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**U.S. Department of Housing and Urban Development**  
Office of Community Planning and Development



# **The Noise Guidebook**

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# **The Noise Guidebook**

**A Reference Document for  
Implementing the Department of  
Housing and Urban Development's  
Noise Policy**

**Prepared By The Environmental  
Planning Division,  
Office of Environment and Energy**

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## **Preface**

### **Introduction**

This *Noise Guidebook* has been prepared to serve as the basic reference document for all HUD field staff who are responsible for implementing the Department's noise policy. It brings together in one place all the various reports, informational papers and other items that have been put out by the Department over the past several years. It also contains several new items designed to make your job easier.

This *Guidebook* is designed to serve not only the experienced HUD staff member but also the new employee or the old employee who is new to the noise field. Because of this, the *Guidebook* contains some fairly basic background material as well as quizzes and other material specifically geared for the "learner."

## Chapter 1

### Basic Overview of the Environmental Noise Problem

#### Introduction

#### Background

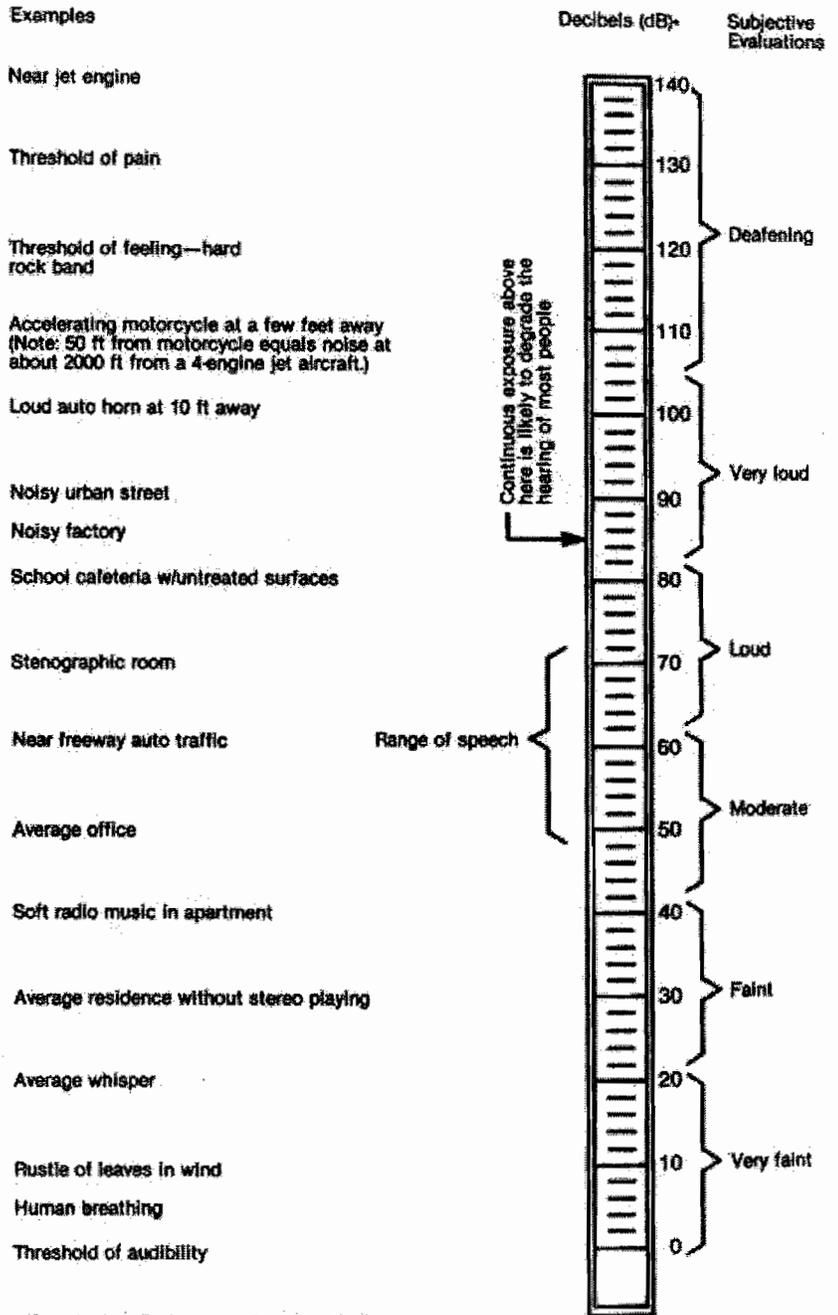
##### Definition and Scope of the Noise Problem

The air around us is constantly filled with sounds, yet most of us would probably not say we are surrounded by noise. What then is the difference between ordinary sound and what we call noise? The traditional definition of noise is that it is "unwanted sound." Sound becomes unwanted when it either interferes with our normal activities such as sleeping, conversation or recreation, when it causes actual physical harm such as hearing loss or has adverse effects on mental health. As we have become a more urbanized country and as technology has advanced, the level of sound in our environment has reached the point when it sometimes does cause interference and does cause physical and psychological harm, and thus we have developed a noise problem. (See Figure 1 for a listing of common sounds.)

The dimensions of the noise problem have grown larger and larger over the past few decades. In its 1979 Annual Report, The Council on Environmental Quality stated that "nearly half the US population is regularly exposed to levels of noise that interfere with ...normal activities" and about "1 in 10 ...are exposed to noises of duration and intensity sufficient to cause a permanent reduction in their ability to hear."

**Figure 1**  
Common Sounds  
Basic Theory: Common Sounds in Decibels (dB)

Some common, easily recognized sounds are listed below in order of increasing sound intensity levels in decibels. The sound levels shown for occupied rooms are typical general activity levels only and do not represent criteria for design.



\*dB are "average" values as measured on the A-scale of a sound-level meter  
(From *Concepts in Architectural Acoustics*: M. David Egan, McGraw Hill, 1972.)

### The Dynamics of the Noise Problem

There are basically two types of noise problems. There is the specific, job related, occupational noise problem created by extremely loud machinery. Then there is the community noise problem where the combined effect of many individual noise sources creates an overall noise level that is unacceptable. In the following pages we will be addressing the community noise problem only.

The main contributors to a community noise problem are transportation sources such as highways, railroads and airports. These sources are the most pervasive and continuing of the noise sources within the community. Of course, at any given site, there may be other noise sources which add to the problem, sources such as jackhammers at a construction site. But in general, and for the purposes of this section, the main concern is with the transportation sources.

The dynamics of a noise problem are based on the relationship between the noise source, the person or place exposed to the noise (hereafter called the receiver) and the path the noise will travel from source to receiver.

The source generates a given amount of noise which travels along the path and arrives at the receiver. The amount of noise will be reduced to some extent as a result of how long that path is or whether there are any barriers along the path. The severity of the impact on the receiver is a function of what type of activity is taking place, whether it is indoors or outdoors, and what type of building it is in if the activity is indoors. Figure 3 contains some basic compatibility guidelines.

The impact of the noise can be altered or mitigated by changing the characteristics of any of the three elements: source, path or receiver. Later on we will look at the various mitigation measures that are possible. Our concern however will be primarily with the receiver and the path. Control of the sources themselves is the specific responsibility of agencies such as the Environmental Protection Agency (EPA) or the Federal Aviation Administration (FAA).

Figure 2  
Dynamics of a Noise Problem

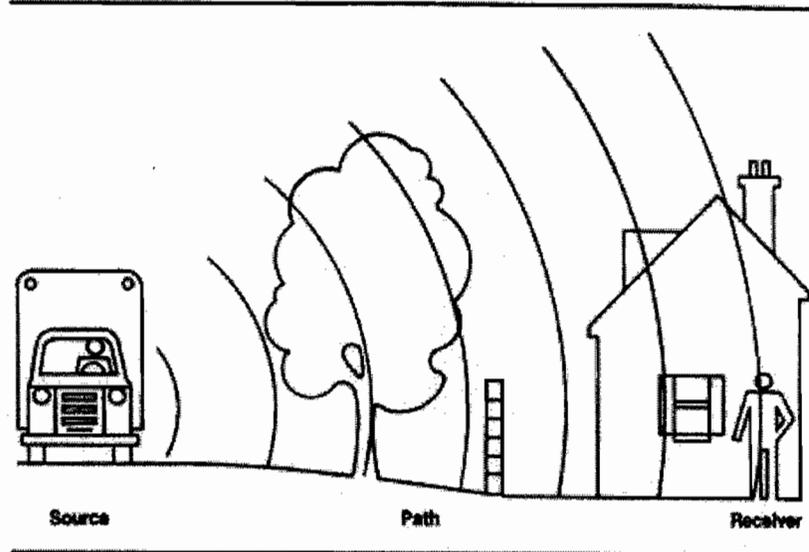


Figure 3  
Land Use Compatibility Guidelines

LAND USE CATEGORY	LAND USE INTERPRETATION FOR NEF VALUE*			
	20	30	40	50
Residential — Single Family, Duplex, Mobile Homes		Normally Unacceptable	Clearly Unacceptable	Clearly Unacceptable
Residential — Multiple Family, Dormitories, etc.		Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable
Transient Lodging		Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable
School Classrooms, Libraries, Churches		Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable
Hospitals, Nursing Homes		Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable
Auditoriums, Concert Halls, Music Shells	Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable
Sports Arena, Outdoor Spectator Sports		Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable
Playgrounds, Neighborhood Parks		Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable
Golf Courses, Riding Stables, Water Rac., Cemeteries		Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable
Office Buildings, Personal, Business and Professional		Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable
Commercial — Retail, Movie Theaters, Restaurants		Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable
Commercial — Wholesale, Some Retail, Ind., Mfg., Util.		Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable
Manufacturing, Communication (Noise Sensitive)	Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable
Livestock Farming, Animal Breeding		Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable
Agriculture (except Livestock), Mining, Fishing			Clearly Unacceptable	Clearly Unacceptable
Public Right-of-Way			Clearly Unacceptable	Clearly Unacceptable
Extensive Natural Recreation Areas		Clearly Unacceptable	Clearly Unacceptable	Clearly Unacceptable

\*Ldn = NEF Value + 35

85 75 85  
Ldn VALUES

- Clearly Acceptable
- Normally Unacceptable
- Normally Acceptable
- Clearly Unacceptable

The ideal solution to a potential problem is to reduce the noise being produced by the source. The best solution available to HUD, or the community, however, is to make sure that noise sensitive uses are located where they will not be exposed to high noise levels. The next best approach to mitigating noise impact is to attempt to reduce the amount of noise that reaches the receiver. This can be accomplished through the use of barriers such as walls or earthen berms, or combinations of both, along the noise path. If the use of barriers is not possible then the only alternative available is to provide noise reduction measures in any structures associated with the activity so that at least the interior spaces are not exposed to high noise levels. This approach is considered the least desirable because most of the land uses we are concerned about, such as residential, do have outdoor areas and activities associated with them which would remain exposed to high noise levels.

#### **A Note on Descriptors**

A key factor in the growth of our ability to evaluate and reduce noise impacts has been the development of better tools to measure and describe the noise levels generated by various sources. The development of better tools (called noise descriptors or metrics) has been particularly important for dealing with community noise problems. Many of the older descriptor systems could only be used for one or two sources such as cars and railroads, but not airplanes. Since the community noise problem very often includes noise from all these sources the lack of an adequate descriptor made it difficult to do an adequate evaluation.

The most advanced descriptor currently in general use is the day night average sound level system, abbreviated as DNL and symbolized mathematically as  $L_{dn}$ . The day night average sound level is the 24 hour average sound level, expressed in decibels, obtained after the addition of a 10 decibel penalty for sound levels which occur at night between 10 PM and 7 AM. This nighttime penalty is based on the fact that many studies have shown that people are much more disturbed by noise at night than at any other time. This is not unusual in that background noise is often much less at night and also people tend to be doing very noise sensitive things at night, such as trying to sleep.

Another feature of the DNL system that is very important is that it can be used to describe noise from all sources. Thus, using the DNL system, we can describe the total noise exposure at a site, something many other descriptor systems couldn't do.

The DNL system has been adopted by the EPA, the Department of Defense (DOD) and HUD, and more recently by the FAA, specifically for describing environmental impacts for airport actions. We expect that very soon it will be in almost universal use in the U.S.

#### **Issues**

The main issues involved in any noise analysis can be summarized briefly.

- How much noise is a site exposed to
- What types of activities are being affected and how severely
- Is it reasonable to redesign the site to relocate noise sensitive activities
- And, if not, how much protection can be provided through various attenuation measures.

Your approach to these issues will be affected in many ways by the location of the project in question. Projects in suburban or rural areas can be approached differently because the available mitigation options are greater and often the noise exposure itself is not so severe. In urban situations, however, the noise exposure is often more severe but at the same time the options for mitigation or resiting are more limited. In the urban setting innovative design and the use of advanced attenuation measures becomes critical. Fortunately our experience has shown that good design and construction can relieve or substantially reduce major noise problems.

## **Legal Provisions**

### **General Legislation and Background**

The Federal legislation which addresses noise issues is somewhat different from other environmental legislation. The Clean Air Act, for example, required the Environmental Protection Agency to set up actual mandatory standards for air quality which were supposed to be met by all jurisdictions. EPA even has the authority to take punitive steps against cities which are not making "reasonable further progress" towards achieving these air quality goals. There is no similar legislation that covers noise. The approach has been to tackle the noise problem at the source by controlling the amount of noise that can be emitted by the individual airplane engine or the individual jackhammer. Agencies like HUD or the Farmers Home Administration have developed regulations which are related to the overall community noise level, but they only affect their own programs and are not binding on local communities. The Veterans Administration program only relates to aircraft noise and also only affects its own programs.

The major pieces of Federal legislation related to noise include: **The Noise Control Act of 1972** directed EPA to promote an environment for all Americans free from noise that jeopardizes their health and welfare. It also included a requirement for EPA to set a criterion for noise level adequate to protect health and welfare with an adequate margin of safety but without regard to cost or feasibility.

**Quiet Communities Act of 1978** amended The Noise Control Act of 1972 to encourage noise control programs at the State and community level.

**Federal Aid Highway Act of 1970** established the requirement that noise control be a part of the planning and design of all federally aided highways.

**Aviation Safety and Noise Abatement Act of 1979** requires FAA to develop a single system for measuring noise at airports and under certain conditions to prepare and publish noise maps.

## HUD Regulations

While the Department of Housing and Urban Development has no specific responsibility to try to reduce the noise problem at the source the way the Environmental Protection Agency and the Federal Aviation Administration do, it does have the responsibility to be aware of the noise problem and its impact on the housing environment. The most basic mandate which drives the Department's involvement with the noise issue is the Housing Act of 1949 (Public Law 81-171) which sets forth the national goal of "a decent home and suitable living environment for every American family." This goal was affirmed by the Housing and Urban Development Act of 1968 (Public Law 90-448). The Department was tasked by the Housing and Urban Development Act of 1965 (Public Law 89-117) "to determine feasible methods of reducing the economic loss and hardships suffered by homeowners as a result of the depreciation in the value of their properties following the construction of airports in the vicinity of their homes." The Noise Control Act of 1972, in addition to its specific tasking to EPA, tasked all Federal agencies to administer their programs in ways which reduce noise pollution. Finally, the Department is tasked by Federal Management Circular 75-2: *Compatible Land Uses at Federal Airfields* to make sure that its actions do not promote incompatible land uses around Federal airfields.

All of these legislative and regulatory mandates combine to create a serious requirement for the Department of Housing and Urban Development to be aware of the problem of noise and to take positive steps to protect residential and other sensitive land uses from high noise levels.

The Department of Housing and Urban Development first issued formal requirements related specifically to noise in 1971 (HUD Circular 1390.2). These requirements contained standards for exterior noise levels along with policies for approving HUD supported or assisted housing projects in high noise areas.

In general the requirements established three zones: an acceptable zone where all projects could be approved, a normally unacceptable zone where mitigation measures would be required and where each project would have to be individually evaluated for approval or denial, and an unacceptable zone in which projects would not, as a rule, be approved.

In 1979, the Department issued revised regulations (24 CFR Part 51B) which kept the same basic standards but adopted new descriptor systems which were considerably advanced over those in use under the old requirements.

HUD's regulations also require that recipients of Community Development Block Grants (CDBG) and Urban Development Action Grants (UDAG) take into consideration the noise criteria and standards in the environmental review process and consider ameliorative actions when noise sensitive land developments are proposed in noise exposed areas. If CDBG or UDAG activities are planned in a noisy area, and HUD assistance is contemplated later for housing and/or other noise sensitive activities, the HUD standards must be met for those activities.

## Project Analysis

### General

While most of the analysis for noise focuses on noise sources located around the project site, there are some characteristics of the project itself that you should know about. These characteristics will help you to determine what is called the noise assessment location (NAL) for site analysis. (The NAL is a representative point (or points) on the site where significant noise exposure is expected. All distances, etc. are measured from the NAL). This information will also be helpful later in evaluating the potential for mitigating or reducing the impact of noise. All of this data should be available from preliminary plans and specifications. If not, a quick phone call to the developer/sponsor should get you all the information you need.

## Data Required

- Location of outdoor noise sensitive uses relative to the noise source.
- Location of buildings containing noise sensitive activities.
- Location of other buildings, particularly ones which might serve to shield sensitive buildings or areas from the noise source.
- Design and construction features of buildings, particularly features such as use of central air conditioning which could provide noise reduction benefits by permitting windows to be kept closed.

## Analysis of Site and Environs

### General

The primary focus of this impact analysis is on noise sources and the primary item to be determined is the noise level created by those sources. In many instances, particularly with airports, data on the noise levels generated by the source will have already been prepared by another agency such as the airport operator, the local or State highway/transportation department or other similar agency. (Figure 4 shows typical airport noise contours.) In those cases no site or environs analysis is necessary and one can proceed directly to impact analysis. For those instances where there are no current data already prepared, the Department of Housing and Urban Development has developed a handbook called the *Noise Assessment Guidelines* which contains a detailed desk top methodology for use by individuals to determine noise impacts (see Chapter 5). Included in the handbook is a complete listing of the data about the site and its environs that are necessary to conduct an analysis. We don't want to repeat all the detailed requirements here, but the following are some of the types of information you would have to collect if you were to do your own analysis. You might note that most of the information is related to the noise sources themselves.

For the purpose of analysis, the *Noise Assessment Guidelines* require that you consider all military/civilian airports within 15 miles of the project, all significant roads within 1000 feet and basically all railroads within 3000 feet.

### Types of Data Required

- Number and type of vehicles
- Operational data:
  - speed
  - daytime/nighttime split
- Conditions where the vehicles are operated, i.e., freely flowing traffic versus stop and go, level versus hilly, welded railroad track versus bolted railroad track.

