ENGINEERS

CORE

CURRICULUM

HIGHWAY TRAFFIC NOISE

by

Noise and Air Analysis Division (HEV-30)
Office of Environmental Policy
Federal Highway Administration

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CHAPTER 1

INTRODUCTION

Numerous studies indicate that the most pervasive sources of noise in our environment today are those associated with transportation. Traffic noise tends to be the dominant noise source in our urban as well as rural environment. In response to the problems associated with traffic noise, FHPM 7-7-3, "Procedures for Abatement of Highway Traffic Noise and Construction Noise," establishes a requirement for a noise study for any proposed Federal or Federal-aid project. This regulation specifies procedures that State transportation agencies must follow in preparing assessments for highway noise for proposed projects.

The purpose of this document is to provide a simple and concise discussion on how to implement these procedures. Two individual 1-week long training courses are available for instructing FHWA field staffs and State highway agencies (SHA) in the detailed technical methodologies for analyzing and abating traffic noise impacts. This document is intended to provide information necessary for FHWA Regional and Division office staffs' reviews of SHA noise analyses.

Legislation for Mitigation of Highway Traffic Noise

An important piece of Federal legislation for reducing traffic noise is the National Environmental Policy Act (NEPA) of 1969. This legislation provides broad authority and responsibility for evaluating and mitigating adverse environmental effects in general. This, of course, includes traffic noise. The NEPA directs the Federal Government to use all practical means and measures to promote the general welfare and foster a healthy environment.

The more important Federal legislation for abatement of highway traffic noise is the Federal-Aid Highway Act of 1970. This law mandates the FHWA to develop noise regulations for mitigating highway traffic noise. The law requires promulgation of traffic noise-level criteria for various land-use activities. The law further provides that FHWA not approve the plans and specifications for a federally aided highway project, unless the project includes adequate noise abatement measures to comply with the regulations.

Legislation on Vehicle Noise Control

Another important piece of Federal legislation is the Noise Control Act of 1972. This legislation gives the Environmental Protection Agency (EPA) the authority to establish noise regulations to control major sources of noise, including transportation vehicles and construction equipment.

In addition, this legislation requires EPA to issue noise emission standards for motor vehicles used in Interstate commerce (vehicles used to transport commodities across State boundaries). Moreover, it requires FHWA to enforce these noise emission standards.

Regulations for Abatement of Highway Traffic Noise and Construction Noise

The FHWA regulations for mitigation of highway traffic noise in the planning and design of federally aided highways are contained in the Federal-Aid Highway Program Manual, Volume 7, Chapter 7, Section 3. The regulations require during the planning and design of a highway project the following: identification of traffic noise impacts; examination of potential mitigation measures; the incorporation of reasonable and feasible noise mitigation measures into the highway project; and coordination with local officials to provide helpful information on compatible land use planning and control. The regulations contain noise abatement criteria which represent the upper limit of acceptable highway traffic noise for different types of land uses and human activities. The regulations do not require that the noise abatement criteria be met in every instance. Rather, they require that every reasonable and feasible effort be made to provide noise mitigation when the noise abatement criteria are exceeded or when the predicted traffic noise levels substantially exceed the existing noise levels. Compliance with the noise regulations is a prerequisite for the granting of Federal-aid highway funds for construction or reconstruction of a highway.

Federal Highway Administration's (FHWA) Traffic Noise Abatement Program

The FHWA is utilizing a three-part approach toward effective control of highway traffic noise. The FHWA's program involves source control, improved highway design, and encouragement of improved land-use planning and control.

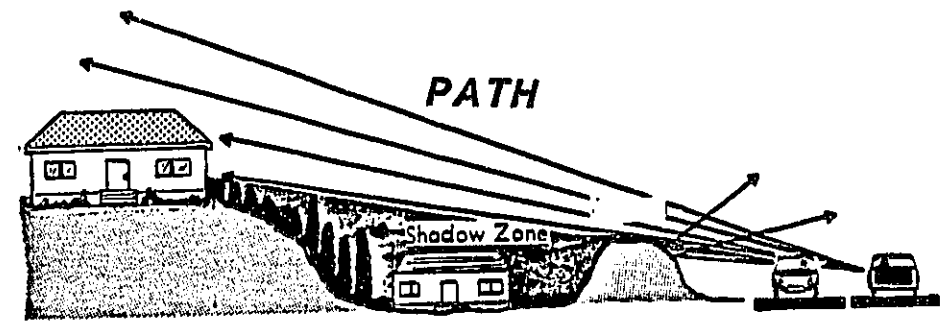
Controlling noise at its source in the vehicle requires the adoption of laws or the issuance of regulations affecting the manufacture, operation, and maintenance of vehicles. One step in this direction is the Environmental Protection Agency's regulation limiting noise emitted by medium- and heavy-duty trucks involved in Interstate commerce, which is enforced by FHWA's Bureau of Motor Carrier Safety.

The principal means of controlling noise through highway design are installing barriers or changing the alignment of the highway. Both methods can be effective, but only under limited circumstances. In addition to providing noise mitigation for normal highway construction projects, FHWA may also participate in projects solely for the purpose of noise abatement on existing highways if a SHA so requests. Funding eligibility is normally limited, however, to those lands developed prior to the date of FHWA's noise policy (May 14, 1976). Localities are responsible under FHWA policy for mitigating any new impacts created after May 14, 1976, along existing Federal-aid highways. However, noise abatement measures may be approved for activities and land uses which come into existance after May 14, 1976, provided local governments have taken measures to exercise land-use control over the remaining undeveloped lands to prevent development of incompatible activities.

To assist local public officials and planning agencies in dealing with existing highway traffic noise--land-use development considerations, FHWA has published "The Audible Landscape: A Manual for Highway Noise and Land Use." This booklet describes a wide range of administrative and physical techniques for achieving noise-compatible land use near existing highways.

CHAPTER 2

FUNDAMENTALS OF NOISE



Sound and Noise

As we all know, sound is created when an object moves; the rustling of leaves as the wind blows, the air passing through our vocal chords, the almost invisible movement of the speakers on a stereo. The movements cause vibrations of the molecules in air to move in waves like ripples on water. When the vibrations reach our ears, we hear what we call sound.

Noise is defined as unwanted sound. Sound is produced by the vibration of sound pressure waves in the air. Sound pressure levels are used to measure the intensity of sound and are described in terms of decibels. The decibel (dB) is a logarithmetic unit which expresses the ratio of the sound pressure level being measured to a standard reference level. Sound is composed of various frequencies, but the human ear does not respond to all frequencies. Frequencies to which the human ear does not respond must be filtered out when measuring highway noise levels. Sound-level meters are usually equipped with weighting circuits which filter out selected frequencies. It has been found that the A-scale on a sound-level meter best approximates the frequency response of the human ear. Sound pressure levels measured on the A-scale of a sound meter are abbreviated dBA.

In addition to noise varying in frequency, noise intensity fluctuates with time. In the past few years, there has been a definite trend toward the use of the equivalent (energy-average) sound level as the descriptor of environmental noise in the U.S. The equivalent sound level is the steady-state A-weighted sound level which contains the same amount of acoustic energy as the actual time-varying, A-weighted sound level over a specified period of time. If the time period is 1 hour, the descriptor is the hourly equivalent sound level, Leq(h), which is widely used by SHAs as a descriptor of traffic noise. An additional descriptor, which is sometimes used, is the L_{10}. This is simply the A-weighted sound level that is exceeded 10 percent of the time.

A few general relationships may be helpful at this time in understanding sound generation and propagation. First, as already mentioned above, decibels are logarithmic units. Consequently, sound levels cannot be added by ordinary arithmetic means. A chart for decibel addition is shown in Table 1. From this table it can be seen that the sound pressure level from two equal sources is 3 dB greater than the sound pressure level of just one source. Therefore, two trucks producing 90 dB each will combine to produce 93 dB, not 180 dB. In other words, a doubling of the noise source produces only a 3 dB increase in the sound pressure level. Studies have shown that this increase is barely detectable by the human ear.

TABLE 1

RULES FOR COMBINING SOUND LEVELS BY "DECIBEL ADDITION"

For noise levels known or desired to an accuracy or ±1 decibel (acceptable for traffic noise analyses):

When two decibel values differ by	Add the following amount to the higher value
0 or 1 dB	3 dB
2 or 3 dB	2 dB
4 to 9 dB	1 dB
10 dB or more	0 dB

Secondly, an increase or decrease of 10 dB in the sound pressure level will be perceived by an observer to be a doubling or halving of the sound. For example, a sound at 70 dB will sound twice as loud as a sound at 60 dB.

Finally, sound intensity decreases in proportion with the square of the distance from the source. Generally, sound levels for a point source will decrease by 6 dBA for each doubling of distance. Sound levels for a highway line source vary differently with distance, because sound pressure waves are propagated all along the line and overlap at the point of measurement. A long, closely spaced continuous line of vehicles along a roadway becomes a line source and produces a 3 dBA decrease in sound level for each doubling of distance. However, experimental evidence has shown that where sound from a highway propagates close to "soft" ground (e.g., plowed farmland, grass, crops, etc.), the most suitable drop-off rate to use is not 3 dBA but rather 4.5 dBA per distance doubling. This 4.5 dBA drop-off rate is usually used in traffic noise analyses.

For the purpose of highway traffic noise analyses, motor vehicles fall into one of three categories: (1) automobiles - vehicles with two axles and four wheels, (2) medium trucks - vehicles with two axles and six wheels, and (3) heavy trucks - vehicles with three or more axles. The emission levels of all three vehicle types increase as a function of the logarithm of their speed (see Figure 1, Chapter 3).

The level of highway traffic noise depends on three things: (1) the volume of the traffic, (2) the speed of the traffic, and (3) the number of trucks in the flow of the traffic. Generally, the loudness of traffic noise is increased by heavier traffic volumes, higher speeds, and greater numbers of trucks. Vehicle noise is a combination of the noises produced by the engine, exhaust, and tires. The loudness of traffic noise can also be increased by defective mufflers or other faulty equipment on vehicles. Any condition (such as a steep incline) that causes heavy laboring of motor vehicle engines will also increase traffic noise levels. In addition, there are other more complicated factors that affect the loudness of traffic noise. For example, as a person moves away from a highway, traffic noise levels are reduced by distance, terrain, vegetation, and natural and manmade obstacles. Traffic noise is not usually a serious problem for people who live more than 500 feet from heavily traveled freeways or more than 100 to 200 feet from lightly traveled roads.

