will generally be attenuated in level by 20 dBA or more.

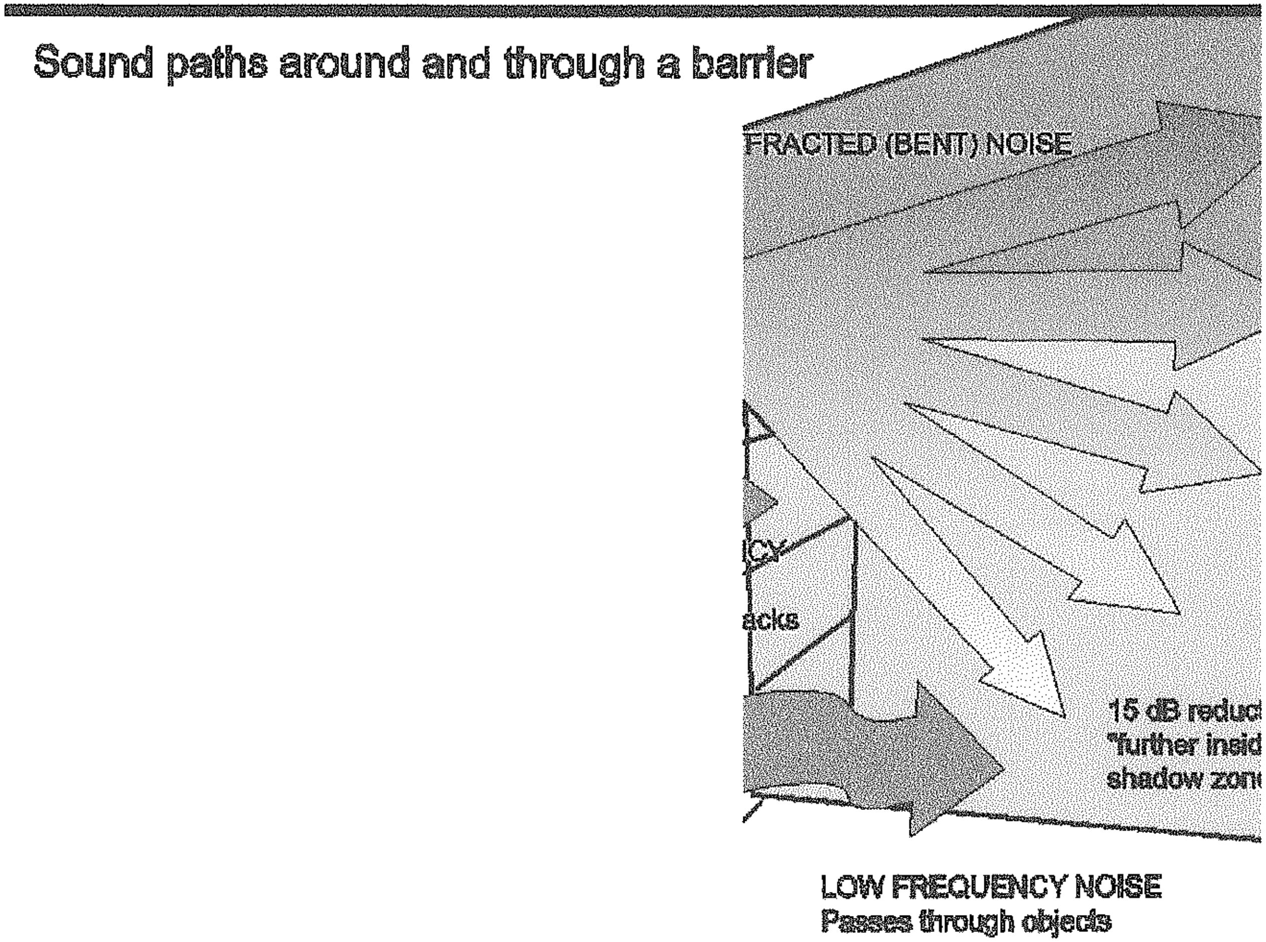


Figure 6: Basic noise barrier concepts - the three paths by which sound can reach a receiver behind a barrier

4.3.2 How much noise reduction can a barrier practically provide?

If a noise barrier is heavy enough and free from leakage, then the amount of noise reduction it will provide depends on where it is located relative to the noise source and receiver positions. The greater the extra distance (compared to the direct line form source to receiver) that sound must travel to get over or around the barrier and reach the receiver, the greater the noise reduction provided. For this reason, a noise barrier works best when it is located close to the noise source, the receiver or both. The following range of noise reductions can generally be achieved (see Figure 6):

- 5 dBA (about 30% reduction in perceived loudness) – usually achievable once the barrier just blocks the line of sight from the receiver to the source,

- 10 dBA (about 50% perceived loudness reduction) - achievable at locations well within the acoustic "shadow zone" but the line of sight must be substantially blocked, i.e., the barrier must typically rise 2 to 3 m above the "*line of sight*" from the receiver position to the dominant source position,

- 15 dBA (about 65% perceived loudness reduction) – achievable only in very favourable situations where the receiver is deep within the acoustic "shadow zone", such a where the barrier can be made very high relative to the source and receiver or where the receiver is located at a much lower elevation than the source. e.g., a residence located below the level of an adjacent highway.

4.3.3 What can noise barriers be made of?

Noise barriers can be made of almost any solid, reasonably heavy and durable material. The materials most commonly used for noise barriers in the Greater Vancouver area are listed below along with some examples:

- Pre-cast concrete posts and panels (e.g., Lonsdale and Westview Interchanges on the Upper Levels Highway, Deer Lake Parkway in Burnaby, Highway 17 east of Highway 10 in Delta),

- Concrete block (e.g. Highway 1 at south end of Cassiar Tunnel),

- Corrugated steel panels and steel posts (e.g., Hamilton/Westminster Interchanges at north end of Alex Fraser Bridge in Richmond),

- Timber posts and planks, minimum 50 mm (2") thick (Boundary Road, Burnaby),

- Earth berms or berm/wall combinations (Deer Lake Parkway, Burnaby and Highway 17 west of Highway 10 in Delta). Note, while earth berms require much more space than vertical walls, they tend to have advantages in terms of cost, visual impact and the ability of their soft, inclined surfaces to both absorb sound and deflect it upwards.

With the exception of earth berms, the above noise barriers have acoustically "hard" surfaces which reflect (bounce) most of the sound energy back in the general direction that it can from. That is, they do not absorb or "destroy" much of the noise but simply redirect it away from the most noise-sensitive areas. Sound-absorbing noise barriers are available however. A local example is located on the Upper Levels Highway just east of Lonsdale Avenue. It is of a double-layer steel "sandwich panel" construction with perforated sheet steel on the highway-facing side and 75 to 100 mm (3" to 4") of sound-absorbing insulation in the wall cavity.

4.4 Soaking up noise with sound absorbing materials

4.4.1 Most building materials reflect sound waves

Similar to most of the noise barriers described above, common building materials (e.g., concrete, brick, steel, timber, glass and gypsum board) are largely sound reflective, that is, they reflect back most of the sound energy that strikes them.. In many cases such sound reflections are not a problem because they do not significantly increase noise levels at any sensitive receiver locations. However, in some situations they can substantially increase noise exposures. For example:

- Where hard, vertical noise barrier walls are constructed on both sides of a relatively narrow roadway, repeated sound reflections back and forth between these hard surfaces reduce the effectiveness of both noise barriers,

- Where a large reflective surface, such as a building or wall, directs noise towards a receiver location that is otherwise shielded from direct exposure to the noise by another building, wall or land form,

- Where a building, group of buildings or other structures "focus" sound reflections toward a particular sensitive receiver location,

- The common situation where rows of tall buildings line both sides of downtown streets and confine traffic noise within *"urban canyons"* as illustrated in Figure 7,

- Where the hard surfaces of a room (or other enclosed space) repeatedly reflect sound back and forth and result in the "build-up" of noise levels within the space. This *"excessive reverberation"* effect is commonly experienced in gyms, ice arenas, lobbies or other large public spaces and even in some open-design, *"west coast style"* houses with high ceilings and little carpeting or draperies.

4.4.2 Sound absorbing materials

The reflected noise problems described above can be largely avoided by making the surfaces involved sound absorbing. Most common sound absorbing materials are highly porous and can absorb 60 to 90% of the sound energy that strikes them while some materials can absorb 95 to 99% of high-frequency sound energy. The tiny pores and passages within such materials (e.g., heavy fabrics, draperies, carpeting and upholstery, glass or mineral fibre insulation and open-celled foam rubbers), permit sound waves to enter. In squeezing through these tiny passages, the energy of the sound waves is dissipated – i.e., turned into heat in the same way that heat is generated when you rub your hands together briskly (i.e., through friction). Mid to high frequency sound can be effectively absorbed by quite thin (25 to 50 mm) porous materials while thicker materials (75 to 100 mm) are required to efficiently absorb lower-frequency sounds. Lower-frequency sounds may also be absorbed, to varying degrees, by thin, flexible panels of wood, plastic, steel, glass or gypsum board. Sound waves set these panels into vibration and the resulting rapid back and forth flexing of the panels turns some of the sound/vibration energy into heat – in the same way that a piece of wire gets hot when you bend it back and forth rapidly.

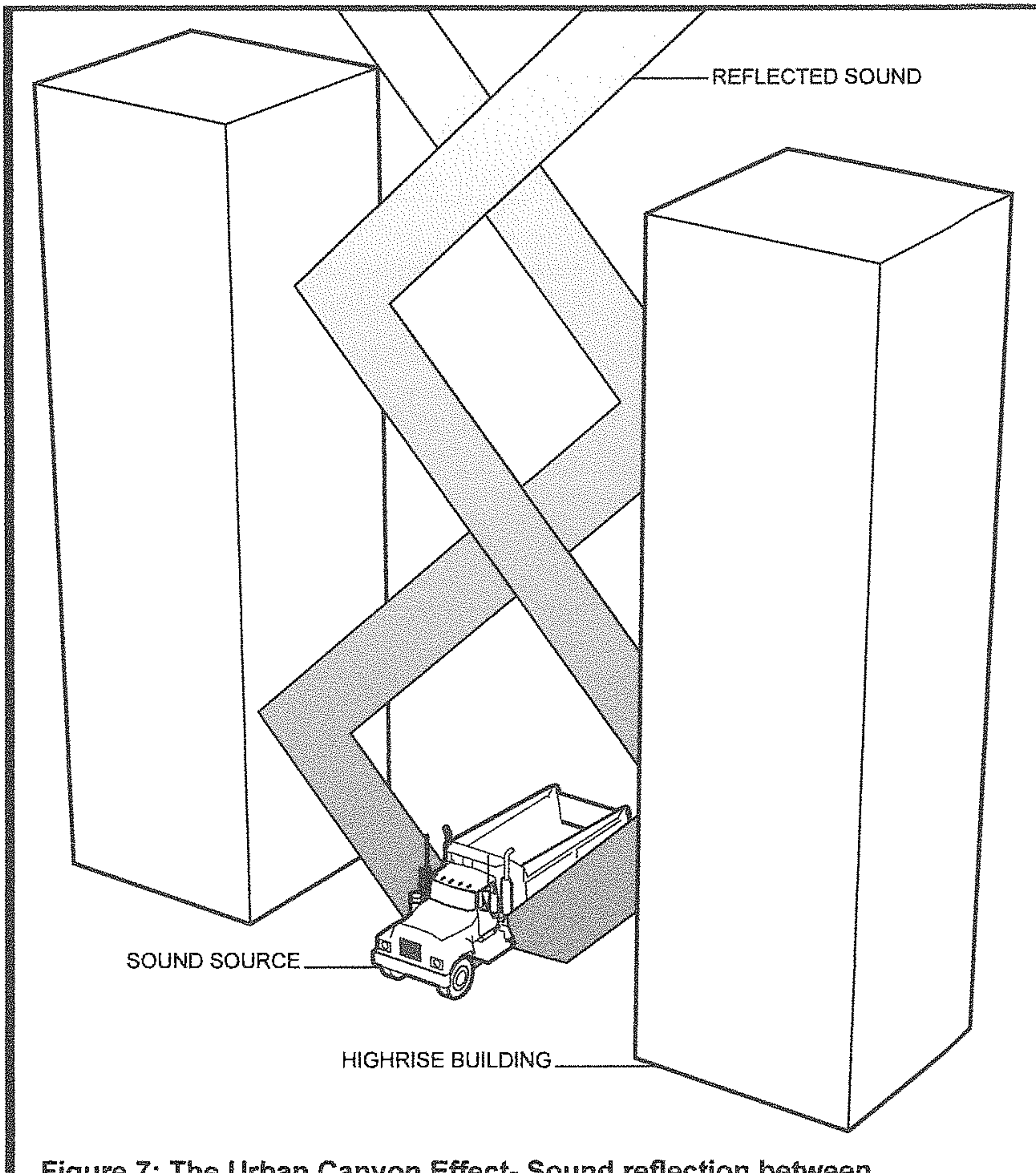


Figure 7: The Urban Canyon Effect- Sound reflection between highrise buildings

4.5 Controlling noise by controlling vibration

4.5.1 Damping materials

Since sound is often produced and transmitted by vibrating objects, it makes sense that we can control noise by controlling vibration. Consider what happens when we place a hand on a ringing bell or a wine glass that been make to "sing" by rubbing its rim – the sound quickly dies away. Here we are "damping" the ringing object by allowing its vibrational energy to flow into an object (our hand) which has much greater damping capacity than either brass or glass. More practical examples of damping materials include the soft "mastic" material used to coat car body panels to control engine and road noise and the thin plastic layer which separates the two sheets of glass used in making laminated or safety glass.

4.5.2 Vibration isolation

As most people will have observed, when an operating power tool or appliance comes in contact with a large, flexible surface such as a sheet of plywood, a table top or a wall, its noise is amplified. This phenomenon is demonstrated in a pleasing way by the bodies of violins and guitars which greatly amplify the sound of their vibrating strings. The amplification of noise from engines, electric motors, appliances or power tools can then be avoided by eliminating any rigid contact between these devices and flexible surfaces such as machinery enclosures, counter tops or the wooden floors and gypsum board walls of residences. In practice this can be done by placing resilient rubber pads or matting beneath appliances and the countertops or floors supporting them. Similarly, fans, pumps and motors can be mounted on neoprene pads or steel springs to prevent their vibration and noise from entering supporting floors and walls and spreading throughout the building.

4.6 Common misconceptions about noise and noise control materials

Sound goes up!

Unlike hot air, sound/noise does not prefer to rise or "go up". While some sound sources, such as high-frequency loudspeakers, or "tweeters", are quite directional, most common noise sources tend to radiate sound fairly evenly in all directions. Once created, sound (think of it as a "ray" in this case) tends to continue traveling in a straight line until it encounters a solid object or until wind or air temperature gradients cause it to bend. The impression that "sound goes up" may come from the common observation that sounds appear louder when the listener is in an elevated position such as on a hill top or the upper floors of a high-rise building. While this is often true, it is because sound waves traveling well above the ground tend to suffer little or no extra attenuation due to shielding and/or ground effect, not because sound prefers to "go up".

Styrofoam is a good sound control material.

Because Styrofoam is a very good insulator against heat and cold and is commonly placed against building foundations and inside exterior walls, it is often assumed to be a good sound control material as well. However, unlike like glass, mineral or cellulose fibre insulations which absorb sound effectively due to their open surface structure and small-scale porosity, Styrofoam has a closed-cell structure which does not allow sound waves to enter it easily. As such, it is not a good sound absorber and should not be placed inside wall or floor cavities where effective sound control is required. Further, Styrofoam is too light to act as an effective noise barrier. For the same reason, glass and mineral fibre blankets (batts) or semi-rigid boards are not good noise barriers on their own.

Lead is the ultimate noise barrier.

Because of its extreme heaviness and high damping capacity (i.e., it does not vibrate), inch for inch, lead sheet provides the greatest airborne noise reduction of any widely available material. However, lead sheet is expensive, weak, limp and toxic. In some situations (e.g. improving the noise insulation of an engine or pump enclosure on small boat or under a hot tub) where the areas involved are small and out of the way and available space is very limited, lead sheet can be applied (either on its own or in combination with a sound absorbing material) to wood, aluminum or other lightweight panels to boost their noise insulation value. Lead, Barium or other mass-loaded vinyl sheets can also be used as noise curtains, for example to enclose or isolate a particularly noisy machine in a factory. However, in most cases of sound transmission between residential properties or between rooms within a building, sufficient noise control can be achieved using more common, and much less expensive, building materials such as timber, plywood, gypsum board, and glass or mineral fibre insulation.

A row of vegetation can be an effective noise barrier.

It is quite commonly believed that planting a row of vegetation (hedges, rows of trees or bushes) across the front of one's property will reduce exposure to noise from traffic or other sources. This is an understandable misconception since, by obscuring one's view of the traffic, vegetation may have perceptual benefits (i.e., noise levels may appear reduced due to the *"out of sight, out of mind"* effect). This may in fact be a beneficial perception when it helps to reduce our awareness of, and resulting annoyance with, intrusive noise at low to moderate levels. However, landscaping vegetation, in amounts that may generally be planted as treed borders or hedges, is too open and porous to significantly attenuate noise. Belts of mature forest (25 m or more) can, however, provide worthwhile extra noise attenuation (compared to open ground) and should be maintained whenever possible. Dense vegetation can also be useful when placed in front of a fence, wall or building as it will absorb some sound energy and thereby reduce the noise that is reflected back from these hard surfaces.

Doubled-glazed windows are much better at blocking sound than single-glazed.

Provided window perimeters are well sealed, double glazed windows are not significantly better at blocking traffic noise than a single-glazed window with the same total thickness of glass. This is because, as far as sound waves are concerned, particularly at lower frequencies, the standard (13 mm or 0.5") airspace between the two sheets of glass is not wide enough to effectively disconnect or "decouple" them. Note however, that since standard double-glazed windows have roughly twice the total thickness of glass as single glazed windows, they tend to provide (see Section 6.5.7) about 3 dBA more sound reduction.

If double-glazed windows are good, triple-glazed windows must be better

Tests have shown that triple-glazed windows are no better than double-glazed if they include the same total weight of glass and the same maximum airspace width between the outer panes of glass. Using heavier double glazing (with wider airspace) is then a less expensive means of getting similar performance. However, applying a widely-spaced storm window (see Section 6.5.7) over an existing double-glazed window is effective, as it is when applied over a singe-glazed window.

The walls of my house are of 2" x 6" (38 x 140 mm) construction - I won't have any problems with traffic noise.

While walls of insulated 2" x 6" wood stud construction provide greater thermal insulation than similarly insulated 2" x 4" walls, they do not provide significantly more traffic noise insulation (see Section 6.5.10). This somewhat counterintuitive result occurs because, regardless of the depth of the wood studs, they still create direct, rigid connections between the outside and inside surfaces of the wall. These connections provide pathways by which structure-borne sound can travel efficiently from the exterior to the interior of the residence.

I plan to replace the carpeting in my condo with hardwood flooring. As long I use one of those "sound control" underlays, I won't create any noise problems for the neighbours below me.

None of the thin (less than 12 mm or 0.5" thick) resilient underlay materials available commercially provide nearly the degree of footstep noise control provided by good carpet and underlay. Before replacing carpet with hardwood, ceramic tile, vinyl sheet, cork or other relatively hard floor finishes, permission should be sought from the strata council. The strata council should then consult with a noise control professional (see Appendix C), not a hardwood flooring or resilient underlay salesperson (see Sections 7.13 to 7.18 for further discussion of noise transmission through floors).

Egg crates make good sound absorbers and scatterers

It is common to see the wall and ceilings of home studios or music practice rooms lined with cardboard egg crates (cartons) in an attempt to make the room acoustically "dead" (non-reverberant) and to encourage uniformity of sound within the space. While egg crates are cheap and readily available and no doubt absorb and scatter some mid to high frequency sound, they are not particularly effective. Much better sound absorption can be attained from heavy draperies, deep pile carpeting or upholstered furniture or by applying fiberglass batt insulation or semi-rigid fiberglass boards to the walls and covering them with stretched fabric, perforated paneling (such as pegboard) or with narrow wooden slats spaced 12 to 25 mm apart. Better sound diffusion (uniformity) can be attained by making the interior walls of the room non-parallel and by placing larger, randomly-shaped and sized solid objects (e.g. furniture) on the floor or applying them to the walls.

