A REPORT TO THE 1971 LEGISLATURE
ON
THE SUBJECT OF NOISE
PURSUANT TO
ASSEMBLY CONCURRENT RESOLUTION 165, 1970

STATE OF CALIFORNIA
RONALD REAGAN, GOVERNOR
HUMAN RELATIONS AGENCY
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FOREWORD

ASSEMBLY CONCURRENT RESOLUTION 165, 1970, (Appendix A) requested the State Department of Public Health to prepare a report to the Legislature on the subject of noise, identifying the sources of noise pollution and recommending means of controlling the harmful effects of noise, including recommended standards of noise level emissions; that the Department appoint an advisory committee consisting of public and private groups having knowledge and interest in the subject matter, including representatives of those private industrial concerns which might be affected by the study.

There being neither time nor resources to make detailed assessments of noise in California, it was evident from the first that the report would have to be based on information at hand. This proved to be voluminous.

Available data on the effects of noise on people were reviewed to document the harmful effects of noise and to determine the quantity of noise that produces these effects.

An almost equal volume of material was used as a basis for specifying environmental noise limits to prevent the harmful effects of noise.

Much less information is available on which to base emission standards for various noise sources. Clearly this is an area that needs considerable further attention.

The State Department of Public Health wishes to acknowledge a deep debt of gratitude to the members of the Advisory Committee who assisted in this study. Their help was invaluable, and the public members served at considerable personal sacrifice.

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Authorized By
Assembly Concurrent Resolution 165, 1970

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FINDINGS

Noise is ubiquitous in the environment and has many adverse effects on man. It causes hearing loss, interrupts sleep, interferes with speech and generally degrades the quality of life. The findings below consider these harmful effects of noise and outline measures for their abatement.

The Sources and Levels of Noise Are Increasing

Noise is a problem in many California communities and threatens to become a problem in others. The reasons are twofold. Industry is producing an ever increasing number of noise-making objects and fosters urbanization of the population. Thus, more and more people are being exposed to sources of noise at an accelerated rate. Suburban areas are not immune. Air conditioners, hobby-shop tools, power lawn mowers, and other noise makers are part and parcel of suburban life. Construction equipment, industrial activities, and the many noises of transportation add to the din and increase the overall levels of noise in both urban and suburban areas. Even wilderness areas are being invaded by off-the-trail motorcycles, snowmobiles, and other noise-making devices.

Noise Can and Should Be Controlled

Criteria are at hand on which to base noise limits which will protect people, wherever they are, and the technology is available to control most sources of noise to any degree desired. Noise sources can be made quieter by improvements in design or by acoustical enclosure; they can be separated from people by distance or by acoustical barriers that provide equivalent attenuation.

Environmental Noise Limits Should Be Devised

The harmful effects of noise are known and so are the levels of sound that produce them. With a few, but important, exceptions technology is available to control all noise to levels at which these harmful effects will not occur. In order to apply this technology intelligently, noise producers must know how much noise reduction is needed; noise receivers should know when remedial action is justified; and legislative and administrative bodies need to know what levels of noise are acceptable in order to promulgate and enforce noise control regulations. To provide this information, *Environmental Noise Limits* based on prevention of the harmful effects of noise on people should be developed.

Standards for Noise Emissions Should Be Developed

An effective noise abatement program will require strict control of noise emission sources. To bring this about, comprehensive *Noise Emission Standards* need to be developed for all significant noise-making devices. Standards are required to guide manufacturers of new equipment and the operators of existing equipment in the design and incorporation of noise control features, and for prompt replacement of these features if they deteriorate with use.

New Sources of Excessive Noise Should be Proscribed

It is futile to attempt to solve existing community noise problems while admitting new sources of excessive noise; therefore, the first step in noise abatement is proscription of such sources. There are other advantages. Noise can best be controlled by equipment design, for which the cost is generally much less than control by secondary techniques, and is usually more effective. Most new products can be made quiet at a small percentage of their overall production cost, if the quiet is included in product design. Motivation is needed to bring this about and proscription will provide the motivation. Proscription should not proceed out of hand, however, but rather on a scheduled basis. There is considerable lag time between design and production, and proscription schedules should allow for this.

Existing Sources of Excessive Noise Should Be Controlled

While proscription schedules for new products will bring about noise reduction with time, a great many existing sources will be around for years. Transportation, industrial, construction, and other equipment is expensive and cannot be economically replaced simply because quieter equipment happens to be available. Most existing sources of noise can be quietened, however, and this should be done for those sources that contribute most to community noise problems. As with the proscription of new noise sources, reasonable time should be allowed to accomplish control of existing sources.