CHAPTER 3

Procedures for Abatement of Highway Traffic Noise and Construction Noise

The current FHWA procedures for highway traffic noise analysis and abatement were updated on July 8, 1982 (47 F.R. 29653), and a revised FHPM 7-7-3 was issued on August 9, 1982. These procedures contain the requirements that State highway agencies (SHA's) must meet when using Federal-aid funds for highway projects.

This Chapter will discuss those requirements and point out the most important issues related to States' past performances of the requirements. Each paragraph of FHPM 7-7-3 will be presented and followed by a short discussion of that paragraph. Some parts are self-explanatory which may need only a sentence or two of discussion. Other, more complicated paragraphs will have much more discussion.

1. PURPOSE. *To provide procedures for noise studies and noise abatement measures to help protect the public health and welfare, to supply noise abatement criteria, and to establish requirements for information to be given to local officials for use in the planning and design of highways approved pursuant to Title 23, United States Code (U.S.C.).*

The protection of the public's health and welfare is an important responsibility that FHWA helps to accomplish during the planning and design of the highway project. The U.S. Congress has directed that this be done when the 1970 Highway Act was passed. Concerned citizens and States encouraged Congress to provide this protection.

2. AUTHORITY. *23 U.S.C. 109(h), 109(i); 42 U.S.C. 4331, 4332; and 49 CFR 1.48(b).*

Section 136(b) of the Federal-Aid Highway Act of 1970 is codified in 23 U.S.C. 109(i). This regulation (FHPM 7-7-3) creates the standards called for in the Act.

3. NOISE STANDARDS. *The highway traffic noise prediction requirements, noise analyses, noise abatement criteria, and requirements for informing local officials in this directive constitute the noise standards mandated by 23 U.S.C. 109(i). All highway projects which are developed in conformance with this directive shall be deemed to be in conformance with the Federal Highway Administration (FHWA) noise standards.*

This paragraph makes the whole FHPM 7-7-3 the FHWA noise standard. The standard is required by 23 U.S.C. 109(i). Some people mistake the noise abatement criteria for the FHWA standard. Early on FHWA did not want to be restricted to specific noise levels that may not be achieved in most highway projects. So, a procedure was developed that would best serve the public in terms of protection and reasonable cost.

4. DEFINITIONS

a. *Design Year - the future year used to estimate the probable traffic volume for which a highway is designed. A time, 10 to 20 years, from the start of construction is usually used.*

b. *Existing Noise Levels - the noise, resulting from the natural and mechanical sources and human activity, considered to be usually present in a particular area.*

c. *L_{10} - the sound level that is exceeded 10 percent of the time (the 90th percentile) for the period under consideration.*

d. *$L_{10}(h)$ - the hourly value of L_{10}.*

e. *Leq - the equivalent steady-state sound level which in a stated period of time contains the same acoustic energy as the time-varying sound level during the same period.*

f. *Leq(h) - the hourly value of Leq.*

g. *Traffic Noise Impacts - impacts which occur when the predicted traffic noise levels approach or exceed the noise abatement criteria (Table 2), or when the predicted traffic noise levels substantially exceed the existing noise levels.*

h. *Type I Projects - a proposed Federal or Federal-aid highway project for the construction of a highway on new location or the physical alteration of an existing highway which significantly changes either the horizontal or vertical alignment or increases the number of through-traffic lanes.*

i. *Type II Projects - a proposed Federal or Federal-aid highway for noise abatement on an existing highway.*

Most of these definitions are self-explanatory; however, two need further discussion. The definition for "Traffic Noise Impacts" indicates that noise impacts occur under two criteria. First, an impact occurs when the predicted levels approach or exceed the noise abatement criteria. This criterion is widely recognized and is included in noise analysis. Secondly, an impact can occur when predicted noise levels substantially exceed the existing noise level, even though the predicted levels may not exceed the noise abatement criteria. This criterion is often overlooked by some States in their noise analysis. In order to adequately assess the noise impact of a proposed project, both criteria must be analyzed.

TABLE 2 - Noise Abatement Criteria

Hourly A-Weighted Sound Level - decibels (dBA) 1/

Activity Category	Leq(h)	$L_{10}(h)$	Description of Activity Category
A	57 (Exterior)	60 (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (Exterior)	70 (Exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals.
C	72 (Exterior)	75 (Exterior)	Developed lands, properties, or activities not included in Categories A or B above.
D	--	--	Undeveloped lands.
E	52 (Interior)	55 (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

1/Either $L_{10}(h)$ or Leq(h) (but not both) may be used on a project.

These sound levels are only to be used to determine impact. These are the absolute levels where abatement must be considered. This also means that a severe impact exists at these levels.

The definition of Type I projects makes noise analysis and abatement necessary only on those projects where the possibility of a noise impact could occur. Type I projects include projects which would significantly modify the geometric relationship (i.e. horizontal or vertical alignment) between the noise source and noise receiver or projects which provide for additional traffic capacity by adding additional through-traffic lanes.

5. APPLICABILITY

a. Type I Projects. This directive applies to all Type I projects unless it is specifically indicated that a section applies only to Type II projects.

b. Type II Projects. The development and implementation of Type II projects are not mandatory requirements of 23 U.S.C. 109(i) and are, therefore, not required by this directive. When Type II projects are proposed for Federal-aid highway participation at the option of the highway agency, the provisions of paragraphs 6, 8, and 11 of this directive shall apply.

This regulation is mandatory for all Type I projects, but optional for Type II projects.

6. ANALYSIS OF TRAFFIC NOISE IMPACTS AND ABATEMENT MEASURES

a. The highway agency shall determine and analyze expected traffic noise impacts and alternative noise abatement measures to mitigate these impacts, giving weight to the benefits and cost of abatement, and to the overall social, economic and environmental effects.

b. The traffic noise analysis shall include the following for each alternative under detailed study:

(1) identification of existing activities, developed lands, and undeveloped lands for which development is planned, designed and programmed, which may be affected by noise from the highway;

(2) prediction of traffic noise levels;

(3) determination of existing noise levels;

(4) determination of traffic noise impacts; and

(5) examination and evaluation of alternative noise abatement measures for reducing or eliminating the noise impacts.

c. Highway agencies proposing to use Federal-aid highway funds for Type II projects shall perform a noise analysis of sufficient scope to provide information needed to make the determination required by paragraph 8a of this directive.

Paragraph 6.a. is the major requirement for doing noise analysis on all Type I projects. However, this requirement includes the evaluation of noise reduction benefits, abatement cost, and social, economic, and environmental (SEE) effects. This evaluation requires a balancing by the SHA of benefits versus disbenefits. This can be a difficult task because very little guidance exists on this topic. Noise reduction benefits and abatement cost will be discussed in detail in paragraph 7. The process of balancing noise abatement and the SEE effects of the mitigation is strongly influenced by the public involvement process. The people who live next to the highway project can best evaluate if the abatement benefits will outweigh the SEE effects. The SHAs should not do this evaluation without public involvement.

Paragraph 6.b.1 requires the identification of existing activities. This identification includes not only the type (i.e. residential, commercial), but the number or extent of activity. This quantification is often overlooked in the analysis. The extent of the noise impact on the people living near the highway project cannot be evaluated correctly without the quantification of the existing activities.

Paragraph 6.b. lists the minimum requirements needed to adequately evaluate the impacts and abatement for each alternative under detailed study for the proposed highway project. The analysis should present the noise impacts and evaluation of alternative abatement measures in a comparative format. In this way, the potential noise impacts and likely abatement measures associated with the various alternatives, including the "no-build" alternative, are clearly defined. Chapter 4 explains how the noise analysis should be documented. Detailed procedures on how to do the analysis exists in the text of the two National Highway Institute noise training courses, "Fundamentals and Abatement of Highway Traffic Noise" and "Advanced Prediction and Abatement of Highway Traffic Noise."

7. NOISE ABATEMENT

a. In determining and abating traffic noise impacts, primary consideration is to be given to exterior areas. Abatement will usually be necessary only where frequent human use occurs and a lowered noise level would be of benefit.

b. In those situations where there are no exterior activities to be affected by the traffic noise, or where the exterior activities are far from or physically shielded from the roadway in a manner that prevents an impact on exterior activities, the interior criterion shall be used as the basis of determining noise impacts.

In most situations if the exterior area can be protected, the interior will also be protected. The selection of the exterior area where "frequent human use occurs" is very important. This requires a site visit to determine whether people are using the entire exterior area or only a small portion, like a patio or porch. Some States choose the right-of-way line (a point farthest away from a house) to be on the conservative side when doing the noise impact analysis. Interior use applies mostly to hospitals and schools.

Interior noise level predictions may be computed by subtracting from the predicted exterior levels the noise reduction factors for the building in question. If field measurements of these noise reduction factors are obtained (or if the factors are calculated from detailed acoustical analyses), the measured (or calculated) values should be used.

(1) In the absence of such calculations or field measurements, the noise reduction factors may be obtained from the following table:

Table 3
Building Noise Reduction Factors

Building Type	Window Condition	Noise Reduction Due to Exterior of the Structure
All	Open	10 dB
Light Frame	Ordinary Sash (closed)	20
	Storm Windows	25
Masonry	Single Glazed	25
Masonry	Double Glazed	35

(2) The windows should be considered open unless there is firm knowledge that the windows are in fact kept closed almost every day of the year.

c. *If a noise impact is identified, the abatement measures listed in paragraph 8c of this directive must be considered.*

This self-explanatory paragraph requires consideration of noise abatement when noise impacts occur. As noted in paragraph 4g., noise impacts occur when noise levels approach or exceed the noise abatement criteria and when predicted levels substantially exceed existing levels. Consequently, this paragraph requires consideration of noise abatement for both of these types of noise impacts.

d. *When noise abatement measures are being considered, every reasonable effort shall be made to obtain substantial noise reductions.*

Abatement must provide between 5 dBA and 15 dBA reduction in highway traffic noise level in order to provide noticeable and effective attenuation. When noise abatement is proposed, it is recommended that an attempt be made to achieve the greatest reduction possible.