Research Inventy: International Journal Of Engineering And Science
Vol.2, Issue11 (April 2013), Pp 20-25
Issn(e): 2278-4721, Issn(p):2319-6483, Www.Researchinventy.Com

Estimation of Noise Reduction by Different Vegetation Type as a Noise Barrier : A Survey in Highway along Waru – Sidoarjo in East Java, Indonesia

[1,2]U.R.Pudjowati, [1,3]B. Yanuwiyadi, [1,4]R. Sulistiono, [1]Suyadi
[1](*Environmental Science and Technology Graduate Program, University of Brawijaya, Indonesia*)
[2](*Department of Civil Engineering, State Polytechnics of Malang, Indonesia*)
[3](*Department of Biology, Faculty of Mathematics and Natural Science, University of Brawijaya, Indonesia*)
[4](*Department of Agroecotechnology, Faculty of Agriculture, University of Brawijaya, Indonesia*)

Abstract - *Noise pollution has become a common problem in big cities. Most of the noise generated the sounds of transportation. All of these noises on the highways impact to the increasing intensity of noise pollution. The research objective was to estimate the noise reduction using vegetation as a noise barrier in the highway. The present study was conducted on the highway along Waru - Sidoarjo with existing vegetation at the side of the highway. A series of SLM (Sound Level Meter) was arranged at various distances from the highway, in the presence of vegetation, while another series was arranged in the absence of vegetation over the vegetation, the other series as control of those was placed without vegetation. Vegetation types used as samples were Samanea saman,Pterocarpus indicus,Tectona grandis and Pithecellobium dulce. The result was the estimation of noise reduction could be generated for specific distances. It showed that Pithecolelobium dulce have the highest noise reduction of 10.12% at 20 m distance, and the noise reduction equation for this vegetation was* $y=2.67\ ln(x) + 2.18$ *with coefficient determination* (R^2) = *0.92, and the settlement should be built more than 20 m away from the highway.*

Keywords : *noise; noise barrier; vegetation diversity; highway; settlement*

I. INTRODUCTION

Noise is unwanted sound, allowing sound to interrupt the conversation, or cause pain, as well as the convenience of living activities impede the environment. Nowadays the noise has become a problem for many people. Noise sources can be produced by transportation, such as buses, trains, airplanes, cars, and motorcycles [14]. Noise above 55 dB is considered to get attention because disturbing the comfort of hearing. The noise between 65-80 dB can cause damage to the hearing function when the contact occurred in a long time [2]. In addition can cause deafness, noise can also affect a person's mental health, such as stress or tension. If the tension of the soul cannot be resolved then further impact is declining physical health.

The need for housing developments encourage developers to build housing, in areas that have high noise levels, such as in the area around the highway. The land around the highway are quite sought after because of relatively broad, relatively land price and not too far from center of the city. Trend of the increasing number of motor vehicles on highways have an impact of the rising intensity of noise pollution in the form of noise for environment around the road. According to previous research, the level of noise caused by traffic on Highway Waru Sidoarjo – in 2001 ranged from 65-80 dB. The settlement is located about 20 meters from the highway has also been subjected to noise nuisance caused by the sound of a vehicle through the streets [4]. Due to the large number of pass highway motorists who drove at high speed, it will increase the intensity of the noise pollution.Noise caused by traffic is not constant sound level [8] . The level of noise disturbance from traffic noise is influenced by the level of this voice, how often it occurs within a unit of time, and the frequency of the sound it produces. Traffic noise from the sound generated from motor vehicles, especially from vehicle engines, exhaust, and due to the interaction between the wheels to the road. Heavy vehicles (trucks, buses) and passenger cars are the main source of noise on the highway [12].

Noisy traffic also causes deafness [2]. Noisy because of the traffic caused by motor vehicles, not maintained machine and motor vehicle exhaust, as well as the frequent use of the horn. The intensity of the sound produced from the noisy traffic is about 80-88 dB, and this means the maximum a person can only be in this noise for 16-24 hours. People who are more at risk of traffic noise are the police and motorists.

The pattern is physically mute the sound when the wave damping phenomenon with a certain velocity through the medium of air and then blocked by an obstacle then there are three possibilities that occur in waves are transmitted, is reflected and absorbed. If a material has a good impedance of the incident wave then the wave can be well damped. Actually, a phenomenon that is happening around us is able to reduce the noise level without special treatment, for example by placing artificial elements.

The noise level can be controlled by vegetation depends on 1) the type of species, plant height, density, and distance grows. 2) the climate factors, namely wind speed, temperature, and moisture, and 3) the voice type, origin and the decibel level (level of intensity). Sound wave is absorbed by the leaves, branches, twigs of trees and shrubs. It has been reported that the most effective plants for sound absorption is the part that has thick leaves, fleshy with lots of petiole (leaf stalk). This combination provides a high degree of flexibility and vibration [6]. Sound was deflected and refracted by the branches, twigs and branches of larger trees. It is estimated that forests can reduce noise level 7dB every 30 m with distance and frequency at about 1.000cps [6]

The criteria of the types of green open space plants, particularly for the Green Line Road should be not sticky, not easily broken branches, roots do not interfere the foundation, the structure of the leaves is closed, various height plant. Annual plant type, and closed, half closed planting density [9].

From year to year the volume of vehicles has been increasing, especially on the days before the holidays, or weekends. In 2008 the number of vehicles passing through the highway will average 1.28% per month [7]. The increase is predicted to be greater for the next year. Thus, the noise will increasingly exceed the quality standards that have been set.

The purpose of this study was to estimate the noise reduction effect of each type of vegetation on the side of the highway along the Waru-Sidoarjo, and its dependence on distance from the center of the noise source. The results were vied to hold a model to estimate noise reduction of each type of vegetation as a function of distance from the noise source. Noise barrier reduce noise levels from traffic by blocking and deflecting sound waves [10].

This study was intended to help settlement developers and policy makers. In Indonesia, settlement was a primary need for the residents, but nowadays the land for it becomes narrow. Existing land used along sides of the highway to the settlement would be better if developer pays attention to comfort factor. One of these convenience factors was noise reduction. To reduce the noise which was coming from the highway, there were several ways that can be done, but the cheapest way was to utilize the planting of vegetation along the highway. Beneficial vegetation must be grown on the sides of the highway. In addition to cover crops it was also a beautiful sight to the highway users, as well as to reduce the noise coming from the highway.

II. METHOD

2.1 Study Area

The main highway Waru-Sidoarjo was located in East Java Province along over 49 km long (Figure 1). The noise level of this highway has been proven over the quality standard, the noise levels due to traffic on the highway Waru-Sidoarjo in 2001 ranged from 63-80 dBA [12]. Moderate risk in area standards noise levels over 75 dBA [1]. Noise traffic was produced by the sound of motorized vehicles, especially from vehicle engines, exhaust, and due to the interaction between the wheels to the road. Heavy vehicles (trucks, buses) and passenger cars are the main source of noise on the highway [2].

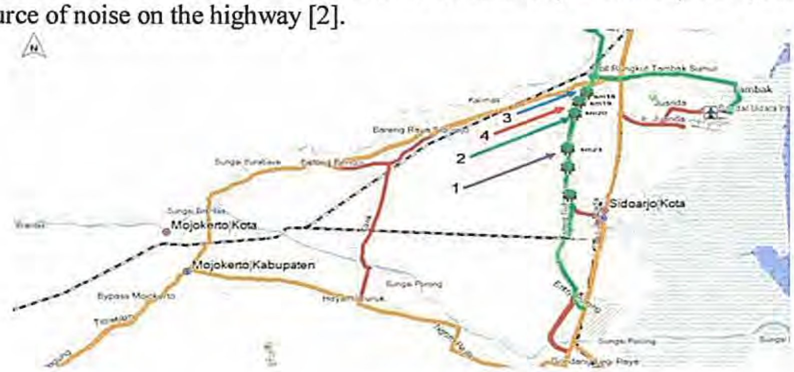


Figure 1: The Location of Highway Waru – Sidoarjo in East Java, Indonesia

(1 was *Pterocarpus indicus* vegetation, 2 was *Tectona grandis* vegetation, 3 was *Samanea saman* vegetation, 4 was *Pithecellobium dulce* vegetation)

The position of vegetation types was not sequential in the rows. Furthermore, the distance between tree is about 5 m. According to the conditions on the field, all kinds of vegetation that are used as the object of study can be seen in Figure 2. The row of main vegetation lies on the side of highway. There are four observation places in different four types of vegetation.

Figure 2: Types of vegetation in highway along Waru-Sidoarjo
2a. *Samanea saman*, 2b. *Tectona grandis*, 2c. *Pterocarpus indicus*, 2d. *Pithecellobium dulce*

2.2 Measurement of Noise Reduction

The survey was conducted by observing the vegetation types. Noise was measured with a Sound Level Meter (SLM), CE mark, model AZ8925, made in Taichung Taiwan. Seven units of SLM are placed on 4 different dots at a distance of 5 m (1 unit), 16 m (2 units), 18 m (2 units), and 20 m (2 units) from the center of the road, 1.5 m above ground (Figure 3). Each pair of SLM are on the place with vegetation and places without vegetation, except the one that has 5 m distance, is placed on the side of the road. All of these measurements will be repeated 5 times.

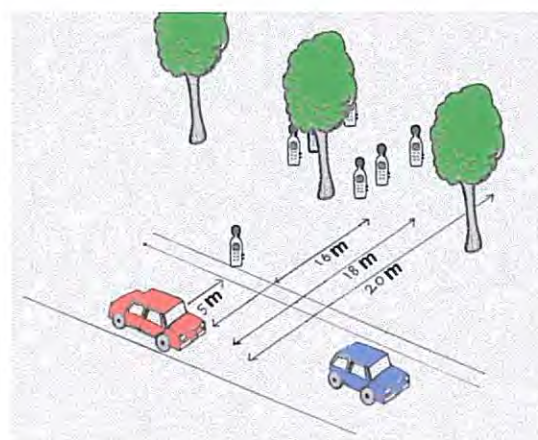


Figure 3: Sketch of the Position of SLM Placement Relative to Highway

2.3 Data Analysis

Having been grouped, the data are processed using Ms. Excel, looking for the difference between the sound intensity level at a distance of 16 meters by 5 meters, 18 meters by 5 meters and 20 meters with a distance of 5 m for each vegetation type. Then the results of sound intensity level is the difference between noise with vegetation and without vegetation , then an average of each distance and each type of vegetation is made. The significance of noise reduction is calculated based on the average using ANOVA. Then line graphs are made from the result of percentage and equations created using the regression equation with the coefficient of determination (R^2) using MS. Excel for graphics and equations [13].

III. RESULT AND DISCUSSION

3.1 The Result

The average of Noise value shown on Table 1 .

Vegetation Type	Distance (m)						
	5	16		18		20	
	Without vegetation	Without vegetation	With vegetation	Without vegetation	With vegetation	Without vegetation	With vegetation
Samanea Saman	86.20±1.76	85.20±1.76	72.60±2.35	74.20±1.76	70.80±2.53	73.20±1.76	69.76±2.49
Tektona Grandis	86.20±1.89	75.40±1.50	71.84±1.40	75.20±1.89	70.84±1.40	74.20±1.89	69.84±1.40
Pterocarpus indicus	84.04±1.37	73.76±1.27	69.48±1.85	73.04±1.37	68.48±1.85	72.04±1.37	67.48±1.85
Pithecellobium dulce	83.20±1.15	72.84±1.14	65.88±2.52	72.20±1.15	64.88±2.52	71.20±1.15	63.88±2.52

Tabel 1: Noise Average Value with Vegetation and Without Vegetation in Different Vegetation Type and Distance

Vegetation Type	Distances (m), Mean ± Std. Deviation			
	5	16	18	20
Samanea Saman	0.00 ± 0.00^{a} (0%)	2.88 ± 1.69^{ac} (3.82%)	3.40 ± 1.85^{ac} (4.41%)	3.44 ± 1.85^{ac} (4.65%)
Tektona Grandis	0.00 ± 0.00^{a} (0%)	3.56 ± 1.39^{ab} (4.7%)	4.36 ± 1.52^{ab} (5.64%)	4.36 ± 1.52^{abc} (5.71%)
Pterocarpus indicus	0.00 ± 0.00^{a} (0%)	4.28 ± 1.28^{abc} (5.81%)	4.56 ± 1.08^{ac} (6.12%)	4.56 ± 1.08^{ac} (6.20%)
Pithecellobium dulce	0.00 ± 0.00^{a} (0%)	6.96 ± 2.84^{abc} (9.53%)	7.32 ± 2.73^{ac} (9.99%)	7.32 ± 2.73^{ac} (10.12%)
Total average	0.00 ± 0.00	4.42 ± 2.43	4.91 ± 2.37	4.92 ± 2.37

Table 2: Noise Reduction Based on the Different Vegetation Type and Distance of Observation to Noise Source

In the Table 1. as shown, at a distance of 16 m, 18 m, and 20 m, *Pithecellobium dulce* have highest noise reduction. This was in accordance with the formula that noise can be reduced when the location of the listener is away from the noise source [5].

In the Table 2, the different superscripts in the same row was significant ($P < 0.001$). Noise reduction at a distance of 5 m, had a very real difference among all types of vegetation. While at a distance of 16, 18 and 20, the difference was almost the same. In the distance of approximately 60 m the noise is not really reduced if it is of meadow (only 17 dB), and 24 dB if it is of forest [11]. The reduction of noise caused by high-speed vehicles can be obtained with the best results by growing trees and shrubs in width 20 – 30 m, buffer of 16 – 20 m from the center of the nearest traffic lane [3].

The noise reduction by vegetation ranges from 3.82% to 10.12%. The best result of noise reduction obtained at 10.12 % for *Pithecellobium dulce*. This is due to this vegetation has a dense leaf position and shape of the canopy which dangle above the soil surface. That plants are effective at reducing noise is the dense leaves throughout the year and leaves pattern spread to the surface of the ground [14].

3.2 The Graph of Noise Reduction and Equation by Each Vegetation

The graph of Noise Reduction and its equation can be made from data by Excel program as shown at Figure 5.

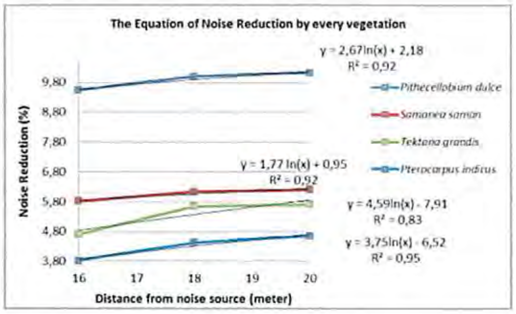


Figure 5: The Equation of Noise Reduction by each vegetation

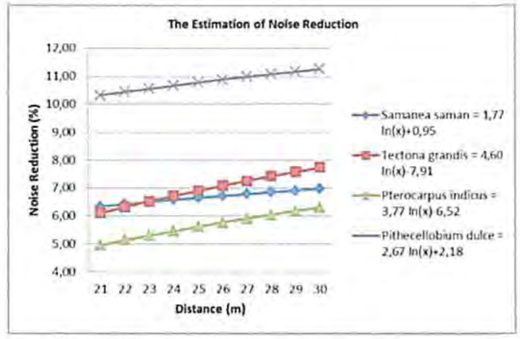


Figure 6. The Estimation of Noise Reduction

From the chart at Figure 5 can be made a summary table (Table 3.) as shown.

Vegetation	Noise Reduction Equation	R^2
Pithecellobium dulce	y = 2,67 ln(x) + 2,18	0,92
Samanea saman	y = 1,77 ln(x) + 0,95	0,81
Tectona grandis	y = 4,60 ln(x) – 7,91	0,83
Pterocarpus indicus	y = 3,77 ln(x) - 6,52	0,96

Table 3: Noise Reduction Equation by every vegetation

The *Pterocarpus indicus*' coefficient determination (R^2) is 0.96 or 96%, it means the influence of vegetation types of noise reduction is 96%, and 4% is the influence of other conditions.

3.3 Estimation of Noise Reduction by Each Vegetation for a Certain Distance

From the resulting equations, can be made an estimate of the amount of noise reduction by each vegetation type in the distance between the center of the toll road to the location of settlements to be built as shown in the Figure 6.

The vegetation which is can reduce the noise among vegetation sample, the greatest is *Pithecellobium dulce* by equation : y=2.67 ln(x) +2.18. To help decrease the noise going on the highway, should the developers who will use the land around the highway of the type of barrier. For this type of barrier should still pay attention to the environment, by utilizing the function of vegetation so that in addition to the noise looks beautiful. As for the settlement position of the motorway, should also consider the distance between the highway with residential location and type of vegetation planted. To estimate the distance of settlement that will be built with the noise source can be helped by using Table 5.

ACKNOWLEDGMENTS

The authors thank to Professor Takanobu Inoue and Dr. Yoshitaka Matsumoto from Department of Architecture and Civil Engineering, Toyohashi University of Technology who reviewed this paper. And also to Indonesian Government which is has funded for study and sandwich to Japan during 3 months.

References

[1]. Badan Litbang PU Departemen Pekerjaan Umum. *Pedoman Mitigasi Dampak Kebisingan Akibat Lalu Lintas Jalan*. Jakarta. 2006.

[2]. Buchari, *Kebisingan Industri dan Hearing Conservation Program* (USU Repository, Medan), 2007.

[3]. Z.I. Djamal, *Tantangan Lingkungan dan Lansekap Hutan Kota* (PT.Bumi Aksara, Jakarta), 2005.

[4]. M.D. Egan, *Concept in Architechtural Acoustics* (Mc-Graw Hill Inc, United States of America), 1976.

[5]. D.C. Giancolli, *Fisika 1* (Penerbit Erlangga, Jakarta), 2001.

[6]. G.W. Grey and F.J. Deneke, *Urban Forestry* (John Willey and Sons, New York), 1978.

[7]. Jasa Marga, *Data Traffic and Toll Revenue Toll Gate Porong, Sidoarjo Toll Gate and Toll Gate Main Waru*, 2009.

[8]. C.E. Mediastika, *Akustika Bangunan : Prinsip-prinsip dan Penerapannya di Indonesia* (Penerbit Erlangga, Jakarta), 2002.

[9]. N. Purnomohadi, *Pengelolaan RTH untuk Mengurangi Kualitas dan Kuantitas Pencemaran Udara, Studi Kasus Kota Jakarta* (Konsep Disertasi tidak dipublikasikan, FPS-IPB, Bogor), 1994.

[10]. R. Baldauf, E. Thoma, A.Khlystov, V. Isakov, G. Bowker, T. Long, and R. Snow, Impact of Noise Barrier on Near-Road Air Quality, *Atmospheric Environment Journal*, 42, 2008, 7502-7507.

[11]. T. Samara and T. Tsitsoni. Road Traffic Noise Reduction by Vegetation in The Ring Road of a Big City. *Proceedings of the International Conference on Environmental Management, Engineering, Planning and Economics*, Skiathos, June 24-28,2007, 2591-2596

[12]. R. Setiawan, T.D. Arief, N. Handayani, P. Sawitri,Studi Awal : Analisa Tingkat Kebisingan Lalu Lintas pada JalanTol Ruas Waru-Sidoarjo, *Jurnal Teknik Sipil Fakultas Teknik dan Perencanaan Universitas Kristen Petra*, Surabaya.2001.

[13]. Soemarno, *Pemodelan Sistem dalam Pengelolaan Sumberdaya Alam dan Lingkungan* (PPSUB, Malang, 2008).

[14]. D. Yuliarti, *Karakteristik Tanaman yang Efektif Mereduksi Kebisingan*, skripsi, IPB, Bogor, 2002.

FINAL REPORT

TECHNICAL ASSESSMENT OF THE EFFECTIVENESS OF NOISE WALLS

APPROVED BY THE INTERNATIONAL INSTITUTE OF NOISE CONTROL ENGINEERING.