Sources of Excessive Noise Which Cannot be Controlled Should be Separated From People

Noise problems that have arisen from encroachment of residential communities on airports and freeways and some other established sources of noise are painfully evident throughout California. Airports and freeways and some commercial activities are inherently noisy and will be for the foreseeable future. Wherever possible they should be separated from residences and other incompatible human activity centers by distance sufficient to attenuate the noise to acceptable levels.

Industrial Noise Exposure Standards Should Be Lowered

The most significant effect of prolonged exposure to intense industrial noise is permanent loss of hearing. Present criteria for preventing such loss are limited to protecting hearing for frequencies ranging from 500 to 2,000 cycles per second, which are considered essential for understanding everyday speech. Existing regulations provide such protection for only 85 to 90 percent of workers exposed to intense noise. Thus, 10 to 15 percent of the workers exposed to noise now rated as safe will suffer hearing impairment for speech sounds after prolonged exposure. Moreover, the standards provide only incidental and limited protection for hearing frequencies above 2,000 cycles per second, which is essential to some attributes of life other than understanding speech.

To prevent hearing loss for all employees and to prevent other harmful effects of noise, the basic criterion for industrial noise exposure should be reduced. While reduction to

acceptable levels is not now technologically and economically feasible for some sources of industrial noise, this is not the case with others. To require adequate noise reduction, where reasonably possible, and to encourage the reduction of industrial noise not amenable to presently practical solutions, the basic criterion should be lowered on a progressive basis with time.

Building Noises Should Be Controlled

Noises generated inside buildings, particularly in multi-family dwellings, are a general source of complaint. Those generated by plumbing systems, elevators, and heating and cooling systems can be reduced by design, but this will not reduce people noises. The sounds of children, pets, domestic quarrels, and parties are particularly annoying. Building units should be designed to reduce transmission of such sounds. Noise transmission standards for buildings and building code provisions based on these standards should be developed to bring this about.

RECOMMENDATIONS

The following recommendations stem largely from the findings in the preceding section:

I. State Agency for Noise Abatement

Rationale: Except for noise which emanates from freeways and major airports, which overlap local jurisdictional boundaries, noise in general is a local problem and should be controlled at that level; however, local groups seeking to improve their noise environment are faced with a lack of authoritative information needed to bring this about. The State should provide this information, but it is not now equipped to do so.

RECOMMENDATION I

ESTABLISH AN OFFICE OF NOISE ABATEMENT AT THE STATE LEVEL. ITS FUNCTIONS SHOULD INCLUDE:

A. COLLECTING AND DISSEMINATING AUTHORITATIVE INFORMATION ON ADVERSE EFFECTS OF NOISE AND OF MEANS FOR ITS CONTROL.

B. DEVELOPING, IN COOPERATION WITH LOCAL GOVERNMENTS, MODEL ORDINANCES FOR URBAN, SUBURBAN, AND RURAL ENVIRONMENTS.

C. PROVIDING ASSISTANCE TO LOCAL GOVERNMENTS ENGAGED IN DEVELOPING AND IMPLEMENTING NOISE ABATEMENT PROCEDURES.

D. DEVELOPING CRITERIA AND GUIDELINES FOR USE IN SETTING STANDARDS FOR HUMAN EXPOSURE TO NOISE.

E. DEVELOPING NOISE EMISSION STANDARDS FOR NEW NOISE-PRODUCING OBJECTS ADMITTED TO CALIFORNIA.

F. DEVELOPING NOISE EMISSION STANDARDS FOR NOISE-PRODUCING OBJECTS NOW IN USE IN CALIFORNIA.

G. DEVELOPING NOISE TRANSMISSION STANDARDS FOR NEW BUILDINGS CONSTRUCTED IN CALIFORNIA AND RECOMMENDING BUILDING CODE PROVISIONS REQUIRING COMPLIANCE WITH THESE STANDARDS.

II. Noise Standards for California Airports

Rationale: Noise which emanates from airports is a major offense to large segments of the population who live in the vicinity of airports. The State Department of Aeronautics has adopted "Noise Standards for California Airports" which, if not changed by the Legislature, will become effective in 1971. The standards are comprehensive and will, over a period of time, improve the noise environment in the vicinity of airports. While the standards may not produce noise reduction acceptable to all who live in the vicinity of airports, they represent a major step toward this goal.