This paragraph does not say to reduce down to the noise abatement criteria, it says "substantial noise reductions." Consequently, a projected noise level of Leq 69 for a Category B activity (see Table 2) should not be abated merely to the noise abatement criterion of Leq 67, but rather a more substantial reduction should be obtained.

e. *Before adoption of a final environmental impact statement or finding of no significant impact, the highway agency shall identify:*

(1) *noise abatement measures which are reasonable and feasible and which are likely to be incorporated in the project, and*

(2) *noise impacts for which no apparent solution is available.*

This paragraph ties the noise regulation to the NEPA requirements.

An important point is that the requirements for the draft EIS are the same as the final. Therefore, both 7.e.(1) and 7.e.(2) are needed in the draft EIS and the final EIS. The choice of the word "likely" was deliberate. If a decisionmaker is to make an informed decision and if the public is to be made aware of the impacts, the State must make its intentions known. If the State later decides that mitigation is not warranted, the decision should have strong support. If the State would like to qualify the word "likely," this is acceptable. The following is an illustration of some appropriate words.

Based on the studies so far accomplished, the State intends to install noise abatement measures in the form of a barrier from Station(s) _____ to _____. These preliminary indications of likely abatement measures are based upon preliminary design for a barrier cost $ _____ that will reduce the noise level by _____

dBA for _____ residents. If it subsequently develops during final design that these conditions have substantially changed, the abatement measures might not be provided. A final decision of the installation of the abatement measure(s) will be made upon completion of the project design and the public involvement processes.

f. The views of the impacted residents will be a major consideration in reaching a decision on the abatement measures to be provided.

Paragraph 6.a. discussed the importance of public involvement in evaluating the overall benefits of noise reduction versus the disadvantages of the noise abatement techniques.

g. The plans and specifications will not be approved by FHWA unless those noise abatement measures which are reasonable and feasible are incorporated into the plans and specifications to reduce or eliminate the noise impact on existing activities, developed lands, or undeveloped lands for which development is planned, designed, and programmed.

This is a summary statement of the requirements in the 1970 Highway Act (23 U.S.C. 109(i)).

The key words in this paragraph are "reasonable" and "feasible." The reasonableness of noise abatement measures includes subjective criteria such as property owner's input, cost of noise reduction, impact of project, people's perception of the noise reduction, etc. Reasonableness implies that common sense was applied in arriving at a decision. Feasibility deals more with the engineering considerations, i.e., can the barrier be built, can the noise reduction be achieved, etc.

The following is an extensive discussion of screening criteria used by SHAs for determining reasonableness and feasibility. Also included is an evaluation of these criteria.

Barriers are not Feasible for Uncontrolled Access Facilities

This criterion is based on several considerations, but primarily on the lack of effectiveness of barriers in reducing noise when access openings must be provided. For a barrier to provide significant noise reduction, it must be high enough and long enough to shield the receptor from significant sections of the highway. Access openings in the barrier severely reduce the noise reduction provided by the barrier. It then becomes economically unreasonable to construct a barrier for a small noise reduction. Safety at access openings due to restricted sight distances is also a concern. To provide a significant reduction, a barrier's length would normally be eight times the distance from the barrier to the receptor. A receptor located 50 feet from the barrier would require a barrier 400 feet long. An access opening of 40 feet (10 percent of the area) would limit its noise reduction to approximately 4 dB.

This criterion is acceptable, but it should not be a blanket criterion. Sensitive receptor locations must be evaluated to see if the criterion is applicable.

There are many subdivisions where frontage roads and/or parallel roads are used to get into the neighborhood. Many of these areas can be protected by barriers.

Barriers Will Not Be Provided Where The Build and No-Build Alternatives Result in the Same Noise Levels

This situation arises on projects to improve existing highways. This criterion reflects the position that it is the improvement project and not the highway that must result in an impact. If the existing level is 75 dBA before the improvement and it will be 75 dBA after the improvement, mitigation is not considered.

A parallel can be drawn with highway safety improvement projects. Our present geometric standards have evolved from earlier designs. Some of the earlier designs were good and some were bad. There are many existing roads that were designed for low design speeds that are presently unacceptable. There are other existing roads where no rational geometric design has been performed.

Many of these older roads create dangerous situations that have been identified by the evaluation of accident records. Once a bad design is recognized, it is modified or eliminated. The bad designs that were constructed are corrected when funds become available.

Traffic noise is no different. It has only been in the last 10 years that traffic noise has become recognized as an environmental pollutant. The noise emanates from the highway. Designs have been developed that reduce noise, and they are included on new projects when it is feasible and practical to do so.

The FHPM 7-7-3 requires that on all Type I Federal-aid highway improvement projects noise mitigation must be considered if the noise abatement criteria are exceeded. As long as barriers are feasible and reasonable, they should be implemented provided the highway neighbors do not object.

Barriers Will Not Be Constructed if the Noise Abatement Criteria Are Exceeded by 3 dBA or Less

This concept appears to be based upon two concepts:

a. The public cannot perceive, through their sense of hearing, changes in the noise environment of 3 dBA or smaller.

b. The noise abatement criteria are desirable levels.

People's response to highway noise is not limited to their ability to distinguish between small changes in noise levels. The fact that most people cannot easily distinguish between a 70 and 73 dBA level does not alter the fact that both levels cause an impact and that both levels should be a basis for considering abatement. Increases in the noise environment have an adverse effect, particularly increases at high levels, on annoyance, speech interference, etc.

The noise abatement criteria are not desirable levels. The levels represent a compromise between what is achievable through good highway design and what is desirable.

This screening criterion is not in conformance with FHWA policy. The FHWA requires substantial reduction when noise abatement criteria are exceeded. Thus, a predicted level of 73 dBA would be reduced to about 65 or 63 dBA.

Barriers Will Not Be Provided When the Land Use is Changing From Sensitive (Park and Residence) to Non-Sensitive (Commercial)

This screening criterion incorporates two concepts:

a. If residential areas and commercial areas are intermixed, barriers will not be effective if openings are provided for commercial owners who do not want the view of their establishment from the roadway blocked by barriers. The access openings for the commercial area negate the barrier's effectiveness.

b. Barriers built to protect the residences have high potential for being torn down when the property use changes to commercial. Funds would be wasted in constructing a barrier only to remove it in a few years.

This is an acceptable screening criterion with considerable credibility, if the zoning and land use plans provide for the land use change.

Barriers Will Not Be Provided if the Cost to Mitigate Exceeds the Cost of the Protected Properties

The purpose of the noise barrier is to protect people--not property. Such a criterion could be viewed as discriminatory.

This screening criterion is not in conformance with FHWA policy.

The Barrier Must Provide a Minimum Noise Reduction

Two reasons justify this criterion:

a. If the public cannot perceive the noise reduction, the barrier is not effective.

b. The SHA's will be criticized for "wasting" money if the barriers are not effective in reducing noise.

The choice of what minimum reduction to strive for is certainly a subjective one. The choice of 5 dBA, or 10 dBA is probably related to data found in the technical literature. (See Table 4).

Table 4: Relationship Between Decibel, Energy, and Loudness

A-Level Down	Remove ___% of Energy	Divide Loudness by
3 dBA	50	1.2
6 dBA	75	1.5
10 dBA	90	2
20 dBA	99	4

A reduction of 10 dBA (say 75 dBA to 65 dBA) will be perceived by the public as a halving of the loudness. This is an easily recognizable change. Five dBA and 7 dBA changes can also be recognized, but to a lesser degree.

However, two points must be kept in mind.

a. Any reduction will improve the noise environment in such areas as annoyance, speech interference, task interference, etc.

b. No matter what the reduction, until the level reaches a very low level (about Leq = 55 dBA), the noise environment will continue to be dominated by traffic noise that is clearly audible.

The use of a single criterion such as minimum noise reduction is not in conformance with FHWA policy. The FHWA policy requires that the final decision on noise abatement be based on costs, benefits, and effects. There are obvious reasons for this. Suppose a State had a minimum criterion of 7 dBA. If a solid low-cost, 6-foot high privacy fence (in lieu of a chain-link fence) will provide a 5 dBA reduction, why not provide it? Alternately, such a criterion without public involvement may not be cost-effective. To achieve the minimum reduction, an extremely high barrier may be needed. The public may want a lower and, therefore, cheaper barrier, even though such a barrier will not acoustically do much good. In such an instance, landscaping could be offered as a cheaper alternative to the community. The relationship between effectiveness and cost is similar to the relationship between absolute level and substantial increase.

Reasonable Cost

This criterion appears to be based upon the concept that noise barriers are generally too expensive for the amount of environmental mitigation they provide.

The end result of this criterion is that cost is used as a standard reason for not building barriers. As many barriers as possible are eliminated using the other criteria in this section. Then, the barriers that remain are eliminated due to costs.

The costs shown in Table 5 are based upon an unpublished report prepared for FHWA. The values shown in Table 5 are average values based upon 200 miles of noise barriers constructed prior to 1981. The costs have been adjusted to 1980 dollars.

Table 5: Summary of Barrier Costs

MATERIAL	LINEAR COST/FOOT*
Concrete	105
Combination	146
Wood	105
Earthberm**	45
Metal	137

*Total Costs divided by total length (variable height).

**Includes earthberms with zero costs.

The unit costs in Table 5 seem reasonable. Cost/residence is obtained by dividing the total barrier cost by the number of residences located on property abutting the highway right-of-way. Although this figure has reached $32,000 per residence in some instances, the median range is more typically $8,000 to $15,000 per residence. This range appears to be consistent with the unit costs in Table 5 for an average residential lot size.

Total cost of noise abatement by itself is not an acceptable criterion. The FHWA noise regulation states that "Federal funds may be used for noise abatement measures where: . . . . (3) the overall noise abatement benefits are determined to outweigh the overall adverse social, economic, and environmental effects and the costs of the noise abatement measures." (FHPM 7-7-3, Paragraph 8.a.).

Noise Barriers Will Not be Provided if the Highway Neighbors in the Affected Areas Do Not Want Them

Several reasons have been reported as to why the highway neighbors do not want noise barriers.

a. Highway neighbors do not perceive traffic noise as a problem.

b. Barriers are esthetically unpleasing.

c. Barriers interface with other desirable neighborhood features, such as scenic views.

d. Barriers may provide cover for crimes in the area.

e. Barriers may be poorly maintained and trash and debris may collect around them.

This is one of the possible reasons for not building a barrier, provided it is the highway neighbors in the affected area making the input to the State's decision. A blanket decision for an entire State is not acceptable.