Executive Summary

This initiative of International INCE deals with noise walls—the outdoor barriers erected in parallel with highway and rail lines, and in other areas (such as airport runways), where there is a demand to reduce the noise levels of surface transportation sources. There is worldwide interest in the control of noise by the erection of such barriers. Walls are composed of wood, metal, masonry, earth, and other materials, both opaque and transparent. Most of the walls that have been erected to date completely block the sight lines between vehicles and roadside housing. The cost of installation usually exceeds USD one million per kilometre. In some countries, governmental authorities have authorized the use of highway construction funds for the erection of noise walls. When building a new highway or widening an existing highway, the construction of noise walls is required in some jurisdictions when the predicted noise levels of the road traffic exceed defined governmental guidelines. The key questions are: how valid are the traffic noise predictions, and how effective are the noise walls acoustically after they have been erected? Over the years, a number of analytical studies have facilitated the prediction of the noise reduction afforded by such barriers. It is reported, however, that barriers may not always perform acoustically as well as intended.

The principal objective of this study is to obtain a global view of the effectiveness of noise walls—the outdoor barriers erected in parallel with highway and rail lines, and in other areas (such as airport runways). The report summarizes the scientific basis of noise barriers, including measures of barrier efficiency, the physical phenomena involved (including effects associated with the propagation and effects associated with the noise wall as well as different barrier shapes), and the various models used to predict barrier performance. Different barrier materials are briefly described. The measurement of barrier effectiveness is also discussed. A section discusses the three main application areas where barriers are used: road traffic noise, railroad noise, and ground-based aircraft operations.

The main conclusions of the Working Party are summarized below:

1. There is a strong body of evidence to support the use of barriers as an effective method of abating transportation noise.
2. The best descriptor of barrier performance is its insertion loss, which is the difference in the noise environment before and after the barrier is constructed.
3. It is the collective experience of the Working Party that the most common values for A-weighted insertion loss range between about 5 to 12 dB.

4. Barrier height is of fundamental importance to the effectiveness of a barrier. Proximity of source/receiver relative to the barrier is also of fundamental importance to the insertion loss provided by a barrier.
5. The material used to construct barriers must be such that there is sufficient transmission loss of sound through the wall. It is also important that there be no significant air gaps in the structure nor between the barrier and the ground.
6. Sound-absorbing material may be important in reducing noise between parallel reflective walls

Finally, recommended directions for future research are presented.

Foreword

The International INCE General Assembly on 1994-08-31 approved an initiative to review current knowledge and practice concerning *Effectiveness of Noise Walls* with the objective of obtaining a review of the technical aspects of the acoustical performance afforded by noise barriers for transportation noise sources. This initiative deals with the important physical phenomena and how to model them.

The study was undertaken with the following objectives:

1. Identify the development of barrier usage and performance during the past few decades.
2. Examine the scientific basis behind noise barriers by listing the physical phenomena affecting their performance. Discuss which phenomena are important and to what extent. Review the use of parallel barriers and the need for absorptive material.
3. Collect the available information regarding the performance afforded by noise barriers separated into three areas of application: road, rail, and ground-based airport operations.
4. Provide information on tolerance/spread of prediction to provide an informed judgement for legislation.
5. Discuss the generic properties of products used in the construction of noise barriers.
6. Identify outstanding issues and direction for future work.

The study started in 1995 April, when members of a Working Party on the Effectiveness of Noise Walls were appointed by the Member Societies of I-INCE. The study was completed in 1997 and published as a draft report in *Noise/News International* in 1998 (Vol. 6, No. 1, pp. 11-36), 1998 March. After review and changes, this report was approved for publication by the International INCE General Assembly on 1998-11-15.

Each member of the Working Party which prepared this report represents a different Member Society that supports the International Institute of Noise Control Engineering; in addition, there was a Convenor. Countries and members of the Working Party as follows:

Convenor: Gilles A. Daigle

Australia: Ron Rumble
Belgium: Jean-Pierre Clairbois
Italy: Alessandro Cocchi
Korea: Doo-Hoon Kim
Sweden: Leif Åkerlöf
United Kingdom: David Hothersall
USA (ASA): Ilene Busch-Vishniac
Austria: Dieter Hohenwarter
France: Jacques Beaumont
Japan (ASJ & INCE/Japan): Kohei Yamamoto
Lithuania: Aleksandras Jagniatinskis
The Netherlands: Hans J.A. van Leeuwen
USA (INCE/USA): Christopher W. Menge

This report was approved for publication by a unanimous vote of the General Assembly at its meeting in Christchurch, New Zealand, on 1998.11.15. The Board concurs with the decision of the General Assembly and the final report is published herewith.

Report by the International Institute of Noise Control Engineering Working Party on the Effectiveness of Noise Walls

Gilles A. Daigle
Convenor of the Working Party
National Research Council
Ottawa, Canada K1A 0R6

INCE Classification Numbers:
31, 52, 24

Introduction

Transportation activities are one of the most commonly occurring sources of noise outdoors. Sources can be classified into air, road, and rail transportation. Noise levels from these transportation sources are not usually sufficiently high to cause permanent hearing loss in communities affected, but they may cause considerable annoyance and activity interference. For example, recent reports indicate that a large number of persons worldwide are exposed to outdoor time-average A-weighted sound levels L_{Aeq8h} greater than 65 dB. The most effective noise control measures are those affected at the source, particularly by quieter designs, together with the application of careful land use planning measures in the community. Tangible progress has been made in the abatement of aircraft noise through new generations of quieter engines. Also, in motor vehicles, quieter engines, better air-intake and exhaust mufflers, quieter tires, and more recently, low noise road surfaces reduce the impact of traffic noise in communities along roadways. These advances have been directed by legislation in many countries in which the allowed maximum noise levels from road vehicles and aircraft have been progressively reduced. Recently, I-INCE reviewed the effects of regulations on road vehicle noise.

There are also many ways of modifying the transmission path to reduce the level of noise at the receiver. At the land use planning stage, the distance between source and receiver can be increased by setting aside sufficiently large areas of land along new roads and around new airports. The receiver can be screened from ground transportation noise by erecting noise barriers. Barriers are now in common use as a method of abating noise. They are used to reduce the noise from vehicle traffic, railways, and to some extent, to control noise from ground-based airport operations such as start of take-off roll. A large body of research work has been carried out aimed at understanding the diffraction of sound around barriers, predicting their performance and developing more efficient designs.

This report reviews the scientific basis for the performance afforded by noise barriers. Barriers derive their performance by blocking the line-of-sight as illustrated in Fig. 1 thus creating a sound shadow. Barrier performance is measured by its insertion loss defined as the difference in sound pressure level before and after the barrier is constructed

$$D_{IL} = L_p(\text{before}) - L_p(\text{after}).$$

In some cases L_p(before) is not available and the insertion loss is approximated by some other measure.

The factors affecting the performance of noise walls can be grouped as those relating to the source, to the surrounding total environment, and to the noise wall itself. After a brief discussion of the various source factors, the physical phenomena associated with outdoor noise propagation are then discussed in detail, followed by a review of the effects associated with the noise wall.

Accurate prediction of barrier insertion loss must account for a wide variety of physical phenomena simultaneously. This is beyond current capabilities and thus limits the accuracy of any prediction model. There are currently a large number of models in use today around the world to predict barrier performance. The accuracy of various models depend on how many physical mechanisms are included and to what level of detail they are considered and how the source is modeled. This report will therefore stress that results from models should only serve as a guide to expected barrier performance, as different models will yield differing results.

The report includes a brief discussion of the generic properties of the products and materials used to construct noise barriers. The issues related to the measured field performance of noise barriers are discussed. Finally the report reviews the three main areas of application: road noise, rail noise, and noise from ground-based airport operations.

Purpose

The main purpose of this report is to undertake a state-of-the-art review of the technical aspects of the acoustical performance afforded by noise barriers for transportation noise sources; road, rail, and airport ground operations (runup, taxi, take off, landing). The report describes different types of barriers and focuses on the important physical phenomena and how to model them. The document is intended for the non-specialist as well as technical designers and practicing engineers. Extensive references are provided. The report is also intended as an educational paper to review all the relevant issues as they are understood by the Working Party. The report identifies outstanding issues and directions for future work. The objective is to develop a program of

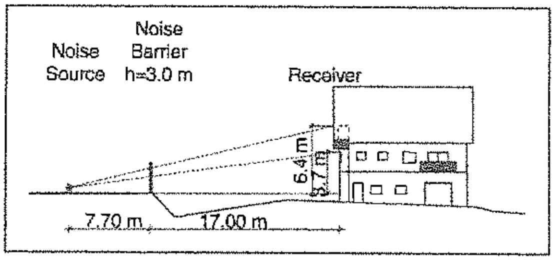


Fig. 1. Barriers derive their performance by blocking the line-of-sight.

work for a future I-INCE Working Party dealing with the measurement and evaluation of noise walls.

Scope

The report describes the work on barriers worldwide and comments on the current state of knowledge. The scientific basis behind noise barriers is reviewed. The report comments on the height of the barriers, the effects of parallel barriers, modification of performance due to multiple edge barriers and the use of absorptive treatments, and the effects of gaps and holes on transmission loss. Particular attention is paid to existing design solutions. Measurement methods are discussed including intrinsic properties and extrinsic *in-situ* performance. The report includes general non-acoustical parameters such as long-term performance but excludes aesthetic, structural and maintenance considerations. Three areas of applications are reviewed; road noise, rail noise, and noise from ground-based airport operations. This document focuses on free standing vertical noise walls.

The International Organization for Standardization (ISO) has an active standards development group that has recently completed a Draft International Standard on a general method of calculating the attenuation of sound during propagation outdoors and includes the presence of noise walls. It is intended that the program of work of the I-INCE working party will not duplicate or overlap the work of the ISO. In addition, the European Committee for Standardization (CEN) is developing acoustical test methods for road side noise barriers in TC226/WG6/TG1. These include tests of sound transmission, sound absorption and definition of the traffic noise spectrum.

Scientific Basis

A noise barrier can be defined as any solid obstacle that is relatively opaque to sound, that blocks the line-of-sight from sound source to receiver, thus creating a sound shadow. Since the dimensions of the barrier are usually of a similar order of magnitude as the wavelength of the sound, the shadow is not sharply defined. Significant sound energy propagates into the shadow region. The factors affecting the performance of noise walls can be grouped into those relating to the source, to the surrounding total environment, and to the noise wall itself.

There are various types of sources. At distances that are large compared with the effective size of the noise source, most sources can be considered a localised point source. Very often barriers are installed close to the noise sources, and these sources must be considered as extended sources. In the case of long moving sources such as trucks or trains, there are often time-related effects on the attenuation associated with multiple reflections between the source and the barrier. Vehicle traffic noise sources can be a distribution of sources such as road vehicles or a line source such as railway vehicles. The spectral characteristics of the source or sources are also important. Many models assume a dominant octave frequency and calculations are performed directly in A-weighted sound levels. In other models, the spectral components of the source are used to perform calculations per octave or 1/3 octave frequency band.

Sound propagating outdoors through the atmosphere generally decreases in level with increasing distance between source and receiver. This attenuation is the result of several mechanisms, principally geometrical divergence from the sound source, absorption of acoustic energy by the air through which the sound waves propagate, and the effect of propagation close to different ground surfaces. Atmospheric conditions, principally wind and temperature, have major effects on the propagation of sound over distances greater than about 100 m. All these effects must be considered to assess accurately the acoustical effectiveness of sound barriers.

There are several effects associated with the noise wall itself. Barrier height is of fundamental importance to the attenuation produced by the barrier. The higher the barrier, the more the line-of-sight is blocked, the greater the path difference (difference in length between the unobstructured path and the path over the barrier top) and the greater the attenuation. The nature of the noise wall is also a factor. There are modifications of performance due to shape of the noise wall, the nature of the diffracting edge, the finite length of the noise wall such as at access gaps, and the addition of absorptive material.

The position of the source or receiver relative to the barrier is also of fundamental importance to attenuation. There is also degradation due to parallel barriers, and interaction between the source and barrier when large sources are close to the wall. In the case of parallel barriers, the ratio of the width (W) separating the two barriers to the height (H) of the barriers is an important factor. Other aspects also come into play such as the construction and transmission loss of the barrier as well as gaps due to deterioration of the structure and gaps between the barrier and the ground. It is important that there be no significant air gaps.

Measures of Barrier Efficiency

In general, a barrier's performance is measured by its insertion loss (D_{IL}). The insertion loss of a barrier at a given point is defined as the difference in sound pressure level (measured at that point) before and after the barrier is constructed.

$$D_{IL} = L_p(\text{before}) - L_p(\text{after}) \quad (1)$$

Insertion loss can be defined for sound of a single frequency, a band of frequencies or a broad band source. Insertion loss is of direct practical interest to those considering the construction of a barrier; it also avoids the ambiguity that arises because the barrier, besides introducing attenuation due to diffraction, also commonly reduces the attenuation due to the ground (by increasing the height of the sound path above the ground). The insertion loss of a barrier varies with several parameters, most notably the frequency of the sound (the higher frequencies are more attenuated). Insertion loss can be determined by means of calculation or measurement.

In some cases, especially when a barrier is already in place, L_p(before) is not available and the insertion loss is approximated by some other means. The Nord Test Nr. 496-84 defines an index called the Barrier Noise Reduction (B.N.R.). According to this index, the "before" condition is estimated from sound pressure levels measured by a microphone located at a height of 1 m above the barrier and correcting these levels to the required distance. The B.N.R. index has sometimes been used in Japan. In the USA, ANSI S12.8-1987 standard describes a similar method, as well as an approach that employs an equivalent site without a barrier.

In many cases, barrier noise reduction is expressed as "attenuation." The term attenuation can have many definitions. The most widely used definition for attenuation is to describe the amount of diffraction behind a barrier and usually refers to sound levels behind the barrier relative to the sound levels in the absence of the barrier and the ground, i.e., in free field.

For lightweight construction, the transmission loss of the barrier is an important measure. The transmission loss (TL) of a partition or test section of a noise wall, for a specified frequency band, is given by

$$\text{TL} = L_{pS} - L_{pR} + 10\lg(S/A) \quad (2)$$

where L_{pS} and L_{pR} are the average sound pressure levels in a reverberant source room and receiving room respectively (expressed in decibels), S is the area of the common partition and A is the Sabine absorption in the receiving room. The construction of the barrier must ensure that it has a closed surface without large cracks or gaps and the surface mass is at least 10 kg/m^2 to ensure adequate TL.

The most commonly used noise index to describe road and rail traffic noise is the A-weighted equivalent continuous noise level, L_{AeqT}, which is specified over a time period T. Other statistical noise level indices are used in some countries, including L_{A10}, L_{A50}, L_{Amax}, L_{Ax} or SEL. For example, L_{A50} is currently used in Japan for road traffic noise and L_{Amax} for railway noise (although the use of L_{Aeq} is currently being proposed).

Physical Phenomena—General

Sound levels in the vicinity of an outdoor source are influenced by the medium through which the sound propagates. Normally occurring variations in meteorological conditions result in sound level variations and the presence of the ground, in particular, or other surfaces normally influence levels. In order to design a noise barrier, it is imperative to understand and consider the influence of environmental variables on the sound levels. Embleton (1996) has recently published a tutorial on sound propagation outdoors. This section summarizes the physical phenomena associated with outdoor sound propagation.[1]

Sound propagating outdoors through the atmosphere generally decreases in level with increasing distance between source and receiver. The octave-band (or 1/3-octave band) sound pressure level L_p, in decibels, at a microphone can be approximated by

$$L_p = L_W - A_T - 10\lg(4\pi) \quad (3)$$

The term L_W in Eq. (3) is the effective sound power level of the source (in decibels re 1 pW) for radiating sound in the direction of propagation from source to receiver. (A temperature of 20° C and an atmospheric pressure of 1 atm has been assumed). The total attenuation in each octave band, A_T in decibels, is the result of several mechanisms and can be approximated by

$$A_T = A_s + A_a + A_e \quad (4)$$

In Eq. (4) the first three terms give the attenuation from three principal mechanisms—geometrical spreading from the sound source (A_s), absorption of acoustic energy by the air through which the sound waves propagate (A_a), and the effects of the environment (A_e). The environmental effects arise principally from propagation close to different ground surfaces in the presence of ambient atmospheric conditions, especially wind and temperature variations. The last term (A_e) also covers attenuation from additional effects which arise only in specific cases, in particular, diffraction by a noise barrier.

In the case of a line source the total attenuation can be obtained by integration of a series of point sources along the line.

Geometrical Spreading

At large distances from a source in a homogeneous, non-dissipative atmosphere in the absence of a reflecting plane, the sound pressure varies inversely with distance from the source. The attenuation due to spreading, A_s, is therefore approximated by

$$A_s = C \lg(r/r_0) \text{ (dB)} \qquad (5)$$

where r is the distance from the source center in metres and r_0 is a reference distance of 1 metre. For a point source $C = 20$ and for a line source $C = 10$.

Air Absorption

As sound propagates through the atmosphere its energy is gradually absorbed by a number of energy-exchange processes in the air. The amount of absorption depends strongly on frequency and relative humidity, and less strongly on temperature. It also depends slightly on the ambient pressure, sufficiently to require consideration with large changes of altitude (thousands of metres).

In most conditions, dry air can produce high attenuation of sound at high frequencies. Therefore, in the case of a predominantly high-frequency source, measurements made under dry conditions can differ considerably from measurements made under more humid conditions.

Details on attenuation by air absorption are given in American National Standard "Method for the Calculation of the Absorption of Sound by the Atmosphere" (ANSI S1.26-1978 (R1995)) or International Standard ISO 9613-1 "Acoustics—Attenuation of sound during propagation outdoors - Part 1: Calculation of the absorption of sound by the atmosphere."

Effects of the Environment

There are two main environmental factors which can influence sound propagation:

- The ground effect—including surface properties, source and receiver heights;
- Meteorological conditions—including wind velocity gradients, temperature gradients, and turbulence.

The propagation of sound close to the ground for horizontal distances less than a few tens of metres is essentially independent of meteorological conditions; for this case the atmosphere can be regarded as homogeneous and the sound paths (see Fig. 2) approximated by straight lines. The attenuation due to the effects of the environment (A_e) is then that due to the ground alone. For greater distances, meteorological conditions usually become a major factor. These factors are refraction by wind and temperature gradients, and atmospheric turbulence. The meteorological effects then modify the ground attenuation to produce the total attenuation due to the environment.

When the sound source is located above a ground surface, sound waves which reflect from the ground will constructively or destructively interfere with those propagating directly from the source (see Fig. 2). Since most grounds are partially reflecting, the reflected wave is also modified in amplitude and phase by its interaction with the ground surface. The amount of attenuation attributable to this ground interaction, and its variation with frequency depends on the surface type and the source/receiver heights and their separation. The effects of the ground are largest for intermediate frequencies (around 500 Hz) when the source is above the ground (1 m or more). If the source is close to the ground all frequencies above 500 Hz display large attenuations.

The main effect of meteorological conditions is refraction, a change in direction of the sound wave propagation, produced by vertical gradients of wind and temperature. Sound refracts (bends) upward, as shown in Fig. 3(a), when the propagation is upwind. Refraction upward often produces a shadow zone near the ground, as shown in the figure, resulting in an excessive attenuation that often reaches 20 dB or more. Sound refracts downward, as shown in Fig. 3(b), when the propagation is downwind. Such downward refracting conditions are favourable for propagation, producing a minimum of attenuation due to the effects of the environment.

During the late morning and afternoon on sunny days, the air temperature usually decreases steadily with increasing height above the ground, a condition known as temperature lapse; sound refracts upward resulting in a shadow zone near the ground [Fig. 3(a)]. In contrast, at night the temperature often increases with increasing height (due to radiation cooling of the ground surface), a condition known as temperature inversion, which may extend to one hundred metres or more above the ground late at night. In a temperature inversion, sound refracts downward, producing a minimum of attenuation due to the environment [Fig. 3(b)].

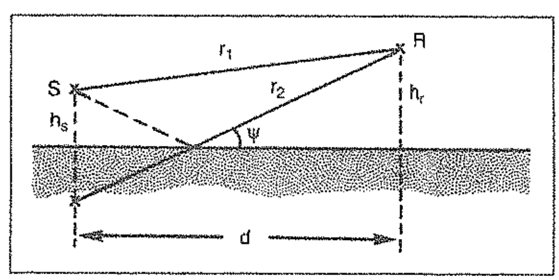


Fig. 2. Direct path r_1 and reflected path r_2 between source S and receiver R.