RECOMMENDATION II

ALLOW "NOISE STANDARDS FOR CALIFORNIA AIRPORTS" AS ADOPTED BY THE STATE DEPARTMENT OF AERONAUTICS, TO BECOME EFFECTIVE WITHOUT CHANGE.

III. Compatible Land Use in the Vicinity of Airports

Rationale: "Noise Standards for California Airports", as adopted by the State Department of Aeronautics, require airport operators to establish noise impact boundaries and to achieve compatible land uses within these boundaries. Designated compatible land uses exclude schools and family residences and can be accomplished only through zoning regulations. Airport operators are not possessed of zoning authority, have limited influence concerning zoning within their own political jurisdictions and probably none with other jurisdictions which may lie within their noise impact boundaries. The implications are serious for major airports which now have thousands of noise impacted residences. It is unthinkable that all these people will be moved by zoning authorities and it is equally unthinkable that the airports will cease to operate. "Noise Standards for California Airports" provide solutions but these solutions will be slow in coming for residents that live near several existing airports. This situation should not be allowed to develop around existing airports which are not impacted or around airports yet to be established. This could be accomplished by appropriate amendment of sections of the Public Utilities Code relating to "airport land use commissions".

RECOMMENDATION III

AMEND THE PUBLIC UTILITIES CODE TO REQUIRE AIRPORT LAND USE COMMISSIONS TO ACHIEVE, BY ZONING, COMPATIBLE LAND USES IN THE VICINITY OF ALL NEW AIRPORTS AND IN THE VICINITY OF EXISTING AIRPORTS WHICH ARE NOT SURROUNDED BY LAND DEVOTED TO INCOMPATIBLE USES

OR

ENACT OTHER LEGISLATION TO ACHIEVE THIS END.

IV. Industrial Noise Exposure Criterion

Rationale: Existing regulations limiting industrial noise exposures do not protect all workers against noise induced hearing loss; moreover, the criteria on which the regulations are based provide only incidental and limited protection for hearing frequencies above 2,000 cycles per second which is essential to enjoyment of some attributes of life, and do not provide adequate protection against other harmful effects of noise. Correcting these deficiencies will require substantial reductions in noise for a number of industrial operations and time should be allowed to accomplish these reductions; however, the criterion should be set as a guide for those industries that can meet it sooner and should become mandatory within a reasonable period of time.

RECOMMENDATION IV

SET THE BASIC CRITERION FOR OCCUPATIONAL NOISE EXPOSURE AT 75 dB(A) AND MAKE THIS LEVEL MANDATORY FOR ALL INDUSTRY BY JANUARY 1, 1980.

V. New Vehicle Noise Limits

Rationale: Noises emitted by motor vehicles constitute the greatest source of noise offense to the greatest number of people. Heavy diesel trucks and motorcycles are particularly noisy; ideally they should make no more noise than standard automobiles. Significant reductions in noise can be achieved for all types of motor vehicles through basic design changes; however, sufficient lead time to accomplish these changes must be allowed. In order to eliminate general complaints about motor vehicle noise, it appears that 70 dB(A) maximum noise for all vehicles should be achieved. For new vehicles, noise reductions toward this goal should be required on a scheduled basis.

RECOMMENDATION V

AMEND VEHICLE CODE SECTION 27160 AS FOLLOWS:

Year	6000 lbs. or more GVW (Trucks and Buses)	Less than 6000 lbs. GVW (Passenger Cars, Pickups and Motor-Driven Cycles)	Motorcycles
Present	88 dB(A)	86 dB(A)	88 dB(A)
1973	86	84	86
1975	83	80	80
1978	80	75	75
1988	70	70	70

Note: The 1973 values are already in the Vehicle Code.

The 1978 levels can be achieved with existing knowledge but will require extensive changes in motor vehicle design.

The 1988 levels are not now feasible for current types of vehicles but should be adopted to encourage achievement of the 70 dB(A) goal.

VI. Operational Vehicle Noise Limits

Rationale: While technological noise reduction can be achieved in new vehicles at reasonable cost, this is not so clearly the case for many vehicles now in use. There is a paucity of information relating cost-to-quiet for such vehicles; hence, the practicability of bringing older vehicles into conformance with substantially lower standards with time has not been resolved. Also, since vehicles now in use will be replaced with quieter new ones in time, limiting the noise produced by them is not as critical to progressive noise abatement as it is for new vehicles. Nevertheless, significant noise reduction is possible for many vehicles now in use through the utilization of better mufflers and quiet running tires. Legislation is needed to bring this about.