Barriers Are Not Feasible If They Create a Safety or Maintenance Problem

Noise barriers placed near the roadway are criticized as creating a safety problem. The reason is the safety "clear zone" recommended by AASHTO highway design guidelines. Many times because of topography and right-of-way constraints, the only place to put a noise barrier is at the edge of the roadway shoulder (within the "clear zone"). The placement on the shoulder can also reduce stopping sight distance on curved roadway sections.

In almost all instances, problems associated with safety or maintenance of noise barriers should be and can be resolved during the design process. This is evident in the many States that have successfully built noise barriers. This criterion should not be used unless thorough documentation has been provided to substantiate it.

Barriers Are Not Feasible if Other Noise Sources Are Present

Noise barriers are built to protect people from traffic noise on adjacent highway facilities. While the noise from a particular highway may create sufficient impacts to warrant mitigation consideration, the intrusive characteristic of noise created by other nonhighway sources, such as periodic aircraft flyovers or train passbys, is felt to be significant enough to render any potential highway noise mitigation unfeasible. Mitigation is also sometimes deemed unfeasible due to the presence of other local streets in the project area.

A complete highway traffic noise analysis should identify all sources of noise in the project area, particularly noting nonhighway sources and other local streets in the area. This criterion is acceptable if the analysis and documentation clearly show that sources other than the proposed highway facility contribute significantly to the total noise environment in the area. This criterion is not a blanket criteria--it should be applied only after careful evaluation.

Barriers Are Feasible Only to a Predetermined Maximum Height

Value engineering has been used to place a blanket limitation on the maximum height of proposed noise barriers. This height limitation can result in an inability to achieve a reasonable and/or desirable noise reduction with barrier construction. Therefore, traffic noise impacts are often only partially abated.

This criterion has restricted the effectiveness of the proposed barrier construction. Barrier height should be determined by a comprehensive acoustical design and/or the desires of the affected residents, not value engineering alone. The Barrier Cost Reduction (BCR) (computerized barrier design) program should assist States in determining optimum barrier designs.

8. FEDERAL PARTICIPATION

a. Federal funds may be used for noise abatement measures where:

(1) a traffic noise impact has been identified,

(2) the noise abatement measures will reduce the traffic noise impact, and

(3) the overall noise abatement benefits are determined to outweigh the overall adverse social, economic, and environmental effects and the costs of the noise abatement measures.

Paragraph 8.a. identifies the simple rules that guide the funding of noise abatement on highway projects. These rules apply to both Type I and Type II projects.

b. For Type II projects, noise abatement measures will not normally be approved for those activities and land uses which come into existence after May 14, 1976. However, noise abatement measures may be approved for activities and land uses which come into existence after May 14, 1976, provided local authorities have taken measures to exercise land use control over the remaining undeveloped lands adjacent to highways in the local jurisdiction to prevent further development of incompatible activities.

Paragraph 8.b. limits funding participation for retrofit barriers on existing highways because in 1976, FHWA publicly stated that local governments must help control noise impacts through noise-compatible, land use planning and zoning. However, it is important to remember that this paragraph does <u>not</u> restrict the approval of Type II barriers after 1976. It says that the land use activity (housing development) built near a highway after 1976 cannot get a Type II barrier, <u>unless</u> the local government has an active land use control program to prevent future incompatible activities.

c. The noise abatement measures listed below may be incorporated in Type I and Type II projects to reduce traffic noise impacts. The costs of such measures may be included in Federal-aid participating project costs with the Federal share being the same as that for the system on which the project is located, except that Interstate construction funds may only participate in Type I projects:

(1) traffic management measures (e.g., traffic control devices and signing for prohibition of certain vehicle types, time-use restrictions for certain vehicle types, modified speed limits, and exclusive land designations),

(2) alteration of horizontal and vertical alignments,

(3) acquisition of property rights (either in fee or lesser interest) for construction of noise barriers,

(4) construction of noise barriers (including landscaping for esthetic purposes) whether within or outside the highway right-of-way. Interstate construction funds may not participate in landscaping,

(5) acquisition of real property or interests therein (predominately unimproved property) to serve as a buffer zone to preempt development which would be adversely impacted by traffic noise. This measure may be included in Type I projects only, and

(6) noise insulation of public use or nonprofit institutional structures.

Several important points about this paragraph are: (1) the participating share is the same as that for the system on which the project is located; (2) Interstate construction funds cannot be used for Type II projects or landscaping of barriers; and (3) buffer zones can only be used in Type I projects.

The approval of Interstate construction funding has been revised so that emphasis is placed on completing the "GAP" sections. Noise abatement on those GAP sections and on incorporated Interstate sections with approved major upgrading can be funded with Interstate construction funds.

Also, Interstate projects with approved stage construction can use Interstate construction funds for noise abatement if the abatement was part of the stage construction.

On other Interstate highway projects, "4R" funds must be used for noise abatement on both Type I and Type II projects. These "4R" funds can be used for abatement measures listed in 8.c. and 8.d.

Although most noise mitigation has been built on Interstate highway projects, Federal funds may be used for mitigation measures on other highway systems (i.e., primary, secondary, urban) if the noise impacts exist and the criteria in 8.a. are met.

The most used abatement measure is the noise barrier; however, paragraph 7.c. requires consideration of all the abatement measures listed in paragraph 8.c. Chapter 5 contains more details on abatement measures.

d. There may be situations where (1) severe traffic noise impacts exist or are expected, and (2) the abatement measures listed above are physically infeasible or economically unreasonable. In these instances, noise abatement measures other than those listed in paragraph 8c of this directive may be proposed for Types I and II projects by the highway agency and approved by the Regional Federal Highway Administrator on a case-by-case basis when the conditions of paragraph 8a of this directive have been met.

This paragraph allows the States the flexibility to propose innovative noise abatement measures when the commonly used measures are unacceptable. The Regional Administrator is delegated the approval authority in these special situations. This special approval has only been used a few times which is a good indication that the common type measures (8.c.) will solve the highway traffic noise problems in most all situations.

9. INFORMATION FOR LOCAL OFFICIALS. *In an effort to prevent future traffic noise impacts on currently undeveloped lands, highway agencies shall inform local officials within whose jurisdiction the highway project is located of the following:*

a. The best estimation of future noise levels (for various distances from the highway improvement) for both developed and undeveloped lands or properties in the immediate vicinity of the project,

b. Information that may be useful to local communities to protect future land development from becoming incompatible with anticipated highway noise levels, and

c. eligibility for Federal-aid participation for Type II projects as described in paragraph 8b of this directive.

The prevention of future impacts is one of the most important parts of noise control ("an ounce of prevention is worth a pound of cure"--Author unknown). The compatibility of the highway and its neighbors is essential for the continuing growth of local areas. Both development and highways can be compatible. But, the local government officials need to know what noise levels to expect from a highway and what techniques they can use to prevent future impacts. States can help by providing this information to local governments.

10. TRAFFIC NOISE PREDICTION

a. Any traffic noise prediction method is approved for use in any noise analysis required by this directive if it generally meets the following two conditions:

(1) The methodology is consistent with the methodology in the FHWA Highway Traffic Noise Prediction Model (Report No. FHWA-RD-77-108).

(2) The prediction method uses noise emission levels obtained from one of the following:

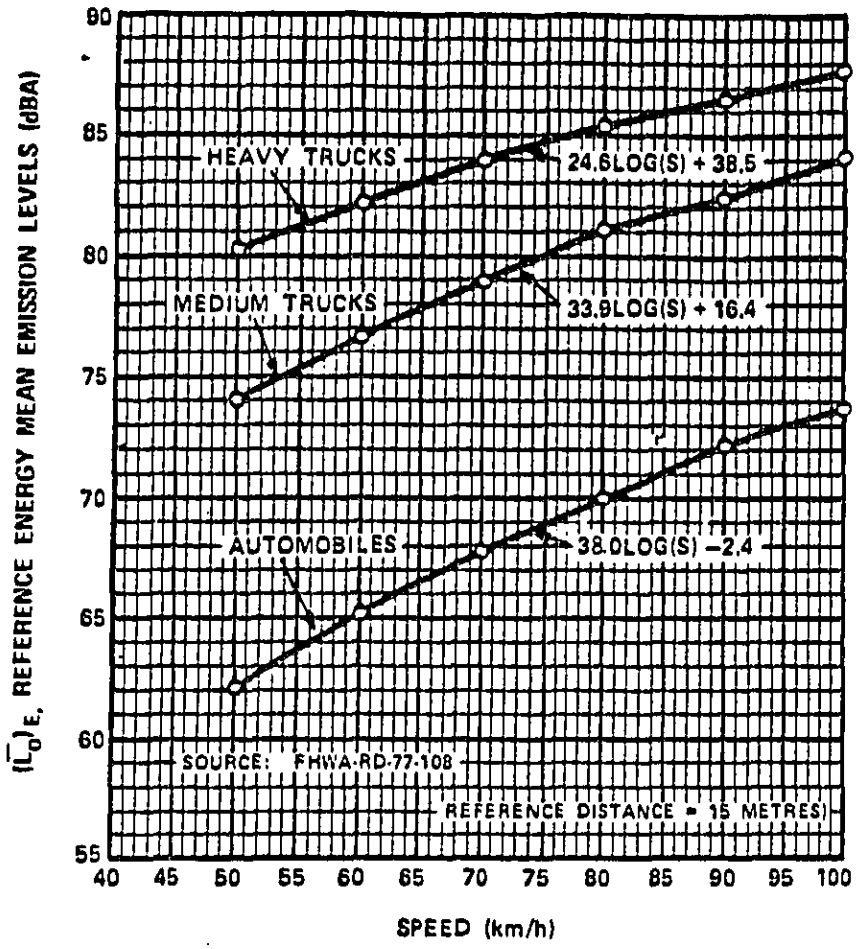
(a) National Reference Energy Mean Emission Levels as a Function of Speed (Figure 1).

(b) Determination of reference energy mean emission levels in "Sound Procedures for Measuring Highway Noise: Final Report," Report No. DP-45-1R.

b. In predicting noise levels and assessing noise impacts, traffic characteristics which will yield the worst hourly traffic noise impact on a regular basis for the design year shall be used.

Most States use the FHWA prediction model with the National emission levels. This model is usually in the form of the computer program "STAMINA 1" or "Barrier Cost Reduction Procedure" (BCR), which is "STAMINA 2.0/OPTIMA"). Also, some States have taken the STAMINA computer program and modified it to change input/output characteristics to suit the State's design process. When the States make these changes they usually put a different name on the computer program. A comparison of results from the examples in the Report FHWA-RD-77-108 and a State's computer program should provide a good check on a State's computer program noise prediction method.