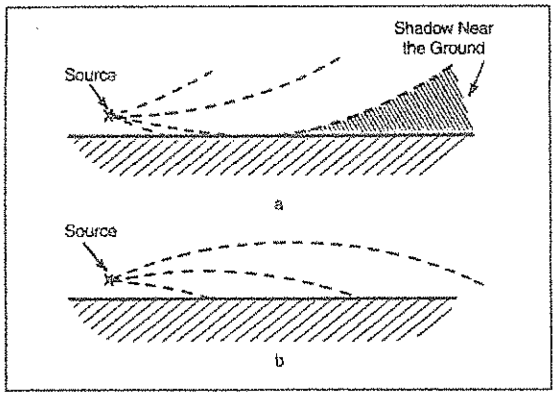


Fig. 3. (a) Sound refracts upward when the propagation is upwind or during sunny days. (b) Sound refracts downward when the propagation is downwind or during a temperature inversion.

The atmosphere is an unsteady medium with random variations in temperature, wind velocity, pressure, and density. In practice, only the temperature, wind direction, and wind velocity variations significantly affect sound waves over a short time period. When sound waves propagate through the atmosphere, atmospheric turbulence scatters the sound energy resulting in random fluctuations in measured sound pressure levels. Many acoustical phenomena are strongly and directly affected by atmospheric turbulence. For example, the scattering of sound energy increases the time-average sound levels behind a noise barrier, thus limiting the attenuation that can be provided by a barrier.

Physical Phenomena Associated with the Noise Wall

Numerous physical features[2-22] associated with the noise wall can influence its insertion loss:

- Barrier height and proximity of source/receiver to the barrier;
- Sound absorbing material in the case of a single wall;
- Sound absorbing material to reduce multiple reflections due to parallel reflecting walls;
- Atmospheric effects;
- Effects associated with the surface of the source;
- Time related effects;
- Transmission loss.

A thin barrier is one in which diffraction occurs at a single edge, as shown in Fig. 4(a). A solid fence, of the type usually constructed to be a noise barrier, and a free standing wall are examples of a thin barrier. A thick barrier is one in which diffraction occurs at two edges, i.e., another diffraction point is provided as shown in Fig. 4(b). A building or an earth berm with a wide flat top are examples of a thick barrier. Typically, if the barrier thickness is greater than 3 m, a barrier is regarded as thick for sound components of all frequencies. If the thickness t is less than 3 m, the barrier is still regarded as thick for sound components of wavelength less than $t/5$.

Barrier Height and Proximity of Source/Receiver to the Barrier

Barrier height and proximity of source and receiver to the wall are of fundamental importance to the attenuation provided by a barrier. In countries around the world, typical barrier heights range between 2 and 6 m. In some countries heights of 8 to 10 m are common and heights as low as 1 m are also found. Barrier protection is greatest for the first row of housing (closest proximity) while reduced protection results for further rows of housing. The most common values for insertion loss range between about 5 and 12 dB, but values between 3 and 25 dB are also measured.

The highest insertion loss is found in the case of rail traffic noise due to the proximity of the source to the barrier. For example, the normal barrier height for the Shinkansen Railway (high speed railway) is only 1.5 to 2 m, while in Europe typical rail barriers are only slightly higher, yet these barriers are found to be quite effective. Intermediate values of insertion loss are characteristic for road traffic noise. For example, in the US highway barrier heights of 6 m and 7 m are very common. In Japan the normal barrier height for highways is 3 m and measured B.N.R. ranges between 15 dB to 23 dB, but barriers tend to reach a height of 8 m to achieve B.N.R.s of 25 to 30 dB in the suburbs of Tokyo. Barrier heights of 5 to 6 m are now common in Australia. Measured insertion losses for barriers 3 to 6 m high are typically between 5 and 12 dB. The smallest insertion loss is obtained in the case of ground-based airport opera-

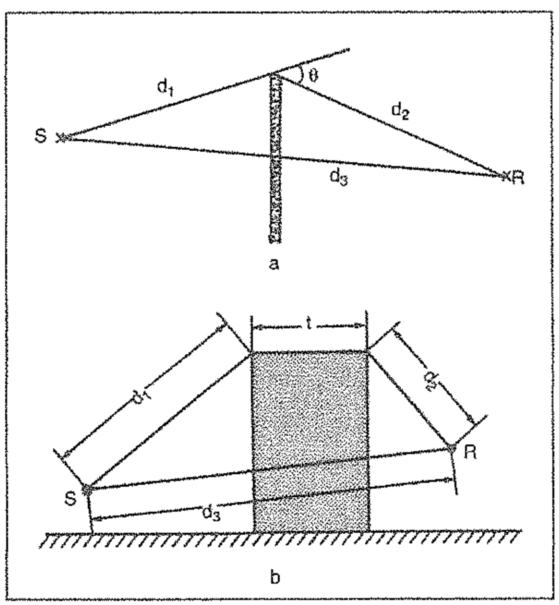


Fig. 4. (a) Diffraction at a single edge. (b) Diffraction occurs at two edges with a thick barrier.

tions due to the larger source/receiver distances and greater source height. For example, barriers 10 m high are common for runup enclosures at US airports, with propagation distances up to 2000 m.

Sound Absorbing Material— Single Walls

Given a thin vertical reflecting noise barrier that obstructs the source-receiver path, an added device, material, or shape may be used to improve its performance. However, such modifications must not be used to reduce the height of such a barrier below the source-receiver direct paths.

There is a body of evidence[10,16,20-22,28,48] to suggest that the use of absorbing materials can enhance barrier performance. The information is based on the effects of absorbers on single barriers and parallel barriers. As with all barrier problems it is very difficult to give a simple description of a particular effect since so many other parameters are involved. Nonetheless, the general principles can be described. Placing absorptive material on a single barrier has theoretically two advantages (see Fig. 5). One is to reduce diffracted sound into the shadow zone. The second is to minimize sound reflection between the source and the barrier surface, thus avoiding the build up of the sound level.

The effectiveness of absorbing surfaces depends upon the efficiencies of the absorbing material. The effectiveness of a porous absorber usually decreases as the frequency decreases. Resonators usually have a maximum of absorption around their resonance frequency. Theoretical and experimental results indicate that the increase in insertion loss of a barrier due to the introduction of absorber on one side is related to the angle θ between the absorbing barrier surface and the ray from the source or receiver to the top of the barrier. When θ is 90° the effect is negligible. The increase in insertion loss rises to approximately 2 dB when θ is 45° and may reach 10 dB for very low angles. If both sides are absorbing the effect is approximately additive. Thus it is necessary for the source or receiver to be close to the barrier for this effect to be significant. For example, a source 1 m above the ground would need to be 4 m from a 3 m high barrier for an absorbing surface on the source side to produce an increase in insertion loss of about 1 dB behind the barrier. The full effect of an absorber on the diffracted path can be achieved by a strip at the top or sides of a barrier which has a width of one wavelength. For a broadband spectrum this means the whole of the side for normal height barriers (e.g. 3.4 m for 100 Hz). Non-flat (structured) barriers can scatter the sound incident over them in many non-specular directions; this diffusion should not be confused with the phenomenon of absorption.

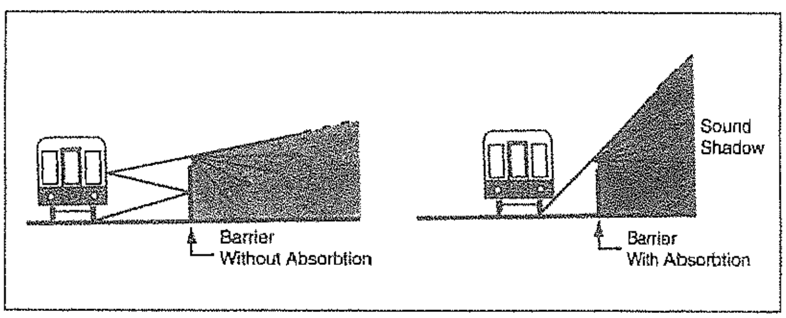


Fig. 5. The effects of placing absorptive material on a single barrier.

Sound Absorbing Material—Parallel Barriers

An important application of absorption is in the case of parallel barriers. The attenuation provided by the barrier on one side of the source is degraded[3,4] due to reflections from the reflective barrier on the opposite side [see Fig. 6(a)]. In the case of road traffic noise, results show that the degradation typically ranges from about 2 to as much as 7 dB. A more complete discussion of the degradation in insertion loss from parallel rigid barriers is given in the applications section under road traffic noise. Application of absorption over the road-facing side of the barrier restores the performance with a progressive improvement depending on the area covered. The performance can also be restored by sloping[17] the barrier, as shown in Fig. 6(b). The required angle will depend on the separation of the barriers. This may not be an optimum solution that should be encouraged, as the reflected sound could cause problems elsewhere. If the sloping surface has dimensions less than the wavelength of the sound, a scattering rather than a reflection process occurs. Unlike absorption, which dissipates acoustic energy, scattered sound may lead to increased sound levels elsewhere.

Atmospheric Effects

Barrier performance is disturbed by other factors such as the atmosphere. Upward-curving sound paths, as in propagation upwind or during the temperature lapse characteristics of sunny days, do not reduce the acoustic performance of a barrier. However, it is generally recognized that downward-curving sound paths, as in propagation downwind or during the temperature inversions that are common at night, do reduce the insertion loss of a barrier. This reduction varies with wind speed, frequency and propagation distance. For example, in Japan, road traffic noise measured behind various barrier sites was analysed to examine the relationship between barrier noise reduction and vector wind. The results showed a wide scatter for vector winds in the range ± 2.0 m/s, indicating no systematic dependence. However, downwind data obtained on one site when the vector wind was greater than 2 m/s showed a decrease in barrier noise reduction.

Atmospheric turbulence scatters[7] sound energy into the acoustic shadow behind a barrier. Therefore, turbulence is responsible for setting an upper limit to the amount of insertion loss that can be obtained from a given barrier configuration. For example, when the barrier noise reduction values obtained from the study in Japan are averaged and plotted against the design chart, close agreement is obtained until the predicted values exceed 20 dB. The measured barrier noise reduction tends to level off at around 20 to 25 dB.

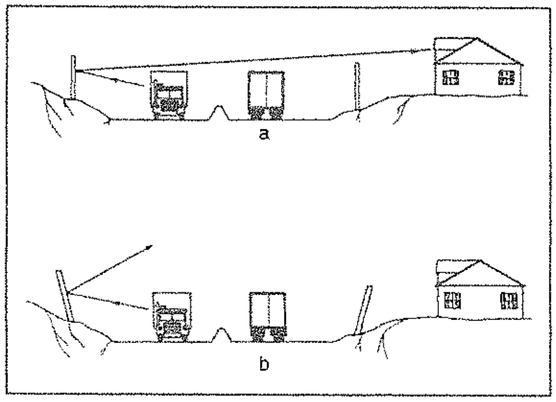


Fig. 6. (a) The attenuation provided by the barrier on one side of the source is degraded due to reflections from the reflective barrier on the opposite side. Application of absorption restores the performance. (b) The performance can also be restored by sloping the barrier.

Effects Associated with the Surface of the Source

For sources which have significant bulk, such as trucks or trains, multiple reflections[14] between the barrier and the surface of the source could be expected to degrade the performance of the barrier particularly when the source and barrier are in close proximity (see Fig. 7). There are two distinct cases; one in which the vehicle side with the major noise sources is visible over the top of the barrier, the other when it is not. Computer simulation results show a progressive degradation of the insertion loss as the height of the vehicle is increased, with an approximately constant degradation of about 5 dB when the vehicle is visible. This number is dependent on many other parameters. Using a sound intensity technique to measure the sound radiation characteristics from Shinkansen trains[13], it was found that the apparent height of the noise source is changed by the effect of the noise barrier.

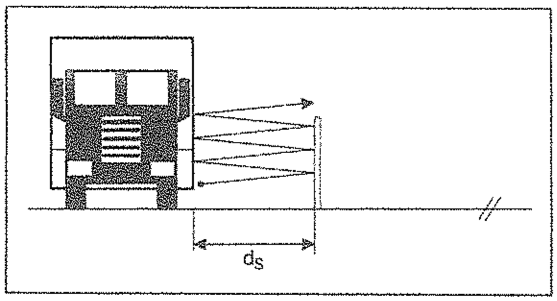


Fig. 7. How multiple reflections can cause a degradation of performance for noise barriers.

Time-Related Effects

The assumption that traffic can be described by a series of fixed sources can lead to problems[5,15] in the derivation of some noise quantities. These arise because the vehicles are actually moving reflecting bodies, and also because practical barriers have a finite length. As a result, the effectiveness of the barrier changes with the vehicle position, which is also related to any effects of multiple reflections that occur between the barrier and the body of the vehicle.

A fundamental descriptor of noise from a road, or a railway, is the function of sound pressure level versus time at a given receiver point for the passby of a single vehicle. This descriptor can then be used to derive the noise assessment indices L_{Ai}, L_{AeqT}, etc.

In the case when the interaction between the vehicle body and the barrier can be neglected, the time function is still required in order to derive the statistical indices. However, in this specific case, the L_{AeqT} can be calculated accurately assuming a series of fixed noise sources. In cases where high sided vehicles are close to barriers with a reflecting surface on the roadway side, multiple reflections can occur, which can degrade the performance of these barriers.

Transmission Loss

Theoretically, the sound transmission loss of noise barriers must be accounted for in determining the insertion loss, since the sound transmitted through the barrier makes some contribution to the sound level at the receiver. However, for practical purposes, barriers are often constructed of materials that have sufficiently high transmission loss such that the contribution from transmission is negligible. To ensure that this is true, and to avoid the need to compute the contribution from sound transmitted through the barrier, the transmission loss should be at least 10 dB more than the desired insertion loss. An important consideration is that laboratory-measured transmission loss may be significantly higher than *in-situ* transmission loss if substantial gaps are present between barrier panels, between panels and support columns, or between panels and the ground. If gaps are present, calculations to estimate *in-situ* transmission loss can assist in determining net barrier insertion loss.

Barrier Shapes

Results in the literature[23-38] have identified a wide range of noise barrier systems, some of which appear to be more effective in terms of acoustic performance than the simple plane reflective barrier widely used. There are two distinct cases; one case is that of a single barrier of different shapes, the other is the case of multiple edge barriers. Many of these systems incorporate absorbing surfaces. Resonant cavities have been used to produce "soft" surfaces and some configurations are designed to promote destructive interference between waves following two different paths. A problem that needs to be overcome with these designs is the narrow band of frequencies for which they are usually effective. Studies have included computer modelling, laboratory experiments, and field measurements. The average improvement in insertion loss for the various designs 2 m high compared with simple plane reflective barriers of identical height ranges from 0.5 to 3.5 dB depending on detailed design.

Single-Shape Noise Barriers

Single-shape noise barriers include wedge-shaped barriers, berms of various kinds, T- shaped and Y-shaped barriers, and arrow-profile barriers. In Japan, barriers in which the upper section is angled or curved over part of the roadway are common. Numerical modelling of the efficiency of single noise barriers of various shapes coufirms that barrier height (i.e., the path length difference effect) is of fundamental importance to the attenuation produced by a barrier. Also, the type of ground cover has a large effect upon the calculated insertion loss.

For barriers with hard reflecting surfaces, those with vertical or nearly vertical sides perform significantly better than those with shallow sloping sides. For example, there is general agreement that the insertion loss for the hard-surface wedge is lower than for a vertical barrier, but no consensus exist as to the magnitude of this effect. Further, for wedge shaped barriers, a progressive reduction in insertion loss is observed with increasing wedge angle. T-shaped barriers give consistent improvements in insertion loss over a wide area compared with a simple plane reflective barrier of the same height. However, when the T-profile is modified to an arrow-profile, a significant reduction in insertion loss is observed.

Application of absorbent material to the upper surface of a T-profile barrier increases the insertion loss by an amount depending upon the width of the cap and the efficiency of the absorber. When the T-shaped barrier with strongly absorbing upper surfaces is modified to an arrow or Y-shape there is a significant reduction in insertion loss. Field data published in Japan show the effects of placing an absorbing cap or modified cylindrical shape on top of a thin hard barrier. By measuring the sound pressure levels from traffic noise before and after the installation of the absorbent material they find that barrier performance is improved by approximately 2 to 3 dB. An attenuation of 2 dB corresponds to the increase in the barrier height of about 2 m. However, this much improvement is only achieved for relatively large diffraction angles, where source and receiver are close to high barriers. The improvement reduces to about 0.5 dB for typical geometries along suburban highways.

Calculations show that when the wall becomes a broad wedge or a berm, an absorbing surface can become very important. When an absorbent surface is introduced to shallow-sided forms of barrier, some improvement in insertion loss is found that is associated with increased attenuation at high frequencies. Some evidence shows that a grass covered wedge is less efficient than a rigid wall of the same height if the wedge angle is more than about 45 degrees. On the other hand for geometries encountered in practice, a flat topped grass covered berm generally performs similarly to a wall of the same height at the same location. Further, when source and/or receiver are very close to the berm there is usually an increase in insertion loss, again mostly associated with increased attenuation at high frequencies. Walls on top of berms are becoming a common approach to noise abatement. Mounting a thin-wall atop an absorptive-topped berm does not initially increase the insertion loss, since the beneficial effect of the absorptive top is lost and is not fully recovered by the increase in the total barrier height. However, as the height of the thin-wall increases, the performance is recovered. The wall/berm combination has the advantage of not requiring as much land as a full berm.

Multiple-Edge Barriers

Multiple-edge barriers can be of two different kinds. There are multiple-edge barriers with a single foundation and there are those comprised of several parallel barriers on the same side of the road. Studies show that multiple-edge barriers give consistent improvements in insertion loss over a wide area compared with simple plane reflective barriers. A benefit of this type of barrier is that an extra edge could be incorporated onto existing noise barriers. The number of possible multiple-edge designs is large, and studies of different configurations are on-going.

Double barriers represent the second type of multiple-edge barriers. They can be efficient in attenuating noise, in comparison with a vertical screen of the same effective height. Double barriers can provide large gains where significant diffraction occurs at the upper edge of both screens. The attenuation improves as the distance between the barriers increases beyond a few wavelengths but also depends on the absorption between the barriers and/or ground absorption (spacing must be much greater than a wavelength and absorbers present to effect substantial improvements). As further barriers are added the efficiency increases, although if working within a limited ground space, there may be a trade-off between the addition of another barrier and the subsequent reduction in barrier spacing. It is noted that the benefits from multiple barriers occur throughout the spectrum, even at low frequencies.

Models

Accurate prediction of barrier insertion loss must somehow simultaneously account for all of the physical phenomena discussed above. Although this goal is still beyond current capabilities, developments[39-79] in our ability to predict sound propagation through the atmosphere has increased dramatically during recent years. Models can be separated to two main categories; *empirical* models and *theoretical* models. Both types of models include the attenuation due to geometrical spreading. Where the empirical models differ from theoretical models is in the incorporation of the other attenuation mechanisms. The empirical models tend to rely on general tendencies found in experimental data bases. They often work well as long as the specific situation of interest falls within the bounds of the databases. Theoretical models on the other hand rely on our mathematical ability to describe real-life situations.

The incorporation of the effects of the ground[48,51,68] is now fairly widespread in the theoretical models. Only a very limited number of models include the effects of curved sound paths due to refraction. However, refraction is most important at longer ranges where barriers generally begin to lose their effectiveness. Only a very limited number of models include the degradation due to scattering by atmospheric turbulence, but the limiting insertion loss due to this phenomenon is generally known through the empirical databases. Often the calculation involves propagation from traffic located on a paved road surface to a receiver on grass covered ground. There are few theoretical models[39] that account for the effect of the hard/soft transition and this effect is most often ignored. There are virtually no theoretical models that incorporate more complex topographical features, and most often a ray tracing approach is used. However, these effects are included in most empirical models.

It is very important to recognize the limitations of the models being used for prediction or design purposes. The Working Party recommends comparison of various models when designing a barrier. It is also important to appreciate how to enter data and to be confident in these inputs. It is the collective experience of the Working Party that inexperienced users cannot use models as effectively as experts, largely due to inadequate documentation on the protocol to follow in using models and insufficient appreciation of their limitations.