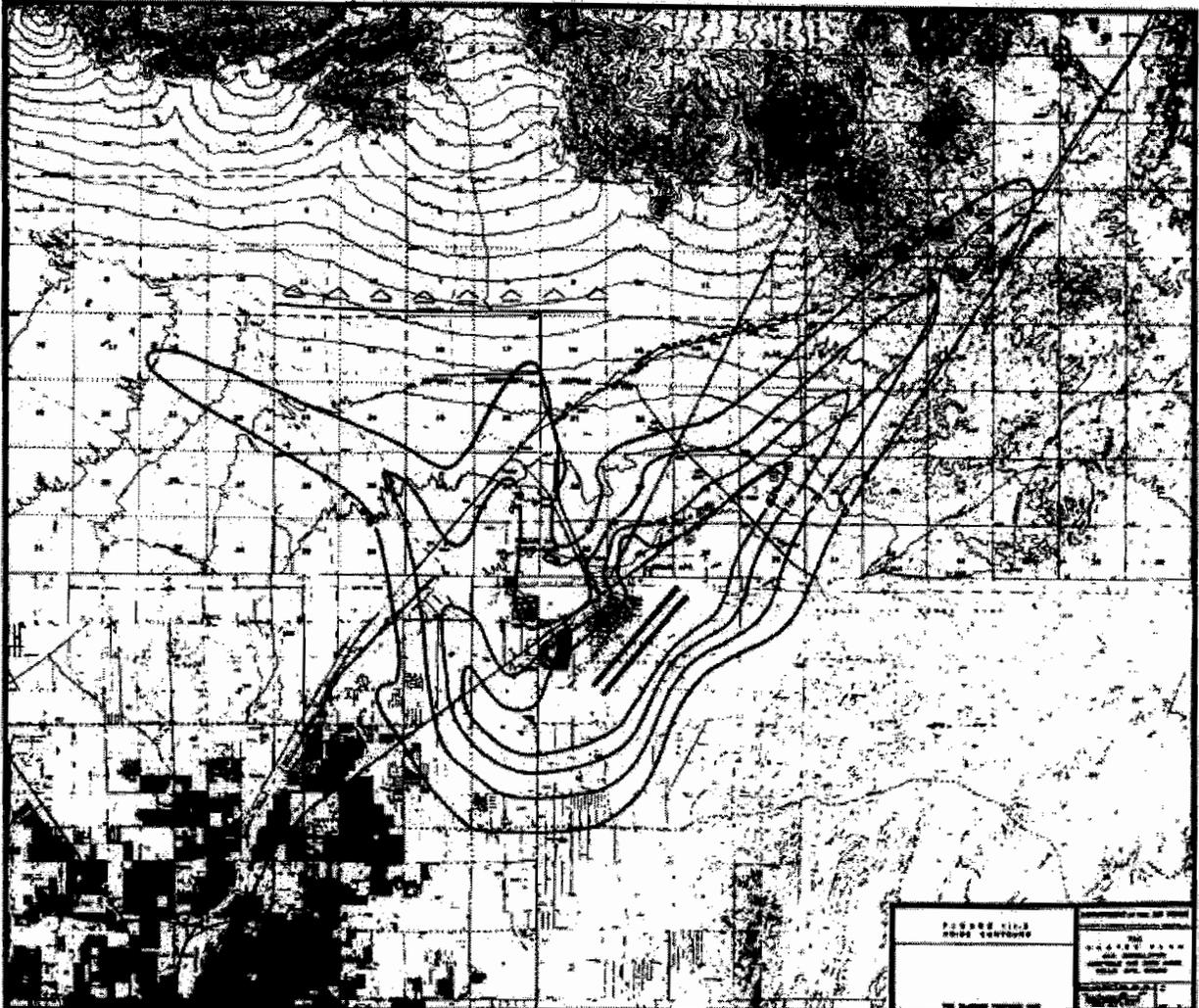
The *Noise Assessment Guidelines* contain guidance on sources for this data. Most of them are obtained from the "operator" of the transportation source. The *Guidelines* also contains model figures which can be used when actual data is unavailable. For example, if the actual number of vehicles traveling at night is not available then the *Guidelines* state that a figure of 15% should be used. Thus it is possible to make reasonably accurate noise level determinations even if some information is not available.

### Determination of Impact

#### General

The specific procedures for determining the noise exposure levels for a site are clearly spelled out in the *Noise Assessment Guidelines*. The process is a fairly simple one in which the noise level from each source affecting the site is calculated and then combined to derive the overall exposure. If some kind of barrier exists or is proposed, the noise levels can be adjusted to reflect the mitigation provided by the barrier. The overall noise level is then compared to HUD's standards and the appropriate action, as spelled out in the regulations, is taken.

Figure 4  
Noise Contours



## Evaluation of Impact

HUD Regulations set forth the following exterior noise standards for new housing construction assisted or supported by the Department:

65  $L_{dn}$  or less - Acceptable

Exceeding 65  $L_{dn}$  but not exceeding 75  $L_{dn}$  - Normally Unacceptable - appropriate sound attenuation measures must be provided: 5 decibels attenuation above the attenuation provided by standard construction required in 65  $L_{dn}$  to 70  $L_{dn}$  zone; 10 decibels additional attenuation in 70  $L_{dn}$  to 75  $L_{dn}$  zone.

Exceeding 75  $L_{dn}$  - Unacceptable

HUD's regulations do not contain standards for interior noise levels. Rather a goal of 45 decibels is set forth and the attenuation requirements are geared towards achieving that goal. It is assumed that with standard construction any building will provide sufficient attenuation so that if the exterior level is 65  $L_{dn}$  or less, the interior level will be 45  $L_{dn}$  or less.

Once you have determined the overall noise exposure for the site you compare it to the above standards. If the overall site exposure is 65  $L_{dn}$  or less the project is acceptable. If the exposure is between 65  $L_{dn}$  and 75  $L_{dn}$  you should consider alternative locations or providing adequate attenuation with the first preference, as we've noted, being for the construction of some kind of barrier to prevent noise from reaching the site. If providing adequate attenuation is impossible or impractical then the project should be considered unacceptable.

## Suggested Mitigation

### General Considerations

As discussed briefly earlier, there are three basic approaches for mitigating the high noise exposures. The first and best is to relocate noise sensitive uses out of the high noise area. The second is to prevent noise from reaching the noise sensitive user through some sort of barrier. And the third, and least desirable approach, is to provide attenuation for at least the interiors of any buildings located in the high noise areas.

## Specific Considerations

### Relocating Noise Sensitive Uses

By far the most desirable mitigation approach is to relocate noise sensitive uses out of the high noise area although. If the site is large enough it may be possible to locate non-noise sensitive uses between the source and the sensitive use, for example a parking lot might be located between a road and a park (see Figure 5). The workcharts in the *Noise Assessment Guidelines* can be used in reverse to tell you exactly how far away from the noise source you need to be.

When sites are small, very dense or when the source affects the entire site it is very difficult to mitigate by changing the site plan. Then the next option must be considered: erecting some type of barrier between the source and the receiver.

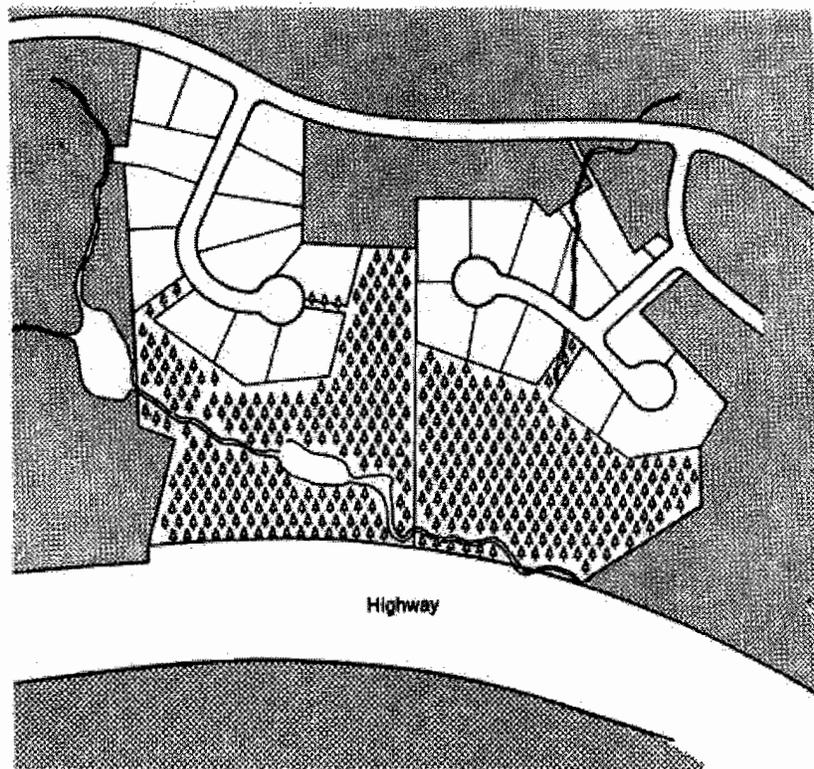
## Barriers

Barriers are most effective for at or below ground level sources. They have no effect on noise from aircraft overflights and are limited in practical application with elevated sources such as elevated trains. The key to the effectiveness of a barrier is whether or not it breaks the line of sight between the source and the receiver. If a barrier does not completely break the line of sight either because it is not high enough, or not long enough then its effectiveness is greatly reduced.

Barriers can be actual walls, earthen mounds (called berms) or even other buildings. The use of other non-noise sensitive buildings as barriers is a particularly good approach in that it need not add to the cost of the project and may not create the aesthetic problem a large wall might create (see Figure 6).

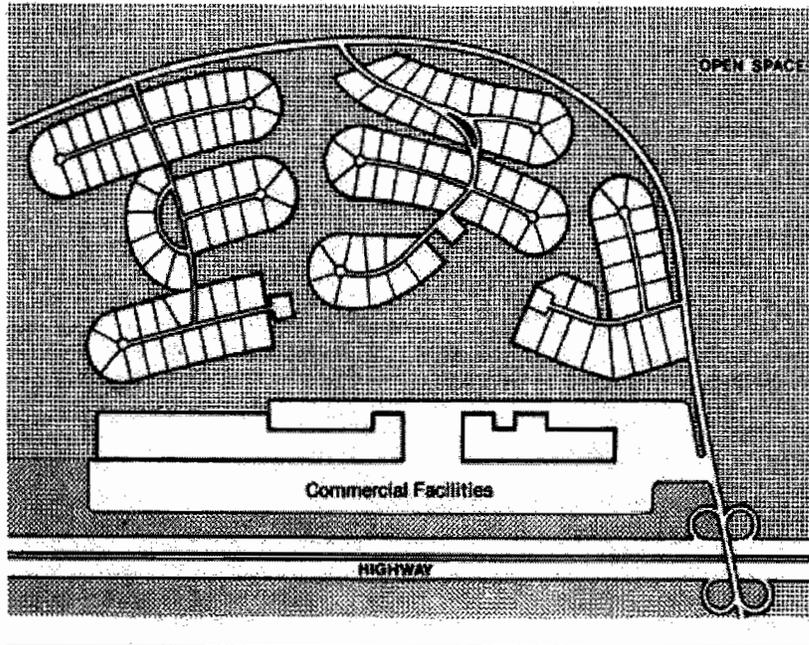
Figure 5  
The Audible Landscape

In cluster development, open space can be placed near the highway to reduce noise impacts on residences



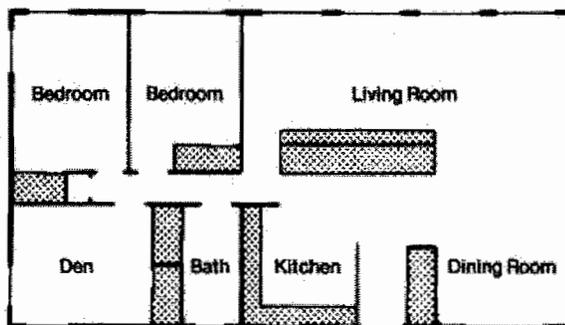
**Figure 6**  
The Audible  
Landscape

Placement of noise compatible land uses  
near highway in Planned Unit Development



**Figure 7**  
The Audible  
Landscape

Use of acoustical architectural design to  
reduce noise impacts on more noise  
sensitive living spaces



Highway

As pointed out earlier, the effectiveness of a barrier is determined in large part by its height and length. Some studies have shown that the effectiveness of a barrier can be reduced by as much as 50% if it isn't long enough. Again, the *Noise Assessment Guidelines* contain procedures for determining the effectiveness of barriers.

#### Incorporating Noise Attenuation Measures into the Building

If neither relocation or barriers is a reasonable noise attenuation option, the last resort is to incorporate noise attenuation measures into the buildings themselves. This is not considered the best solution because it leaves the outdoor areas, some of which may be for quiet recreation, exposed to high noise levels. But if development must take place and barriers are impossible, then the noise attenuation measures should be employed in building design and construction.

Without going into great technical detail, noise attenuation construction measures generally fall into four categories.

- (1) Reducing the total area of windows or other acoustically weaker building elements
- (2) Sealing off "leaks" around windows, doors, vents.
- (3) Improving the actual sound attenuating properties of small building elements such as windows, doors, etc.
- (4) Improving the actual sound attenuating properties of major building elements such as roof and wall construction.

In addition, noise attenuation in buildings can be provided by designing interior spaces so that "dead" spaces such as closets or corridors act as buffer zones (see Figure 7). And finally noise attenuation can be provided by reducing the need for open windows by providing air conditioning.

Many of the steps that would be taken to provide noise attenuation also help conserve energy. Good weatherstripping around windows and doors is one example. Another might be reducing window areas in walls if the noise source is to the north or west. Because many of these measures serve two purposes, they should not necessarily be considered a burdensome requirement but rather just good design and construction.

## Information Resources

### Publications

*HUD Regulation 24 CFR Part 51 Subpart B - Noise Abatement and Control.*

*Noise Assessment Guidelines*, HUD 1983, basic technical procedural resource.

*Aircraft Noise Impact*, HUD 1972, a bit dated but good overview of problem.

*The Audible Landscape*, DOT (FHWA) 1974, an excellent discussion of mitigation measures including land use planning and building design and construction.

*Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare With an Adequate Margin of Safety*, EPA, 1974. The "levels document" that explains basis for EPA standards.

*Noise Barrier Design Handbook*, Federal Highway Administration 1976. Good discussion of barriers, technical but readable.

*Handbook of Noise Control*, 2nd edition, 1979, McGraw Hill. A basic technical handbook covering all aspects of noise for those who wish to go into the subject further.

### Experts

HUD environmental officers have been trained in the use of the *Noise Assessment Guidelines* and can help you work with them. Many architects are trained in acoustics and can help in development of noise attenuation strategies.

## Quiz

### Questions

1. Why is noise considered "unwanted sound"?
2. What is a community noise problem?
3. What are the three main contributors to a community noise problem?
4. What are the three components of a noise problem?
5. What are two key characteristics of the day-night average sound level descriptor system?
6. What are HUD's noise standards?
7. How do HUD's standards apply to CDBG recipients?
8. What are the three general mitigation measures available to HUD and the community and in what order of preference?
9. When are barriers effective and when are they not effective?
10. Describe how the *Noise Assessment Guidelines* can be used to determine appropriate mitigation measures.

## Quiz

### Answers

1. because it interferes with normal activities or causes physical or psychological damage
2. a community noise problem is where the combined effect of many individual sources creates an overall noise level that is unacceptable
3. highways, railroads and aircraft
4. the source, the path, the receiver
5. it is an average sound level and it can be used for all sources
6. 65 L<sub>dn</sub> or below: acceptable
7. CDBG recipients must take into consideration the standards in their planning and environmental review, if they expect to use HUD assistance later for housing or other noise sensitive activities the standards must be met for those activities
8. 1st relocate noise sensitive uses
9. barriers are effective for at or below ground level sources. Are not effective for aircraft overflights or most elevated sources
10. can be used to determine separation distance required for relocation and the height and length of barriers required

## Chapter 2

### The Noise Regulation

#### Introduction

The basic foundation for and structure of the HUD noise program is set out in the noise regulation, 24 CFR 51B. The regulation establishes the actual standards, assigns implementation responsibilities, describes review and approval procedures, and identifies special situations which may warrant waivers of procedures or standards.

Therefore, the key to your understanding and implementation of the HUD noise program is a clear understanding of the regulation.

There is no way to escape the task of sitting down and simply reading the regulations, over and over until you thoroughly understand them. We have however done two things that will help you apply the regulations. First, for quick reference, we have prepared a list of the key sections in the regulation and second we have prepared an annotated copy of the regulation.

The list of key sections was prepared to help you find the specific section you need for a specific question or issue. While the regulation itself is not really long, an index is always useful. We caution you, however, against using the index to avoid learning the regulations. The list was prepared for your convenience in applying the regulation once you have come to understand it.

We prepared the annotated regulation because, try as we might, it was impossible to anticipate all the questions, implementation problems and special situations that might arise and to address them in the regulation. So, now that we have had a few years' experience with the regulation, we have gathered together the important questions, notes, second thoughts etc. and prepared this annotated regulation. We hope it will give you further insight into what the regulation means when it is applied in the field.

#### Key Sections in Noise Regulation

Section	Subject
51.101(a)(2)	Application of Policy to Block Grants
51.101(a)(3)	Policy for New Construction
51.101(a)(4)	Policy for Existing Construction
51.101(a)(5)	Policy for Modernization and Rehabilitation
51.101(a)(8)	The Exterior Noise Goal
51.101(a)(9)	The Interior Noise Goal
51.102(a)	Authority to Approve Projects
51.103(a)	Identification of DNL as <i>The Noise Descriptor</i> to be Used
51.103(b)	How to Measure Loud impulsive Noises
51.103(c)	The Noise Standards
51.104(a)	Attenuation Requirements Discussed
51.104(b)(1)	Special Approval and Environmental Review Requirements for the Normally Unacceptable Zone
51.104(b)(2)	Special Approval and Environmental Review Requirements for the Unacceptable zone
51.105(a)	Flexibility for Non-acoustic Benefits Provisions
51.106(a)	How to Tell if Existing Data on Noise Are Acceptable
51.106(a)(4)	Specific Review and Approval Procedures For Airport Noise Contours
51.106(d)	When Noise Measurements May be Used Instead of Calculated Levels
51.106(f)	When to Give Credit for Proposed Barriers

Part 51—Environmental Criteria  
and Standards

Subpart A—General Provisions

Sec.

§51.1 Purpose.

§51.2 Authority.

§51.3 Responsibilities.

§51.4 Program coverage.

§51.5 Coordination with environ-  
mental clearance requirements.

§51.6 [Reserved]

Subpart B—Noise Abatement and  
Control

§51.100 Purpose and authority.

§51.101 General policy.

§51.102 Responsibilities.

§51.103 Criteria and standards.

§51.104 Special requirements.

§51.105 Exceptions.

§51.106 Implementation.

Appendix to Subpart B

Authority: Sec. 7(d), Department of  
HUD Act (42 U.S.C. 3535(d)).

Subpart B—Noise Abatement and  
Control

§51.100 Purpose and authority.

(a) *Purpose.* The Department of  
Housing and Urban Development  
finds that noise is a major source of  
environmental pollution which  
represents a threat to the serenity  
and quality of life in population  
centers and that noise exposure may  
be a cause of adverse physiological  
and psychological effects as well as  
economic losses.

It is the purpose of this Subpart  
to:

- (1) Call attention to the threat of  
noise pollution;
- (2) Encourage the control of noise  
at its source in cooperation with  
other Federal departments and  
agencies;
- (3) Encourage land use patterns  
for housing and other noise sensitive  
urban needs that will provide a  
suitable separation between them  
and major noise sources;
- (4) Generally prohibit HUD support  
for new construction of noise  
sensitive uses on sites having  
unacceptable noise exposure;
- (5) Provide policy on the use of  
structural and other noise  
attenuation measures where needed;  
and

This regulation replaces  
HUD Circular 1390.2,  
Noise Abatement and  
Control, 1971, which is  
now cancelled, along  
with all instructions and  
clarifying memoranda  
pertaining to the  
circular.

(6) Provide policy to guide  
implementation of various HUD  
programs.

(b) *Authority.* Specific authorities  
for noise abatement and control are  
contained in:

(1) The Noise Control Act of 1972  
(Pub. L. 92-574) which directs Federal  
agencies to administer their programs  
in ways which reduce noise pollution.

(2) The Quiet Communities Act of  
1978 (Pub. L. 95-609) which amended  
Pub. L. 92-574.

(3) The General Services  
Administration, Federal Management  
Circular 75-2: *Compatible Land Uses  
at Federal Airfields* prescribes the  
Executive Branch's general policy  
with respect to achieving compatible  
land uses on either public or privately  
owned property at or in the vicinity of  
Federal airfields.

(4) Section 1113 of the Housing  
and Urban Development Act of 1965  
(Pub. L. 89-117) directs the Secretary  
" \* \* \* to determine feasible methods  
of reducing the economic loss and  
hardships suffered by homeowners as  
a result of the depreciation in the  
value of their properties following the  
construction of airports in the vicinity  
of their homes, including a study of  
feasible methods of insulating such  
homes from the noise of aircraft."

§51.101 General policy.

(a) It is HUD's general policy to  
provide minimum national standards  
applicable to HUD programs to  
protect citizens against excessive  
noise in their communities and places  
of residence.