Traffic characteristics used in predicting future noise levels could make a significant difference in the results. "Worst hourly traffic noise impact" should be decided through some logical analysis of real traffic data on different highway classifications. The numbers of medium and heavy trucks are very important.



LEGEND:

1. AUTOMOBILES: ALL VEHICLES WITH TWO AXLES AND FOUR WHEELS.
2. MEDIUM TRUCKS: ALL VEHICLES WITH TWO AXLES AND SIX WHEELS.
3. HEAVY TRUCKS: ALL VEHICLES WITH THREE OR MORE AXLES.

National Reference Energy Mean Emission Levels as a Function of Speed

Figure 1

These levels are to be used in the prediction of future highway traffic noise. If a State uses different emission levels, documentation must be provided to the FHWA Division Office to justify its use. Paragraph 10.a(2)(b) specifies that the method in Report No. DP-45-1R be used to obtain these emission levels. The FHWA Division Office should forward the proposed emission levels to FHWA Headquarters (HEV-30) for review and comment.

11. CONSTRUCTION NOISE. *The following general steps are to be performed for all Types I and II projects:*

    a. *Identify land uses or activities which may be affected by noise from construction of the project. The identification is to be performed during the project development studies.*

    b. *Determine the measures which are needed in the plans and specifications to minimize or eliminate adverse construction noise impacts to the community. This determination shall include a weighing of the benefits achieved and the overall adverse social, economic, and environmental effects and the costs of the abatement measures.*

    c. *Incorporate the needed abatement measures in the plans and specifications.*

The impact of construction noise does not appear to be serious in most instances. Chapter 4 provides appropriate guidance for the consideration of construction noise in traffic noise analyses.

CHAPTER 4

HIGHWAY TRAFFIC NOISE STUDIES

1. INTRODUCTION

The major objectives of a noise study for new highway construction or a highway improvement are:

- To define areas of potential noise impact for each study alternative
- To evaluate measures to mitigate these impacts
- To compare the various study alternatives on the basis of potential noise impact and the associated mitigation costs

Highway noise studies thus provide useful information, directed primarily to two distinctly different audiences - the government decisionmaker and the lay public. For the government decisionmaker, the noise study should provide a portion of the data needed for the informed selection of a satisfactory project alternative and appropriate mitigation measures. For the lay public, the noise study should provide discussion of potential impacts in any areas of concern to the public.

The key elements of a highway noise study are as follows:

- Definition of noise impact criteria and identification of noise-sensitive land uses
- Prediction of noise levels for study alternatives
- Depiction of existing noise levels
- Projection of noise impacts for study alternatives
- Identification and evaluation of mitigation measures
- Evaluation of construction noise
- Coordination with local government officials

2. IMPACT CRITERIA/NOISE-SENSITIVE LAND USES

The first step in the highway noise study is the definition of criteria for noise impact. With this definition established, the location of noise-sensitive land uses in the vicinity of the various study alternatives can be identified.

A noise impact may be expected to occur when either or both of the following situations occur:

- The projected highway noise levels approach or exceed the noise abatement criteria in FHPM 7-7-3.
- The projected highway noise levels substantially exceed existing noise levels in an area.

Based upon the noise criteria established above, noise-sensitive land uses in the vicinity of each of the study alternatives that may be impacted by future highway noise levels should be identified. Noise-sensitive areas may be identified by individual land uses, or by broad categories of land use for which a single criterion level may apply. In some cases, lands

that are undeveloped at the time of the project may be known to be under consideration for development in the future. If this is the case, then these lands should be treated as developed and the severity of highway noise impact should be assessed accordingly.

An example of a brief categorization of land-use types is the following:

> In this study, all land along the project is considered to fall in activity category B.

Somewhat more detail is provided by this example:

> The region is primarily residential, although it is zoned for general business as well. Two apartment complexes and 50 residences are east of Airport Drive, at the south end. The nearest facade of these buildings is approximately 70 feet from the road centerline, and the farthest facade is roughly 400 feet away. The apartments house about 200 families.

3. NOISE LEVEL PREDICTION

The second step involved in the highway noise study is to analyze the noise levels expected to occur as a result of the proposed highway or highway extension. Noise levels should be estimated for each of the potential project alternatives, including the "do-nothing" case. The method used to predict traffic noise levels and traffic data for the various alternatives should be well documented.

Example

The following excerpt from an environmental impact statement shows how the prediction model may be explained, the data documented, and the results presented.

Prediction of the Future Traffic Noise Levels. For each of the seven alternatives under consideration, traffic noise at each receptor for the year 2000 was predicted using the FHWA Level 2 Highway Traffic Noise Prediction Model, STAMINA 1.0. This model uses the number and type of vehicles on the planned roadway, their speeds, and the physical characteristics of the road, i.e., curves, hills, depressed, elevated, etc. In this regard it is to be noted that only preliminary alignment and roadway elevation charteristics were available for use in this noise analysis. Each alternative was modeled assuming no special noise abatement measures would be incorporated. Only those existing natural or man-made barriers were included. The roadway sections were assumed to be at-grade, except where grade separation of intersections was necessary. Thus, the analysis represents "worst-case" topographic conditions. The traffic volumes used in the projections were obtained from the Metropolitan Council Regional Traffic Assignment Model. The noise predictions made in this

report are highway-related noise predictions for the traffic conditions during the year being analyzed. It was assumed that the peak-hour volumes and corresponding speeds for trucks and automobiles result in the noisiest conditions. During all other time periods, the noise levels will be less than those indicated in this report.

4. EXISTING NOISE LEVELS

The primary method to determine existing noise levels is to measure them. Such measurements should be made at the identified noise-sensitive locations. Noise level measurements should be clearly documented. If it is clear that existing levels at locations of interest are predominantly due to an existing highway, then noise prediction estimates can be used instead of field measurements.

The following excerpt from an environmental impact statement shows how existing noise levels can be documented.

Example

Figure _ is a plan map of the study area and the location of the noise measurement sites. The microphone was located 4 to 5 feet above the ground. Measurement Site Nos. 1, 2, and 4 are along the existing Airport Drive and near the apartment buildings closest to the project roadway. These locations were chosen to document existing noise levels and traffic conditions at the residential area where the potential for the most noise impact due to the project exists. Sites 3 and 5 are located in residential areas near the location of the proposed extension of Airport Drive. In these areas, existing noise levels are expected to be the lowest in the project corridor. Sites 6 and 7 are near the other roadways in the study area that carry significant traffic and connect to the proposed project.

The existing noise measurements were made during mid-day hours on June 12 and 13, 1978. The temperature varied from 71 degrees F to 85 degrees F, and winds were light and variable, having little effect on sound propagation over moderate distances.

Noise measurements were obtained with the BBN Model 614 portable Noise Monitor, set to compute sound level distributions on a minute-by-minute basis. During each minute of analysis, the ambient noise sources were noted and local traffic counts were made. The duration of each measurement period was between 20 and 35 minutes.

5. PROJECTION OF NOISE IMPACT

The next step in the noise study involves a comparison of the predicted noise levels for each project alternative with the noise abatement criteria and existing noise levels. This comparison defines the degree of noise impact associated with each alternative, in terms of the change in existing levels and the amount by which criteria may be exceeded. The main purpose of this comparison is to contrast the noise impacts that are expected to occur as a result of the highway project, for each active alternative, with the existing noise impacts.

The noise abatement criteria from FHPM 7-7-3 are listed in Table 2. Abatement must be considered when future noise levels approach or exceed these criteria.

If impacts occur when the future noise levels substantially exceed the existing noise levels, what constitutes a substantial increase? There is no mandated definition. Several criteria have evolved and are used by different State highway agencies. Three sets of criteria are shown below.

Table 6: Criteria Used by States to Define "Substantial"

	Increase (dB)	Subjective Descriptor
Criteria 1	0-5	No Impact
	5-15	Some Impact
	> 15	Great Impact
Criteria 2	< 10	No Impact
	>10	Serious Impact
Criteria 3	0-5	No Impact
	5-10	Minor Impact
	10-15	Moderate Impact
	>15	Serious Impact

The following example illustrates a discussion of impact in an environmental impact statement:

Example

A noise analysis has been conducted for the proposed actions. The greatest noise impact will be felt at residential sites which are near the proposed loop location. Table No. 7 shows the results of this analysis. The average impact on the selected noise sites is +12 dBA which will seem about 2-1/2 times as loud as the existing noise environment. The largest impacts (up to +25 dBA) will be felt at rural residences that are now on the less traveled backroads and will be close to the proposed highway.

For the recommended Alternate 3, 52 single-family residences, 12 multiple-family residences and 2 churches equal or exceed the noise abatement criteria. Fifty-two single-family residences, 28 multiple-family residences, 2 businesses, and 2 churches will experience a substantial increase in existing noise levels, that is, an increase of 10 dBA or more (at least doubling the loudness).

6. MITIGATION MEASURES

The next step in the noise study is identification and evaluation of various noise abatement measures that could mitigate the adverse impacts predicted for the proposed highway project. For example, traffic management measures such as the following should be included in the evaluation:

- Prohibition of certain vehicle types
- Time use restrictions for certain vehicle types
- Modified speed limits
- Exclusive land use designations
- Traffic control devices
- Combinations of the above measures.

Additional noise abatement measures are discussed in detail in Chapter 5.

For each mitigation measure, the following information should be presented:

- Description of the measure
- Anticipated costs, problems, and disadvantages
- Anticipated benefits relative to the criterion levels, existing levels, and other factors.

Examples

The most likely method available to lessen the noise levels and thus alleviate noise impact from Airport Drive is to incorporate noise control into the highway design stage. Since the alignment and grade of Airport Drive have already been established, noise barriers beside the roadway are probably the most acceptable means of noise control.