Computation of barrier insertion loss is done in two parts according to Eq. (1). First, sound levels in the absence of the barrier are calculated followed by sound levels calculated in the presence of the barrier. The techniques[59] available to calculate sound levels in the absence of the barrier include empirical codes, analytical solutions for propagation above a flat porous ground, analytical solutions for selected atmospheric profiles, ray tracing techniques which include interaction with the ground and meteorological conditions, and more sophisticated numerical solutions to the full wave equation: the fast field program (FFP) and the parabolic equation (PE). There is also an International Standard[80] covering prediction of levels from a source. The attenuation that can exist due to natural features, particularly absorbing ground cover, before the construction of a barrier is often not appreciated. For this reason the measured insertion loss of a barrier when constructed is not as large as predicted from the barrier diffraction attenuation and can sometimes result in negative values in certain regions of the spectrum. Approximations in models can also lead to calculations indicating negative insertion loss.

The presence of the barrier imposes an additional challenge for computational techniques. Most of the theoretical methods which have been developed to calculate the attenuation of barriers are semi-empirical and based on ray tracing and geometrical acoustics. These methods fall into two categories: those in which only the amplitude of the sound field is predicted; and those in which the phase of the sound field is estimated so that interference effects can be studied.

Empirical

In the first category the most influential early studies were those of Maekawa[61] and Kurze and Anderson[57]. These researchers predicted the sound attenuation due to a reflecting knife-edge in terms of the Fresnel number. These prediction methods have been applied to predict the insertion loss of a vertical rigid barrier located on the ground, and form the basis of the current road and railway traffic noise barrier prediction method in many countries. In some countries barrier height is determined by other specific design charts.

In its simplest form, the attenuation provided by a thin barrier represented by an infinite half-plane is calculated as a function of Fresnel number N defined as

$$N = (2/\lambda)(d_1 + d_2 - d_3) \quad (6)$$

(see Fig. 4(a); λ is the wavelength of the sound). The curve in Fig. 8 is the attenuation provided by a thin barrier as a function of Fresnel number and forms the basis for the well-known chart developed by Maekawa. Maekawa empirically corrected the curve in Fig. 8 to account for the presence of the ground. The remarkable agreement, on average, with a large body of measured field data and its simplicity of use has led to the widespread engineering use of the chart.

Theoretical

In the second category of theoretical methods some form of a geometrical theory of diffraction[40,48,71] is used, coupled with an approximation for the spherical wave reflection coefficient at an impedance plane, to account for ground reflections. The sound field behind the barrier is determined by the sum of the terms associated with the four paths shown in Fig. 9 and a complex interference spectrum is formed. Mostly these methods have been restricted to a thin vertical barrier on a reflecting or finite impedance ground.

To produce predictions for configurations which are more complicated in terms of barrier shape and absorptive treatment, the use of the boundary element method has been investigated[48,75]. This method has important advantages over the methods based on a geometrical theory of diffraction approach. A main advantage is its flexibility, in that, by positioning the boundary elements appropriately, arbitrary shapes and surface acoustic properties can be accurately represented. Secondly, it has the advantage of accuracy in that, provided that the boundary elements are made a small enough fraction of a wavelength, a solution of the governing wave equations of acoustics can be produced that is correct to any required accuracy. The disadvantage of the boundary element method is that large computing times and storage can be required, especially for barrier designs which vary along the length as well as in cross-section. A further limitation which it shares with the other methods described above, is that atmospheric effects are not considered, so that only predictions for a neutral quiescent atmosphere are obtained.

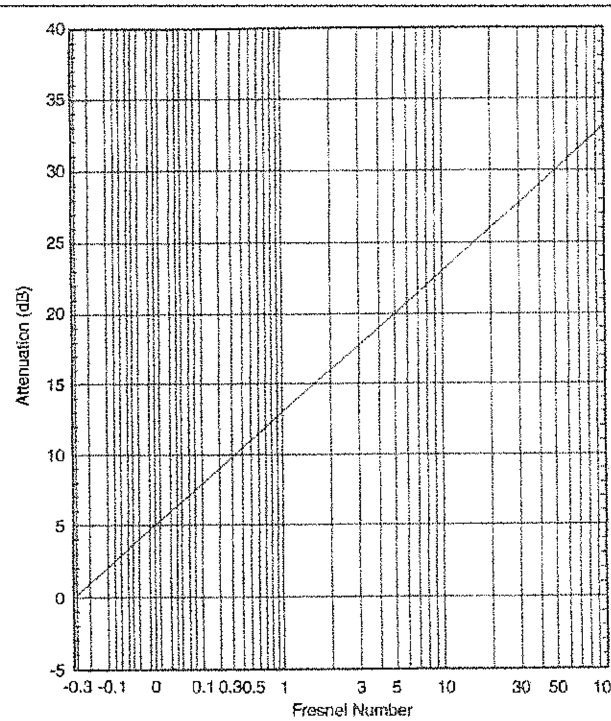


Fig. 8. Attenuation provided by a thin barrier as a function of Fresnel number according to the chart developed by Maekawa.

Application of the Models

International Standard ISO 9613-2 Acoustics—"Attenuation of sound during propagation outdoors—Part 2: General method[80] of calculation"—specifies an engineering method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of noise at a distance from a variety of sources. It aims to determine the average time-interval equivalent continuous A-weighted sound pressure levels under meteorological conditions favourable to propagation from sources of known sound emission above natural ground surfaces. These conditions are for downwind propagation, or equivalently, propagation under a well developed moderate ground-based temperature inversion, such as commonly occurs at night.

It also aims to determine a long-term average A-weighted sound pressure level. The duration of the long-term interval is much longer than that required for specifying the average equivalent continuous A-weighted sound pressure level for downwind propagation described above, and encompasses a wide variety of meteorological conditions.

The method consists specifically of octave band algorithms (with nominal midband frequencies from 63 Hz to 8 kHz) for calculating the attenuation of sound which originated from a point source, or an assembly of point sources. The source may be moving or stationary. The method is applicable in practice to a great variety of noise sources. It is applicable, directly or indirectly, to most situations concerning road or rail traffic, and many other ground-based noise sources. Specific terms are provided in the algorithms for a variety of physical effects, including screening by noise barriers.

The formulas to be used are for the attenuation of sound from point sources. Extended noise sources, therefore, such as road and rail traffic are represented by a set of sections, each having a certain sound power and directivity. A line source may be divided into line sections, an area source into area sections, each represented by a point source at its centre.

The International Standard calculates diffraction over the top edge and around a vertical edge of a barrier. Double diffraction over thick barriers can also be calculated. (The Working Party notes, however, that the formulas for calculating double diffraction yields a discontinuity in the solution when passing from single diffraction to double diffraction). The screening attenuation is not taken to be greater than 20 dB in the case of single diffraction from thin screens, and 25 dB in the case of double diffraction by thick screens. The screening attenuation for two screens is calculated as in the case for double diffraction.

Each country[81-103] has usually adopted its own specific method for predicting the performance of barriers for specific transport noise sources. For example in the UK[84], calculation of the attenuation of road traffic noise by a barrier is performed using a chart in terms of path length difference. In Japan, barrier height is determined by a design chart[79] such as Maekawa's or other specific design charts using a representative spectrum of road traffic noise. In Lithuania the decrease in A-weighted noise level due to a noise wall is estimated in decibels using a design chart which assumes that the wall is 3 m from the edge of the road. When walls in city streets are used as barriers, they must be sound absorbing. The frequency dependence of sound absorption is chosen in accordance with the typical spectrum of noise for the transportation source. In the USA, STAMINA/OPTIMA has been the official highway noise prediction and barrier design model[92,93].

The US Department of Transportation's Federal Highway Administration (FHWA) is developing the next generation of highway noise prediction computer code[82] called the Traffic Noise Model (TNM). In addition, the new model has the potential for standardizing and improving rail and transit noise prediction in the USA. The only significant sound propagation components that have not been included in the TNM are those due to atmospheric effects such as wind and temperature gradients; the model assumes a neutral atmosphere. This decision was motivated by FHWA's purpose that propagation over relatively short distances (less than about 200 m) is most important. The expected increases in development cost, computation time, and user input complexity associated with including such atmospheric algorithms would be quite significant.

Many models such as the TNM and the Dutch

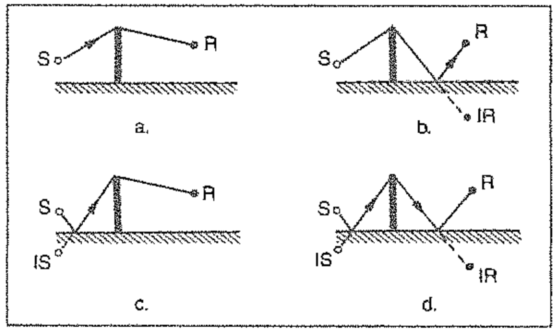


Fig. 9. The sound field behind a barrier is determined by the sum of four paths.

model calculate all important sound propagation paths from the source to the receiver, including reflection and diffraction, at one-third octave or octave band centre frequencies. The TNM model includes diffraction from ground impedance discontinuities, such as the edge of the pavement adjacent to a highway. Ground lines and earth berms are included, so that the exact terrain between source and receiver can be entered. Special reflective barriers can be coded which generate an image of the roadway to account for reflection at the barrier surface. Only single reflections are supported in the three dimensional portion of the TNM. (A two dimensional ray-tracing module is included for analysis of multiple reflections.) Multiple diffraction is included. The model computes the cumulative effects of diffraction from various points in the geometry, if they are significant contributors to the total sound level at the receiver. Perturbable barrier and berm heights are included, so that a matrix of results for several barrier heights at once can be constructed for rapid barrier design decisions later. Rows of buildings can be included, and require the user to specify the percentage of area that the buildings block in each row. Tree zones are included, and incorporate the ISO values for attenuation due to dense foliage. Sound level descriptors include L_{Aeq1h} and L_{dn}. Traffic data input tables allow traffic input for both descriptors.

The US Army Construction Engineering and Research Laboratory (USA-CERL) has developed a long-distance sound propagation model[78] called *SoundProp* that incorporates the effects of atmospheric conditions. It is a point-to-point model that operates in 1/3 octave bands and computes the propagation of sound in the atmosphere above the ground and in the presence of a barrier if one exists. The propagation mathematics are based on a fast field program that was exercised many times on a supercomputer to generate a large database of results under various conditions of atmospherics, ground type, and geometry (source and receiver height and range).

Products and Materials

Barrier materials are briefly described here[104]. Different products have their own characteristics apart from their acoustical performance, including cost, durability, safety and aesthetics.

There are a range of traditional building materials commonly used for noise barriers, This is being supplemented by innovative, proprietary products developed for specific barrier applications. All of these barriers can be categorized as either reflective or absorptive.

Reflective Barriers

Reflective barriers are constructed using all of the common building materials and include:

- concrete—precast panels, masonry blocks, and purpose-designed masonry units
- lightweight concrete - fibrous cement, purpose-designed elements
- metal sheeting
- plastics
- glass
- wood
- other materials

The use of these various products tends to be regionalized, obviously dependent on relative economies of the different materials in different areas and other factors mentioned above.

Concrete walls are common reflective barriers. They are usually made up of stacked panels 3 to 5 m long and 0.5 to 1.8 m high. The thickness is 90 to 200 mm and the surface density of this type is 200 to 400 kg/m^2. There are also barriers designed with elements that consist of combinations of flower boxes on different heights on the barrier. In this case a luxuriant vegetation can be obtained and the barrier becomes more or less absorptive.

Lightweight concrete and other fibrous cement can also be used for barriers. In most cases the low density is not a problem since the transmission loss of the barrier is not the critical parameter.

Metal sheeting is also used for barriers. Commonly used is steel and aluminium that is sea water resistant. Mostly thin sheets from 1 to 2 mm are being used. These materials are often combined with mineral fibres giving an absorptive barrier. With metal barriers, care must be given to ensure that they are thick enough to give a high enough transmission loss, particularly at low frequencies. Also metal sheet barriers are combined with vegetation (fast growing trees or shrubs) in front of and behind the barrier to obtain a "green" barrier.

Plastic elements are also used for barriers. Sometimes they are made of recycled materials. The surface density averages around 10 to 20 kg/m^2. Plastic elements are used more in absorptive barriers.

Glass and other transparent plastic elements are coming into use for barriers. They are made of glass, of acrylic or polycarbonate resin of 5 mm to 8 mm thickness, or polymethylmethacrylate of 15 to 20 mm thickness. The surface density averages around 10 to 20 kg/m^2. The advantage of this material is that drivers and passengers can see the landscape through the barrier and residents can see the road or railway line. This can be important when barriers are erected in front of dwellings. Problems are visual reflections on the barriers (as a mirror) and the cleaning of the barrier, but these can be solved by inclining the construction.

Wooden barrier materials are commonly used in the UK, the US, The Netherlands and in Austria. Timber is also widely used in Northern Europe, Scandinavia, Australia and Canada.

Other materials or combination of materials can be used as well. For example, metal sheeting or plastic elements in combination with glass and other transparent plastic elements can be employed. Also combinations with absorptive elements, glass and other transparent plastic elements can be very practical. Architects can make some attractive designs by combining different materials with special shapes. There are many examples of interesting shapes and material combinations in France, Germany and The Netherlands.

Absorptive Barriers

Absorptive barriers are a fairly recent innovation and their use is not as widespread as reflective barriers. Absorptive barriers include:

- composites—using traditional acoustical techniques such as commercial mineral fibres behind a perforated facing, wooden network, perforated plastics, porous concrete, etc.
- ceramics
- sintered metals
- cement-bonded wood-wool or wood chips
- aerated concrete

There are two general types of systems that are used to create absorbing surfaces of barriers.

Systems with Cavities Incorporating Absorbing Materials

The most common systems of this type are perforated metal boxes containing fibrous materials. An example of this is the standard absorptive panel design specified by the Public Highway Corporation of Japan since the early 1970s. The barrier panel consists of a glass fibre sheet 50 mm in thickness, wrapped with polyvinyl fluoride film of 21 μm thickness. This fibre sheet is inserted in a metal box with a back air space of 33 mm thickness. The front surface of the box is made from an aluminum panel with slits and the back side of the panel is made of steel sheet of 1.6 mm thickness. The absorption coefficients (measured in a reverberation chamber) are greater than 0.7 and 0.8 for 400 Hz and 1000 Hz respectively. This type of material is widely applied to barriers used for inter-city highways.

A second type is a construction of cement or baked clay blocks with internal cavities. The traffic-facing side of the block contains holes or slots. Sound is absorbed at the resonance frequencies of the cavities and the range of frequencies absorbed is extended by the inclusion of fibrous or foam fillers.

Systems with Panels of Open Textured Porous Materials

Absorption within the material is achieved by inertial and frictional losses. These materials are usually incorporated with a hard backing to prevent sound being transmitted through the panel. If the panel is directly mounted on the backing a thickness of 50 to 100 mm is required to provide good absorption characteristics at the lower frequencies. The front faces are often profiled rather than flat. If an air gap is introduced between the panel and the backing, the thickness can be reduced and the low frequency performance retained.

Materials used in this category are porous cement and concrete, wood chips in a cement matrix and small particles in an epoxy matrix. Ceramic sound absorbers are made from particles of a hard porcelain and are formed into a porous board of 10 mm to 50 mm in thickness. This material has thermal resistance and resistance to chemical substances in exhaust gases from heavy trucks and cars. However, it is not as resistant to physical impact such as the impact resulting from a collision with a car. A common absorptive material used adjacent to highways and railways in the US and Canada is made from wood fibres bonded together with portland cement of 50 to 100 mm thickness and backed with a solid concrete panel.

Vegetative barriers are constructed from vegetation that is rooted in a soil mound or in specially-constructed panels. The insertion loss of these constructions is determined primarily by the dimensions of the earth bank or solid structure. For artificial, steep-sided structures, some form of irrigation is necessary to retain viable plants.

Measurements

It is the collective experience of the Working Party that well conceived and documented experimental measurements are the only reliable way to verify the effectiveness of road and rail noise barriers. Measurements can be of two types; verification of the field insertion loss and laboratory measurements on sample constructions. Field measurements verify how the design is performing. A program of *in-situ* field measurements[105-108] shows how assembled components age and also how movement of a barrier with time affects the insertion loss and/or transmission loss. Sample constructions can be tested in the laboratory and include methods to measure the absorption and transmission loss. However, intrinsic properties of the individual components may not necessarily reflect the *in-situ* performance and as a result it is important to test sample constructions.

Standards for Measuring Barrier Insertion Loss

American National Standard "Methods for determination of insertion loss of outdoor noise barriers" (ANSI S12.8-1987) covers insertion loss determination by measurement or by measurement and prediction for outdoor noise barriers of all types. The standard adopts insertion loss as the basis for determining effectiveness of a barrier. The standard recommends use of the A-weighted sound exposure level or time-averaged sound level or octave band sound pressure level, but does not preclude use of other noise descriptors. It provides methods for determining the insertion loss of outdoor noise barriers at receiver locations of interest under conditions of interest. In addition, the standard presents requirements for the documentation of the procedures and results to permit interpretation and independent evaluation of the results. It may be used for routine barrier performance checking, or engineering or diagnostic evaluation, and may be used in situations where the barrier is to be installed, or has already been installed. Three methods are presented. The recommended method is the "direct measured" method where the user measures levels at the reference and receiver positions both before and after barrier installation. The same receiver and reference positions are used in both the "before" and "after" case. It may be used only if the barrier has not yet been installed or can be removed for the "before" measurements.

Alternative methods are an "indirect measured" method and an "indirect predicted" method. If the barrier has been installed prior to any direct "before" measurement and it cannot be readily removed to permit such measurements, the user may simulate the "before" condition by measuring at a site that is equivalent to the study site minus the barrier. If it is not possible either to make actual before measurements or to make substitute "before" measurements at an equivalent site, then "before" predictions may be possible. When predictions are used, errors inherent in the chosen prediction method further decrease the precision of the resulting insertion loss.

Draft International Standard ISO/DIS 10847 Acoustics—"*In-situ* determination of insertion loss of outdoor noise barriers of all types"—also specifies methods for the determination of insertion loss of outdoor noise barrier intended to shield various kinds of noise sources. The International Standard only specifies two methods for the determination of insertion loss of outdoor noise barriers. The recommended method is the direct measurement method discussed above. The alternative method is the indirect measurement method also discussed above using measured "before" levels at an equivalent site. The International Standard does not include the indirect predicted method.

Applications

This section discusses three main application areas[109] where barriers are used: road traffic noise, railroad noise, and ground based aircraft operations.

Road

Road traffic[110-113] is the most widespread source of noise in all countries and the primary reason for annoyance and interference with human activities. Figure 10 shows the typical profile of a road noise barrier installed between four lanes of traffic and residential dwellings. Several factors affect the performance of the barrier and most of these have been discussed in general terms above. The height of the barrier is of fundamental importance to the attenuation of road traffic noise. In many countries, typical highway barrier heights range between 2 and 3 m, while in other countries heights range between 3 to 6 m and barriers up to 8 m high can also be found. Proximity of source to barrier is an important factor in determining the attenuation. For example, in Fig. 10, the barrier provides less attenuation for the westbound traffic than for the eastbound traffic. A very important issue in the case of road traffic noise barriers is the degradation in performance of a barrier on one side of the road by the presence of a second parallel barrier on the other side of the road.

The effects of multiple reflections between two barriers placed on both sides of a highway because noise reduction is needed on both sides, has been the subject of much debate and some research. Research shows that under various circumstances, the degradation (reduction) in barrier insertion loss (A-weighted) can be as high as several decibels when normal reflective walls are used. Since some models do not compute this degradation, many users are ignorant of the potential compromise of their barrier designs by this effect. Several models have been developed to attempt to compute the effect, but measurements have shown less degradation than the models have predicted. (Partly as a result, the FHWA in the US has not taken an official stand or recommended a procedure to deal with multiple reflections.) Consequently, some barriers are being constructed without this effect having been computed or accounted for in the acoustical design. In many cases, these barriers are not providing the expected insertion loss. The FHWA's new Traffic Noise Model will include a two-dimensional multiple-reflection module that is calibrated to match measurements.