(1) *Comprehensive planning assist-  
ance.* HUD requires that grantees  
give adequate consideration to noise  
exposures and sources of noise as an  
integral part of the urban environment  
in HUD assisted comprehensive plan-  
ning, as follows:

(i) Particular emphasis shall be  
placed on the importance of  
compatible land use planning in  
relation to airports, highways and  
other sources of high noise.

(ii) Applicants shall take into  
consideration HUD environmental  
standards impacting the use of land  
as required in 24 CFR Part 600.

(iii) Environmental studies,  
including noise assessments, are  
allowable costs.

(2) *Community Development Block  
Grants.* Recipients of community  
development block grants under the  
Housing and Community  
Development Act of 1974 (Pub. L.  
93-383), as amended by the Housing  
and Community Development Act of  
1977 (Pub. L. 95-128), must take into

consideration the noise criteria and standards in the environmental review process and consider ameliorative actions when noise sensitive land development is proposed in noise exposed areas. Grant recipients shall address deviations from the standards in their environmental reviews as required in 24 CFR Part 58.

Where CDBG activities are planned in a noisy area, and HUD assistance is contemplated later for housing and/or other noise sensitive activities, the CDBG grantee risks denial of the HUD assistance unless the HUD standards are met. Environmental studies, including noise assessments, are allowable costs.

(3) *HUD support for new construction.* HUD assistance for the construction of new noise sensitive uses is prohibited generally for projects with Unacceptable noise exposures and is discouraged for projects with Normally Unacceptable noise exposure. (Standards of acceptability are contained in §51.103(c).) This policy applies to all HUD programs providing assistance, subsidy or insurance for housing, college housing, mobile home parks, nursing homes, hospitals, and all programs providing assistance or insurance for land development, new communities, redevelopment or any other provision of facilities and services which are directed to make land available for housing or noise sensitive development. The policy does not apply to research demonstration projects which do not result in new construction or reconstruction, flood insurance, interstate land sales registration, or any action or emergency assistance under disaster assistance programs which are provided to save lives, protect property, protect public health and safety, remove debris and wreckage, or assistance provided that has the effect of restoring facilities substantially as they existed prior to the disaster.

(4) *HUD support for existing construction.* Noise exposure by itself will not result in the denial of HUD support for the resale and purchase of otherwise acceptable existing buildings. However, environmental noise is a marketability factor which HUD will consider in determining the amount of insurance or other assistance that may be given.

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The old definition of major or substantial rehabilitation and modernization as being any project where cost is 75% or more of replacement cost no longer applies. Now the criteria contained in individual program guidance applies.

(5) *HUD support of modernization and rehabilitation.* For modernization projects located in all noise exposed areas, HUD shall encourage noise attenuation features in alterations. For major or substantial rehabilitation projects in the Normally Unacceptable and Unacceptable noise zones, HUD actively shall seek to have project sponsors incorporate noise attenuation features, given the extent of the rehabilitation being undertaken and the level of exterior noise exposure. In Unacceptable noise zones, HUD shall strongly encourage conversion of noise-exposed sites to land uses compatible with the high noise levels.

(6) *Research, guidance and publications.* HUD shall maintain a continuing program designed to provide new knowledge of noise abatement and control to public and private bodies, to develop improved methods for anticipating noise encroachment, to develop noise abatement measures through land use and building construction practices, and to foster better understanding of the consequences of noise. It shall be HUD's policy to issue guidance documents periodically to assist HUD personnel in assigning an acceptability category to projects in accordance with noise exposure standards, in evaluating noise attenuation measures, and in advising local agencies about noise abatement strategies. The guidance documents shall be updated periodically in accordance with advances in the state-of-the-art.

(7) *Construction equipment, building equipment and appliances.* HUD shall encourage the use of quieter construction equipment and methods in population centers, the use of quieter equipment and appliances in buildings, and the use of appropriate noise abatement techniques in the design of residential structures with potential noise problems.

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Existing construction means units which are either more than 1 year old or for which this is the second or subsequent purchaser.

(8) *Exterior noise goals.* It is a HUD goal that exterior noise levels do not exceed a day-night average sound level of 55 decibels. This level is recommended by the Environmental Protection Agency as a goal for outdoors in residential areas. The levels recommended by EPA are not standards and do not take into account cost or feasibility. For the purposes of this regulation and to meet other program objectives, sites with a day-night average sound level of 65 and below are acceptable and are allowable (see Standards in §51.103(c)).

(9) *Interior noise goals.* It is a HUD goal that the interior auditory environment shall not exceed a day-night average sound level of 45 decibels. Attenuation measures to meet these interior goals shall be employed where feasible. Emphasis shall be given to noise sensitive interior spaces such as bedrooms. Minimum attenuation requirements are prescribed in §51.104(a).

(10) *Acoustical privacy in multifamily buildings.* HUD shall require the use of building design and acoustical treatment to afford acoustical privacy in multifamily buildings pursuant to requirements of the Minimum Property Standards.

#### **§51.102 Responsibilities.**

(a) *Authority to approve projects.* (1) Decisions on proposed projects with acceptable noise exposures shall be delegated to the program personnel within field offices, including projects where increased noise levels are considered acceptable because of non-acoustic benefits under §51.105(a). Field office program personnel may also approve projects in normally unacceptable noise exposed areas where adequate sound attenuation is provided and where the project does not require an Environmental Impact Statement under §51.104(b).

(2) Other approvals in normally unacceptable noise exposed areas require the concurrence of the Regional Administrator.

(3) Requests for approvals of projects or portions of projects with unacceptable noise exposures shall be referred through the Regional Office to the Assistant Secretary for Community Planning and Development for approval pursuant to §51.104(b).

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The Noise Control Act of 1972 required EPA to "publish information on the levels of environmental noise...which...are requisite to protect the public health and welfare with an adequate margin of safety." EPA has interpreted this to mean that the levels should not reflect technical feasibility or economic costs. "Health and welfare" is defined as being "complete physical, mental and social well-being and not merely the absence of disease and infirmity."

(4) In cases where the Regional Administrator determines that an important precedent or issue is involved, such cases shall be referred with recommendations to the Assistant Secretary for Community Planning and Development.

(b) *Surveillance of noise problem areas.* Appropriate field staff shall maintain surveillance of potential noise problem areas and advise local officials, developers, and planning groups of the unacceptability of sites because of noise exposure at the earliest possible time in the decision process. Every attempt shall be made to insure that applicants' site choices are consistent with the policy and standards contained herein.

(c) *Notice to applicants.* At the earliest possible stage, HUD program administrators shall:

(1) Determine the suitability of the acoustical environment of proposed projects;

(2) Notify applicants of any adverse or questionable situations; and

(3) Assure that prospective applicants are apprised of the standards contained herein so that future site choices will be consistent with these standards.

(d) *Technical assistance.* Technical assistance in the measurement, estimation, interpretation, or prediction of noise exposure is available from the Office of Community Planning and Development and the Office of Policy Development and Research. Field office questions shall be forwarded through the Regional Office to the Assistant Secretary for Community Planning and Development or his designee.

(e) *Interdepartmental coordination.* Regional Administrators shall foster appropriate coordination between field offices and other departments and agencies, particularly the Environmental Protection Agency, the Department of Transportation, Department of Defense representatives, and the Veterans Administration. HUD staff shall utilize the acceptability standards in commenting on the prospective impacts of transportation facilities and other noise generators in the Environmental Impact Statement review process.

**§51.103 Criteria and standards.**

These standards apply to all programs as indicated in §61.101.

(a) *Measure of external noise environments.* The magnitude of the external noise environment at a site is determined by the value of the day-night average sound level produced as the result of the accumulation of noise from all sources contributing to the external noise environment at the site. Day-night average sound level, abbreviated as DNL and symbolized as  $L_{dn}$ , is the 24-hour average sound level, in decibels, obtained after addition of 10 decibels to sound levels in the night from 10 p.m. to 7 a.m. Mathematical expressions for average sound level and day-night average sound level are stated in the Appendix.

(b) *Loud impulsive sounds.* On an interim basis, when loud impulsive sounds, such as explosions or sonic booms, are experienced at a site, the day-night average sound level produced by the loud impulsive sounds alone shall have 8 decibels added to it in assessing the acceptability of the site (see Appendix). Alternatively, the C-weighted day-night average sound level ( $L_{Cdn}$ ) may be used without the 8 decibel addition, as indicated in Section 51.106(a)(3).

Methods for assessing the contribution of loud impulsive sounds to day-night average sound level at a site and mathematical expressions for determining whether a sound is classed as "loud impulsive" are provided in the Appendix.

(c) *Exterior standards.* The degree of acceptability of the noise environment at a site is determined by the sound levels external to buildings or other facilities containing noise sensitive uses. The standards shall usually apply at a location 2 meters (6.5 feet) from the building housing noise sensitive activities in the direction of the predominant noise source. Where the building location is undetermined, the standards shall apply 2 meters (6.5 feet) from the building setback line nearest to the predominant noise source. The standards shall also apply at other locations where it is determined that quiet outdoor space is required in an area ancillary to the principal use on the site.

The noise environment inside a building is considered acceptable if (a) the noise environment external to the building complies with these standards, and (b) the building is constructed in a manner common to the area or, if of uncommon construction, has at least the equivalent noise attenuation characteristics.

This is because the reverberation effect of sound waves hitting the wall will increase the noise levels at the site. You won't pick this up unless you back off from the wall to measure.

**Site Acceptability Standards**

	Day-night average sound level (in decibels)	Special approvals and requirements
Acceptable _____	Not exceeding 65 dB(1) _____	None
Normally Unacceptable _____	Above 65 dB but not exceeding 75 dB _____	Special Approvals (2) Environmental Review (3) Attenuation (4)
Unacceptable _____	Above 75 dB _____	Special Approvals (2) Environmental Review (3) Attenuation (5)

Notes.—(1) Acceptable threshold may be shifted to 70 dB in special circumstances pursuant to Section 51.105(a)

(2) See Section 51.104(b) for requirements.

(3) See Section 51.104(b) for requirements.

(4) 5 dB additional attenuation required for sites above 65 dB but not exceeding 70 dB and 10 dB additional attenuation required for sites above 70 dB but not exceeding 75 dB. (See Section 51.104(a).)

(5) Attenuation measures to be submitted to the Assistant Secretary for CPD for approval on a case-by-case basis.

**§51.104 Special requirements.**

(a) *Noise attenuation.* Noise attenuation measures are those required in addition to attenuation provided by buildings as commonly constructed in the area, and requiring open windows for ventilation. Measures that reduce external noise at a site shall be used wherever practicable in preference to the incorporation of additional noise attenuation in buildings. Building designs and construction techniques that provide more noise attenuation than typical construction may be employed also to meet the noise attenuation requirements.

(1) *Normally Unacceptable noise zone.* Approvals in this zone require a minimum of 5 decibels additional sound attenuation for buildings having noise-sensitive uses if the day-night average sound level is greater than 65 decibels but does not exceed 70 decibels, or a minimum of 10 decibels of additional sound attenuation if the day-night average sound level is greater than 70 decibels but does not exceed 75 decibels.

(2) *Unacceptable noise zone.* Noise attenuation measures require the approval of the Assistant Secretary for Community Planning and Development (See §51.104(b)(2).)

(b) *Special Approvals and Environmental Review Requirements.* Environmental clearances shall be conducted pursuant to the requirements of HUD's Departmental Policies, Responsibilities and Procedures for Protection and Enhancement of Environmental Quality (38 FR 19182 as amended) or other environmental regulations which may be issued by the Department. The Special Clearance and Environmental Impact Statement (EIS) threshold requirements are hereby modified for all projects proposed in the Normally Unacceptable and Unacceptable noise exposure zones as follows:

(1) *Normally Unacceptable noise zone.* (i) All projects located in the Normally Unacceptable Noise Zone require a Special Environmental Clearance except an EIS is required for a proposed project located in a largely undeveloped area, or where the HUD action is likely to encourage the establishment of incompatible land use in this noise zone.

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Berms and barriers are our first choice because they provide protection for yards, playgrounds, etc. Since outdoor activity is often very important to residents we want to protect the outdoor areas as much as possible.

By definition a barrier must be separate from the building or area it is providing attenuation for. After all barriers are preferred because they improve exterior as well as interior levels. Non-noise sensitive buildings can, however, be used as barriers for noise sensitive buildings or exterior areas.

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Assumption is that standard construction provides an average of 20 L<sub>dn</sub> attenuation. At 65 L<sub>dn</sub> or below this amount of attenuation would be sufficient to meet interior level of 45 L<sub>dn</sub>. Additional requirements are designed to meet this goal even when exterior noise levels are higher.

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Substitute Environmental Assessment (with ECO concurrence) wherever you see Special Clearance.

(ii) When an EIS is required, the concurrence of the Regional Administrator is also required before a project can be approved. For the purposes of this paragraph, an area will be considered as largely undeveloped unless the area within a 2-mile radius of the project boundary is more than 50 percent developed for urban uses and infrastructure (particularly water and sewers) is available and has capacity to serve the project.

(iii) All other projects in the Normally Unacceptable zone require a Special Environmental Clearance, except where an EIS is required for other reasons pursuant to HUD environmental policies.

(2) *Unacceptable noise zone.* An EIS is required prior to the approval of projects with unacceptable noise exposure. Projects in or partially in an Unacceptable Noise Zone shall be submitted through the Regional Administrator to the Assistant Secretary for Community Planning and Development for approval. The Assistant Secretary may waive the EIS requirement in cases where noise is the only environmental issue and no outdoor sensitive activity will take place on the site. In such cases, a Special Environmental Clearance is required.

#### §51.105 Exceptions.

(a) *Flexibility for non-acoustic benefits.* Where it is determined that program objectives cannot be achieved on sites meeting the acceptability standard of 65 decibels, the Acceptable Zone may be shifted to  $L_{dn}$  70 on a case-by-case basis if all the following conditions are satisfied:

(1) The project does not require an Environmental Impact Statement under provisions of section 104(b)(1) and noise is the only environmental issue.

(2) The project has received a Special Environmental Clearance and has received the concurrence of the Environmental Clearance Officer.

(3) The project meets other program goals to provide housing in proximity to employment, public facilities and transportation.

(4) The project is in conformance with local goals and maintains the character of the neighborhood.

(5) The project sponsor has set forth reasons, acceptable to HUD, as to why the noise attenuation measures that would normally be required for new construction in the  $L_{dn}$  65 to  $L_{dn}$  70 zone cannot be met.

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When the area in question is in a small community outside an SMSA and the application of the 2 mile radius rule would be unreasonable, an area can be considered largely developed if it is contiguous to existing development and infrastructure is available and has capacity to serve the project. The Assistant Secretary will review them on a case-by-case basis. In all other cases the 2 mile radius/50% rule still applies.

Caution—every effort should be made to get official contours—particularly for military installations and large air carrier airports rather than trying to use the *Noise Assessment Guidelines*.

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What this really means is that the 5db attenuation requirement for the 65-70  $L_{dn}$  zone is waived. Primarily intended for urban areas where alternative sites are not available. Note that *all* conditions must be met.

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These requirements are very important. Be careful with design hour values.

(6) Other sites which are not exposed to noise above  $L_{dn}$  65 and which meet program objectives are generally not available.

The above factors shall be documented and made part of the project file.

#### §51.106 Implementation.

(a) *Use of available data.* HUD field staff shall make maximum use of noise data prepared by others when such data are determined to be current and adequately projected into the future and are in terms of the following:

(1) *Sites in the vicinity of airports.* The noise environment around airports is described sometimes in terms of Noise Exposure Forecasts, abbreviated as NEF or, in the State of California, as Community Noise Equivalent Level, abbreviated as CNEL. The noise environment for sites in the vicinity of airports for which day-night average sound level data are not available may be evaluated from NEF or CNEL analyses using the following conversions to DNL:  
DNL = NEF + 35  
DNL = CNEL

(2) *Sites in the vicinity of highways.* Highway projects receiving Federal aid are subject to noise analyses under the procedures of the Federal Highway Administration.

Where such analyses are available they may be used to assess sites subject to the requirements of this standard. The Federal Highway Administration employs two alternate sound level descriptors: (a) The A-weighted sound level not exceeded more than 10 percent of the time for the highway design hour traffic flow, symbolized as  $L_{10}$ ; or (b) the equivalent sound level for the design hour, symbolized as  $L_{eq}$ . The day-night average sound level may be estimated from the design hour  $L_{10}$  or  $L_{eq}$  values by the following relationships, provided heavy trucks do not exceed 10 percent of the total traffic flow in vehicles per 24 hours and the traffic flow between 10 p.m. and 7 a.m. does not exceed 15 percent of the average daily traffic flow in vehicles per 24 hours:

DNL =  $L_{10}$  (design hour) - 3 decibels  
DNL =  $L_{eq}$  (design hour) decibels

Where the auto/truck mix and time of day relationships as stated in this Section do not exist, the HUD Noise Assessment Guidelines or other noise analysis shall be used.

(3) *Sites in the vicinity of installations producing loud impulsive sounds.* Certain Department of Defense Installations produce loud impulsive sounds from artillery firing and bombing practice ranges. Noise analyses for these facilities sometimes encompass sites that may be subject to the requirements of this standard. Where such analyses are available they may be used on an interim basis to establish the acceptability of sites under this standard.

The Department of Defense uses day-night average sound level based on C-weighted sound level, symbolized  $L_{Cdn}$ , for the analysis of loud impulsive sounds. Where such analyses are provided, the 8 decibel addition specified in 51.103(b), is not required, and the same numerical values of day-night average sound level used on an interim basis to determine site suitability for non-impulsive sounds apply to the  $L_{Cdn}$ .

(4) *Use of areawide acoustical data.* HUD encourages the preparation and use of areawide acoustical information, such as noise contours for airports. Where such new or revised contours become available for airports (civil or military) and military installations they shall first be referred to the Regional Office (Environmental Clearance Officer) for review, evaluation and decision on appropriateness for use by HUD. The Regional Office shall submit revised contours to the Assistant Secretary of Community Planning and Development for review, evaluation and decision whenever the area affected is changed by 20 percent or more, or whenever it is determined that the new contours will have a significant effect on HUD programs, or whenever the contours are not provided in a methodology acceptable under §51.106(a)(1) or in other cases where the Regional Office determines that Headquarters review is warranted. For other areawide acoustical data, review is required only where existing areawide data are being utilized and where such data have been changed to reflect changes in the measurement methodology or underlying noise source assumptions.

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Contours for future noise levels based on new construction, mission changes etc. which become available as part of the Environmental Impact Statement process shall not be used until the NEPA process is complete and a decision on the proposed action is made.

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When new or revised contours are approved, make sure all interested people in local area are informed that HUD will be using different contours. Make a special effort to inform the most active developers in area or developers who have worked with HUD before.

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This is also required for noise studies for developers by consultants, whether to provide original data, or to contest existing data or a HUD analysis. It is particularly important to make sure the same traffic, vehicle or operational data were used for each study, when one study is being contested.

Requests for determination on usage of new or revised areawide data shall include the following:

(i) Maps showing old, if applicable, and new noise contours, along with brief description of data source and methodology.

(ii) Impact on existing and prospective urbanized areas and on development activity.

(iii) Impact on HUD-assisted projects currently in processing.

(iv) Impact on future HUD program activity. Where a field office has determined that immediate approval of new areawide data is necessary and warranted in limited geographic areas, the request for approval should state the circumstances warranting such approval. Actions on proposed projects shall not be undertaken while new areawide noise data are being considered for HUD use except where the proposed location is affected in the same manner under both the old and new noise data.

(b) *Site assessments.* Compliance with the standards contained in §51.103(c) shall, where necessary, be determined using noise assessment guidelines, handbooks, technical documents and procedures issued by the Department.

(c) *Variations in site noise levels.* In many instances the noise environment will vary across a site, with portions of the site being in an Acceptable noise environment and other portions in a Normally Unacceptable noise environment. The standards in §51.103(c) shall apply to the portions of a building or buildings used for residential purposes and for ancillary noise sensitive open spaces.