Table 7: Existing and Future Exterior Noise Levels (Leq in dBA)

Noise Receptor Number	Land Use Activity Category	Numbers by Activity (1)	Average Distance to Roadway	Noise Abatement Criteria	Measured Existing Noise Level	Future Noise Levels by Project Alternative Without and With Abatement (2)			
						1 (No-Build)	2	3	4
1	B	3 MF	300'	67	55	63	66/58	68/60	68/60
2	B	7 SF	170'	67	58	58	70/60	72/61	73/65
3	C	2 B	260'	72	54	55	67/60	69/60	70/63
4	B	11 SF, 7 MF	100'	67	56	62	73/65	75/65	75/69
5	B	16 MF	150'	67	52	52	62/59	66/61	67/64
6	B	14 SF	170'	67	52	54	75/66	77/69	77/71
7	B	12 SF, 1 MF	200'	67	53	56	66/62	69/67	69/66
8	B	2 CH	180'	67	53	54	69/61	73/62	73/69
9	C	3 B	150'	72	62	67	69/-	69/-	70/-
10	B	7 SF, 1 MF	230'	67	57	61	69/66	69/64	70/64

(1) SF = Single-Family Residence
MF = Multiple-Family Residence
B = Business
CH = Church

(2) 66/58: 66 = Noise Level Without Abatement
58 = Noise Level With Abatement
- = Abatement Not Considered

The first location for which a noise control barrier has been designed is along Airport Drive at the East Avenue-Fair Oaks apartment complex. The proposed barrier is located 12 feet from the edge of Airport Drive, is about 1,770 feet long, and runs from a point about 145 feet north of the edge of Nine Mile Road at the Airport Drive intersection to about 70 feet north of the northernmost apartment building. If the top of the barrier is 10 feet above grade level, it will provide 9-11 dB reduction in the noise levels at the nearest building, first floor elevation (5 feet above ground). This will reduce the predicted exterior L_{10} noise levels near these buildings from 73-74 dB to 62-65 dB.

The cost of noise barriers depend directly on the material used to build it. If an earth berm is feasible, costs including installation may be as little as $15 per lineal foot for a 10-feet-high berm. A comparable steel barrier may cost $75 per lineal foot. Masonry and wood barriers cost approximately $35 per lineal foot (10 feet high), and concrete barriers are about $50 per lineal foot. If masonry or wood barriers were to be erected along Airport Drive, the cost for the barrier for the apartments would be about $65,000 to $85,000 and the cost for the barrier for the three homes would be about $35,000.

7. CONSTRUCTION NOISE ANALYSIS

The following items should be considered to ensure that potential construction noise impacts are given adequate consideration during highway project development:

a. Calculation of construction noise levels is usually not necessary for traffic noise analyses. If a construction noise impact is anticipated at a particular sensitive receptor, use of the model contained in "Highway Construction Noise: Measurement, Prediction, and Mitigation" to predict construction noise levels should be sufficient. A newly developed computerized prediction model HICNOM is quite sophisticated and requires considerable input, and, therefore, should be used only on highly complex or controversial major urban projects.

b. Potential impacts of highway construction noise should be addressed in a general manner for traffic noise analyses. The temporary nature of the impacts should be noted. An indication of the types of construction activities that can be anticipated and the noise levels typically associated with these activities can be obtained from existing literature and presented in the noise analysis.

c. Utilizing a common sense approach, traffic noise analyses should identify measures to mitigate potential highway construction noise impacts. Low cost, easy to implement measures should be incorporated into project plans and specifications.

d. Major urban projects with unusually severe highway construction noise impacts require more extensive analyses. Sensitive receptors should be identified, existing noise levels should be measured, construction noise levels should be predicted, and impacts should be discussed so

as to properly indicate their severity. Mitigation measures likely to be incorporated into these projects may be quite costly and should be thoroughly discussed and justified in the analyses. The use of portable noise barriers and special quieting devices on construction equipment have been used for construction noise mitigation.

The following example illustrates a construction noise discussion from an environmental impact statement.

Example

It is difficult to predict reliable levels of construction noise at a particular receptor or group of receptors. Heavy machinery, the major source of noise in construction, is constantly moving in unpredictable patterns. Daily construction normally occurs during daylight hours when occasional loud noises are more tolerable. No one receptor is expected to be exposed to construction noise of long duration; therefore, extended disruption of normal activities is not anticipated. However, provisions will be included in the plans and specifications requiring the contractor to make every reasonable effort to minimize construction noise through abatement measures such as work hour controls and maintenance of muffler systems.

8. COORDINATION WITH LOCAL GOVERNMENT OFFICIALS

The final part of the noise study is coordination with local officials whose jurisdictions are affected. The primary purpose of this coordination is to promote compatibility between land development and highways.

The highway agency should furnish the following information to appropriate local officials:

- Estimated future noise levels at various distances from the highway improvement.
- Locations where local communities should protect future land development from becoming incompatible with anticipated highway noise levels.

CHAPTER 5

NOISE ABATEMENT

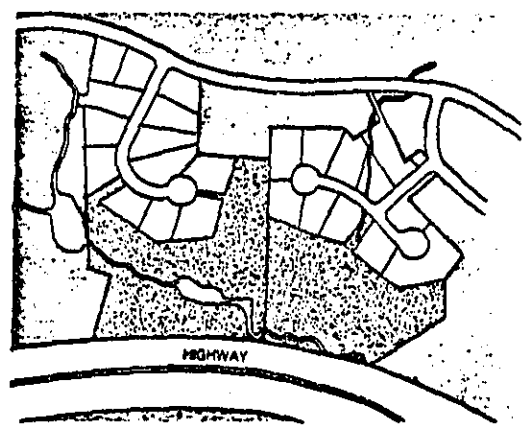
Introduction

Early in the planning stages of most highway improvements, highway agencies do a noise study. The purpose of this study is to determine if the project will create any noise problems. If the predicted noise levels cause an impact, the noise study must consider measures that can be taken to lessen these adverse noise impacts. There are a variety of things that a highway agency can do to lessen the impacts of highway traffic noise.

Noise Abatement Measures

Some noise abatement measures that are possible include creating buffer zones, constructing barriers, planting vegetation, installing noise insulation in buildings, and managing traffic.

Buffer zones are undeveloped, open spaces which border a highway. Buffer zones are created when a highway agency purchases land, or development rights, in addition to the normal right-of-way, so that future dwellings cannot be constructed close to the highway. This prevents the possibility of constructing dwellings that would otherwise have an excessive noise level from nearby highway traffic. An additional benefit of buffer zones is that they often improve the roadside appearance. However, because of the tremendous amount of land that must be purchased and because in many cases dwellings already border existing roads, creating buffer zones is often not possible.



Open space can be left as a buffer zone between residences and a highway

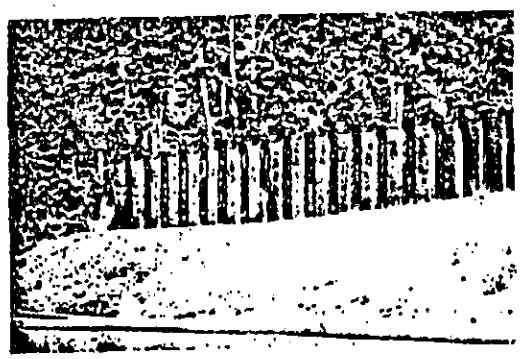
Noise barriers are solid obstructions built between the highway and the homes along the highway. Effective noise barriers can reduce noise levels by 10 to 15 decibels, cutting the loudness of traffic noise in half. Barriers can be formed from earth mounds along the road (usually called earth berms) or from high, vertical walls. Earth berms have a very natural appearance and are usually attractive. However, an earth berm can require quite a lot of land if it is very high. Walls take less space. They are usually limited to 25 feet in height because of structural and aesthetic reasons. Noise walls can be built out of wood, stucco, concrete, masonry, metal, and other materials. Many attempts are be. · made to construct noise barriers that are visually pleasing and that blend in with their surroundings.

BARRIER ATTENUATION

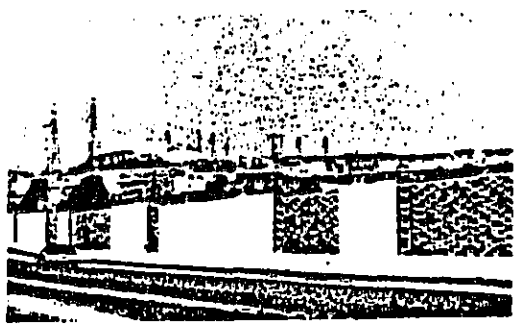
5 dBA-Simple
10 dBA-Attainable
15 dBA-Very Difficult
20 dBA-Nearly Impossible

However, barriers do have limitations. For a noise barrier to work, it must be high enough and long enough to block the view of a road. Noise barriers do very little good for homes on a hillside overlooking a road or for buildings which rise above the barrier. Openings in noise walls for driveway connections or intersecting streets destroy the effectiveness of barriers. In some areas, homes are scattered too far apart to permit noise barriers to be built at a reasonable cost.

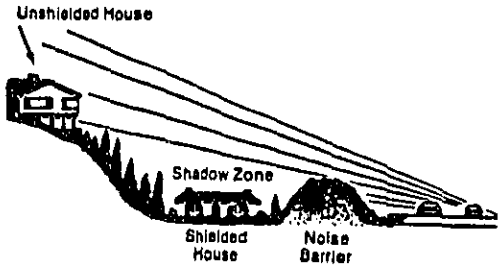
Earth Berm Noise Barrier



Wooden Noise Barrier



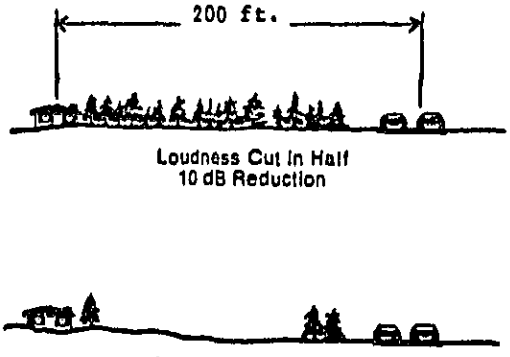
Masonry Noise Barrier



Shadow Effect of Noise Barrier

The lower house is protected by the barrier, but the upper one is not.

Vegetation, if it is high enough, wide enough, and dense enough that it cannot be seen through, can decrease highway traffic noise. A 200-foot width of dense vegetation can reduce noise by 10 decibels, which cuts in half the loudness of traffic noise. It is often impractical, however, to plant enough vegetation along a road to achieve such reductions. But, if dense vegetation already exists, it could be saved. If it does not exist, roadside vegetation can be planted to create a psychological relief, if not an actual lessening of traffic noise levels.



Vegetation and Noise Reduction

Insulating buildings can greatly reduce highway traffic noise, especially when windows are sealed and cracks and other openings are filled. Sometimes noise-absorbing material can be placed in the walls of new buildings during construction. However, insulation can be costly because air conditioning is usually necessary once the windows are sealed.