RECOMMENDATION VI

AMEND VEHICLE CODE SECTION 23130 AS FOLLOWS:

	6000 lbs. or more GVW (Trucks and Buses)		Less than 6000 lbs. GVW (Passenger Cars, Pickups, and Motor-Driven Cycles)		Motorcycles	
Year	35 MPH and Under	Over 35 MPH	35 MPH and Under	Over 35 MPH	35 MPH and Under	Over 35 MPH
Present	88	90	76	82	82	86
1973	86	90	76	82	82	86
1975	83	86	74	78	74	78

VII. Standard Test for Maximum Motor Vehicle Noise

Rationale: Motor vehicle noise emission test procedures are prescribed by the Department of California Highway Patrol. The test procedures for new vehicles differ from those for vehicles in operation. Neither test necessarily measures maximum motor vehicle noise. In order to implement RECOMMENDATION V, a test procedure relating to maximum noise should be developed for new vehicles. Further, to insure that noise does not increase with vehicle use, the same test should be applied to all vehicles on a scheduled basis with time.

RECOMMENDATION VII

AMEND THE VEHICLE CODE TO MAKE PROVISION FOR ESTABLISHING A TEST PROCEDURE FOR ASSESSING MAXIMUM MOTOR VEHICLE NOISE PROVIDING THAT THIS TEST APPLY FOR NEW VEHICLES AND ULTIMATELY FOR ALL VEHICLES ON A SCHEDULED BASIS WITH TIME.

VIII. Urban Transit Bus Noise Limits

Rationale: In pulling away from curbside stops, urban transit buses produce more noise than is generally acceptable to sidewalk patrons. While the buses are required to meet existing motor vehicle noise regulations, these are based on street and highway criteria which do not anticipate acceleration noise generated in close proximity to people. Analysis indicates that, for equivalent noise exposure to sidewalk patrons, urban bus noise measured at 15 feet from the center line of the bus should not exceed noise levels produced by buses on standard tests measured at 50 feet. Noise limits should be established to bring this about and a test procedure to ensure compliance should be developed.

RECOMMENDATION VIII

AMEND THE VEHICLE CODE TO MAKE PROVISION FOR ESTABLISHING NOISE LIMITS AND TEST PROCEDURES FOR URBAN TRANSIT BUSES TO THE END THAT THEY PRODUCE NO MORE NOISE ON CURBSIDE-PULLOUT MEASURED AT A DISTANCE OF 15 FEET FROM THE CENTER LINE OF THE BUS THAN IS PRODUCED BY BUSES AT 50 FEET BY STANDARD TEST.

IX. Motor Vehicle Exhaust Mufflers and Muffler Systems

Rationale: The exhaust is the predominant source of noise produced by motor vehicles under most conditions of operation. Exhaust noise can be controlled at the outset by installation of adequate muffling systems, and continuously by proper maintenance and replacement. Sections 27150, 27151, and 24005 of the Motor Vehicle Code require that every motor vehicle be equipped with an adequate muffler; require that no person shall modify, repair, or replace the exhaust system of a motor vehicle in such a manner that will increase the noise above that emitted by the original exhaust system of the vehicle; and make it unlawful for any person to sell, install, or replace any muffler not in conformance with regulations. In spite of these regulations, inadequate muffling systems are being installed and arrests are being made because of inadequate exhaust noise control. To help obviate this situation, standards for motor vehicle muffling systems should be established and regulations based on these standards should be adopted and implemented.

RECOMMENDATION IX

AMEND THE VEHICLE CODE TO MAKE PROVISION FOR ESTABLISHING STANDARDS FOR MOTOR VEHICLE MUFFLERS AND MUFFLER SYSTEMS AND FOR ADOPTING AND IMPLEMENTING MUFFLER AND MUFFLER SYSTEM REGULATIONS BASED ON THESE STANDARDS. CONSIDERATION SHOULD ALSO BE GIVEN TO LICENSING MUFFLER SHOPS FOR BETTER ENFORCEMENT OF STANDARDS.