(d) *Noise measurements.* Where noise assessments result in a finding that the site is borderline or questionable, or is controversial, noise measurements may be performed. Where it is determined that noise measurements are required, such measurements will be conducted in accordance with methods and measurement criteria established by the Department. Locations for noise measurements will depend on the location of noise sensitive uses that are nearest to the predominant noise source (see §51.103(c)).

(e) *Projections of noise exposure.* In addition to assessing existing exposure, future conditions should be projected. To the extent possible, noise exposure shall be projected to be representative of conditions that are expected to exist at a time at least 10 years beyond the date of the project or action under review.

(f) *Reduction of site noise by use of berms and/or barriers.* If it is determined by adequate analysis that a berm and/or barrier will reduce noise at a housing site, and if the barrier is existing or there are assurances that it will be in place prior to occupancy, the environmental noise analysis for the site may reflect the benefits afforded by the berm and/or barrier.

In the environmental review process under §51.104(b), the location height and design of the berm and/or barrier shall be evaluated to determine its effectiveness, and impact on design and aesthetic quality, circulation and other environmental factors.

**Appendix to Subpart B—definition of acoustical quantities**

1. *Sound Level.* The quantity in decibels measured with an instrument satisfying requirements of American National Standard Specification for Type 1 Sound Level Meters S1.4-1971. Fast time-averaging and A-frequency weighting are to be used, unless others are specified. The sound level meter with the A-weighting is progressively less sensitive to sounds of frequency below 1,000 hertz (cycles per second), somewhat as is the ear. With fast time averaging the sound level meter responds particularly to recent sounds almost as quickly as does the ear in judging the loudness of a sound.

(2) *Average Sound Level.* Average sound level, in decibels, is the level of the mean-square A-weighted sound pressure during the stated time period, with reference to the square of the standard reference sound pressure of 20 micropascals.

When projections for airports are based on new construction or similar actions the likelihood that such major action will actually take place should be carefully evaluated. This is particularly important if local funding is required. Check to see if initial actions such as land purchases, bonds etc. been taken. If projections are just based on expanded traffic levels make sure they are reasonable for the area. Projections for smaller communities are often overly optimistic.

This provision should be used with caution. Very clear and strong assurances that berms or barriers will be constructed should be obtained in writing before approval.

Again also note that by definition a barrier must be physically separate from the building or area it is providing attenuation for.

The *Noise Assessment Guidelines* contain procedures for evaluating barrier effectiveness.

$$L_{\text{eq}} = 10 \log_{10} \left[ \frac{1}{86400} \left( \int_{0000}^{0700} 10 [L_A(t) + 10] 10 dt + \int_{0700}^{2200} 10 L_A(t) 10 dt + \int_{2200}^{2400} 10 [L_A(t) + 10] 10 dt \right) \right]$$

Time *t* is in seconds, so the limits shown in hours and minutes are actually interpreted in seconds.  $L_A(t)$  is the time varying value of A-weighted sound level, the quantity in decibels measured by an instrument satisfying requirements of American National Standard Specification for Type 1 Sound Level Meters S1.4-1971.

3. **Loud Impulsive Sounds.** When loud impulsive sounds such as sonic booms or explosions are anticipated contributors to the noise environment at a site, the contribution to day-night average sound level produced by the loud impulsive sounds shall have 8 decibels added to it in assessing the acceptability of a site.

A loud impulsive sound is defined for the purpose of this regulation as one for which:

(i) The sound is definable as a discrete event wherein the sound level increases to a maximum and then decreases in a total time interval of approximately one second or less to the ambient background level that exists without the sound; and

(ii) The maximum sound level (obtained with slow averaging time and A-weighting of a Type 1 sound level meter whose characteristics comply with ANSI S1.4-1971) exceeds the sound level prior to the onset of the event by at least 6 decibels; and

(iii) The maximum sound level obtained with fast averaging time of a sound level meter exceeds the maximum value obtained with slow averaging time by at least 4 decibels.

Issued at Washington, D.C., on July 5, 1979.

Patricia Roberts Harris,  
Secretary of Housing and Urban  
Development.

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am]

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## Quiz on the Noise Regulations

### Questions

1. What is the HUD policy on support for existing construction in high noise areas?
2. What is the definition of "major or substantial rehabilitation"?
3. What is HUD's interior noise goal?
4. What project approval authority does the Field Office have?
5. Who approves projects in the Unacceptable Zone?
6. What noise descriptor is used to express noise levels in the regulation?

7. How are loud impulsive sounds to be evaluated?

8. At what point on a building's exterior are sound levels to be determined?

9. What is the basic assumption behind the attenuation levels required?

10. What type of attenuation measures are preferred?

11. When should building attenuation measures be considered?

12. When are EIS's required?

13. When is an area considered "largely undeveloped"?

14. What is "Flexibility for Non-Acoustic Benefits"?

15. Six conditions are listed for waiving the attenuation requirement under the Flexibility for Non-Acoustic Benefits provision, how many must be met for the waiver to be granted?

16. Who has the authority to grant the attenuation requirements waiver under the "flexibility" provision?

17. What noise descriptors other than DNL are acceptable for aircraft noise contours?

18. Who normally approves areawide noise data such as airport noise contours?

19. If a site is partially in the Unacceptable Zone and partially in the Normally Unacceptable Zone, which review and approval procedures apply?

20. When should noise measurements be used in lieu of areawide data or *Noise Assessment Guidelines* calculations?

## Quiz on the Noise Regulations

### Answers

14. A provision in the regulations which allows the attenuation requirements for the 65-70  $L_{dn}$  zone to be waived. (Section 51.105(a) and marginal note)
15. All six conditions must be met. (Section 51.105(a))
16. The field office. (Section 51.102(a))
17. NEF and CNEL. (Section 51.106(a)(1))
18. The Regional Office. (Section 51.106(a)(4))
19. The review and approval procedures for projects in the Unacceptable Zone apply. (Section 51.104(b)(2))
20. Only when the noise assessment indicates that the site is on the borderline between Acceptable and Unacceptable, or when the site is controversial. (Section 51.106(d))

1. Noise exposure can not, by itself, be the basis for denying support for resale and purchase of existing buildings. (Section 51.101(a)(4))
2. "Major or substantial rehabilitation" is defined in individual program guidance. There is no single definition. (51.101(a)(5) marginal note)
3. 45  $L_{dn}$  (Section 51.101(a)(9))
4. projects in Acceptable Zone; also projects in Normally Unacceptable Zone provided that
- adequate sound attenuation is provided
- no EIS is required (Section 51.102(a)(1))
5. The Assistant Secretary for Community Planning and Development. (Section 51.102(A)(3) and 51.104(b))
6. The day night average sound level system (DNL). (Section 51.103(a))
7. Two ways:
  - If plain DNL levels have been calculated or measured, add a 8 decibel penalty.
  - Alternatively, the C weighted day night average sound level system ( $L_{CN}$ ) can be used as is. (Section 51.103(b))
8. Two meters (6.5 feet) away from the building exterior, moving towards the predominant noise source. (Section 51.103(c))
9. That current construction practices provide about 20 db attenuation. Thus in a 65  $L_{dn}$  or lower area the interior goal of 45  $L_{dn}$  would be met with standard construction. The additional attenuation required is the increment over that provided by standard construction necessary to achieve the interior goal of 45  $L_{dn}$ . (Section 51.104(a) marginal note)
10. Measures which reduce exterior noise levels. (51.104(a))
11. Only after it has been determined that berms and barriers or site redesign are not practical alternatives. (Section 51.104(a))
12. When the project is located in the Unacceptable Zone or the project is located in a largely undeveloped area and the project is in the Normally Unacceptable Zone. (Section 51.104(b))
13. When the area within a 2 mile radius of the project is less than 50% developed for urban uses and intrasuburban is not in place and available to serve the project. (Section 51.104(b)(1)(iii))

## Chapter 3

### Major Policy and Implementation Questions Related to the Noise Regulation

As regulations are applied in the field, it is inevitable that questions will arise. It is, after all, very difficult to anticipate every situation when preparing a regulation. Sometimes the questions relate to specific and unique situations of limited interest to anyone but the office involved. Other questions, however, raise issues of more general concern. In this section we have brought together the most important and most relevant questions that have arisen since the noise regulation went into effect in August of 1979. We have used a question and answer format for your convenience.

The following are the topics included:

1. Noise projections for civil airports
2. Definition of infill for small towns
3. Areawide EIS waivers
4. Requirements for modernization and rehabilitation projects
5. Use of berms and barriers as attenuation measures
6. New and revised airport noise contours

### Questions and Answers

1. How valid and useful are civil airport noise projections that show significant reductions in the amount of land exposed to high noise levels? Should we be suspicious?

Contours that show significant reductions in the area exposed to high noise levels may seem questionable, but, according to the Environmental Protection Agency, they may be quite accurate. The EPA does expect to see some significant reductions in the number of people exposed to high levels of aircraft noise over the next 15 years. In their report *Aviation Noise: The Next Twenty Years*, EPA stated that they expected to see the number of people exposed to levels of 65 Ldn or greater to drop from a 1975 figure of 5,550,000 to about 2,650,000 in the year 2000. Much of this reduction would occur during the period 1980-1985 with more modest decreases thereafter. The reductions are expected to result from the Federal Aviation Administration's current noise certification requirements, even with up to 100% increases in aircraft operations. (Current certification requirements are for all new aircraft to achieve stage three noise levels and all older aircraft to achieve stage two levels by 1985. Progress has been good in meeting these requirements.)

In general then, you should not be surprised to see significant reductions in contour size if the following conditions are met:

- the decrease in size is no more than 50%;
- the increase in operations is no more than 100%; and
- FAR stage 3 aircraft, such as the B757 and B767, are included in the fleet mix, but not to the total exclusion of all other aircraft. Assuming that the contours are otherwise technically correct, significantly smaller contours should be acceptable.

2. Many small towns aren't big enough for a project to meet the definition of infill contained in section 51.104 (b)(1)(II). However, a project located in the heart of town can hardly be considered to be in a largely undeveloped area. Must an EIS be prepared?

Not necessarily. If the jurisdiction in which the project is located is not part of a standard metropolitan area, a project may be considered infill if it is within or contiguous to the already developed area and infrastructure (particularly water and sewer) is available and has the capacity to serve the project. It must also be clear that the project will not encourage the establishment of other incompatible land uses in the normally unacceptable noise zone.

If you believe a project meets these criteria, submit documentation to the Office of Environment and Energy for their review and determination.

3. What can we do to reduce the procedural burden when, for a variety of reasons, the Department expects to be considering a number of projects in an unacceptable noise zone? Most of the projects would probably qualify for an EIS waiver, but how can we avoid filing repetitive, individual requests?

While the number of cases where the Department would be seriously considering a number of projects exposed to unacceptable noise levels in the same jurisdiction is likely to be limited, there is an alternative to individual processing in those situations. The alternative is to issue an areawide waiver for the entire affected jurisdiction. Such a waiver can be useful when the unacceptable noise zone heavily impacts a substantially developed community with limited site alternatives. (In most cases we would expect that the noise source would be aircraft, but in very small towns it is possible that a heavily used rail line could create a large unacceptable noise zone.)

An areawide EIS waiver would, of course, have to have a more detailed environmental assessment than an individual project request, and there are other special processing steps.

But if you have a situation where you think the Department has a good reason to expect to process a number of projects within the unacceptable noise zone, there is an alternative to individual EIS waivers. Contact the Office of Environment and Energy for details on how to request the areawide waiver.

4. What exactly are the processing requirements and general policies for modernization and rehabilitation projects? Does section 51.104 apply to them as well as to new construction? The noise regulation is a bit confusing on this.

Yes, the noise regulation is a bit confusing on this question. We have seen several instances where field offices have mistakenly applied the provisions of Section 51.104 to modernization and rehabilitation projects. We believe that this happens because section 51.104 is not as clearly titled as it might have been. It would be better if it read "special requirements for new construction" rather than simply "special requirements".

The only parts of the regulation that apply to modernization and rehabilitation projects are sections 51.101 (a)(5) and the definitions of normally unacceptable and unacceptable noise zones contained in the table in section 51.103. None of the other processing or policy provisions of the table or of sections 51.102 and 51.104 apply. Therefore:

- modernization and rehabilitation projects are to be processed by the field offices regardless of the noise zone.

- EIS's are not required for modernization and rehabilitation projects unless mandated by other applicable environmental regulations.

You must however continue to encourage attenuation features in modernization and rehabilitation projects, in accordance with the general policy stated in section 51.101(a)(5).

5. We know that berms and barriers are the preferred type of noise attenuation because of the protection they provide for outdoor living areas, but we need some further guidance on when they are really the best choice.

While barriers can be an effective noise attenuation technique, they must, indeed, be used with caution and common sense because they can create more problems than they solve. Very high noise barriers can create significant aesthetic and financial problems relative to the noise benefit to be achieved. Barriers can block light, hinder natural ventilation, create an unpleasant sense of being walled in, and can be very unattractive. In addition, barriers do require continuing maintenance and can be very costly to build.

It is important to remember that the noise regulation says that "measures that reduce external noise at a site shall be used wherever practicable." Is it practicable to propose a 20 foot high barrier only 15 feet from the rear of a two-story building? Granted it would certainly protect the building from noise, but what about the blocked light, the reduced ventilation, the visual impact, and the cost? The purpose of a barrier is primarily to reduce the noise levels in those outdoor areas that people use. The secondary purpose is to reduce the need for structural attenuation. Therefore, the barrier should only be as high as is necessary to protect those areas. Structural attenuation should be required for the parts of the building not protected by the barrier. And if there aren't any outdoor areas where low noise levels are important, barriers shouldn't be required unless they would be more cost effective than building attenuation measures.

6. What should we be doing once we have processed new or revised aircraft noise contours and they have been approved for use?

The most important thing you can do once new or revised aircraft noise contours have been approved for use is to tell the people who are most likely to be affected by the change. If you have a newsletter that you regularly publish, that is one way to get the word out. At the very least you should specifically notify the affected jurisdictions and the builders/developers who are known to be active in the vicinity of the noise impacted areas. Make sure you notify builders and developers who have large scale projects that you have been processing in sections. Go back and check your files to find them. Even though you should have done an overall environmental review of the project at the time the first section was submitted, the approval of individual sections is dependent on the noise levels at the time that section is submitted.

## Chapter 4 Noise Attenuation

### Introduction

HUD's noise policy (24 CFR 51B) clearly requires that noise attenuation measures be provided when proposed projects are to be located in high noise areas. The requirements set out in Section 51.104(a) are designed to insure that interior levels do not exceed the  $45 L_{dn}$  level established as a goal in Section 51.101(a)(9). Thus, in effect, if the exterior noise level is  $65 L_{dn}$  to  $70 L_{dn}$ , 25 db of noise attenuation must be provided; if the exterior noise level is between 70 and  $75 L_{dn}$ , then 30 db of attenuation is required. Likewise, for projects proposed for areas where noise levels exceed  $75 L_{dn}$ , sufficient attenuation must be provided to bring interior levels down to  $45 L_{dn}$  or below.

There are three basic ways to provide the noise attenuation required:

1. the use of barriers or berms
2. site design
3. acoustical construction

Of these, only the first two provide any improvement in the exterior environment. Because HUD considers a quiet exterior environment to be important, we prefer the use of those measures that reduce exterior levels as well as interior levels. The use of acoustical construction by itself is, therefore, the least preferred alternative since it only affects the interior levels. While we recognize that in many cases barriers or site design cannot provide all the attenuation necessary, you should combine them with acoustical construction whenever possible.

Your responsibility as a HUD staff member is to:

- make sure the project sponsor or developer is aware of the attenuation requirements for the project.
- make the sponsor aware of the options available and
- review attenuation proposals to make sure they are adequate.

While it is not your responsibility to provide detailed design assistance to the sponsor or developer, you should know enough about the attenuation options to give him or her a basic understanding of what must be done. In many cases, you may be able to reassure the sponsor or developer that the necessary attenuation can be achieved through the use of common construction techniques or materials. Or you may be able to point out how a simple site design change can achieve the desired result without additional cost.

The following sections are designed to provide you with the information you will need to fulfill your responsibilities. Each attenuation approach is discussed both in terms of basic concepts and in terms of what to look for in reviewing attenuation proposals. The discussion does assume that you have a working knowledge of the *Noise Assessment Guidelines*. If you have not worked with the *Guidelines* before or not recently you may want to go back and review them, particularly the section on calculating the effects of barriers.

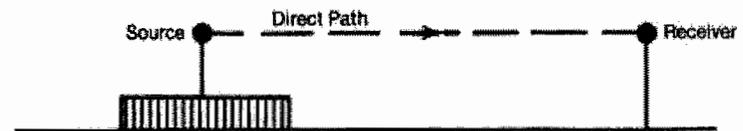
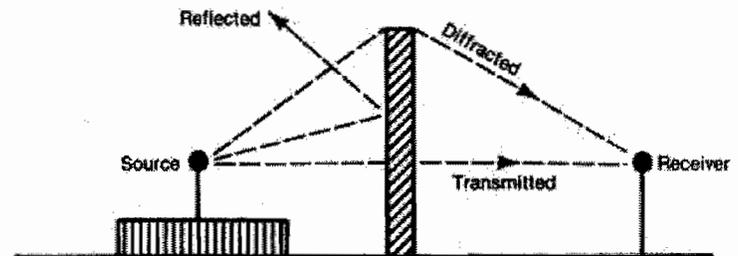
### Barrier Noise Reduction Concepts

(The following, with some editing and with some additional graphics, is taken from the Federal Highway Administration's *Noise Barrier Design Handbook*.<sup>1</sup>)

When no obstacles are present between [a source] and adjoining areas, sound travels by a **direct path** from the "sources" ... to [the] "receivers" ..., as shown in Figure 1. Introduction of a barrier between the source and receiver redistributes the sound energy into several [indirect] paths: a **diffracted path**, over the top of the barrier; a **transmitted path**, through the barrier; and a **reflected path**, directed away from the receiver. These paths are also illustrated in Figure 1.

<sup>1</sup>*Noise Barrier Design Handbook* US Department of Transportation, Federal Highway Administration, February 1976. (FHWA-RD-76-58).

Figure 1  
Alteration of Noise  
Paths by a Barrier



## Barrier Diffraction and Attenuation

Consider an infinitely long, infinitely massive noise barrier placed between a highway and the receiver. Figure 2 illustrates a cross-section through such a configuration. [In] this example, the only way that sound can reach the receiver is by bending over the top of the barrier; as shown in the figure. The bending of sound waves in this manner over an obstacle is known as diffraction. The area in which diffraction occurs behind the barrier is known as the "shadow zone." The straight path from the source over the top of the barrier forms the boundary of this zone.

All receivers located in the shadow zone will experience some sound attenuation; the amount of attenuation is directly related to the magnitude of the diffraction angle  $\phi$ . As  $\phi$  increases, the barrier attenuation increases. The angle  $\phi$  will increase if the barrier height increases, or if the source or receiver are placed closer to the barrier. Clearly then the barrier attenuation is a function of the geometrical relationship between the source, receiver, and barrier. One way of relating these parameters to the barrier attenuation is to define the path-length difference as shown in Figure 3. This parameter is the difference in distance that the sound must travel in diffracting over the top of the barrier rather than passing directly through it.

In the preceding discussion it was assumed that the barrier was "infinite"; i.e., long enough to shield the receiver from all sound sources up and down the highway. For short barriers, the attenuation can be seriously limited by the sound from sections of highway beyond the barrier's ends, which are unshielded from the receiver, as shown in Figure 4. Similarly, when there are large gaps in the barrier (to permit access, for example), sound from the unshielded section of highway adjacent to the gap can greatly compromise barrier attenuation, especially for those receivers close to the opening.