In many parts of the country, highway agencies do not have the authority to insulate buildings; thus, in those States, insulation cannot be included as part of a highway project. Noise insulation is normally limited to public use structures such as schools and hospitals.

Controlling traffic can sometimes reduce noise problems. For example, trucks can be prohibited from certain streets and roads, or they can be permitted to use certain streets and roads only during daylight hours. Traffic lights can be changed to smooth out the flow of traffic and to eliminate the need for frequent stops and starts. Speed limits can be reduced; however, about a 20 mile-per-hour reduction in speed is necessary for a noticeable decrease in noise levels.

Pavement is sometimes mentioned as a factor in traffic noise. While it is true that noise levels do vary with changes in pavements and tires, it is not clear that these variations are significant when compared to the noise from exhausts and engines, especially when there are a large number of trucks on the highway. More research is needed to determine to what extent different types of pavements and tires contribute to traffic noise. Until this research is completed, the use of different types of pavement cannot be depended upon to reduce traffic noise.

Questions and Answers

Q. Must a traffic noise analysis be done for all proposed Federal-aid highway projects?

A. No. Traffic noise analyses must be done only for a proposed Federal-aid highway project for the construction of a highway on new location or the physical alteration of an existing highway which significantly changes either the horizontal or vertical alignment or increases the number of through-traffic lanes. Projects which do not fit this description do not require a traffic noise analysis.

Q. Are the noise abatement criteria (Leq = 67,72, etc.) a Federal standard?

A. No. The noise standard mandated by the Federal-Aid Highway Act of 1970 is the entire Federal-Aid Highway Program Manual (FHPM) 7-7-3. The noise abatement criteria are absolute levels at which a traffic noise impact occurs and measures to abate this impact must be considered.

Q. Can a traffic noise impact occur if the noise abatement criteria are not approached or exceeded?

A. Yes. When predicted traffic noise levels substantially exceed existing noise levels, FHPM 7-7-3 defines this substantial increase as a second impact criterion. Substantial increase has been interpreted by State highway agencies around the country as occurring in the range of a 10-15 dBA increase.

Q. Must measures always be included in a proposed Federal-aid highway project to abate traffic noise impacts that are expected to occur?

A. No. If traffic noise impacts are identified, abatement measures must be considered and reasonable and feasible abatement measures must be incorporated into the proposed project. Noise problems for which no prudent solution is reasonably available and the reasons why must be identified in environmental documentation, along with noise abatement measures likely to be incorporated into the proposed project.

Q. Must traffic noise abatement measures be designed to meet the noise abatement criteria?

A. No. The noise abatement criteria are absolute levels used to determine when a noise impact is expected to occur and mitigation must be considered. When noise abatement measures are being considered, every reasonable effort shall be made to achieve a substantial noise reduction. A common design goal for substantial noise reduction is 10 dBA.

Q. Can the planting of trees or shrubs be included as a traffic noise abatement measure in a proposed highway project?

A. No. While vegetation can provide a psychological benefit, it provides very little physical noise reduction. Traffic noise abatement measures should provide a substantial reduction in noise levels. Trees and shrubbery can be provided as landscaping of visual screening measures in a highway project but not as traffic noise abatement measures.

APPENDIX B

Current Issues

Major items of current interest in the highway traffic noise area should be discussed in this section. For information on current activities, please contact the Office of Environmental Policy, Noise and Air Analysis Division (HEV-30) at FTS 426-4836.

APPENDIX C

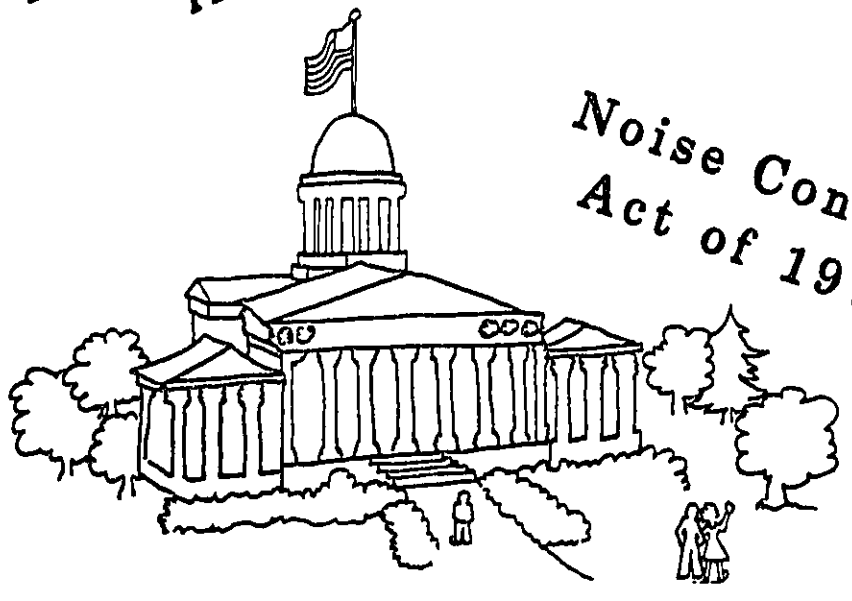
Sources of Additional Information and Technical Assistance

For information on highway traffic noise, contact the Office of Environmental Policy, Noise and Air Analysis Division (HEV-30) at FTS 426-4836. Technical assistance is readily available to meet any of the needs of highway traffic noise consideration in the Federal-aid highway program.

LEGISLATION

National Environmental Policy Act of 1969

Federal-Aid Highway Act of 1970

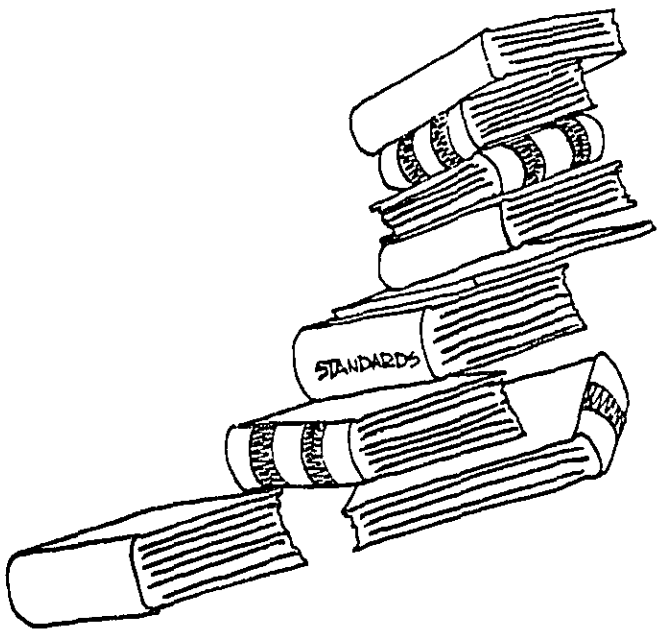


Noise Control Act of 1972

REGULATION

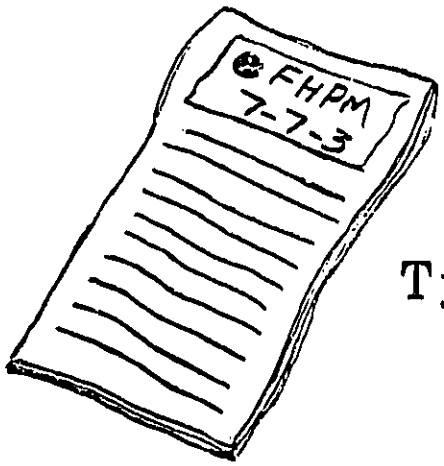
Federal-Aid Highway Program Manual 7-7-3

August 9, 1982 Revision



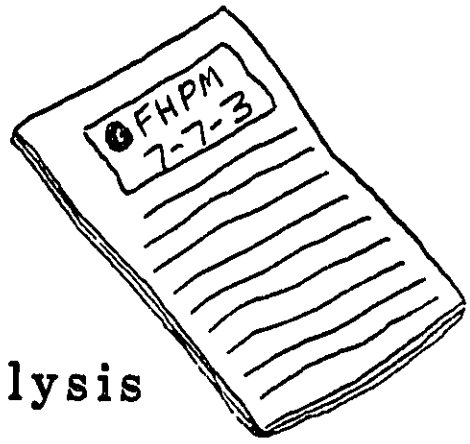
Noise Standards

2 Impact Criteria



Type I Projects

Type II Projects (May 14, 1976)