Studies[3,91] in the US going back into the 1970s have shown that degradation of single-barrier performance does occur when parallel reflective walls are used. The studies showed that as much as 7 dB degradation of insertion loss could be expected with certain highway geometries. Measurements of insertion loss degradation outdoors at a full scale test roadway have been performed at Dulles International Airport and along highways in California and Maryland. It was found that the measured degradation is a function of the ratio of the distance between the two barriers (W) and the barrier height (H). Table I shows the highest measured insertion loss degradation for A-weighted traffic noise from each of the three studies, along with the W/H ratio of the measured geometry.

In Japan, measured results from a parallel barrier site were analysed and the results show that the dif-

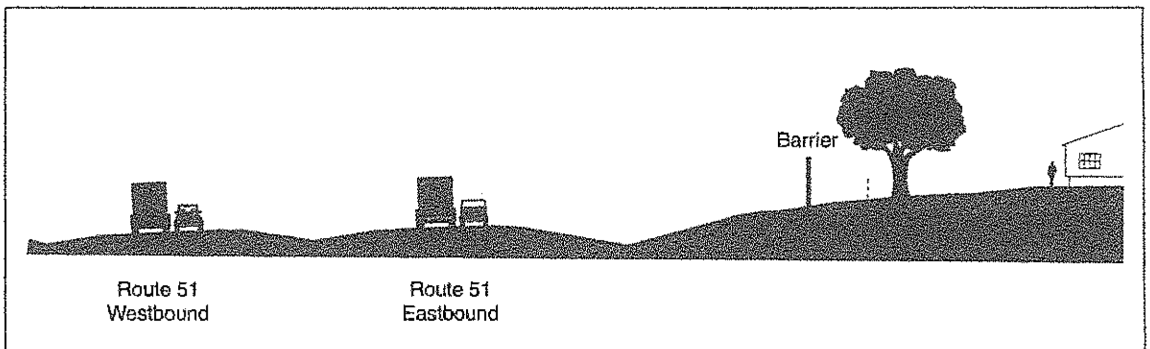


Fig. 10. Proximity of source to barrier is an important factor in determining attenuation. The barrier provides less attenuation for the westbound traffic than for the eastbound traffic.

ference in barrier efficiency between single and parallel barrier is less than 1.5 dB for barriers of 3 m height at roads with 24 m to 30 m width (*W/H* ratio betweeu 8 and 10). Experimental results are summarized in Table 1.

There is a body of literature evaluating the improvement in parallel barrier insertion loss by the use of absorbers. In Japan, measurements[21] were made of the insertion loss for parallel barriers at a test field where all conditions except meteorological factors were artificially controlled. The test was carried out under calm wind conditions. The results showed that the absorptive treatment of the wall surface was important and the improvement of barrier efficiency was 2 dB to 5 dB for parallel barriers 3 m high with a separation of 15 m (a width-to-height ratio, or *W/H*, of 5). When the separation of the barriers is 45 m, the increase is 4 dB. In Canada, field measurements in the Toronto area[111,112] showed no significant change in site results when parallel 3 m barriers 74 m apart were treated with absorbers. These results are summarized in Table 2.

Trees and bushes are very poor road noise barriers; they provide very little attenuation as a result of shielding. Their roots do provide some ground attenuation by keeping the soil porous. Therefore, the principal contribution of vegetation is not to barrier attenuation but instead to ground attenuation, which is inherent in the calculation for A_e. However, if the foliage is dense enough to completely obstruct the view, and if it also intercepts the path of sound propagation, and if it is also deep enough, there may be some additional attenuation caused by propagation through the foliage. A hedge, a row of bushes, a strip of vegetation left to grow naturally, or a forest may all be examples of dense foliage. There is little or no attenuation from bare branches or trunks of trees at frequencies of interest. Nonetheless, aesthetic consideration should not be ignored. If noise barriers are made to appear more attractive visually, by incorporating vegetation in the design, they may reduce annoyance further than would be predicted from the actual acoustic attenuation provided.

Elevated roads or viaducts are common in urban areas, and without noise barriers they present the worst case for noise propagation, as compared with at-grade roads and depressed roads (roads in cuttings). Elevating the noise sources allows sound to propagate at higher levels to larger distances from the road, because the noise-reduction benefits of building shielding and ground-effect attenuation are reduced or eliminated [Fig. 11(a)]. However, adding noise barriers to elevated roadways provides more efficient noise reduction than barriers for at-grade and depressed roadways.

Table 1. Highest measured insertion loss degradation for A-weighted traffic noise from five studies, along with the *W/H* ratio of the measured geometries.

Study	Max. IL degradation (dB)	*W/H*
Dulles	6.2	6
Maryland	2.8	9
California	1.4	15
Japan	1.5	8 to 10
Canada	0	25

There are two reasons for this. One reason is that the path length difference is greater for elevated roads. The other reason is that since little noise shielding is present at distant receivers, the introduction of a barrier on an elevated road can make a significant improvement; whereas barriers along at-grade and depressed roads provide little or no benefit to distant receivers, since they represent little *additional* shielding over the substantial amount that already exists.

However, building barriers on viaducts or embankments is not always easy: one must often limit their height for specific reasons (foundations, weight, aesthetics, safety...). Meanwhile, barriers below 2 m cannot be really effective for the traffic on the farthest lanes: the use of a "central" barrier can solve the problem [Fig. 11(b)]. The close position of these barriers to the vehicles gives high interactions between these (see the related paragraph). The use of high absorptive (one side lateral, double sided central) barriers is necessary to get the real benefit of this screening design.

Rail

The use of barriers to control railway noise[114-120] is most common in the European countries. They are considered easier to design. In general railway noise barriers are lower than road noise barriers; except in Australia where there are barriers up to 8 m high. The main source of noise at speeds less than 270 km/h is due to the wheel/rail interaction. At greater speeds, aerodynamic noise tends to dominate. For

Table 2. Improvement in parallel barrier insertion loss by the use of absorbers.

Study	Inprovement (dB)	*W/H*
US	6	4
Japan	2 to 5	5
Canada	0	25

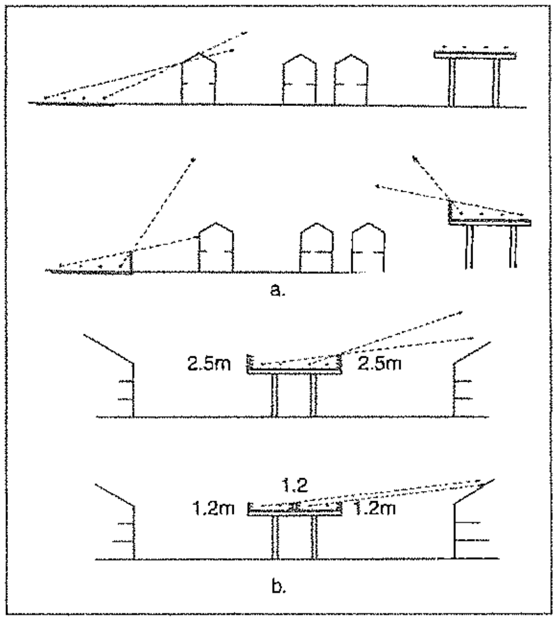


Fig. 11. (a) Comparison of the sound propagation with a road and with a viaduct. Adding a barrier to elevated roadways provides more efficient noise reduction than bariers for at-grade roadways. (b) Ways to reduce barrier height on a viaduct.

trains, vehicles are longer and more reflective than road traffic and the directivity patterns are different and must be accounted for.

A survey[120] of fourteen models (see Table 3) for the prediction of the effectiveness of a noise barrier along a railway line has recently been completed. The models are compared with each other and to some measurements. The main objective of the investigation is to gain insight into the rules of calculation used in order to determine the acoustic effect of barriers. The calculation methods show differences in the acoustical and geometrical characterization of the noise source or noise sources. A wide range of source locations is specified and also the calculation of the attenuation of a barrier and the calculation of the effect of the ground absorption gives a variety of mathematical formulas. The computed insertion loss of an absorptive barrier of 2 m high, along a two track railway, varies between approximately 7 and 12 dB. For the nearest track the result varies between 8 and 15 dB.

Figure 12 gives an overview of the various source locations. The most frequently used location of the source is at the head of the nearest rail and at a height of 0 m. With the exception of the model from Japan, all other source locations are, seen from the top of the barrier, at a higher position. We note that the model for the Channel tunnel calculates the effect of a barrier for the two tracks together. The highest source location is found in the French Mithra-fer model. This model is mostly used for TGV trains where, at high running speeds, the noise sources from air turbulence especially on the top of the train becomes important. Due to the fact that there are various source locations, every model will yield a different path difference, but the models also use different relationships between the path difference and the barrier attenuation.

In Fig. 13, an overview is given for the measured effect of the barrier and the calculated insertion loss of a barrier with a height of 2 m above the railhead along a two track railway and 4.5 m from the centre line of the nearest track. The overview is given for acoustically absorptive barriers. If one compares the insertion loss of an absorptive barrier for the nearest track (Track 1), the result of the calculations for the standard situation (a barrier of 2 m) with the different calculation models varies between 8.0 and 15 dB.

Differences of Barrier Effectiveness between Roads and Railways

Beyond the fact that the diversity of vehicles is much higher with road traffic than with trains, some important differences play a big role in the way a barrier can be effective. These differences should be taken into account in order to assess the real effectiveness of a barrier either along a highway or along a railway.

Location of Vehicles/Barriers

While the location of road vehicles is "free" on the width of the roadway, trains are normally well localized on the tracks. Moreover, the width of a railway is much narrower than that of a highway. Finally, for road safety reasons, it is not possible to erect barriers too close to a highway, while barriers can usually be place quite close to trains. For these reasons, noise barriers are generally more effective along railways than along highways.

Need for Absorption

The large size of the railway vehicle allows multiple reflections between the side of the train and the barrier, which may be located quite close to the train. Therefore, absorptive materials are often required on the side of the barrier facing the train, to reduce reflected sound energy and retain desired insertion loss. For highways, absorptive materials may only be needed to prevent multiple reflections with an opposite-side barrier or large vehicles if they are very close to the barrier, or if reflections could cause unwanted sound-level increases on the opposite side of the highway.

Directivity Patterns

The performance of a noise barrier will be affected by the directivity of the source and this should be taken into account in the design. Single road vehicles can be approximated as monopole sources, but the rail-wheel noise source from railways is strongly directional with high intensity in the horizontal direction.

Table 3. Survey of fourteen models for the prediction of the effectiveness of a noise barrier along a railway line.

	Calculation in dB(A) and spectra	Type of model	Reflective and/or adsprptive barriers	Barrier attenuation calculation method	Source location		Ground absorption	
					Horizontal	Height (m)	Without barrier	With barrier
Nordic model	dB(A)	complete	both	straight line path diff.	track center line	0.50	yes	yes
British Rail	dB(A)	barrier	both	straight line path diff.	railhead	0.00	no	no
Channel Tunnel	dB(A)	complete	both	straight line path diff.	railway center line	0.50	yes	0 dB(A)
TRL model	dB(A)	complete	both	straight line path diff.	railhead	0.00/(4.00)	yes	0 dB(A)
The Netherlands	spectra	complete	absorptive	curved line path diff.	railhead	0.00/0.50	yes	yes
German Schall 03	dB(A)	complete	absorptive	straight line path diff.	track center line	0.00	yes	0 dB(A)*
TV7630 Rheda model	dB(A)	barrier	both	straight line path diff.	railhed	0.00	no	no
German 1980	dB(A)	barrier	absorptive	straight line path diff.	railhead	0.00	no	no
Japanese method**	dB(A)	barrier	both	straight line path diff.	near the rail	0.00	0 dB(A)	0 dB(A)
French Cetur model	dB(A)	complete	absorptive	monogram	railhead	0.65	no	no
French Mithra-fer	spectra	complete	both	straight line path diff.	railhead	0.80	yes	yes
Swiss Semibel	dB(A)	complete	absorptive	straight line path diff.	railhead	0.50	yes	same as
								without
Austrian ÖAL 30 simple	dB(A)	complete	absorptive	straight line path diff.	track center line	0.30	no	no
Austrian ÖAL 28/30	spectra	complete	absorptive	curved line path diff.	track center line	0.30	yes	yes

* For short distances from the track

** There are other Japanese methods with the source at the track center line and at 0.0 m height.

Ground-Based Air Operation

There is sometimes a need to control noise from certain specific ground-based airport operations[12]. Barriers are often used for this purpose, but it is recognized that this is not a big market.

Barriers for Aircraft Runups

"Runups" are aircraft engine tests that are performed by mechanics to ensure that the engines they have serviced are ready for carrying passengers. Runups are frequently conducted at night and often at relatively high power settings. Unlike aircraft takeoffs and landings, runups do not follow a predictable time pattern; the duration can be from a few seconds to many minutes. This indeterminate duration of runups adds to the annoyance factor and the usual noise impact criteria are not always appropriate.

Since the noise emissions from jet engines are quite directional, the orientation of the aircraft during a runup has a significant influence on the sound levels radiated into the surrounding community. Where airports have residential land use within a kilometre or so of the runup area, and where the options for orienting the aircraft are limited, many airports have constructed noise barriers or runup "enclosures" to reduce the radiated noise. Barriers or enclosures are located as close to the aircraft as is practical, to increase noise reduction and to minimize cost. In the U.S. the minimum distance between source and barrier is about 6 m, and typical distances range from 10 m to 40 m, depending on aircraft size and engine location. Ordinarily, the barriers are designed to provide 10 to 15 dB of noise reduction. Where wide body jets such as the DC-10 and L-1011 must use the runup area, the barriers must be up to 10 m high to block the propagation for the high tail-mounted engine.

Multiple sound reflections within the runup area must be controlled in order to maximize the barrier effectiveness. In some cases, sound-absorptive material is used or sloped sides are used to eliminate multiple reflections. Long propagation distances give rise to issues that need to be considered in the acoustical design of barriers used to control runup noise. The primary issues are atmospheric effects and ground effects. Many times, noise problems from runups occur at night when winds are light and do not affect barrier performance substantially. However, in areas where prevailing winds or temperature inversions are common, reduced barrier effectiveness due to curved propagation paths should be considered. If there is soft ground in the vicinity of the runup area, barrier insertion loss may be reduced due to loss of ground-effect attenuation.

Barriers for Start of Takeoff Roll

Jet aircraft create high noise levels especially to the side and behind them during their takeoff roll down the runway. Many airports are located in areas where only a few hundred meters separates the planes from the nearest homes. Often, the terrain is flat and unobstructed. A-weighted sound levels of around 90 dB have been measured at homes 300 m from the runways during the start of the takeoff roll.

Since areas around runways must be clear of obstruction, barriers cannot be located near the aircraft for safety reasons. In the U.S., the Federal Aviation Administration imposes restrictions that prevent useful barriers from being located within about 200 m of a runway. This means that barriers for start of takeoff roll noise must be constructed near the receivers to be effective.

Because aircraft are generally assigned to use runways so that they take off into the wind, there is frequently a wind component in the source-to-receiver

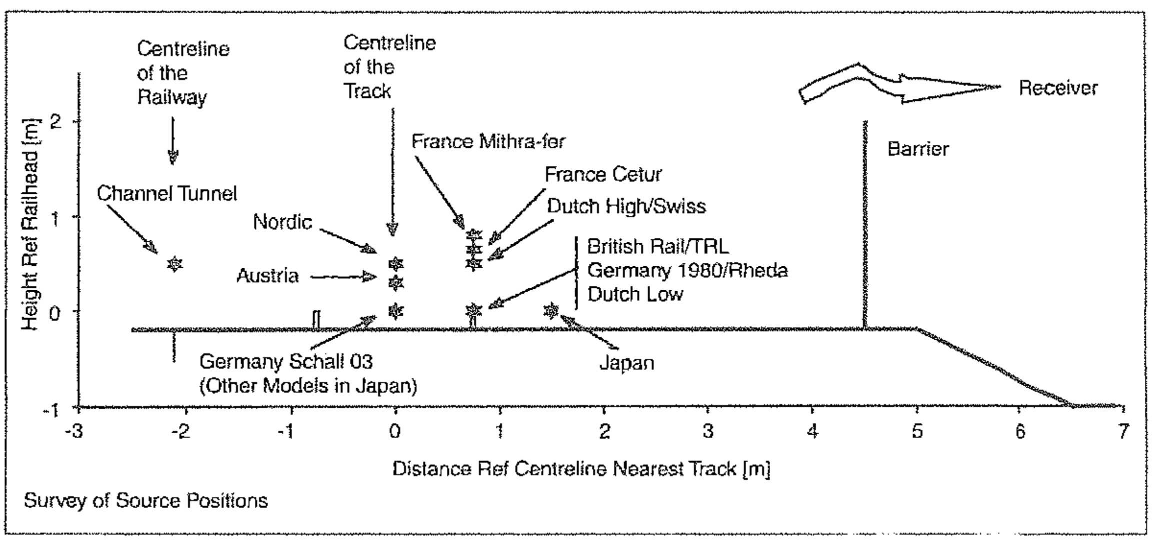


Fig. 12. Overview of the various source locations.

direction during takeoff. This tends to reduce the effectiveness of the barrier, however, a study in the U.S. has shown that even fairly strong winds degraded insertion loss to only a minor degree when the barrier was in close proximity to the receiver.

In designing barriers to control start of takeoff roll, ground-effect attenuation must usually be considered to assess properly the expected insertion loss, unless all ground surfaces between source and receiver are acoustically hard. Since propagation distances can be large, accurate prediction of the expected loss of attenuation due to soft ground is difficult, particularly over terrain with variable geometry and impedance. Often the expected loss of ground-effect is determined through measurement at different heights.

Earth berms are sometimes constructed at airports in the U.S. to control start of takeoff roll noise. Berms are often less expensive than walls, they receive wide acceptance for aesthetics, and the necessary land is often available on the airport's property. If walls are used, they are usually in the range of 6 to 10 m high.

Other

The most effective noise control measures are those effected at the source, particularly by quieter designs. Tangible progress[122] has been made in the abatement of motor vehicles noise by quieter engines, better air-intake and exhaust mufflers and quieter tires and road surfaces to reduce the impact of traffic noise in communities along roadways. Also there are many ways of modifying the transmission path to reduce the level of noise at the receiver. At the land use planning stage, the distance between source and receiver can be increased by setting aside sufficiently large areas of land as buffer zones along new roads and around new airports. Valuable land close to new highways or railways which is not suitable for housing development because of noise nuisance may be used for the construction of light industrial or commercial premises where the sensitivity of the occupants would be less. These structures then act as noise barriers. The buildings can be connected by noise walls to provide a continuous screen. It is also possible to erect barrier blocks of single aspect dwellings where the facades of the buildings facing the noise source have a high noise insulation specification and may contain no windows or access points.

A growing number of studies have described the design of specific surfaces to exploit the interaction of the sound field with the ground to obtain noise reduction. In Europe, a new road structure[123] called drainage asphalt has appeared in which discontinuous granular formulation can produce an important void content (porosity) inside the structure. It is possible to obtain a porosity of 20% or more with 0-10 mm aggregates and a 2-6 mm discontinuity. Some results show an overall noise reduction. In Europe and beginning in North America, much research has been conducted on reducing tire/road noise through the use of open-graded or porous road surfaces. Many different types of surfaces have been investigated, with reported reductions of up to about 5 dB. However, the noise reduction realized by such pavements has been found to deteriorate within a few years, as the voids fill or wear down. Also, recent studies have shown that rougher pavements can increase roadside noise levels substantially. Some examples of rough pavements include grooved concrete, chemically-washed concrete and pavement blocks.

In Europe false tunnels have been used when important insertion loss is required rather than the barriers of height greater than 3 m that would be required to achieve the desired attenuation.

Direction for Future Work

The Working Party believes that the issue of the accuracy of noise level estimation calculated with prediction models requires more attention. Calculation of A-weighted levels cannot be as accurate as calculations made per octave frequency band or per 1/3-octave frequency band. If 1/3-octave or octave band levels are known or predicted, this opens up the possibility of using a loudness scale in sones or phons. Sone values relate directly to subjectively perceived loudness which is a major component of noise nuisance. The effects of a barrier could then be more closely gauged in terms of human perception.