Figure 2  
Barrier Diffraction

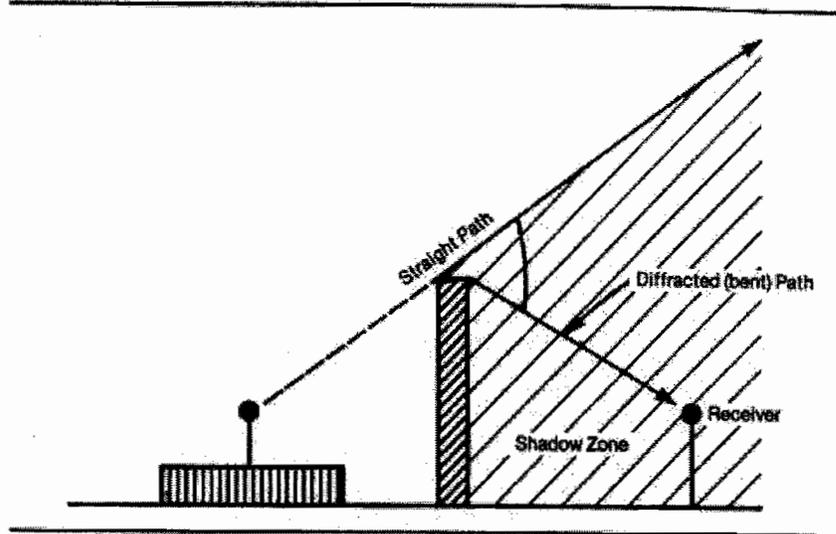


Figure 3  
Path Length  
Difference  $\delta = A + B - d$

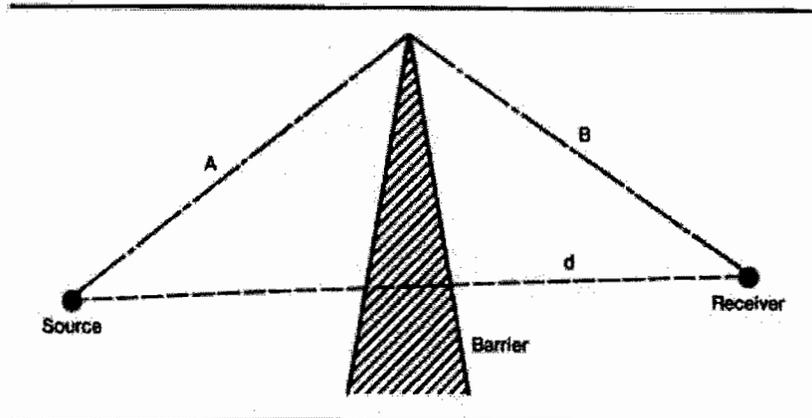
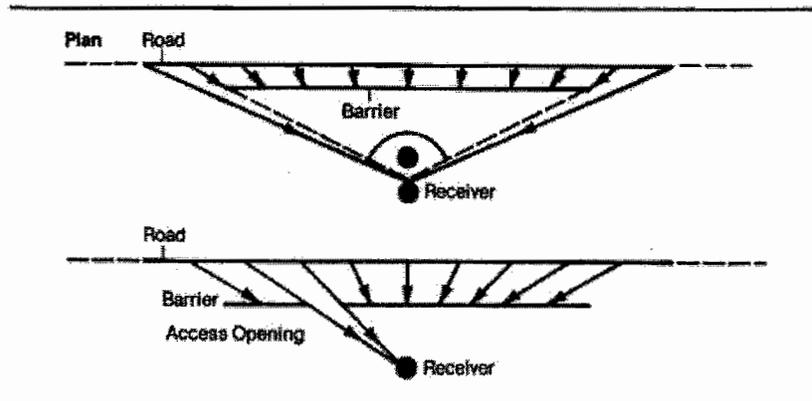


Figure 4  
Short-circuit of Barrier Around Ends  
and Through Openings



## Barrier Transmission

In addition to the sound that travels over the top of the barrier to reach the receiver, sound can travel through the barrier itself. The amount of sound "transmission" through the barrier depends upon factors relating to the barrier material (such as its weight and stiffness), the angle of incidence of the sound, and the frequency spectrum of the sound. One way of rating a material's ability to transmit noise is by the use of a quantity known as the transmission loss, TL. The TL is related to the ratio of the incident noise energy to the transmitted noise energy. Transmission loss values are normally expressed in decibels and represent the amount noise levels will be reduced when the sound waves pass through the material. The higher the TL value the less noise transmitted through the material. Typically, the TL value improves with increasing surface weight of the material.

The noise reduction provided by a barrier can be severely compromised if the TL value of the material permits too much noise to pass through the barrier. This is due to the fact that when attenuation is a function of two or more factors, the noise level at the measurement point is actually the combination of the reduced noise levels resulting from each attenuation factor. For example, with a typical barrier the noise levels are reduced by (1) sound waves being diffracted over the barrier and (2) sound waves passing through the barrier. The noise level at the receiver point is the combination of the attenuated levels resulting from each attenuation step. If the starting noise level is 85 db and the noise level is reduced 10 db when the sound waves pass through the barrier then the attenuated level reaching the receiver is 55 db. If the attenuation provided by the sound waves being diffracted over the barrier is also 10 db then the attenuated level reaching the receiver along that path is 55 db as well. Using the table in the *Noise Assessment Guidelines* to combine the two individual attenuated levels, one finds that the combined attenuated level is actually 58 db. Thus even though the attenuation value of each attenuation step was 10 db, the actual reduction for the receiver is only 7 db. It is, however, a function of the way noise levels combine that if the difference between levels is greater than 10 db it does not affect the levels. As a general rule, therefore, if the TL value

is at least 10 dB above the attenuation value resulting from diffraction over the top of the barrier, the barrier noise reduction will not be significantly affected by transmission through the barrier (decreased by less than 0.5 dB). For many common materials used in barrier construction, such as concrete and masonry blocks, TL values are usually more than adequate. For less massive materials such as steel, aluminum and wood, TL values may not be adequate, particularly for those cases where large attenuations are required. (See Table 1 for a list of typical TL values.)

Even if a barrier material is massive enough to prevent significant sound transmission, the barrier noise reduction can be severely compromised if there are holes or openings in the barrier. For large openings, sound energy incident on the barrier will be directly transmitted through the opening to the receiver. When the opening is small an additional phenomenon occurs: upon striking the barrier wall the sound pressure will increase, resulting in an amplification of the transmitted sound to the receiver. Thus, the presence of openings or holes may seriously degrade the noise reduction provided by otherwise effective barriers.

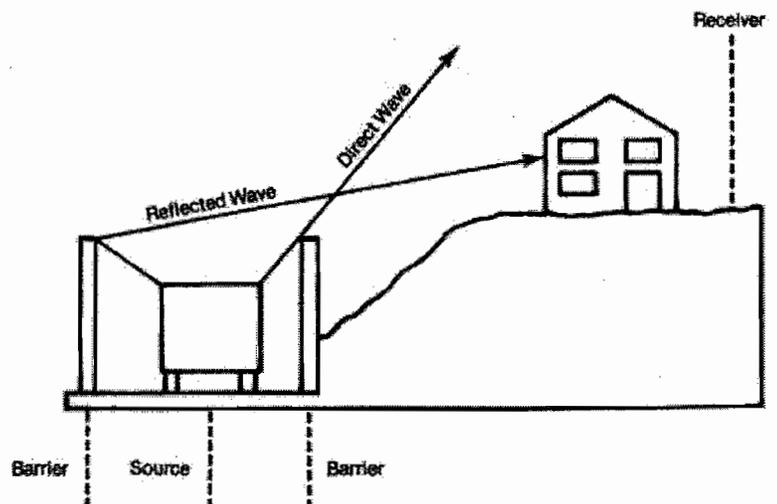
## Barrier Reflections

As shown in Figure 1, sound energy can be reflected by a barrier wall. For the configuration shown in that figure, the reflected energy does not affect the receiver, but may affect receivers located to the left of the highway. However the increase in noise level for these receivers would be less than 3 dB, because this single reflection can at most double the sound energy. (Remember how you combine noise levels? The most you add is 3 db when levels are the same.)

The situation is entirely different, however, when a double barrier situation is involved (refer to Figure 5). In addition to the energy that reaches the receiver by diffraction over the top of the barrier, if the barrier walls are reflective, additional sound energy can reach the receiver by a reflection from the left wall as illustrated in the figure. The same principles apply when there is a vertical retaining wall opposite a noise barrier; similarly, in a deep vertical cut the opposite walls will create multiple reflections.

If the barrier walls are not perfectly reflecting but absorb some of the sound energy, the contribution of each reflection is decreased by an amount that depends upon the absorptive characteristics of the barrier. For very hard, reflective surfaces, the absorption characteristics are very poor. Although a serious degradation in barrier performance may result for the double barrier situation, use of materials with good absorption values will usually recover all of the lost noise reduction.

Figure 5.  
Reflections from an  
Opposing Barrier



It should be mentioned that the use of barrier walls with sloped sides (forming angles of greater than 10–15 degrees from the vertical) will also generally eliminate multiple reflections. Use of earth berms is particularly appropriate to accomplish this. Sloped barrier walls will require more material to achieve a desired height than a vertical wall, while berms will require greater right-of-way than a thin wall.

### Ground Effects

Consider again the direct path of sound from the source to receiver as illustrated in Figure 1 in the absence of any obstacles. For sources and receivers located close to the ground, in addition to this direct path sound energy may reach the receiver by reflecting off the ground. When the terrain is relatively hard and flat, such a reflection will add to the noise from the direct path to increase the level at the receiver. However, when the ground is soft, there may be a phase reversal upon reflection such that the noise from the ground reflection path will destructively interfere with the noise from the direct path resulting in a significant reduction in noise levels at the receiver.

This reduction in level, known as ground-effect attenuation, is in excess of the 3 dB per doubling of distance propagation loss for a line source of noise and occurs only above soft absorptive ground (such as normal earth and most ground with vegetation). Over hard ground (such as concrete, stone and very hard-packed earth) these effects do not occur. These effects are most apparent for receivers on the ground floor, and decrease rapidly as receiver height above ground increases.

While ground absorption effects are not completely understood, it is generally believed that these effects account for the 4.5 dB per doubling of distance propagation loss observed over soft ground, as compared to the 3 dB propagation loss observed over hard ground. The implication with regard to barrier design is that placement of a barrier over soft ground between source and receiver will re-direct the sound over the top of the barrier, thus destroying the ground reflection and the additional 1.5 dB per doubling of distance attenuation. Thus, the barrier must be designed to provide more reduction than would otherwise be necessary, to compensate for the lost ground effects over absorptive ground.

### Summary

(From: *Design Guide*, National Bureau of Standards<sup>1</sup>)

In summary, the following can be said about noise barriers.

- If a barrier does not block the line-of-sight between the source and receiver, the barrier will provide little or no attenuation.
- If a barrier is constructed of a material with a surface weight density greater than 4 lb/ft<sup>2</sup> and there are no openings through the barrier, transmitted sound will usually be negligible.
- If there are openings totaling over 10 percent or more of the barrier area, barrier attenuation will be negligible.
- Diffracted sound is usually the most important aspect in estimating barrier attenuation.
- Reflected sound can be important for receivers on the source side of a barrier, but it normally is not a factor for receivers on the side opposite from the source. Hence reflected sound is usually not important to your building and site.
- Transmission of sound around the ends of the barrier can be critical if the barrier included angle is less than 170°.
- Barrier attenuations greater than an A-weighted sound level difference of 10 dB are difficult to obtain.
- For two or more barriers "in series," consider only the "dominant" barrier.
- Assume no attenuation for a receiver located beyond the end of a barrier.

### Reviewing Barrier Proposals

An effective barrier is one which reduces the noise level behind the barrier to 65 L<sub>dN</sub> or lower. If a barrier can reduce the exterior noise level to 65 L<sub>dN</sub>, then standard construction techniques should be sufficient to insure an interior level of 45 L<sub>dN</sub> or below. Therefore, if you determine that a proposed barrier is adequate to reduce the exterior noise level to 65 L<sub>dN</sub> then no additional attenuation measures should be necessary.

<sup>1</sup>*Design Guide for Reducing Transportation Noise in and Around Buildings*, US Department of Commerce, National Bureau of Standards, April 1978. (Building Science Series 84)

There are four things to check when determining the adequacy of a proposed barrier:

1. Is it high enough?
2. Is it long enough?
3. Is it made of the right materials?
4. Is it properly constructed?

### Is It High Enough?

In order for a barrier to be effective it must be at least high enough to break the line of sight between the source and the receiver. In the *Noise Assessment Guidelines* you will find the procedure for determining how much attenuation is provided by a barrier of a given height.

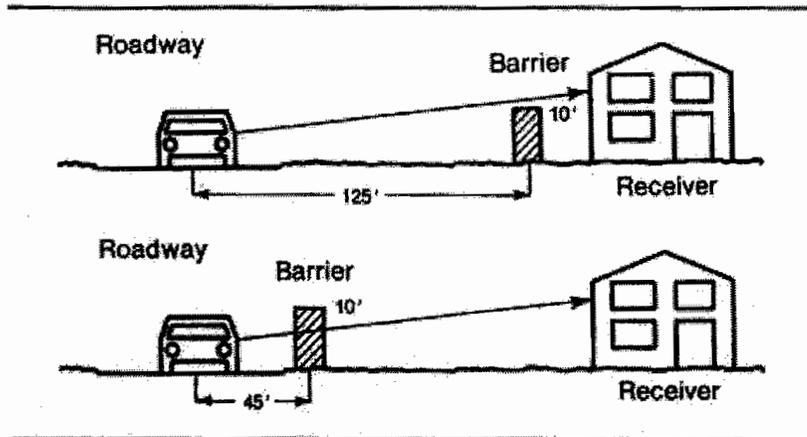
In general, barriers and berms are most effective for one and two story buildings because a relatively low barrier can often provide the attenuation needed. The height that might be required to provide attenuation for much taller buildings is often not feasible for either cost or aesthetic reasons. However, even if a barrier can not be made high enough to attenuate the upper floors of a multistory building, it may still be able to provide some protection for outdoor recreational areas. Before discarding the barrier idea check for this possibility.

If you find that the barrier as proposed is too short to be effective but the sponsor or developer tells you that he or she can not make the barrier any higher, there are some alternatives you can suggest. There are ways to get more attenuation out of each foot of overall height.

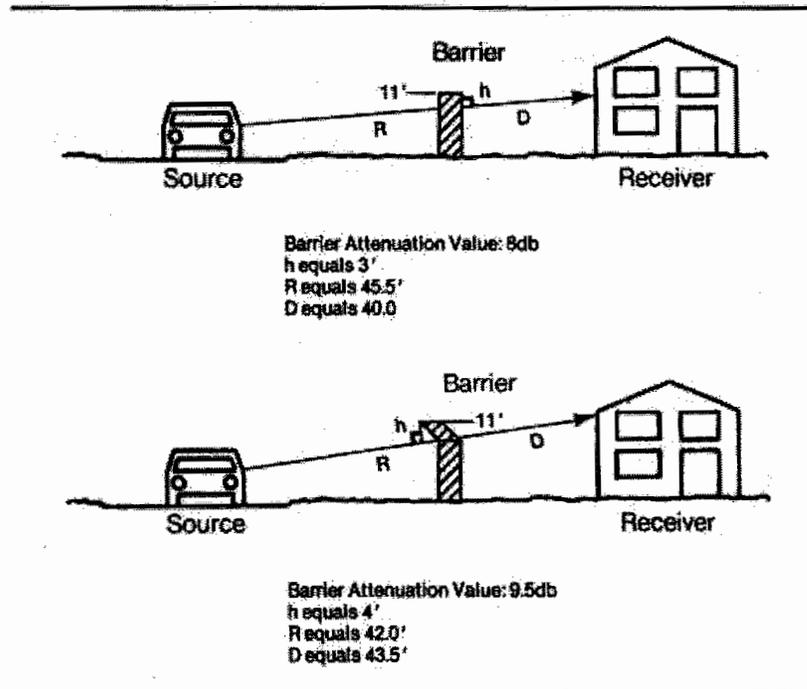
As a general rule, barriers work better the closer they are to the source. Figure 6 shows a barrier that does not block the line of sight at all when it is located next to the receiver, yet is quite tall enough when located next to the source. Thus, if the sponsor or developer can not make the barrier any taller, perhaps he or she can move it closer to the source.

Another way to get more attenuation without increasing overall barrier height is to bend the top of the barrier towards the source. Figure 7 shows a case where a barrier built perfectly straight provides 8 dB of attenuation. A barrier with the same overall height but with a 45 degree bend towards the source provides 9.5 dB of attenuation. Thus if the project sponsor or developer wants to keep the overall height of the barrier down, he or she can still increase the attenuation provided simply by bending the top.

**Figure 6**  
Effect of Moving the Barrier  
Closer to the Source



**Figure 7**  
Effect of Bending the Top of the  
Barrier Towards the Source



Thus, if your review of a proposed barrier shows it to be too short, but it can not be made any higher, suggest that the barrier be moved closer to the source or that it be bent at the top, or both.

**Is It Long Enough?**

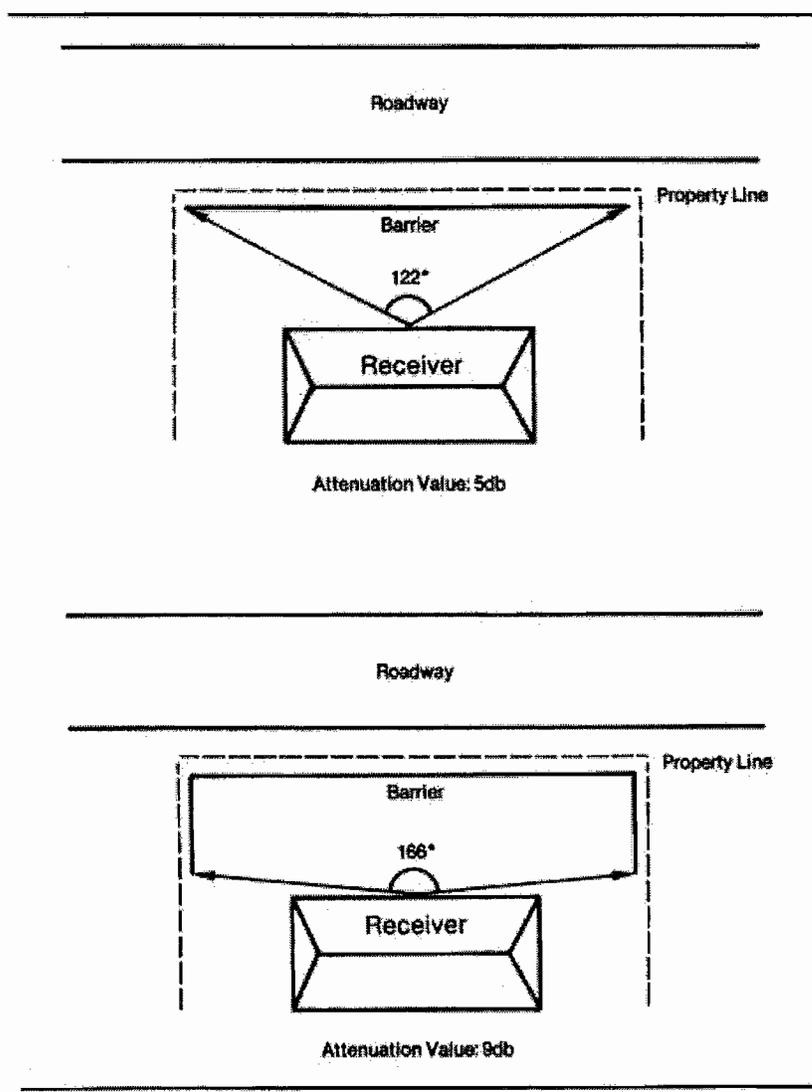
Once you have established how much attenuation the barrier provides due to its height, you must determine if the length of the barrier compromises that attenuation level. Again, the *Noise Assessment Guidelines* contain a procedure for calculating the effect of barrier length.

If you find that the barrier is too short but that there are limitations on how long it can be made, there are, as there were with barrier heights, some recommendations you can make on how to improve the effectiveness of the barrier.

Again, if you bend the edges of the barrier, this time towards the receiver not the source, you will increase the effectiveness of the barrier. Figure 8 shows how much a barrier's effectiveness can be improved by bending the edges.