X. Motor Vehicle Tires

Rationale: At speeds in excess of 60 miles per hour on level roadways, tire noise usually predominates over other noise produced by motor vehicles. Tire noise can be reduced by design, but the degree of reduction that is compatible with traction and safety requirements has not been established. The U.S. Bureau of Standards under contract with the U.S. Department of Transportation is developing data on tire noise produced by tires representing 80 to 90 percent of all vehicle tires now in use. The basic data have been collected and are undergoing computer analysis. The results will be available by April 1971. From these data it should be possible to develop legislation to the end that tires sold in California will not generate more noise than is consistent with safety and traction considerations.

RECOMMENDATION X

AMEND THE VEHICLE CODE TO MAKE PROVISION FOR ESTABLISHING STANDARDS FOR VEHICLE TIRE NOISE EMISSION AS SOON AS RELIABLE INFORMATION RELATING TO TIRE NOISE EMISSIONS BECOMES AVAILABLE, AND FOR ADOPTING AND IMPLEMENTING REGULATIONS LIMITING TIRE NOISE EMISSIONS TO THE EXTENT CONSISTENT WITH SAFETY AND TRACTION CONSIDERATIONS.

XI. Compatible Land Use Along Freeways

Rationale: Noise problems that have arisen from the penetration of residential communities by freeways or by encroachment of residential areas on freeways are evident throughout California. Achievable noise reduction in individual motor vehicles will not solve these problems because freeway noise is generated by many vehicles in unison, which multiplies the noise. Freeways are inherently noisy and will be for the foreseeable future. Wherever possible they should be separated from people by distance sufficient to attenuate the noise to acceptable levels, or by barriers or freeway designs that provide equivalent protection. For freeways bordered by rural land, distance separation might best be achieved by reserving the land for uses compatible with the freeway noise environment. This excludes schools and residential areas. Acceptable noise criteria suggest the distance, in most cases, should be at least 500 feet. Residential areas now subjected to unacceptable freeway noise, or which may be subjected to such noise by future freeway penetration, should be protected from excessive noise by equivalent barriers or equivalent freeway design techniques.

RECOMMENDATION XI

ENACT LEGISLATION REQUIRING THAT SCHOOLS AND RESIDENCES BE EXCLUDED FROM LAND BORDERING FREEWAYS FOR A DISTANCE OF 500 FEET OR THAT THEY BE PROTECTED FROM FREEWAY NOISE BY EQUIVALENT BARRIERS OR EQUIVALENT FREEWAY DESIGN TECHNIQUES.

XII. Government Leadership and Purchasing Power

Rationale:

(a) Proscription of new noise sources is considrably easier than controlling those already in existence because proscription is less expensive and encounters less resistance. To this end, both State and local governments should use their purchasing power to ensure that new equipment they buy for their own use incorporates noise control features. This will demonstrate government leadership and provide incentive for development of quiet products.

(b) Projects financed by government funds should be used to promote noise abatement. For example, equipment used on government financed projects should be required to meet noise emission standards, and government financed redevelopment projects should be required to consider noise control in all stages of planning and construction.

(c) To dispel contentions that certain products cannot be made quiet, the State should sponsor demonstrations of available quiet prototypes.

RECOMMENDATION XII

A. ENACT LEGISLATION TO THE END THAT ALL STATE AGENCIES REQUIRE NOISE CONTROL IN EQUIPMENT PURCHASED FOR STATE USE AND THAT THEY REQUIRE NOISE CONTROL IN ALL STAGES OF PLANNING AND CONSTRUCTION OF PROJECTS FINANCED BY STATE FUNDS.

B. ENCOURAGE LOCAL GOVERNMENTS TO ADOPT SIMILAR REGULATIONS.

C. THROUGH APPROPRIATE AGENCIES, IDENTIFY AND IMPLEMENT MEANS, INCLUDING DEMONSTRATION PROJECTS, TO ACCELERATE THE APPLICATION OF EXISTING NOISE CONTROL TECHNOLOGY TO ALL SOURCES OF NOISE IN CALIFORNIA.

XIII. Advisory Committee on Noise

Rationale: The State Department of Public Health and its Advisory Committee on Noise have not had sufficient time to respond in full to the requests of ACR 165, particularly with respect to recommending standards for noise level emissions and for human exposure to noise. Standard setting is time consuming and requires a great deal of inquiry into how much noise reduction is required together with consideration of what is technologically and economically feasible; however, considerable momentum was generated in developing standards for motor vehicle noise emissions. Both the Department and the Advisory Committee feel that this momentum should be maintained and be applied to developing standards for other noise-making objects and for human exposure to noise.