Also it is desirable that each source on a vehicle be characterized by a height, position, and sound power level depending on the type of vehicle (road or rail) and on the speed. For example, in the case of passenger cars or light trucks, a first noise source just above the road surface is the corresponding source for the tire-road noise. The other source, slightly higher, corresponds to the engine exhaust, fan, and/or aerodynamic noise. Currently, it is common to perform calculations using normalized traffic flow. In the future, effort should be devoted to the average characteristic of the source(s) of a traffic flow with passenger cars, light trucks and heavy trucks, and for different types of trains such as rim braked passenger trains, discbraked passenger trains, diesel trains and different types of freight trains. It is necessary to define and standardize these characteristics for every type of vehicle separately, so that when a calculation is made with a prediction model the different vehicles can be combined with different speeds to the actual

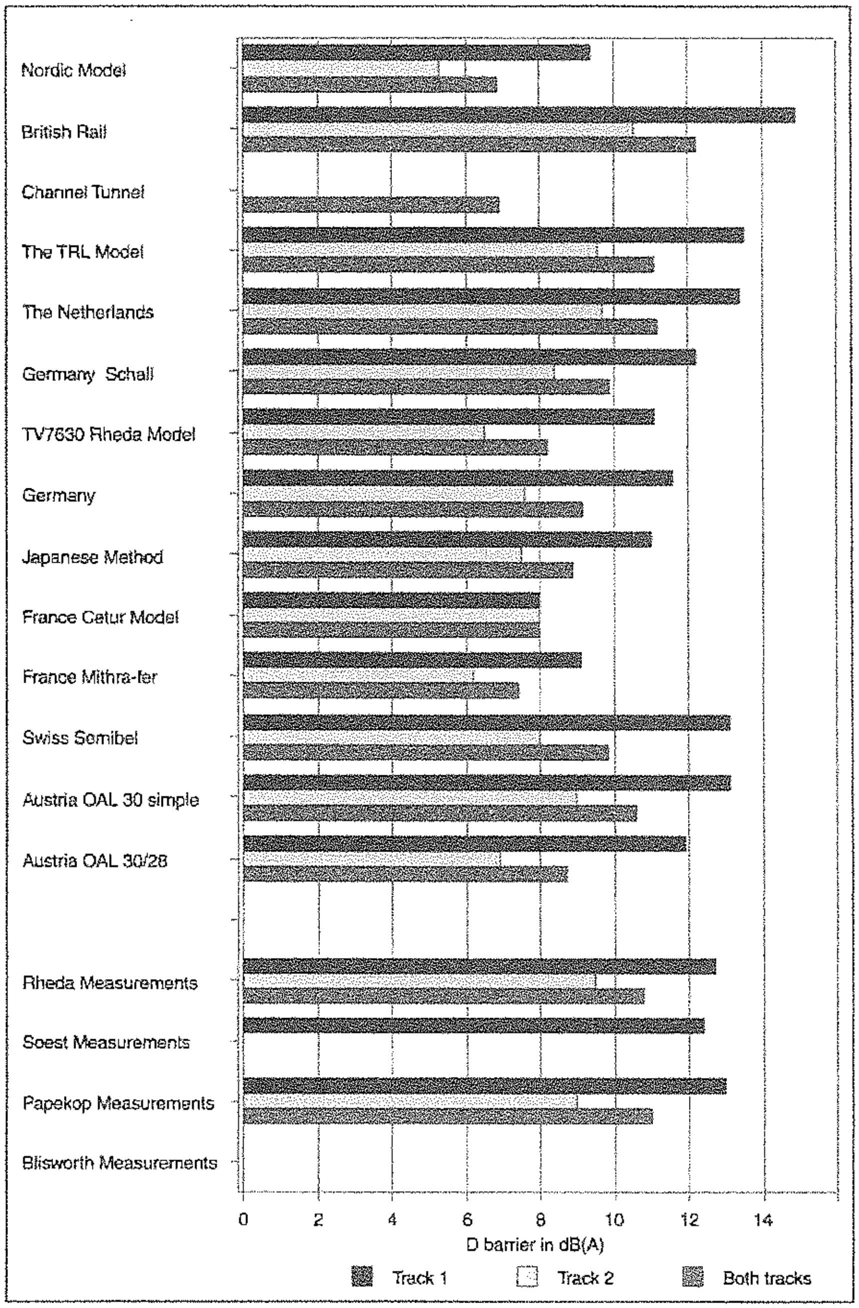


Fig. 13. Comparison of the prediction models with measurements of the effect of absorptive acoustic barriers.

traffic flow in order to get the equivalent sound levels at the receiver.

Further, road side studies of the effectiveness of absorptive treatment on noise barriers should be made where traffic and meteorological factors are strictly quantified.

Conclusion

The Working Party believes that there is strong body of evidence to support the use of barriers as an effective method of abating transportation noise. Barrier height and proximity of source and receiver are of fundamental importance to the attenuation produced by a barrier. In countries around the world typical barrier heights range between 2 and 6 m. It is the collective experience of the Working Party that the most common values for insertion loss range between about 5 and 12 dB, but values between 3 and 25 dB are also often found. There is smaller body of evidence to support the use of absorbing material to improve the performance of barriers. Parallel vertical reflective barriers along both sides of a roadways may degrade performance. The use of absorbing material is particularly important in this type of application. It is the collective opinion of the Working Party that generally documentation on noise walls are difficult to interpret and apply in practice.

The reduction in noise levels provided by barriers can be expressed in other quantitative terms or in terms of psychoacoustical measures of the effects of noise of people. For example, a 12 dB reduction is equivalent to a four fold increase in the source to receiver distance (for "point" sources). Sociological studies have shown a direct relationship between community noise levels and the number of persons highly annoyed in a given population. Although the relationship in not linear, a reduction of 12 dB is roughly expected to reduce the percentage of people highly annoyed by traffic noise in typical circumstances by as much as 20 to 30%. Speech communication is clearly essential in human society. When speech sounds are masked by noise, speech intelligibility is reduced and the quality of communication is impaired. An improved speech-to-noise ratio of 12 dB can improve the percentage of correct words by about 40%.

Acknowledgments

This report would not have been possible without the collective experience of the Working Party members. The Convenor gratefully acknowledges the numerous inputs and written material provided by the members.

References

1. Embleton, T.F.W. (1996). "Tutorial on sound propagation outdoors," *J. Acoust. Soc. Am.* **100**, 31-48.
2. Alegre, D. and Clairbois, J.P. (1989). "The ends of tunnels and their access trenchs as noise sources in urban areas." Environmental Acoustics, FASE '89, Zaragoza, Spain.
3. Bowlby, W. and Cohn, L.F. (1986). "A model for insertion loss degradation for parallel highway noise barriers." *Journal of the Acoustical Society of America* 80, 855-868.
4. Clairbois, J.P., Houtave, P., and Trefois, V. (1996). "How multiple reflections can cause a degradation of performance for noise barriers." Proceedings INTER-NOISE 96, Liverpool, UK.
5. Clairbois, J.P., Houtave P., and Weyers, E. (1993). "The level/time evolution of passing trains to evaluate the noise impact of T.G.V. Part 2: Practical validation." INTER-NOISE '93, Leuven, Belgium.

6. Clairbois, J.P. and Ottmer, T. (1987). "Schalldampfung in Strassentunnelmundungen." D.A.G.A., Aachen, Germany.

7. Daigle, G.A. (1982). "Diffraction of sound by a noise barrier in the presence of atmospheric turbulence." *J. Acoust. Soc. Am.* **71**, 847-854.

8. Fujiwara, K., Ando, Y., and Maekawa, Z. (1971). "Noise control by barriers—part 1: noise reduction by a thick barrier." *Appl. Acoust.* **10**, 147-59.

9. Fujiwara, K., Ando, Y., and Maekawa, Z. (1973). "Attenuation of a spherical sound wave diffracted by a thick plate." *Acustica*, **28**(6), 341-347.

10. Fujiwara, K., Ando, Y., and Maekawa, Z. (1977). "Noise control by barriers—part 2: Noise reduction by an absorptive barrier." *Applied Acoustics*, **10**, 176-179.

11. Fujiwara, K. (1990). "Sound shielding efficiency of a barrier with soft surface." Proc. INTER-NOISE 90.

12. Hayek, S.I. and Nobile, M.A. (1981). "Diffraction by absorbent wide barriers." *J. Acoust. Soc. Am.*, **69**(Supplement 1) S101.

13. Hidaka, Y., Tachibana, H., Matsui, Y., and Kaneko, R. (1995). "Measurement of sound radiation from shinkansen train by sound intensity method." Proc. INTER-NOISE '95, Newport Beach, Ca, USA, 215-219.

14. Hothersall, D.C. and Tomlinson, S.A. (1995). "High sided vehicles and road traffic noise barriers." Proc. INTER-NOISE 95, 397-400.

15. Houtave, P. and Clairbois, J.P. (1993). "The level/time evolution of passing trains to evaluate the noise impact of T.G.V. Part 1: Mathematical development." Proc. INTER-NOISE '93, Leuven, Belgium.

16. L'Espérance, A., Nicolas, J., and Daigle, G.A. (1989). "Insertion loss of absorbent barriers on ground." *J. Acoust. Soc. Am.* **83**, 1060-1064.

17. Menge, C.W. (1980). "Highway noise: Sloped barriers as an alternative to absorptive barriers." *Noise Control Engineering J.* **14**, 74-78.

18. Nicolas, J. and Daigle, G.A. (1986). "Experimental study of a slow waveguide barrier on finite impedance ground." *J. Acoust. Soc. Am.* **86**, 869-876.

19. Rawlins, A.D. (1975). "Diffraction by an absorbing wedge." *J. Sound Vib.* **41**, 391-393.

20. Yamamoto, K. (1989). "Reduction of road traffic noise by absorptive cylinder adapted at the top of a barrier." Proc. INTER-NOISE 89, 349-352.

21. Yamashita, M., Kaku, J., and Yamamoto, K. (1985). "Net effects of absorptive acoustic barrier." Proc. INTER-NOISE '85, Munich, 507-510.

22. Yuzawa, M. (1977). "Sound attenuation by absorptive barriers." *J. Acoust. Soc. Japan* **33**, 664-666.

23. Crombie, D.H. and Hothersall, D.C. (1994). "The performance of multiple noise barriers." *J. Sound and Vibr.* 176, 459-730.

24. Crombie, D.H., Hothersall, D.C., and Chandler-Wilde, S.N. (1995). "Multiple-edge noise barriers." *Appl. Acoust.* **44**, 353-367.

25. Hajek, J.J. (1982). "Are earth berms acoustically better than thin-walled barriers." *Noise Control Eng. J.* **19**, 41-48.

26. Hayek, S.I. (1980). "Efficiency of double walled noise barriers." Proceedings of INTER-NOISE 80, 585-590.

27. Hayek, S.I. (1984). "Acoustic scattering by double thin noise barriers." Proc. INTER-NOISE '84, Honolulu, HI, pp. 363-368.

28. Hayek, S.I. (1990). "Mathematical modeling of absorbant highway noise barriers." *J. Sound.Vib* 31, 77-100.

29. Hayek, S.I. (1985). "Noise reduction by absorbent double parallel barriers over hard ground." Proceedings of INTER-NOISE 85, 495-498.

30. Hayek, S.I. (1987). "Attenuation by cylindrically topped wedge noise barriers." Proc. INTER-NOISE '87, Beijing, China, pp. 387-390.

31. Hayek, S.I. (1988). "Traffic noise reduction by absorbent cylindrical berms." Proc. INTER-NOISE '88, Avignon, France, pp. 1507-1510.

32. Hayek, S.I. (1984). "Acoustic diffraction by absorbent wedge-shaped barriers." Proc. INTER-NOISE '84, Honolulu, HI, pp. 313-318.

33. Hothersall, D.C., Crombie, D.H., and Chandler-Wilde, S.N. (1991). "The performance of T-profile and associated noise barriers." *Applied Acoustics* **32**, 269-287.

34. Hothersall, D.C., Chapman, B.C., and Chandler-Wilde, S.N. (1985). "The propagation of road traffic noise over earth mounds." Proc. IOA 1, 135-142.

35. Shinohara, N., Saito, H., and Yamada, I. (1995). "Examination of effectiveness of afforestation and embankment for noise abatement in the sidelines of airport." INTER-NOISE '95, Newport Beach, CA, USA, 373-376.

36. Takagi, K., Park, Y., Hotta, R., and Yamamoto, K. "Comparison of simple prediction methods for noise reduction by double barriers." Proc. INTER-NOISE 96, 779-782.

37. Yuzawa, M. and Sone, T. (1981). "Noise reduction by various shapes of barrier." *Applied Acoustics* **14**, 65-73.

38. Yuzawa, M., Sone, T., and Nimura, T. (1979). "Sound attenuation by multiple barriers." *Applied Acoustics* **12**, 447-458.

39. Chandler-Wilde, S.N. and Hothersall, D.C. (1985). "Sound propagation above an inhomogeneous impedance plane." *Journal of Sound and Vibration* 98, 475-491.

40. Daumas, A. (1978). "Etude de la diffraction par un écran mince disposé sur le sol." *Acustica* **40**, 213-222.

41. DeJong, R. and Stusnick, E. (1976). "Scale model studies of the effects of wind on acoustic barrier performance." *Noise Contr. Eng.* **6**, 101-9.

42. Duhamel, D. (1996). "Efficient calculation of the 3-dimensional sound pressure field around a noise barrier." *J. Sound Vib.* **197**, 547-571.

43. Foss, R.N. (1979). "Double barrier noise attenuation and a predictive algorithm." *Noise Contr. Eng.* **13** 83-90.

44. Fujiwara, K. (1989). "Sound shielding efficiency of a barrier with a cylinder at the edge." International Conference Noise & Vibration 89, Singapore.

45. Hayek, S.I. and Grosh, K. (1986). "Influence of ground absorption on barrier attenuation." Proc. INTER-NOISE '86, Cambridge, MA, pp. 447-52.

46. Hayek, S.I. and Nobile, M.A. (1981). "Diffraction by barriers over absorbent ground." Proc. INTER-NOISE '81, Conference, Amsterdam. The Netherlands, 243-248.

47. Hothersall, D.C. (1992). "Modelling the performance of noise barriers." Proceedings of the Eurosymposium in Nantes: The Mitigation of Traffic Noise in Urban Areas, 251-262.

48. Hothersall, D.C., Chandler-Wilde, S.N., and Hajmirzae, N.M. (1991). "Efficiency of single noise barriers." *J. Sound Vib.* **146**, 303-321.

49. Hutchins, D.A., Jones, H.W., and Russell, L.T. (1984). "Model studies of barrier performance in the presence of ground surfaces, Part I-thin, perfectly-reflecting barriers." *J. Acoust. Soc. Am.* **75**(6), 1807-1816.

50. Hutchins, D.A., Jones, H.W., and Russell, L.T. (1984). "Model studies of acoustic propagation over finite impedance ground Part II-different shapes." *J. Acoust. Soc. Am.* **75**(6), 1817-1826.

51. Isei, T., Embleton, T.F.W., and Piercy, J.E. (1980). "Noise reduction by barriers on finite impedance ground." *J. Acoust. Soc. Am.* **67**, 46-58.

52. Jonasson, H.G. (1971). "Diffraction by wedges of finite acoustic impedance with application to depressed roads." *J. Sound Vib.* **25**, 577-585.

53. Jonasson, H.G. (1972). "Sound reduction by barriers on the ground." *J. Sound Vib.* **22**, 113-126.

54. Kawai, T. (1981). "Sound diffraction by a many-sided barrier or pillar." *J. Sound Vib.* **79**, 229-242.

55. Kawai, T., Fujimoto, K., and Itow, T. (1978). "Noise propagation around a thin half-plane." *Acustica* **38**, 313-323.
56. Kendig, R.P., and Hayek, S.I. (1981). "Diffraction by a hard-soft barrier." *J. Acoust. Soc. Am.* **70**, 1156-1165.
57. Kurze, U.J., and Anderson, G.S. (1971). "Sound attenuation by barriers." *Appl. Acoust.* **4**, 35-53.
58. Kurze, U.J. (1974). "Noise reduction by barriers." *J. Acoust. Soc. Am.* **55**, 504-518.
59. Attenborough, K., etal. (1995). "Benchmark cases for outdoor sound propagation models." *J. Acoust. Soc. Am.* 97, 173-191.
60. Maekawa, Z. (1962). "Experimental study on acoustical designing of a screen for noise reduction." *J. Acoust. Soc. Japan* **18**, 187-196.
61. Maekawa, Z. (1966). "Noise reduction by screen of finite size." Mem. Fac. Eng., *Kobe University*, **12**, 1-12.
62. Maekawa, Z. (1968). "Noise reduction by screens." *Appl. Acoust.* **1**, 157-173.
63. Maekawa, Z. and Osaki, S. (1985). "A simple chart for the estimation of the attenuation by a wedge diffraction," *Applied Acoustics* **18**, 355-368.
64. Medwin, H. (1981). "Shadowing by finite noise barriers." *J. Acoust. Soc. Am.* 69, 1060-1064.
65. Medwin, H., Childs, E., and Jebsen, G.M. (1982). "Impulse studies of double diffraction: a discrete Huygens interpretation," *J. Acoust. Soc. Am.* 72, 1005-1013.
66. Nicolas, J., Embleton, T.F.W., and Piercy, J.E. (1983). "Precise model measurements versus theoretical prediction of barrier insertion loss in presence of the ground." *J. Acous. Soc. Am.* **73**, 44-54.
67. Nijs, L. (1980). "Combined effects of ground absorption and diffraction by obstacles." Proc. INTER-NOISE '80, 545-548.
68. Nobile, M.A. and Hayek, S.I. (1985). "Acoustic propagation over an impedance plane." *J. Acoust. Soc. Am.* **78**, 1325-1336.
69. Nobile, M.A., Hayek, S.I., and Lawther, J.M. (1980). "A comprehensive model for the straight edge noise barrier." *J. Acoust. Soc. Am.*, **68**(Supplement 1) S54.
70. Pierce, A.D. and Hadden, W.J. Jr. (1978). "Plane wave diffraction by a wedge with finite impedances." *J. Acoust. Soc. Am.* **63**, 17-27.
71. Pierce, A.D. (1974). "Diffraction of sound waves around corners and over wide barriers." *J. Acoust. Soc. Am.* **55**, 941-955.
72. Pinazza, O. and Garai, M. (1996). "Sound propagation in a real atmosphere," Proc INTER-NOISE 96, 619-622.
73. Rasmussen, K.B. (1982). "Sound propagation over non-flat terrain." Danish Acoustical Laboratory Report No. 35, The Danish Academy of Technical Sciences.
74. Rasmussen, K.B. (1985). "On the effect of terrain profile on sound propagation outdoors," *J. Sound Vib.* **98**, 35-44.
75. Seznec, R. (1980). "Diffraction of sound around barriers: use of the boundary elements technique." *J. Sound Vib.* 73(2), 195-209.
76. Takagi, K., Hotta, R., and Yamamoto, K. (1994). "A simple method for the calculation of noise attenuation by a finite length barrier." *Applied Acoustics* **43**, 353-365.
77. Varadan, V.K., Varadan, V.V., Tsao, S.J., and Hayek, S.I. (1983). "Acoustic scattering by highway noise barriers." Proc. INTER-NOISE '83, Edinburg, Scotland, 301-310.
78. White, M.J. (1994). "Estimating Attenuation and Propagation of Noise Bands from a Distance Source using the Lookup Program and Data Base," (User's guide for *SoundProp* program), USACERL Technical Report EC-94/12.
79. Yamamoto, K. and Takagi, K. (1992). "Expressions of Maekawa's Chart for Computation," *Applied Acoustics* **37**, 75-82.
80. International Organization for Standardization. ISO 9613-2. "Acoustics-Attenuation of Sound during proparation outdoors—part 2: A general method of calculation."
81. Anderson, G.S., C. Lee, G. Fleming, and C. Menge (1997). "FHWA Traffic Noise Model, User's Guide, Version 1.0," Report No. DOT-VNTSC-FHWA-97, March 1997.
82. Anderson, G.S., C. Menge, and C. Rossano (1996). "The Federal Highway Administration's new Traffic Noise Model (FHWA TNM): Functionality, Input Types, and Computations," Proc. NOISE-CON 96, Seattle, WA, pp. 837-842.
83. Barry, R.P. and Reagan, J.A. (1978). FHWA-RD-77-108 Report, Federal Highway Administration, Washington. Highway traffic noise prediction model.
84. Department of the Environment (1988). "The Calculation of Road Traffic Noise." London: Her Majesty's Stationery Office.
85. Document CEN/TC 226/WG6/TG1/N106, "Road traffic noise reducing devices—Test method for determining the acoustic performance—Part 1: Intrinsic characteristics- sound absorption."
86. Document CEN/TC226/WG6/TG1/N107, "Road traffic noise reducing devices—Test method for determining the acoustic performance—Part 2: Intrinsic characteristics—airborne sound insulation."
87. Document CEN/TC226/WG6/TG1/N108, "Road traffic noise reducing devices—Test method for determining the acoustic performance—Part 3: Normalized traffic noise spectrum."
88. Document CEN/TC226/WG6, "Road traffic noise reducing devices—non-acoustic performance—Part 1: Mechanical performance and stability requirements."
89. Document CEN/TC226/WG6, "Road traffic noise reducing devices—non-acoustic performance—Part 2: General safety and environmental considerations."
90. Hölzl, G. and Hafner, P. "Schienenverkehrsgeräusche und ihre Minderung durch Schallschutzwände," *Zeitschrift fur Lärmbekämpfung* **27**, 92-99.
91. Menge, C.W. (1996). "Barrier Diffraction and Sound Propagation in USDOT's new Traffic Noise Model," Proc. INTER-NOISE '96, Liverpool, U.K., 3121-3126.
92. Menge, C.W., with W. Bowlby, J. Higgins, and J. Reagan, eds. (1982). "Noise Barrier Cost Reduction Procedure STAMINA 2.0/OPTIMA: User's Manual," Federal Highway Administration Report No. FHWA-DP-58-1.
93. Menge, C.W., with P. Zimmerman and J. Higgins, eds. (1982). "Noise Barrier Cost Reduction Procedure STAMINA 2.0/OPTIMA: Program Maintenance Manual," Federal Highway Administration Report No. FHWA-DP-58-2.
94. Menge, C.W., C.F. Rossano, G.S. Anderson, and C.J. Bajdek (1995). "FHWA Traffic Noise Model (FHWA-TNM), Version 1.0, Technical Manual," Report No. DOT-VNTSC-FHWA-95.
95. Nelson, P.M., Hemsworth, B., *et al.* (1987). Transportation Noise Reference Book, Butterworth & Co Ltd.
96. Noise from Railway Traffic—A Nordic Prediction Method for noise emitted by rail traffic, February 1984.
97. ÖAL-Richtline nr 28 Schallabstrahlung und Schallausbreitung. Österreichischer Arbeitsring für Lärmbekämpfung, 1987.
98. ÖAL-Richtline nr 30 Berechnung der Schallimmission durch Schienenverkehr, 1993.
99. Richtlinie zur Berechnung der Schallimmissionen von Schienenwegen. Schall 03 Deutsche Bundesbahn, 1990.
100.Schall Ausbreitung im Freien (outdoor sound propagation). VDI 2714. Verein Deutscher Ingenieure, January 1988.
101.Schallpegelmindernder Wirkung von sieben Scahllschutzwandvarianten seitlich einer Eisenbahstrecke. TV 7630.
102.Schallschutz durch Abschirmung im Freien (outdoor sound propagation). VDI 2720. Entwurf Februar 1991.
103.Semibel 'Schweizerisches Emissions- und Immissionsmidell fur die Berechnung von Eisenbahnlarm, Bundesamtes Verkehr.,
104.Menge, C.W. and N. Powers (1978). "Sound-absorbing barriers: materials and applications," Proc. TRB Conference on Highway Traffic Noise Mitigation, Los Angeles, CA, pp. 198-211.
105.Barrett, D.E. and C. W. Menge (1994). "La Guardia Airport ground-noise abatement study," Transportation Research Record No. 1444, Transportation Research Board.