You can also improve the effectiveness of the barrier by moving it closer to the receiver. Figure 9 shows how much a barrier's effectiveness can be increased by moving it closer to the receiver. Now obviously, this creates a conflict with what we said earlier about moving the barrier closer to the source. Clearly each case will require a different compromise. If height is not a limiting factor but length is, you might recommend to the project sponsor or developer that the barrier be moved closer to receiver and the height increased as necessary. If the reverse is true, you would want to recommend the opposite. If both height and length are limited, then the sponsor or developer must find that optimum point where the effectiveness of both the barrier height and the barrier length is as high as possible.

**Figure 8**  
**Effect of Bending the Edges of Barrier**  
**Towards Receiver**  
**(Both Barriers have Potential Value of 10db)**



**Is It Made of The Right Materials?**

Even if a barrier is high enough and long enough, its effectiveness can be severely reduced if it is made up of lightweight materials that easily transmit sound waves. In the preceding section on barrier concepts we talked about how if the transmission loss value for the barrier material was not at least 10 db higher than the attenuation value of the barrier based on length and height there would be a significant reduction in the effectiveness of the barrier.

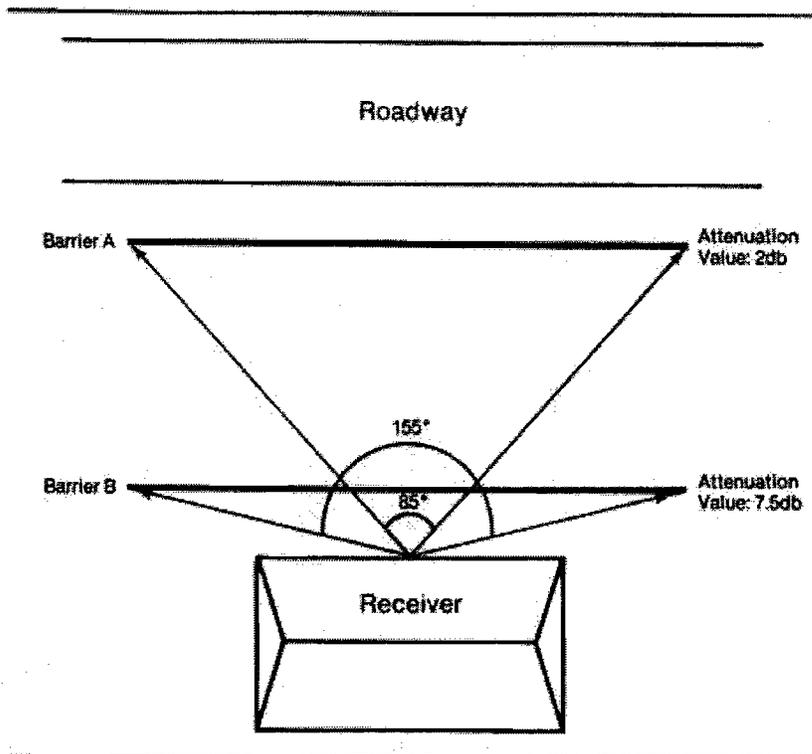
Therefore, once you have calculated the basic attenuation potential of the barrier, you must check to make sure the proper material is being used to build the barrier. Table 1 lists the transmission loss values for materials commonly used in barrier construction. Once you have found the transmission loss value for the material being used, go to Table 2. Read down the column with the transmission loss for the material at its top and across the line that has the attenuation potential for the barrier listed. Where the two intersect you will find the actual attenuation capability of the barrier.

If you find that the choice of material has severely reduced the effectiveness of the barrier, you should recommend that the sponsor or developer select another material.

**Is It Properly Constructed?**

Holes or openings can substantially reduce the effectiveness of a barrier. A barrier that has openings totaling 50% or more of its total area will provide no attenuation. A barrier that has openings totaling 10% of its total area has a maximum attenuation value of approximately 4db. That is 4db no matter how high, how long or how thick the barrier. So you can see that it is very important that the barrier is made of solid materials and that it is tightly constructed. In general the intended openings in a barrier should equal no more than 1% of total area and the construction specifications should require that all joints are tightly sealed.

**Figure 9**  
Effect of Moving Barrier  
Closer to Receiver



**A Final Note**

One thing should have become clear to you as you have been reading this section, and that is that in order for you to adequately review a project sponsor or developer's proposed barrier you must be given fairly specific information about the exact dimensions of the proposed barrier, the type and thickness of the barrier material, and the exact design of the barrier including construction specifications. Without this information you will be unable to do any more than a cursory evaluation, an evaluation that could be far from accurate. Make sure you make it clear to the developer or sponsor what you need to have.

**Table 1**  
Transmission Loss Value for Common  
Barrier Materials

Material	Thickness, (Inches)	Transmission Loss, dBA (1)
<b>Woods</b>		
Fir	1/2	17
	1	20
	2	24
Pine	1/2	16
	1	19
	2	23
Redwood	1/2	16
	1	19
	2	23
Cedar	1/2	15
	1	18
	2	22
Plywood	1/2	20
	1	23
Particle Board	1/2	20
<b>Metals</b>		
Aluminum	1/16	23
	1/8	25
	1/4	27
Steel	24 ga	18
	20 ga	22
	16 ga	15
Lead	1/16	28
<b>Concrete, Masonry, etc.</b>		
Light Concrete	4	36
	6	39
Dense Concrete	4	40
Concrete Block	4	32
	6	36
Cinder Block (Hollow Core)	6	28
Brick	4	33
Granite	4	40
<b>Composites</b>		
Aluminum Faced Plywood	3/4	21-23
Aluminum Faced Particle Board	3/4	21-23
Plastic		
Lamina on Plywood	3/4	21-23
Plastic Lamina on Particle Board	3/4	21-23
<b>Miscellaneous</b>		
Glass (Safety Glass)	1/8	22
	1/4	26
Plexiglass (Shatterproof)		22-25
Masonite	1/2	20
Fiberglass/Resin	1/8	20
Stucco on Metal Lath	1	32
Polyester with Aggregate Surface	3	20-30

<sup>1</sup>A-weighted TL based on generalized truck spectrum. Source: *Noise Barrier Design Handbook*, FHWA

**Table 2**  
**Noise Reduction of a Barrier as a**  
**Function of Its Transmission Loss**

Designed Attenuation, dB (from height) and length)	Transmission Loss, dB of Materials				
	10	15	20	25	30
5	3.8	4.6	4.9	5.0	5.0
6	4.5	5.5	5.8	6.0	6.0
7	5.2	6.4	6.8	6.9	7.0
8	5.9	7.2	7.7	7.9	8.0
9	6.5	8.0	8.7	8.9	9.0
10	7.0	8.8	9.6	9.9	10.0
11	7.5	9.5	10.5	10.8	11.0
12	7.9	10.2	11.4	11.8	11.9
13	8.2	10.9	12.2	12.7	12.9
14	8.5	11.5	13.0	13.7	13.9
15	8.8	12.0	13.8	14.6	14.9
16	9.0	12.5	14.5	15.5	15.8
17	9.2	12.9	15.2	16.7	16.8
18	9.4	13.2	15.9	17.2	17.7
19	9.5	13.5	16.5	18.0	18.7
20	9.6	13.8	17.0	18.8	19.6

Source: *Noise Barrier Design Handbook*, FHWA

## Acoustical Site Planning Concepts

(This section, with some editing, is from *The Audible Landscape*, FHWA.<sup>1</sup>)

The arrangement of buildings on a site can be used to minimize noise impacts. If incompatible land uses already exist, or if a noise sensitive activity is planned, acoustical site planning often provides a successful technique for noise impact reduction.

Many site planning techniques can be employed to shield a residential development from noise. These can include:

1. increasing the distance between the noise source and the receiver;
2. placing noise compatible land uses such as parking lots, maintenance facilities, and utility areas between the source and the

receivers. Playgrounds and parks are not necessarily noise compatible activities.

3. locating barrier-type buildings parallel to the noise source or the highway; and
4. orienting the residences away from the noise.

The implementation of many of the above site planning techniques can be combined through the use of cluster and planned unit development techniques.

### Distance

Noise can be effectively reduced by increasing the distance between a residential building and a highway. Distance itself reduces sound: doubling the distance from a noise source can reduce its intensity by as much as 3 dBA. In the case of highrise buildings, distance may be the only

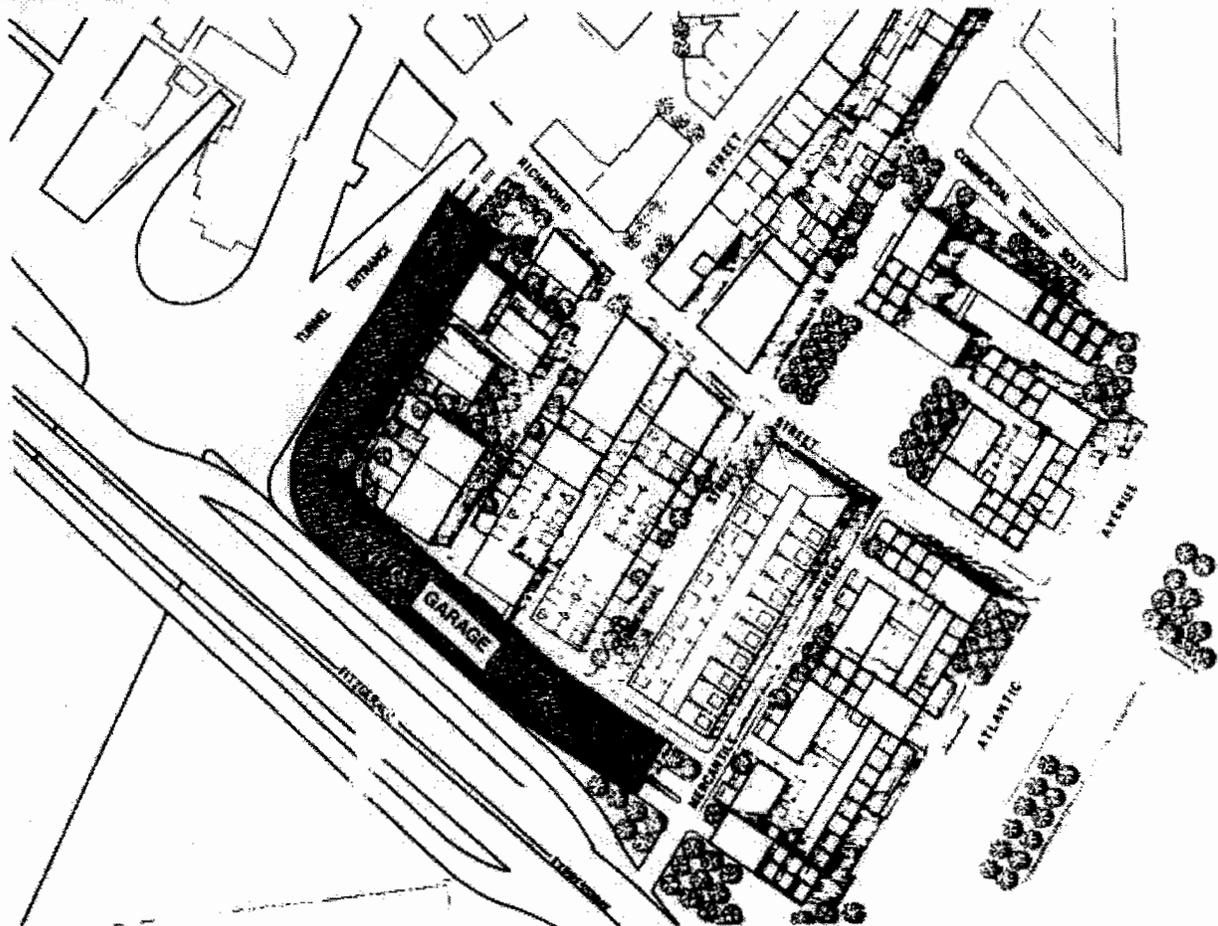
means, besides acoustical design and construction, of reducing noise impacts. This is because it is nearly impossible to provide physical shielding for the higher stories from adjacent noise.

### Noise Compatible Land Uses as Buffers

Noise protection can be achieved by locating noise-compatible land uses between the highway and residential units. Whenever possible, compatible uses should be nearest the noise source. Figure 10 shows a proposed parking garage along two sides of a development in Boston. Both the

<sup>1</sup>*The Audible Landscape: A Manual for Highway Noise and Land Use*, US Department of Transportation, The Federal Highway Administration, November 1974. (GPO Stock Number: 5000-00079.)

Figure 10  
Use of a Parking Garage to  
Shield a Residential Area



Fitzgerald Expressway and the entrance to the Callahan Tunnel which are shown on the site plan are major and noisy traffic routes. In addition to protecting the residential development from the noise and dirt of highway traffic, the parking garage provides needed facilities for the residents.

### Buildings as Noise Shields

Additional noise protection can be achieved by arranging the site plan to use buildings as noise barriers. A long building, or a row of buildings parallel to a highway can shield other more distance structures or open areas from noise.

If the building being used as a barrier is sensitive to highway noise, the building itself must first be soundproofed. This technique was used in a housing project in England where a 3,900 foot long, 18 foot wide and 45-70 foot high wall (depending on the terrain) serves as both residence and a sound shield. The wall/building will contain 387 apartments in which the kitchens and bathrooms are placed towards the noise, and the bedrooms and living rooms face away from the highway. The wall facing the highway will be soundproofed and windows, when they exist, are sealed. Substantial noise reductions are expected.

### Orientation

The orientation of buildings or activities on a site affects the impact of noise, and the building or activity area may be oriented in such a way as to reduce this impact.

Noise impacts can be severe for rooms facing the roadway since they are closest to the noise source. The noise impact may also be great for rooms perpendicular to the roadway

because (a) the noise pattern can be more annoying in perpendicular rooms and (b) windows on perpendicular walls do not reduce noise as effectively as those on parallel walls because of the angle of the sound. Road noise can be more annoying in perpendicular rooms because it is more extreme when it suddenly comes in and out of earshot as the traffic passes around the side of the building, rather than rising and falling in a continuous sound, as it would if the room were parallel to passing vehicles.

Whether the noise impact is greater on the perpendicular or the parallel wall will depend on the specific individual conditions. Once the most severely impacted wall or walls are determined, noise impacts may be minimized by reducing or eliminating windows from these walls.

Buildings can also be oriented on a site in such a way as to exploit the site's natural features. With reference to noise, natural topography can be exploited and buildings placed in low noise pockets if they exist. If no natural noise pockets exist, it is possible to create them by excavating pockets for buildings and piling up earth mounds between them and the noise. Such a structure would obstruct the sound paths and reduce the noise impacts on the residences.

### Cluster and Planned Unit Development

A cluster subdivision is one in which the densities prescribed by the zoning ordinance are adhered to but instead of applying to each individual parcel, they are aggregated over the entire site, and the land is developed as a single entity. A planned unit development, or P.U.D., is similar but changes in land use are included, such as apartments and commercial facilities in what would otherwise be a single-family district.

From Figure 11 it can be seen how the conventional grid subdivision affords no noise protection from the adjacent highway. The first row of houses bears the full impact of the noise. In contrast, the cluster and P.U.D. techniques enable open space and commercial uses respectively to serve as noise buffers. Examples of this are shown in Figures 12 and 13. A word of caution is necessary: in a cluster development, the required open space can be located near the highway to minimize noise to the residences. However, many recreation uses are noise sensitive, and when one takes advantage of the flexibility of cluster development to minimize noise, care must be taken not to use all of the available open space in

Figure 11  
Conventional Grid Subdivision

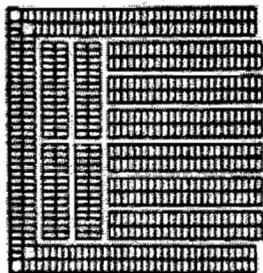
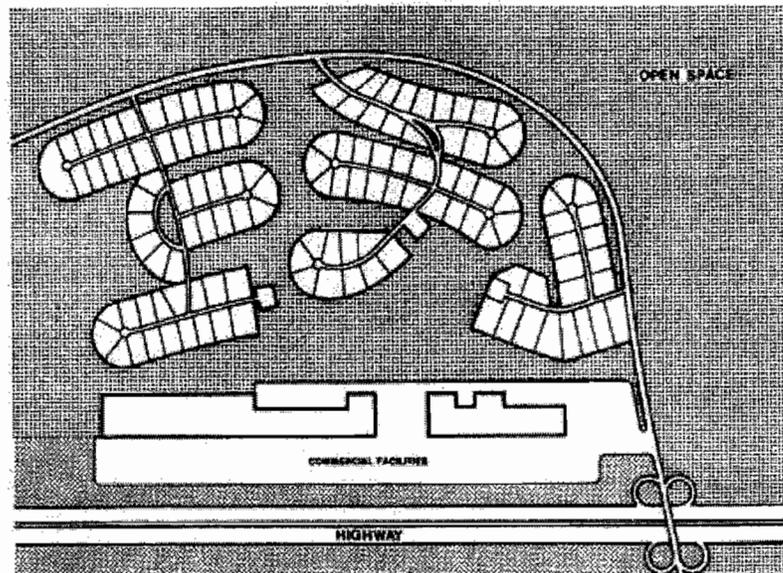


Figure 12  
Placement of Noise Compatible Uses Near a Highway in a PUD



buffer strips, thus depriving the development of a significant open space area. Where high noise levels exist, a combination of buffer strips and other techniques (such as berms and acoustical sound proofing) can be employed.

The flexibility of the cluster and planned unit development techniques allows many of the above site planning techniques to be realized and effective noise reduction achieved.

### Reviewing Site Plans

There are two main things to check when reviewing site plan changes to determine if the revised site plan provides adequate attenuation for the noise sensitive uses:

1. Is the separation between the source and the receiver great enough?
2. If noise-compatible buildings are being used as barriers for other buildings, are they adequate barriers, i.e., are they long enough and are they high enough? (And, if the buildings

being used as barriers contain noise sensitive activities, have the buildings been properly soundproofed.)

In order to determine whether the proposed site plan changes will provide adequate separation between the source and the receiver, you simply go back to the *Noise Assessment Guidelines* procedures. You can use the *Guidelines* both to determine if the proposed separation distance is sufficient or to determine the necessary separation distance. You should at this point check to make sure that the uses being located in the "buffer zone" between the source and the receiver are indeed noise compatible uses. If parks or playgrounds are located in the buffer zone, make sure they are not the only ones associated with the project.

To determine whether the noise compatible buildings being proposed as barriers are adequate, you simply use the procedures outlined in the preceding section. Determine whether the building is high enough to properly break the line of sight

between the receiver and the source. Then determine if the building is long enough. It is not necessary to check to make sure it is made of the proper materials or that it is properly constructed since the building will be inherently thick enough not to have any problems. Again, however, if the building being proposed as a barrier contains noise sensitive uses you must first verify that it is properly soundproofed. (See the next section for guidance on acoustical construction.) If the building is not properly soundproofed then it can not be used as a barrier for other buildings.

As you review the site plan check to see that the building locations will not aggravate noise problems. Figure 14 shows how building arrangement can make the noise problem worse.