RECOMMENDATION XIII

REQUEST THE STATE DEPARTMENT OF PUBLIC HEALTH TO CONTINUE ITS STUDY OF NOISE AND AUTHORIZE CONTINUANCE OF THE ADVISORY COMMITTEE ON NOISE.

Noise, simply, is "unwanted sound" and can be controlled to the extent people feel it is necessary, according to a report released today in Sacramento.

The State Department of Public Health told the Legislature that a number of specific actions can be taken to reduce the intensity of noise produced by trucks, industrial equipment and other noise-making objects. The report was prepared with the assistance of an advisory committee of 20 scientists, businessmen and government representatives appointed by the Health Department. It was prepared in response to a 1970 legislative request for a study of noise and for recommendations to control sources of objectionable noise.

The report made 13 recommendations, ranging from continuation of the noise study to vehicle code changes that would sharply restrict truck motorcycle and passenger car noise by 1978.

"Noises emitted by motor vehicles constitute the greatest source of noise offense to the greatest number of people," the report said. It recommended that by 1978 all new trucks and buses weighing 6,000 pounds or more should emit no more than 80 decibels of noise, and that all other vehicles of less weight be restricted to 75 decibels as determined by a standard test.

Trucks and motorcycles presently are permitted to make 88 dedibels and other vehicles 86. The recommended reductions are several fold greater than the numerical values indicate, because on the decibel scale a reduction of three decibels represents a 50 percent reduction in noise.

As an example, four trucks producing 80 decibels each, together make much less noise than one truck producing 88 decibels. One motorcycle producing 88 decibels makes more noise than 16 motorcycles producing 75 decibels each.

The Health Dept. urged that "NOISE STANDARDS FOR CALIFORNIA AIRPORTS," as adopted by the State Dept. of Aeronautics, become effective in December. The Dept. believes the recommended levels will improve the noise environment in the vicinity of airports, although not all aircraft noise can be muffled.

Also urged was legislation requiring that schools and homes be excluded from land bordering freeways for a distance of 500 feet, or that they be protected from freeway noise by barriers or changes in road design. Furthermore, the report said, compatible land use zoning should be required in the vicinity of all new airports and existing airports which are not now surrounded by land devoted to incompatible uses.

Dr. John M. Heslep, head of the Health Dept.'s environmental and consumer protection program, was chairman of the advisory committee.

SUPPORTING MATERIAL

I. Introduction

"In the area of environment and ecology, it is and must be our continuing goal to refurbish and reclaim what has been debauched and to protect that which is still clean, fresh and open . . . and to do this in a sensible, responsible and balanced manner."-Governor Reagan "The State of the State", January 12, 1971.

The situation, with respect to noise, could not be more succinctly stated. Our acoustical environment is debauched and the degree of debauchment is increasing. Steps should be taken to halt this trend and to reclaim that which can be reclaimed and both should be done in a responsible way.

Noise sources are of various forms which intrude on our life in different ways; hence, they must be controlled by means which take into account a number of factors. Noise produced by industrial equipment, construction activities, and the various modes of transportation are part and parcel of everyday life. Added to this are the noises produced by household appliances, hobby-shop tools, recreational vehicles, chain saws, power lawn mowers, and a great variety of other noise-making objects. The need for these many sources of noise is clearly established by demand; however, this has resulted in an incessant din which has many harmful effects on man. This is almost entirely unnecessary. With but a few important exceptions, the technology is at hand by which to control all sources of noise to any degree desired. This technology should be applied in an orderly manner. A viable economy must be maintained and equitable adjustments must be devised. Solutions lie in the analysis of noise problems, establishment of criteria for their solution, and implementation of these criteria.

This report considers the harmful effects of noise, provides criteria for noise control, and presents the context in which an effective noise abatement program should be developed.

II. Noise

Definition of Noise: Noise, simply, is unwanted sound. This definition adequately describes the problem and avoids disputes which often arise from more detailed definitions. For example, it makes no reference to the quality or intensity of sound, only its desirability which is what noise is all about. Rock band music is not noise to those who want to listen to it, while a soft lullaby may well be noise to those who do not happen to want to hear it.

Why Noise Constitutes a Problem: Man is an evolutionary product. The senses we have are those we developed in order to survive in a primitive world. Early man's ability to detect sound warned him of danger and prepared him for flight or combat. We still react to unwanted sound - we call it noise.