106.Clairbois, J.P., Myncke, H., Nemerlin, J., Lanoye, L., and Delvaux, D. (1989). "*In situ* measurement of noise protection efficiency." Proc. 13th I.C.A., Belgrade, Yugoslavia.

107.Clairbois, J.P. and Laguerre, D. (1988). "NS3: Noise source as a mean of *in situ* measurement of noise protection efficiency." INTER-NOISE 1988, Avignon, France.

108.Watts, G.R., Crombie, D.H., and Hothersall, D.C. (1994). "Acoustic performance of new designs of traffic noise barriers—full-scale tests." *J. Sound and Vibr.* **177**, 289-305.

109.Clairbois, J.P. and Tissseyre, A. (1993). "Noise separation in a multisources environment (Road, rail and air traffic), the Villeneuve Saint Georges survey," Proc. INTER-NOISE '93, Leuven, Belgium.

110.Clairbois, J.P. (1990). "Noise of highways: corrective devices," environmental noise in nrban areas, Ajuntament de Barcelona/F.A.S.E., Barcelona, Spain.

111.May, D.N. and Osman, M.M. (1980). "Highway noise barriers: new shapes." *J. Sound Vib.*,**71**, 73-101.

112.May, D.N. and Osman, M.M. (1980) "The performance of sound absorptive, reflective and T-profile noise barriers in Toronto." *Journal of Sound and Vibration* **71**, 65-71.

113.Pompoli, R. *et al.* (1995). "Intercomparison of traffic noise computer simulations," Suppl Proc. 23rd National Congress Italina Acoust. Assn., 523-559 (Bologna).

114.Clairbois, J.P., Houtave, P., Weyers, E., and Trefois, V. (1994). "High speed train noise abatement: Important parameters and case study." Proceedings INTER-NOISE 94, Yokohama, Japan.

115.Hemsworth, B. (1975). "The effect on noise propagation of a barrier alongside a railway line."

116.Hemsworth, B. and Webb, V. (1977). "Noise barriers for fast passenger trains." Proc. INTER-NOISE 77.

117.Hohenwarter, D. (1980). "Railway noise propagation models," *J. Sound Vib.* **141**, 17-47.

118.Hohenwarter, D. (1996). "Barriers for railway noise: Measurement and calculations of the insertion loss." Proc. INTER-NOISE 96.

119.Transport Research Laboratory Calculation of railway noise (Draft for public comment) 1993.

120.Van Leeuven J.J.A. (1996). "Noise prediction models to determine the effect of barriers alonside railway lines," *J. Sound Vib.*, Vol.193, 269-276.

121.Menge, C.W. (1987). "Wind Effects on an Airport Noise Barrier," TRB Committee on Transportation-Related Noise and Vibration, Summer Conference.

122.Shaw, E.A.G. (1996). "Noise environments outdoors and the effects of community noise exposure." *Noise Control Eng. J.* 44, 109-119.

123.Bérengier, M.C., et al. (1997). "Porous road pavements: Acoustical characterization and propagation effects." *J. Acoust. Soc. Am.* **101**, 155-162.

Acoustiblok All Weather Sound Panels®

(New "Hurricane" Version tested to withstand 270 MPH / 434 KPH wind load)

SPECIFICATIONS I HURRICANE MODEL I INSTALLATION METHODS I HVAC/CHILLER NOISE I INDUSTRIAL APPLICATIONS I RESIDENTIAL HEATPUMPS / AC / GENERATORS I ROAD NOISE I POWER PLANTS I PUMPING STATIONS I POOL & GYMNASIUM I MARINE APPLICATIONS I RAIL & MASS TRANSIT

THIS IS A TYPICAL IMAGE BORDER TABLE Modified on 11-2-10 to stagger images and text to shorten page PICTURE: GENERATOR IN A BOX

For years, **acoustical sound absorbing panels** have been used successfully to control problems with noise and sound in all types of indoor environments. They reduce tension, make music sound better, allow people to speak and hear better and provide a safer work environment.

But, because they are all made of fragile indoor materials, they can in no way withstand any other environment but the clean climate controlled indoors.

Click on Image to see Gallery

http://www.acoustiblok.com/images/cat3.gif

"Acoustiblok All Weather Sound Panels" are engineered specifically to withstand the most rigorous outdoor and industrial environments. Water, moisture, humid salt air or salt water, dirt, dust, constant ultraviolet light, chlorine air, grease, corrosion, and most harsh chemicals are not a problem for this product. Encased by all welded aluminum also prohibits vermin problems. Acoustiblok's **outdoor sound panels** are washable with a hose, very durable, long lasting and usable in hundreds of areas and applications. The panel has an

NRC **(Noise Reduction Coefficient) of 1.00 (highest level possible)**, Riverbank Acoustical Laboratories test results.
Extreme dust conditons can disable conventional sound absorbing systems. The Industrial & Hurricane model All Weather Sound Panels® are available with an acoustically transparent stainless steel dust filter (as much as 5 to 10 microns), which solves this problem for the mining industry, outdoor use in desert areas of the Middle East, and other applications where dust is a concern. Acoustiblok Panels are extremely durable and are currently in use by the United States Army in the Middle East.
In addition, these panels are not just **"sound absorbing"** but also **"sound blocking."** This allows one to not only absorb sound but also stop the sound from penetrating through the panel, a very meaningful advantage over conventional "sound absorbing" panels which stop sound reflections but are poor sound barriers. The panels have an extraordinarily high STC of 30 **(Sound Transmission Class)**, as the panels contain large amounts of the Acoustiblok material.
The most difficult sound blocking problems are the low frequencies (30 to 100 HZ). The annoying bass in music is predominately 40 to 80 HZ. Conventional sound barriers do dramatically less sound blocking below 100 HZ. However because of the "Acoustiblok" barrier material built into each of the "All weather panels" they actually increase in sound blocking from 100 HZ down (see test results) and are beneficial for difficult sound proofing*.
These panels are rigid and self-supporting. They can be used like building blocks to permanently or temporarily enclose a noise source, i.e., chillers and machinery. (Allow for required cooling).
Easily movable, they need not be permanent and may be stored in harsh environments without harm from the elements.
These entirely welded panels use only the highest in quality material and craftsmanship. Strain hardened 0.040" (1.016mm) corrosion resistant perforated aluminum front is resistant to abuse and sharp objects. New heavy duty frames have 18 flush eyelets free from any protrusions or screw heads thus allowing flush stacking and storage: Easily stack 50 panels in only 10 feet of height.

An optional Panel Carriage™ allows easy mounting and mobility in industrial environments.

Other Applications

Here are just a few of the many applications of the Acoustiblok All Weather Sound Panels:

LIST OF APPLICATIONS:

- Highway Road Noise
- Mass Transit
- Railroad Yards
- Residential Air Conditioner / Heat Pumps
- Gymnasiums
- Offshore Drilling Rigs
- Marine Vessels
- Auditoriums
- Industrial Machinery Areas
- Schools
- Hospitals
- Stadiums
- Churches
- Kitchens
- Kennels
- Engine Noise
- Transportation Barriers
- Engine Test Cells
- Shooting Ranges
- Zoos
- Recording Studios
- Racetracks
- Power Plants
- Subways
- Mining Operations
- Airports
- Community Noise Control
- Correctional Facilities
- Childcare Centers
- Swimming Pool Areas
- Construction Sites
- Commercial Vehicles

Restaurants

www.acoustiblok.com

October 18, 2015

To: Tulare County Resources Management

From: Maya Ricci
Vincent Andrus
42669 North Fork Drive
P.O. Box 636
Three Rivers, CA

Re: Special Use Permit No. 14-034, amending Special Use Permit No. PSP–02-013, approved on May 12, 2004

INTRODUCTION:

The intention of our comments are 2-fold – to respond to the document and discuss other relevant considerations or omissions. I fully realize that your department is constrained to some extent with the out-dated land use guidelines for our area as well as the fact that the County of Tulare does not have a specific Noise Ordinance.

However, we do have improved standards and guidelines that illustrate the desired character that are pending for the Three Rivers area within a reasonable time frame that will be more useful in guiding this project in the future.

To that end we would ask the RMA to stay the decision for cause pending the completion of the THREE RIVERS COMMUNITY PLAN update with it various accompanying environmental documents.

There is a neighborhood surrounding this project location. We cannot be penalized by the 300 foot rule as parcels are large, thus spread out by definition, but are related by the transmission of light, sound and/or inadequate roadways.

Additionally we would like to point out that the manner in which citizens have to participate in this particular process is essentially a lousy deal. It exists in a vacuum when those affected do not get notified objectively. It is a bad deal when others are intimidated by the potential of "getting on the bad side" of the project proponent and are afraid to speak out. It is also a bad deal to make it a competitive popularity contest. A number of folks who appreciate the Lion's Club donations to their causes never thought about the impact a "community group" has on the neighborhood – the community spirit intent of the Lion's Club becomes a bit of an oxymoron. For example if one scours the Internet to see what other Lion's Club's do for fundraising they do not stand out in needing amplifies events. Yes, I understand the nature of the property, but a little creativity can go a long, different way.

The current, most active members on this project told us at different times that the Lion's Club makes it money predominantly on alcohol sales and with the ability to have more amplified events they hope to attract large numbers of people to met this goal. It is fairly obvious whom they will have to appeal to and what kind of sound will be needed... This is per Lion Dean Stryd and Lion Tom Sparks.

This process pits neighbor against neighbor and threatens friendships. There are two neighbors in the area, not happy about the sound, but will not speak up because they are afraid of being polarized by members of the community.

There are 7 new houses in this neighborhood since the original permit was granted. This area is a neighborhood.

None of the Lion's Club Board members live in sound vicinity of the project site nor do the majority of the people in the two organizations who sent in letters of support. I asked Lion Tom Sparks this year what he thought of one of the events – he smiled and said "oh I don't know, I wasn't there ... I don't like that kind of music!" (He has a house on the coast he can escape to...)

In a recent community plan meeting Eric Coyne admonished us (Three Rivers residents) for not taking more of a business advantage of the number of tourists passing through our town. Well many of us are trying and with our small businesses – we are marketing nature and the beauty and serenity of the area.

SERVICE CHARITY INTEGRITY — INTERNATIONAL LIONS CLUB — COMMUNITY & FELLOWSHIP

Maya Ricci
P.O. Box 636
Three Rivers, CA 93271

Dear Maya,

9/18/12

First let me apologize for the tardiness of this letter. I did not receive a copy of yours until this last board meeting, having missed the previous months board meeting on account of being away on business.

The board and myself have read and understand the nature of the problem. The June 16th event was the Valley Cycle Association. They did not have permission for amplified usage. This was done in violation of our contract with this group and they will be getting a letter from us.

Let me assure you it is our desire to be good neighbors. There will be events on September 23rd TRUS Foundation Dinner 4:PM to 8:PM and October 6th TRUS Reunion 2:PM to 6:PM. Also first and third Thursdays, Spring through October 18 are our regular dinner meetings at the arena. I do believe that the Foundation Dinner will have minimal amplification. I am checking on the reunion.

Please do not hesitate to call me directly should a problem arise again. This club's single minded purpose is to serve the community of Three Rivers. It is our goal to be a positive influence and to respect our fellows.

Sincerely,

John N. McWilliams

John N. McWilliams
Three Rivers Lions Club President
P. O. Box 1019
Three Rivers, CA 93271
3RJohn@Gmail.com
561-3769
310-7270

EXHIBIT NO. E

Michael J. Spata

Environmental Assessment Officer

Tulare County Resource Management Agency

February, 14, 2016

RE: Lions Club, PSP-14-034

Dear Mr. Spata,

[1] I oppose increasing amplified events at the Three Rivers Lions Club Roping Arena from 5 to 10 events. My home on North Fork Drive is less than 1/8 mile from the event center. Through the past 25 years I have patiently listened to the drone of the PA systems, heard various bands all weekend whether I wanted to or not, and have been woken up as late as 3AM by amplified announcements.

I have never complained out of respect for the good that the Lions Club does for the Community. But pushing their events from 5 to 10 shows a total disregard for all their neighbors. Many of their yearly events run for multiple days. Jazz and Roping are 4 day/night events. Adding 5 more events gives the potential for up to 20 more sleepless nights for the neighborhood. Although the Club is well intentioned, they have not demonstrated the ability to control noise levels during the evening hours.

[2] I formally dispute the validity of the sound study commissioned by the Lions Club by VRPA Technologies the weekend of May 17th 2014. First,, the event sample (one event, one day) was too small to accurately represent the mean decibel increase due to events. Second, the study made no reference to time of day samples were taken. I propose that another study must be commissioned that will sample multiple events especially during the evening hours.

Thank You,

Michael L Cannarozzi

January 20, 2016 EXHIBIT NO. F

Dear Dana Mettler,

[1] I wanted to voice my opinion on the Three Rivers Lions Roping Arena request for more events. Adding one or two maximum might be ok, but as an adjacent resident directly across the river from the extended parking area, I am concerned about the noise and traffic. I support the community events and noise restrictions, but events like the Sober Biker and Blues fest are extremely annoying and not really supportive of our residents. The roping, Jazz Affair, Western Film Festival, Red Bud, and EAA music festivals are good for our residents, but beyond that, I am not supportive of adding more events.

[2] The occasional helicopter traffic is fairly unpleasant, but I know that this is necessary to keep utilities in order, so I accept it. I have lived in this vicinity all my life and the addition of traffic and noise at this location is starting to be an issue for me personally.

Sincerely,

Julie Doctor

Julie Doctor
PO Box 32
42510 North Fork Drive
Three Rivers, California 93271
559 741-5097
Julie.doctor@fruitgrowers.com

EXHIBIT NO. G

Brad and Maggie Bloetscher
42691 North Fork Drive
PO Box 291
Three Rivers, CA 93271

February 12, 2016

Dana Mettlen, Planner III
Project Processing
Economic Development and Planning Branch
Tulare County Resource Management Agency
5961 S. Mooney Blvd.
Visalia, CA 93277

RE: Three Rivers Lions Club – PSP 14-034

Dear Ms. Mettlen,

[1] We have lived in the same location in close proximity to the Three Rivers Lions Club facility for 40 years. Over the last decade or so we have experienced an accumulation of disturbing and annoying noise in our neighborhood of the North Fork.

The Lions Club facility events are not the only contributor. Mid Valley Disposal uses the facility to park their garbage trucks and store their garbage bins (early morning noise from trucks, loading of bins, etc.), Southern California Edison uses the facility as a heliport when they are working on their flumes (early morning and all day noise of helicopters taking off and landing), and the Riverview Restaurant outside music venue (amplified music) occurs late into the night every weekend, and Sunday afternoons, all summer long.

[2] To all of this noise you add the Lions Club amplified events and the quiet, country experience we had is slowly being eroded away. We don't think that the Lions Club realizes how loud these events are and how far the sound can travel. The Lions Club members get to go home after their time at the event, while we are home for the entire event, hearing all of it loud and clear.

We purchased our 130 acres in large part for the peace and quiet. And we feel that our right to that peace and quiet has been compromised.

We respectfully request that you deny the Three Rivers Lion Club Special Use Permit request of five additional amplified events.

Sincerely,

Brad Bloetscher and Maggie Bloetscher

EXHIBIT NO. H

310 Guyanna Ave.
Pismo Beach, Ca. 93449
January 18, 2016

To: Vince Andrus
From: Juanita Toll
Subject: Music Events at Lions Club Arena

I grew up in Three Rivers and currently own property on North Fork Road, and Kaweah River Drive. My understanding is that the Lions Club has permission for five annual events at the Lions Arena and has asked for five more.

[1] I am aware that the local population has grown over the years (traffic on Kaweah River Drive is a good example). Musical events occuring at the airport reverberate around the North Fork canyon. Daytime noise is tolerated but evening noise definitely disturbs the peace

and quiet of the neighborhood.

My family and I visit Three Rivers every year to enjoy the quiet beauty of the area and visit local friends and landmarks. We enjoy the warm community spirit and peacefulness of the area. My family has complained about the evening noise from Riverview, and a second venue in the adjoining area would compound this problem.

[2]

I believe the current schedule of musical events should remain at five for the following reasons.

[1]

1. Noise - these events draw participants from the valley and visiting tourists increasing the volume of people in town. Consideration should be made

to its impact on local residents.

[3] 2. Traffic - will increase locally with each event. The daily traffic on Kaweah River Drive is noteworthy, and the events increas this, producing noise and traffic hazards and dust if RV/Motor Homes are involved.

[4] 3. Number of days - the community needs to spell out the limitation of days for each event, and consider alternative locations for some of the events - not all in one place.

[5] 4. Time limits - the community should designate time limits for opening and

closing events each day.
Musical events should not play loud music during evening hours.

Good luck with this issue!