Figure 13  
Open Space Placed Near a Highway in a Cluster Development

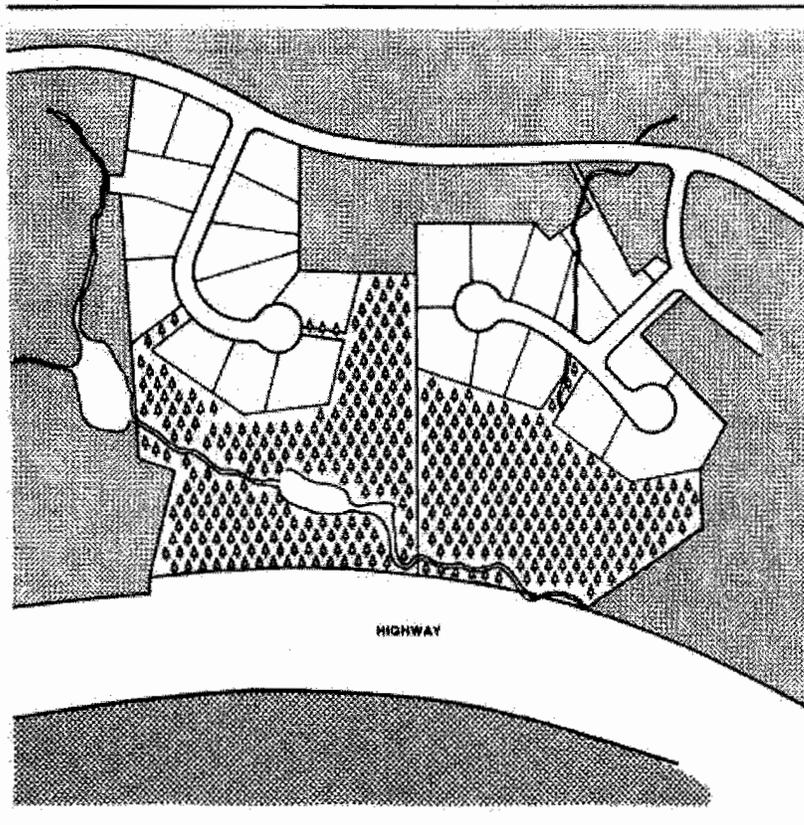
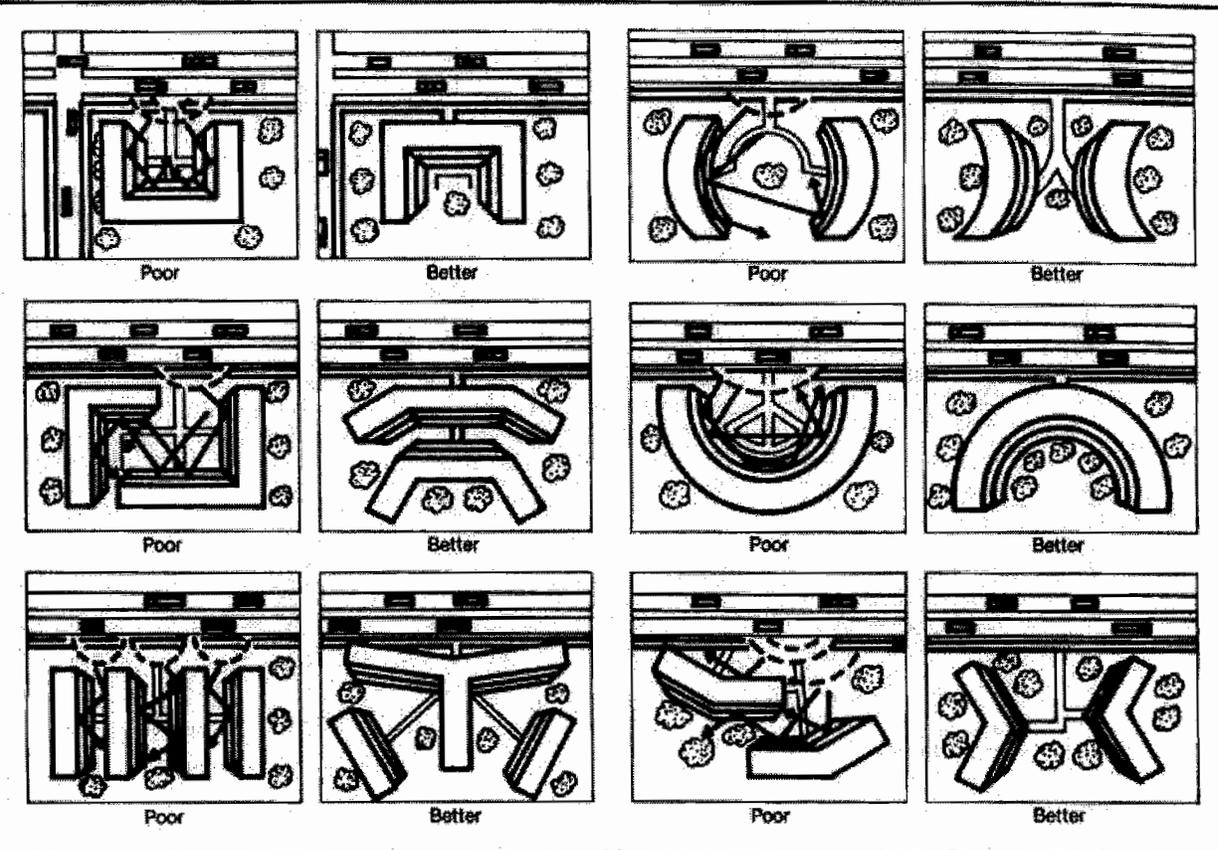


Figure 14  
Orientation of Buildings on Sites



## Acoustical Construction Concepts

(This section, with some editing is taken from the *Audible Landscape*, FHWA.)

Noise can be intercepted as it passes through the walls, floors, windows, ceilings, and doors of a building. Examples of noise reducing materials and construction techniques are described in the pages that follow.

To compare the insulation performance of alternative constructions, the Sound Transmission Class (STC) is used as a measure of a material's ability to reduce sound. Sound Transmission Class is equal to the number of decibels a sound is reduced as it passes through a material. Thus, a high STC rating indicates a good insulating material. It takes into account the influence of different frequencies on sound transmission, but essentially the STC is the difference between the sound levels on the side of the partition where the noise originates and the side where it is received. For example, if the external noise level is 85 dB and the desired internal level is 45 dB, a partition of 40 STC is required. The Sound Transmission Class rating is the official rating endorsed by the American Society of Testing and Measurement. It can be used as a guide in determining what type of construction is needed to reduce noise.

The use of the STC rating system for transportation noise is a subject of some debate. The STC rating was originally intended primarily for use with interior partitions and relates to the "subjective impressions of the sound insulation provided against the sounds of speech, radio, television, music, and similar sources of noise in offices and dwellings."<sup>2</sup> However, since it remains the only widely used noise reduction rating system for materials the STC system is very often used even with transportation noise. When STC ratings are used for transportation noise you should be aware that the STC ratings may be a few dB too high. For example, the STC rating for a standard frame 2 x 4 wall with exterior siding, and sheathing and interior sheetrock may be 37 dB.<sup>3</sup>

If rated specifically for transportation noise the dB reduction rating might drop to 34 dB.<sup>4</sup> All this really means, however, is that you should use the STC ratings with a bit of caution and remain aware of the possible 2-3 dB overstating that you may get with the STC rating system. Throughout this text we will be talking in terms of STC ratings for materials and assemblies.

<sup>1</sup> *The Audible Landscape: A Manual for Highway Noise and Land Use*, US Department of Transportation, the Federal Highway Administration, November 1974, (GPO Stock #5000-00079).

<sup>2</sup> *Acoustical and Thermal Performance of Exterior Residential Walls, Doors, and Windows*, US Department of Commerce, National Bureau of Standards, November 1975, (NBS Building Science Series 77) page 21.

<sup>3</sup> *Ibid.*, p. 29

<sup>4</sup> *Design Guide for Reducing Transportation Noise In and Around Buildings*, p. 137.

## Walls

Walls provide building occupants with the most protection from exterior noise. Different wall materials and designs vary greatly in their sound insulating properties. Figure 15 provides a visual summary of some ways in which the acoustical properties can be improved:

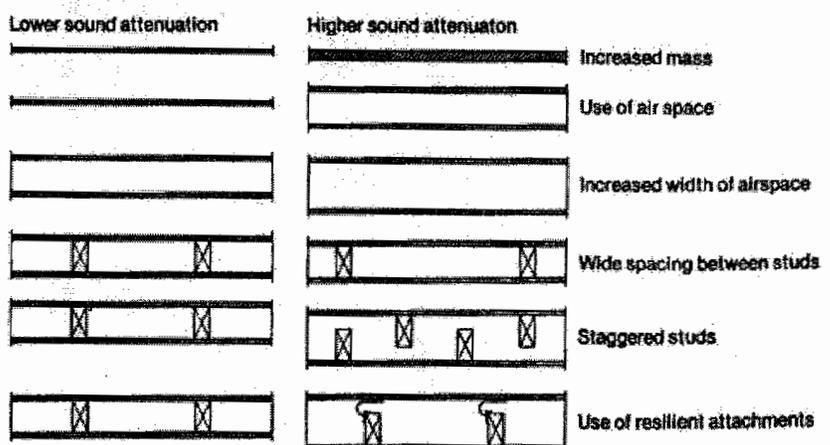
**Increase the mass and stiffness of the wall.** In general, the denser the wall material, the more it will reduce noise. Thus, concrete walls are better insulators than wood walls of equal thickness. Increasing the thickness of a wall is another way to increase mass and improve sound insulation. Doubling the thickness of a partition can result in as much as a 6 dB reduction in sound.<sup>1</sup> However, the costs of construction tend to limit the feasibility of large increases in wall mass.

The relative stiffness of the wall material can influence its sound attenuation value. Care must be taken to avoid wall constructions that can vibrate at audible frequencies and transmit exterior sounds.

<sup>1</sup> R. K. Cooke and P. Chrzanowski, "Transmission of Noise Through Walls and Floors," Cyril Harris, ed., *Handbook of Noise Control*, McGraw-Hill Book Company, Inc. (New York, 1957).

Figure 15  
The Audible  
Landscape

Factors which influence sound attenuation of walls



**Use cavity partitions.** A cavity wall is composed of two or more layers separated by an airspace. The airspace makes the cavity wall a more effective sound insulator than a single wall of equal weight, leading to cost savings.

**Increase the width of the airspace.** A three inch airspace provides significant noise reduction, but increasing the spacing to six inches can reduce noise levels by an additional 5 dBA. Extremely wide airspaces are difficult to design.

**Increase the spacing between studs.** In a single stud wall, 24 inch stud spacing gives a 2-5 dB increase in STC over the common 16 inch spacing.<sup>2</sup>

**Use staggered studs.** Sound transmission can be reduced by attaching each stud to only one panel and alternating between the two panels.

<sup>2</sup>Leslie T. Doelle, *Environmental Acoustics* (New York, McGraw-Hill Book Company, 1972), pp. 232-233.

**Use resilient materials to hold the studs and panels together.** Nails severely reduce the wall's ability to reduce noise. Resilient layers such as fiber board and glass fiber board, resilient clips, and semi-resilient attachments are relatively inexpensive, simple to insert, and can raise the STC rating by 2-5 dB.<sup>1</sup>

**Use dissimilar layers.** If the layers are made of different materials and/or thickness, the sound reduction qualities of the wall are improved.<sup>2</sup>

**Add acoustical blankets.** Also known as isolation blankets, these can increase sound attenuation when placed in the airspace. Made from sound absorbing materials such as mineral or rock wool, fiberglass, hair felt or wood fibers, these can attenuate noise as much as 10 dB.<sup>3</sup> They are mainly effective in relatively lightweight construction.

**Seal cracks and edges.** If the sound insulation of a high performance wall is ever to be realized, the wall must be well sealed at the perimeter. Small holes and cracks can be devastating to the insulation value of a wall. A one-inch square hole or a 1/16 inch crack 16 inches long will reduce a 50 STC wall to 40.<sup>4</sup>

Figure 16 shows a sample of wall types ranging from the lowest to the highest sound insulation values.

Remember that the effectiveness of best wall construction will be substantially reduced if you permit vents, mail slots or similar openings in the walls. If vents are permitted the ducts must be specially designed and insulated to make sure noise does not reach the inside. The best approach is simply to eliminate all such openings on impacted walls.

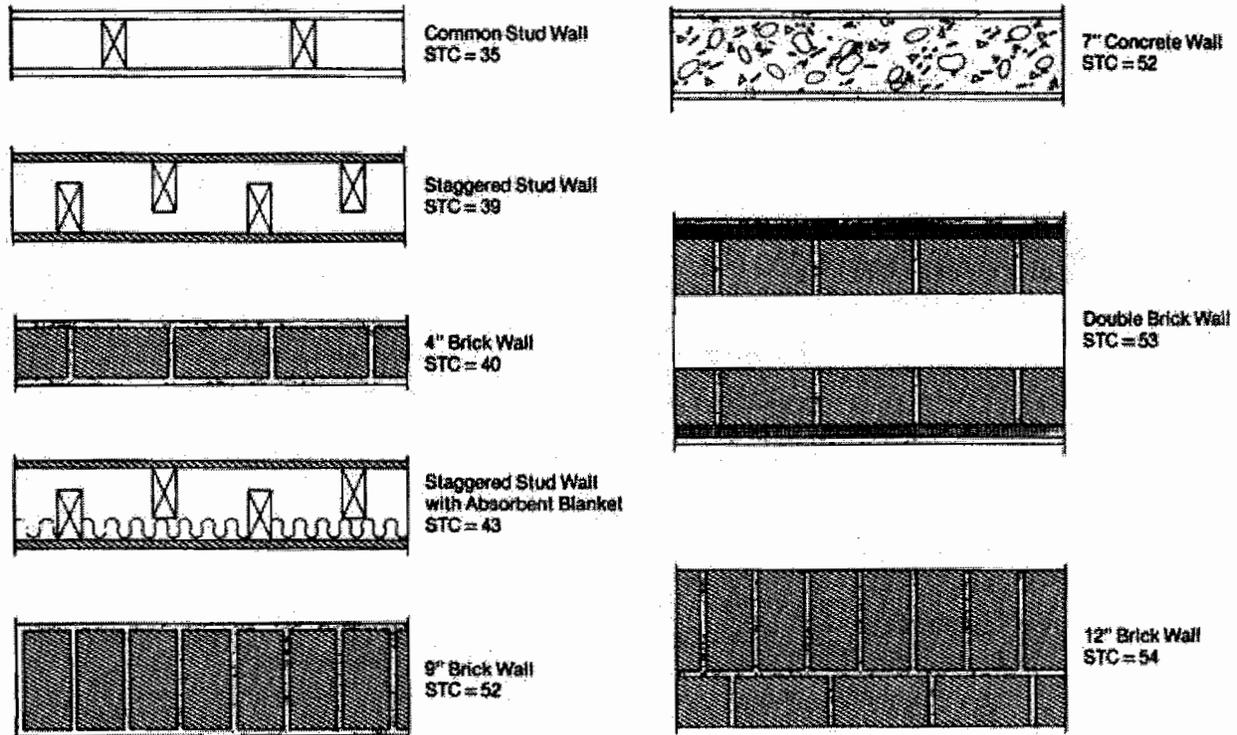
<sup>1</sup>ibid, p. 172

<sup>2</sup>ibid, p. 162

<sup>3</sup>Doelle, p. 20

<sup>4</sup>United States Gypsum, *Sound Control Construction, Principles and Performance* (Chicago, 1972), p. 66

Figure 16  
Walls



## Windows

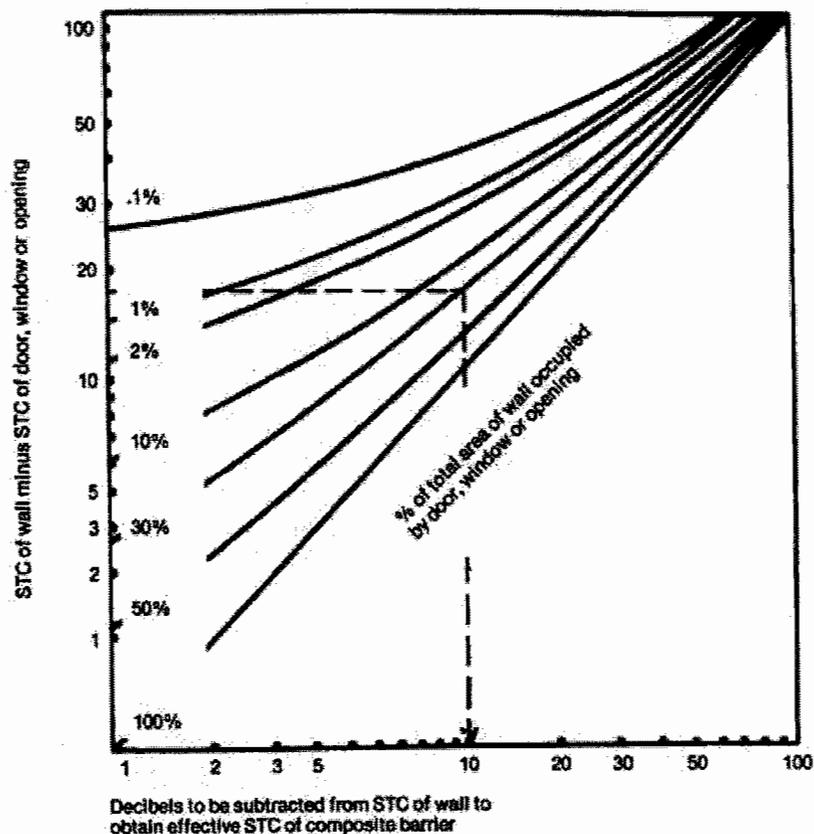
Sound enters a building through its acoustically weakest points, and windows are one of the weakest parts of a wall. An open or weak window will severely negate the effect of a very strong wall. Whenever windows are going to be a part of the building design, they should be given acoustical consideration. Figure 17 illustrates the effects of windows on the sound transmission of walls. For example, if a wall with an STC rating of 45 contains a window with an STC rating of 26 covering 30% of its area, the overall STC of the composite partition will be 35, a reduction of 10 dB.

The following is a discussion of techniques that can be used to reduce noise in a building by means of its windows. These techniques range from a blocking of the principal paths of noise entry to a blocking of the most indirect paths.

**Close windows.** The first step in reducing unwanted sound is to close and seal the windows. The greatest amount of sound insulation can be achieved if windows are permanently sealed. However, operable acoustical windows have been developed which are fairly effective in reducing sound.<sup>1</sup> Whether or not the sealing is permanent, keeping windows closed necessitates the installation of mechanical ventilation systems. If you are dealing with single family houses and some of the windows are facing away from all noise sources, a whole house fan may be better and cheaper than air conditioning. In multifamily housing or where all windows are exposed to the noise sources you will have to go with the air conditioning. If windows must be operable, special seals are available which allow windows to be opened.<sup>2</sup>

**Reduce window size.** The smaller the windows, the greater the transmission loss of the total partition of which the window is a part. Reducing the window size is a technique that is used because (a) it precludes the cost of expensive acoustical windows, and (b) it saves money by cutting down the use of glass. The problems with this technique are (a) it is not very effective in reducing noise; e.g., reducing the proportion of window to wall size from 50% to 20% reduces noise by only 3 decibels; and (b) many building codes require a minimum window to wall size ratio.

Figure 17  
STC



**Increase glass thickness.** If ordinary windows are insufficient in reducing noise impacts in spite of sealing techniques, then thicker glass can be installed. In addition, this glass can be laminated with a tough transparent plastic which is both noise and shatter resistant. Glass reduces noise by the mass principle; that is, the thicker the glass, the more noise resistant it will be. A 1/2-inch thick glass has a maximum STC rating of 35 dB compared to a 25 dB rating for ordinary 3/16 inch glass.

### Instructions on use of graph

1. Subtract the STC value of the door, window or opening from the STC value of the wall.
2. Enter the vertical axis of the graph at the point that matches the value from step 1.
3. Read across to the curve that represents the percentage of the total area of the wall that is taken up by the door, window, or opening.
4. Read down to the horizontal axis.
5. Subtract the value on the horizontal axis from the original STC value of the wall. The result is the composite STC value of the wall and the door, window or opening.

<sup>1</sup>U.S. Department of Housing and Urban Development, A Study of Techniques to Increase the Sound Insulation of Building Elements, Report No. WR 73-5, Washington, D.C., June 1973.

<sup>2</sup>Los Angeles Department of Airports, Guide to the Soundproofing of Existing Homes Against Exterior Noise, Report No. WRC 70-2, March 1970, pp. 9-11, 22-30. In this report, the function and performance of a number of operable seals are described.

However, glass thicknesses are only practical up to a certain point, when STC increases become too insignificant to justify the cost. For example, a 1/2 inch thick glass can have an STC of 35; increasing the thickness to 3/4 inch only raises the STC to 37. However, a double glass acoustical window consisting of two 3/16 inch thick panes separated by an airspace will have an STC of 51 and can cost less than either solid window.