Exterior Analysis

Consider Abatement

Substantial Reductions

Reasonable and Feasible

Likely to Be Incorporated

Undeveloped Lands

Public Use or Nonprofit Structures

Abatement of Severe Impacts

Information for Local Officials

Traffic Noise Prediction

Worst Hourly Traffic Noise Impact

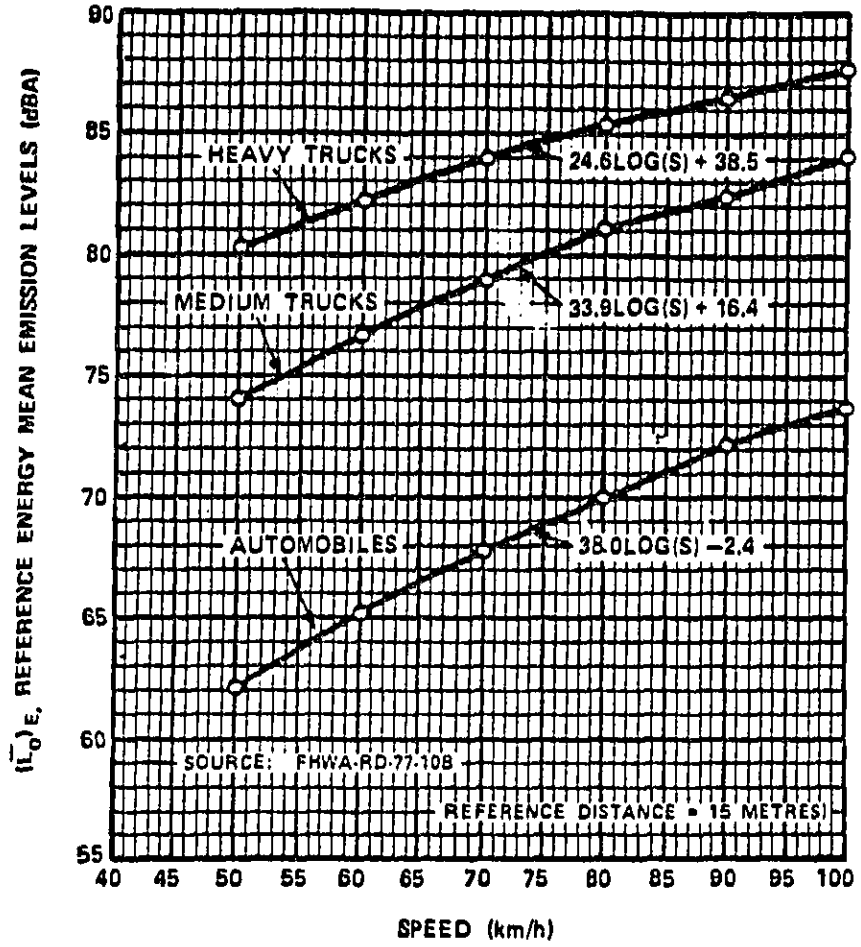
Construction Noise

TABLE 1 - Noise Abatement Criteria

Hourly A-Weighted Sound Level - decibels (dBA) 1/

Activity Category	Leq(h)	$L_{10}(h)$	Description of Activity Category
A	57 (Exterior)	60 (Exterior)	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose.
B	67 (Exterior)	70 (Exterior)	Picnic areas, recreation areas, playgrounds, active sports areas, parks, residences, motels, hotels, schools, churches, libraries, and hospitals.
C	72 (Exterior)	75 (Exterior)	Developed lands, properties, or activities not included in Categories A or B above.
D	--	--	Undeveloped lands.
E	52 (Interior)	55 (Interior)	Residences, motels, hotels, public meeting rooms, schools, churches, libraries, hospitals, and auditoriums.

1/Either $L_{10}(h)$ or Leq(h) (but not both) may be used on a project.

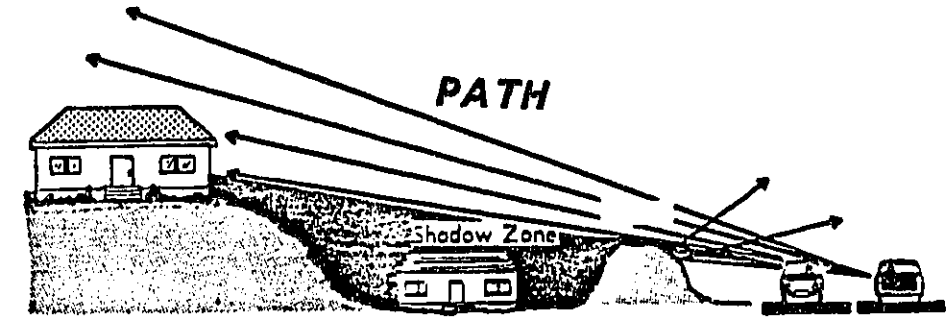


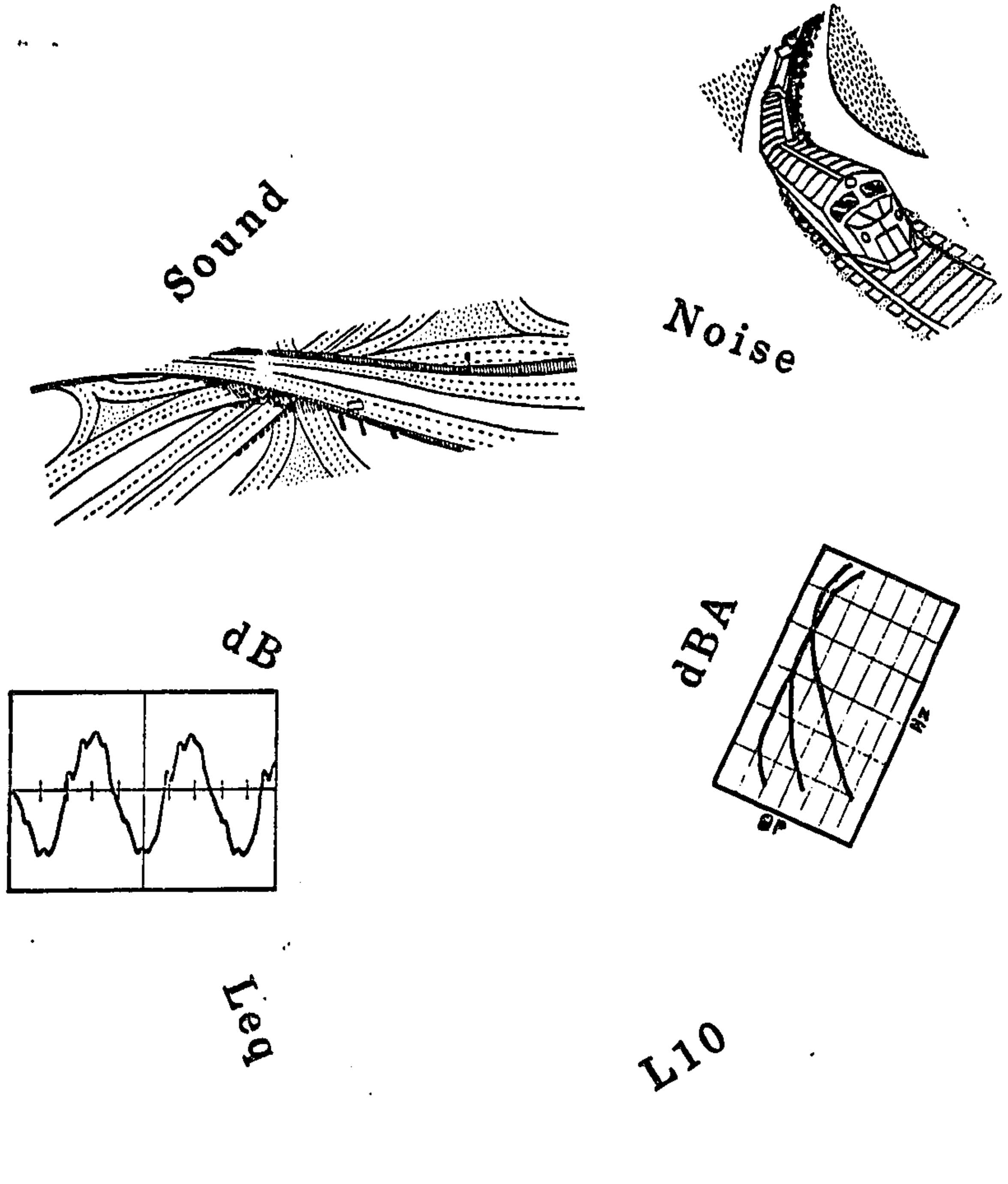
LEGEND:

1. AUTOMOBILES: ALL VEHICLES WITH TWO AXLES AND FOUR WHEELS.
2. MEDIUM TRUCKS: ALL VEHICLES WITH TWO AXLES AND SIX WHEELS.
3. HEAVY TRUCKS: ALL VEHICLES WITH THREE OR MORE AXLES.

National Reference Energy Mean Emission Levels as a Function of Speed

FUNDAMENTALS OF NOISE

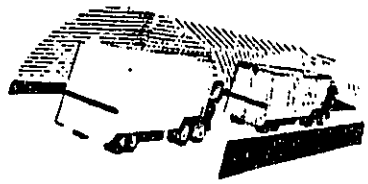


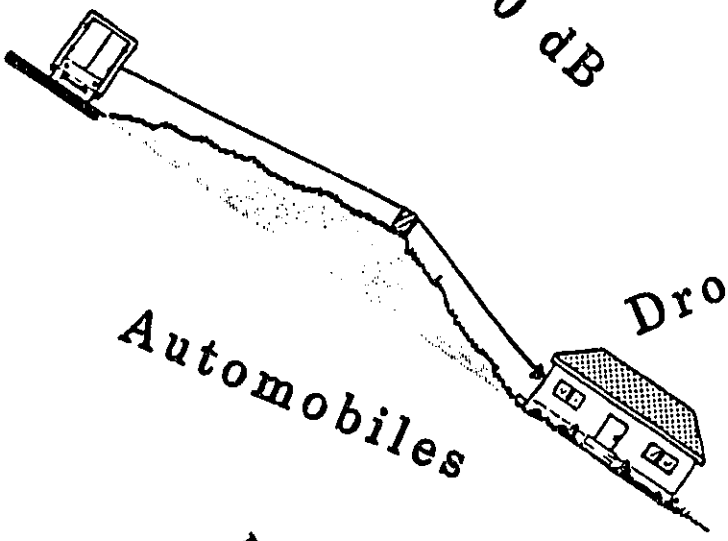

Sound
Noise
dB
dBA
Leq
L10

90 dB + 90 dB = 93 dB

log

10 dB



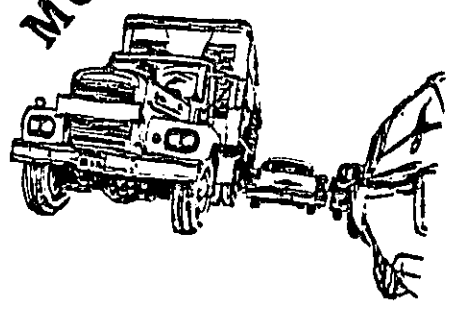


Drop-Off Rate

Automobiles

Medium Trucks

Heavy Trucks



HIGHWAY NOISE STUDIES

1. Identify Impact Criteria /

   Noise Sensitive Land Uses

2. Measure Existing Noise Levels

3. Predict Future Noise Levels

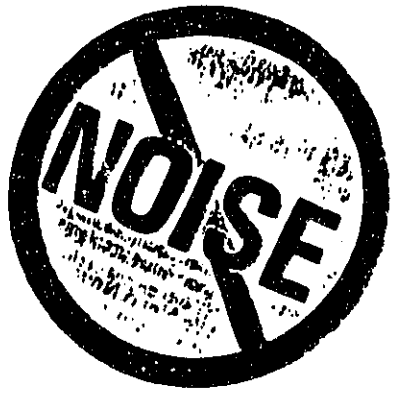
4. Determine Potential Traffic Noise Impacts

5. Consider Mitigation Measures

6. Consider Construction Noise

7. Coordinate With Local Officials

ABATEMENT MEASURES



1. Buffer Zones
2. Barriers
3. Vegetation
4. Building Insulation
5. Traffic Management