In addition to thickness, proper sealing is crucial to the success of the window. To prevent sound leaks, single windows can be mounted in resilient material such as rubber, cork, or felt.

**Install Double-Glazed Windows.** Double-glazed windows are paired panes separated by an airspace or hung in a special frame. Generally, the performance of the double-glazed window may be increased with:

- increased airspace width
- increased glass thickness
- proper use of sealings
- slightly dissimilar thicknesses of the panes
- slightly non-parallel panes

In general the airspace between the panes should not be less than 2-4 inches if an STC above 40 is desired. If this is not possible, a heavy single-glazed window can be used. The use of slightly non-parallel panes is a technique employed when extremely high sound insulation is required, such as in control rooms of television studios.

The thickness of double-glazed panes may vary from 1/8 to 1/4 inch or more per pane. Although thickness is important, the factors which most determine the noise resistance of the window is the use of sealant and the width of the airspace.

As in the case of all windows, proper sealing is extremely important. To achieve an STC above 43, double-glazed windows should be sealed permanently. If the windows must be openable, there are available special frames and sealers for openable windows which allow a maximum STC of 43.<sup>1</sup>

Permanently sealed double-glazed windows often require an air pressure control system to maintain a constant air pressure and minimal moisture in the airspace. Without this system, the panes may deflect, and, in extremely severe cases, pop out of the frames.

To further insure isolation of noise between double-glazed panes, the panes could be of different thicknesses, different weights, and slightly non-parallel to each other. This prevents acoustical coupling and resonance of sound waves.

#### Doors

Acoustically, doors are even weaker than windows, and more difficult to treat. Any door will reduce the insulation value of the surrounding wall. The common, hollow core wood door has an STC rating of 17 dB. Taking up about 20% of the wall, this door will reduce a 48 STC wall to 24 STC. To strengthen a door against noise, the hollow core door can be replaced by a heavier solid core wood door that is well sealed<sup>1</sup> and is relatively inexpensive. A solid core wood door with vinyl seal around the edges and carpeting on the floor will reduce the same 48 STC wall to only 33 dB.<sup>2</sup> An increased sound insulation value can be achieved if gasketed stops or drop bar threshold closers are installed at the bottom edge of the door. (See Figure 18)

The alternative solution to doors is to eliminate them whenever possible from the severely impacted walls and place them in more shielded walls.

In any case no mail slots or similar openings should be allowed in exterior doors.

#### Roofs

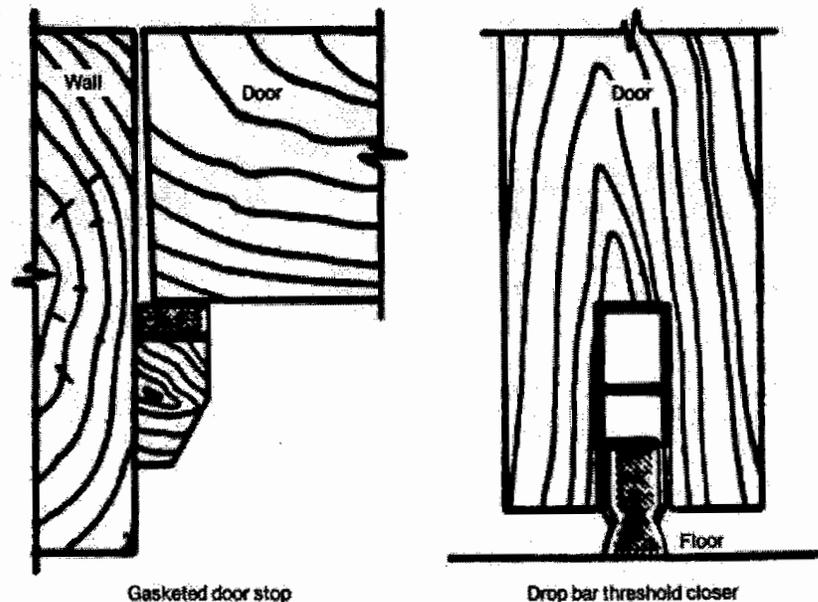
Acoustical treatment of roofs is not usually necessary unless the noise is extremely severe or the noise source is passing over the building. The ordinary plaster ceiling should provide adequate sound insulation except in extremely severe cases. An acoustically weak roof which is likely to require treatment is the beamed ceiling.<sup>3</sup> Beamed ceilings may be modified by the addition of a layer of fiberglass or some other noise resistant material. Suspended ceilings are the most effective noise reducers but they are also the most expensive.

<sup>1</sup>D.E. Bishop and P.W. Hirtle, "Notes on the Sound Transmission Loss of Residential-Type Windows and Doors," Journal of the Acoustical Society of America, 43:4 (1968).

<sup>2</sup>U.S. Gypsum, Sound Control... p. 100.

<sup>3</sup>Ibid p. 15.

Figure 18



<sup>1</sup>Ibid.

## Floors

In the case of highway noise, floors would only require acoustical treatment if the highway were passing under the building. In this case, flooring would have to provide protection against structural vibrations as well as airborne sound.

Two ways to insulate a floor from noise are to install a solid concrete slab at least 6 inches thick or install a floating floor. In general, the floating floor gives the greatest amount of sound and vibration insulation; however, it is extremely expensive. Basically, a floating floor consists of a wood or concrete slab placed over the structural slab, but separated by a resilient material. The resilient material isolates the surface slab from the structural slab and the surrounding walls.

## What to Look for When Reviewing Plans

The number of possible combinations of the building materials that go into walls, ceilings, windows and doors, is, no doubt, considerably short of infinite. It is however still a very large number, large enough that it would be impossible to compile a list of all the possible combinations. Therefore, do not expect to find in this section, or anywhere else for that matter, a neat table showing the STC ratings for all the types of construction you may encounter. In fact, it is not really your responsibility to determine the precise STC ratings for the walls, ceilings, windows and doors in the projects you review. Your job is simply to review the attenuation levels claimed by the sponsor/developer and determine whether or not they are reasonable.

To enable you to perform the above described task, we have prepared a list of the most common types of construction for which we have STC ratings. By comparing the type of construction proposed to one of these "model" types you should be able to tell whether the claimed STC rating is reasonable. For example, the sponsor/developer submits a description of his building stating that a 2 x 6 stud wall with standard sheathing, insulation, wood siding, and 1/2" gypsum board achieves a STC rating of 48. You look at Table 3 and find that the closest "model" wall is a 2 x 4 stud wall with wood siding, sheathing, insulation, and 1/2" gypsum board. This wall has a STC rating of 39. An 9 dB difference is quite significant considering that the walls are really quite similar. You would probably want to go back to the developer/sponsor and ask for some supporting data that proves that the 2 x 6 wall he proposes will indeed provide 48 dB of noise attenuation.

In order to make it easier to review the attenuation levels provided by the proposed construction, we suggest that you ask the developer/sponsor to complete a form such as shown in Figure 19. Such a form will give you all the information you need in a properly organized format that will facilitate your review. You could fill in the first part and simply have the developer/sponsor fill out the second part and return it with the developer certification or other project documents.

As you will recall from the previous section, most walls provide pretty good attenuation by themselves. It is the presence of windows and doors and openings such as vents that reduces the attenuation capability of the wall. Thus, after you have determined whether the basic wall itself has a reasonable STC, you must review the impact of the windows and doors. You do this by using Figure 17. First you determine the difference between the STC ratings for the wall and the windows. You enter the vertical axis of Figure 17 with that number. You read across until you intersect the line that represents the percentage of the wall taken up by the windows. Then you read down to the horizontal axis where you will find the value to be subtracted from the basic STC value of the wall. The resulting number is the combined STC value for the wall. If the wall also contains a door, repeat the same procedure, only start out with the modified STC rating for the wall. If the wall has doors only, then obviously you start with the basic wall STC rating. Finally you compare the number you have derived with that listed by the developer/sponsor. If they are fairly close, you need not pursue it further. If there is a substantial difference, you should ask for an explanation or documentation from the developer.

Once again, we caution you about borderline cases. If the attenuation required is 30 dB and the STC rating for the proposed construction is exactly 30 dB, you may want to ask the developer to provide even more attenuation. Remember that we discussed how the STC rating may overstate the actual attenuation provided by as much as 3 dB. If an additional 3 dB can be achieved at minimum cost, we would strongly urge that you seek it from the developer/sponsor.

Finally check to make sure the developer has provided some form of mechanical ventilation. If it's a single family house and a whole house fan is the means of ventilation being provided make sure that there are operable windows on walls which do not face the noise source(s) nor are perpendicular to the source(s). Otherwise the residents will have to open windows on the exposed wall, thus cancelling out much of the attenuation achieved.

**Table 3**  
**STC Ratings for Typical**  
**Building Components<sup>1</sup>**

Building Component	Description	STC Rating
Frame Wall	a. 5/8" x 10" Redwood Siding b. 1/2" Insulation Board Sheathing c. 2 x 4 studs 16" o.c. d. Fiberglass Building Insulation e. 1/2" Gypsum Board attached directly to studs	39 dB
Stucco/Frame Wall	a. 7/8" Stucco b. No. 15 felt Building Paper and 1" Wire Mesh c. 2 x 4 Studs 16" o.c. d. Fiberglass Building Insulation e. 1/2" Gypsum Board attached directly to studs	46
Brick Veneer Wall	a. Face Brick b. 1/2" Airspace with metal ties c. 3/4" Insulation Board Sheathing d. 2 x 4 Studs 16" o.c. e. Fiberglass Building Insulation f. 1/2" Gypsum Board attached directly to studs	56
Masonry Wall	a. 1" Stucco b. 8" thick Hollow Concrete Block c. 1/2" Gypsum Board attached to furring strips	49 (estimated)
Windows	Wood double hung, closed but unlocked, single glazing	23
	Aluminum sliding, latched, single glazing	24
	Wood double hung, closed but unlocked, glazed with 7/16" insulating glass	22
	Aluminum single hung, closed, glazed with 7/16" insulating glass	25
	Wood, double hung, sealed, glazed with 7/16" insulating glass with single glazed storm sash-2 1/8" separation	35
	Aluminum sliding, closed, single glazed with single glazed storm sash, 1/8" separation	22
Exterior Doors	Wood, flush solid core, with brass weather stripping	27
	Wood, flush solid core, plastic weather stripping, aluminum storm door	34
	Wood, French door, brass weather stripping	26
	Steel, flush, with urethane foam core, with magnetic weather stripping	28
Roof	Shingle Roof with attic, 1/2" gypsum wall board ceiling framed independently of roof	43 (estimated)

<sup>1</sup>Except as noted, all STC ratings are from: *Acoustical and Thermal Performance of Exterior Residential Walls, Doors and Windows*, National Bureau of Standards.

**Figure 19  
Description of Noise Attenuation Measures  
(Acoustical Construction)**

---

**Part I**

Project Name \_\_\_\_\_

Location \_\_\_\_\_

Sponsor/Developer \_\_\_\_\_

Noise Level (From NAG) \_\_\_\_\_ Attenuation Required \_\_\_\_\_

Primary Noise Source(s) \_\_\_\_\_

**Part II**

1. For Walls (a) facing and parallel to the noise source(s) (or closest to parallel):

a. Description of wall construction\* \_\_\_\_\_  
\_\_\_\_\_

b. STC rating for wall (rated for no windows or doors): \_\_\_\_\_

c. Description of Windows: \_\_\_\_\_  
\_\_\_\_\_

d. STC rating for window type \_\_\_\_\_

e. Description of doors \_\_\_\_\_  
\_\_\_\_\_

f. STC rating for doors \_\_\_\_\_

g. Percentage of wall (per wall, per dwelling unit) composed of  
windows \_\_\_\_\_ and doors \_\_\_\_\_

h. Combined STC rating for wall component \_\_\_\_\_

2. For walls perpendicular to noise source(s):

a. Description of wall construction\* \_\_\_\_\_  
\_\_\_\_\_

b. STC rating for wall (rated for no windows or doors) \_\_\_\_\_

c. Description of windows \_\_\_\_\_  
\_\_\_\_\_

d. STC rating for windows \_\_\_\_\_

e. Description of doors \_\_\_\_\_  
\_\_\_\_\_

---

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f. STC rating for doors \_\_\_\_\_

g. Percentage of wall (per wall, per dwelling unit) composed of windows \_\_\_\_\_ and doors \_\_\_\_\_

h. Combined STC rating for wall component \_\_\_\_\_

3. Roofing component (if overhead attenuation is required due to aircraft noise):

a. Description of roof construction \_\_\_\_\_  
\_\_\_\_\_

b. STC rating (rated as if no skylights or other openings) \_\_\_\_\_

c. Description of skylights or overhead windows \_\_\_\_\_  
\_\_\_\_\_

d. STC rating for skylights or overhead windows \_\_\_\_\_

e. Percentage of roof composed of skylights or windows (per dwelling unit) \_\_\_\_\_

f. Percentage of roof composed of large uncapped openings such as chimneys \_\_\_\_\_

g. Combined STC rating for roof component \_\_\_\_\_

4. Description of type of mechanical ventilation provided \_\_\_\_\_  
\_\_\_\_\_

Prepared by \_\_\_\_\_

Date: \_\_\_\_\_

\*If walls contain vents or similar openings, attach a description of duct arrangement and insulation and a statement of how much the wall STC is reduced by the presence of the vent.

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Figure 19  
Description of Noise Attenuation Measures  
(Acoustical Construction)

Part I

Project Name PARADISE HOMES  
 Location ANYTOWN  
 Sponsor/Developer JOHN DOE + ASSOC. INC.  
 Noise Level (From NAG) 73 Attenuation Required 30db  
 Primary Noise Source(s) HIGHWAY

Part II

1. For Walls (s) facing and parallel to the noise source(s) (or closest to parallel):
  - a. Description of wall construction\* 3/4" FIR PLYWOOD SIDING,  
2x4 STUDS 16" O.C. 3/4" FIBERGLASS INSULATION
  - b. STC rating for wall (rated for no windows or doors): 37
  - c. Description of Windows: WOOD DOUBLE HUNG,  
INSULATING GLASS
  - d. STC rating for window type 22
  - e. Description of doors WOOD, FLUSH, SOLID CORE
  - f. STC rating for doors 30
  - g. Percentage of wall (per wall, per dwelling unit) composed of windows 10% and doors 5%
  - h. Combined STC rating for wall component 30db
2. For walls perpendicular to noise source(s):
  - a. Description of wall construction\* SAME AS ABOVE
  - b. STC rating for wall (rated for no windows or doors) 37
  - c. Description of windows SAME AS ABOVE
  - d. STC rating for windows 22
  - e. Description of doors NO DOORS

SAMPLE

- f. STC rating for doors \_\_\_\_\_
- g. Percentage of wall (per wall, per dwelling unit) composed of windows 10% and doors 0
- h. Combined STC rating for wall component 30
- 3. Roofing component (if overhead attenuation is required due to aircraft noise):
  - a. Description of roof construction N/A
  - b. STC rating (rated as if no skylights or other openings) \_\_\_\_\_
  - c. Description of skylights or overhead windows \_\_\_\_\_
  - d. STC rating for skylights or overhead windows \_\_\_\_\_
  - e. Percentage of roof composed of skylights or windows (per dwelling unit) \_\_\_\_\_
  - f. Percentage of roof composed of large uncapped openings such as chimneys \_\_\_\_\_
  - g. Combined STC rating for roof component \_\_\_\_\_
- 4. Description of type of mechanical ventilation provided CENTRAL AIR  
Conditioning

SAMPLE

Prepared by \_\_\_\_\_

Date: \_\_\_\_\_

\* If walls contain vents or similar openings, attach a description of duct arrangement and insulation and a statement of how much the wall STC is reduced by the presence of the vent.

## Quiz on Noise Attenuation

### Questions

1. What are the three basic ways to provide noise attenuation?
2. What are the responsibilities of HUD personnel regarding noise attenuation?
3. When a barrier is introduced between a source and a receiver the sound energy is redistributed along 3 indirect paths. What are these three paths?
4. What is "Path Length Difference" and how does it affect the attenuation level provided by a barrier?
5. What are "Transmission Loss Values?"
6. How does the transmission loss value of barrier material affect the attenuation capability of the barrier?
7. As a general rule, what transmission loss values should you look for?
8. If you have more than one barrier between the source and the receiver is the amount of attenuation increased substantially?
9. What are the four things to check when reviewing a proposed barrier?
10. List 3 ways to make a barrier more effective without increasing its overall height.
11. List 3 ways to make a barrier more effective without increasing its overall length.
12. What is the maximum percentage of the total area of a barrier that can be made up of openings without a significant loss in barrier effectiveness?
13. List 3 site planning techniques that are used to shield residential developments.
14. When are parks and playgrounds not noise compatible uses that can be employed as buffers?
15. What are the two main things to look for when reviewing site plan changes?
16. What are some of the building orientations which can aggravate noise problems?
17. What is the Sound Transmission Class (STC) rating?
18. Which is better a high STC or a low STC rating?
19. What kinds of conditions were STC ratings originally developed for?
20. What should you do when using STC ratings in a transportation noise situation?
21. List 5 ways to improve the attenuation capability of a wall.
22. Windows are one of the acoustically weakest components in a wall. List 3 ways to reduce the negative effects of windows.
23. What is the best way to reduce the effect of doors?

## Quiz on Noise Attenuation

### Answers

1. a. barriers or berms  
b. site design  
c. acoustical construction
2. a. to make sure the project sponsor/developer is aware of the attenuation requirements  
b. provide sponsor/developer with an overview of available options  
c. review attenuation proposals to make sure they are adequate
3. a. A diffracted path over the top of the barrier  
b. A transmitted path through the barrier  
c. A reflected path away from the receiver
4. "Path Length Difference" is the difference in distance that sound must travel diffracting over the barrier rather than passing directly through it. Since sound energy decreases over distance, the greater the path length distance the greater the attenuation.
5. "Transmission Loss Values" represent the amount noise levels will be reduced when the sound waves pass through a barrier.
6. Since the attenuation provided by a barrier is a function of both the sound energy that goes over the top and the energy that goes through the barrier, if the transmission loss value is low then the effectiveness of the barrier will be greatly reduced.
7. If the transmission loss value of the barrier material is at least 10dB greater than the attenuation level provided by diffraction (i.e. barrier height) there shouldn't be any problem.
8. No. The combined effect of multiple barriers does not normally provide significantly greater attenuation than a single barrier. For design purposes, the general procedure is to assume the attenuation of the most effective barrier.
9. a. Is it high enough?  
b. Is it long enough?  
c. Is it made of the right material?  
d. Is it properly constructed?
10. a. move the barrier closer to the source  
b. bend the top of the barrier towards the source  
c. do both
11. a. move it closer to the receiver  
b. bend the ends toward the receiver  
c. do both
12. 1 percent
13. Any 3 of the below:  
a. increasing the distance between the source and the receiver  
b. placing noise compatible land uses between the source and the receiver  
c. locating barrier type buildings parallel to the source  
d. orienting residences away from the noise
14. when they are the only ones associated with the project
15. a. is the separation between the source and receiver great enough  
b. if a noise compatible building is being used as a barrier is it tall and long enough?
16. Building orientations which trap noise and cause it to reverberate off building walls. This would include shapes where a court is open to the source or where a series of buildings are arranged perpendicular to the source.
17. The STC rating is equal to the number of decibels a sound is reduced as it passes through a material.
18. A high STC rating is better.
19. The STC ratings were originally intended primarily for use with interior partitions and for noise such as speech, radios, television.
20. Recognize that the STC rating may overstate the effectiveness of the materials by 2-3db.
21. Any of the 9 below:  
a. increase the mass and stiffness of the wall  
b. use cavity partitions  
c. increase the width of the airspace  
d. increase the spacing between studs  
e. use staggered studs  
f. use resilient materials to hold the studs and finish materials together  
g. use of dissimilar layers (leaves)  
h. add acoustical blankets  
i. seal cracks and edges
22. Any of the 4 below:  
a. close the windows and provide mechanical ventilation  
b. reduce window size  
c. increase glass thickness  
d. install double glazed windows
23. Eliminate them from severely impacted walls