Man-made noise first became a problem when man began to interact in hamlets, villages, and towns - perhaps before. In the words of one outstanding authority, "even cavemen cracked a few stones".

With the invention of power machinery, relatively quiet domestic activities, which characterized preindustrial life, gave way to cheaper and more productive operations concentrated in industrial centers. Industrialization fostered urbanization and increased demands for industrial products. Thus, increased numbers of people were exposed to one another and to more and more noise-making sources. This process is continuing.

Industrial competition is keen, and cost and performance dictate design. Noise is controlled in factories generally only when it threatens to deafen people. Noise is controlled in products only on customer demand. We buy quiet automobiles because we want them quiet. We buy noisy motorcycles because we want them noisy. We also accept a great deal of noise in the name of progress. Aircraft and construction noises are good examples.

The Noises Around Us: Table 1 shows typical noise levels encountered by people at work and elsewhere. In general, the noise levels shown are those that impinge on the ears of listeners.

The noises of mechanized industry, as a group, are more intense than those found in the community or in the home, although some noises encountered in these environments equal or exceed some industrial noises. People who live near airports or who listen to rock bands may experience noise levels equivalent to very loud industrial noises. A home power mower makes as much noise as a farm tractor or a newspaper press and the noise of a food blender may exceed that of a milling machine.

The loudness indices on the left-hand margin of Table 1 relate approximately to subjective judgments of people. Those levels ranging above 90 dB(A) and which most people would call "very loud" are capable of producing permanent hearing loss if incurred for long periods.

The Present Status of Noise Abatement: The noise in our environment has not gone unnoticed by either the public or government. During the past several decades, organized action against noise has been taken by voluntary citizens' groups, governmental committees, commissions, and councils. Such groups have appeared, disappeared, and reappeared, often with new faces and new names. Each appearance is attended with fanfare, publicity, and a resolve to bring about elimination of excessive noise. Not much has happened.

In California, industrial noise is regulated to prevent hearing loss in employees, but not to control other harmful effects of noise. The noise produced by single motor vehicles is limited by provisions in the Motor Vehicle Code, but motor vehicles are still the most frequent cause of complaint about noise. The State Department of Aeronautics has adopted regulations to reduce noise in the vicinity of airports, but effective results will not be realized around some major airports for a considerable period of time. Construction

Table 1

Sound Level, dBA	Industrial or Machine Operator	Community-Outdoors	Home-Indoors
140			
Painful			
130			
Uncomfortably Loud			
120	Oxygen Torch (121 dB)		
	Snowmobile (113 dB)		
110	Riveting Machine (110 dB)	Jet Take Off @ 1000′ (110 dB)	Rock-n-Roll Band (108-114 dB)
	Textile Loom (106 dB)	Jet Flyover @ 1000′ (103 dB)	
Very Loud			
100	Electric Furnace (100 dB) Farm Tractor (98 dB) Newspaper Press (97 dB) Power Mower (96 dB)	Rock Drill @ 50′ (95 dB) Motorcycle @ 50′ (90 dB) Compressor @ 50′ (90 dB)	
90		Snowmobile @ 50′ (90 dB)	Food Blender (88 dB)
	Milling Machine (85 dB)	Power Mower @ 50′ (85 dB) Diesel Truck @ 50′ (85 dB)	
Moderately Loud			
80	Lathe (81 dB)	Diesel Train @ 50′ (85 dB)	Garbage Disposal (80 dB) Clothes Washer (78 dB)
		Passenger Car @ 50′ (75 dB)	Dish Washer (75 dB)
70			Vacuum Cleaner (70 dB)
		Air Conditioning Unit @ 50′ (60 dB)	
60		Large Transformer @ 50′ (60 dB)	Conversation (60 dB)
Quiet			
50			
40			
30			
Very Quiet			
20			
10			
0			

Note: Unless otherwise specified, listed sound levels prevail at typical operator-listener distance from source. Data from general acoustical literature.

'A' WEIGHTED SOUND LEVELS OF SOME NOISES FOUND IN DIFFERENT ENVIRONMENTS

equipment, outboard motors, snowmobiles, off-trail-bikes, lawn mowers, compressors, fans, and a great variety of other noise-making machines and objects are not regulated from a noise standpoint.

III. Harmful Effects of Noise

Noise Induced Hearing Loss: The most significant and most obvious harmful effect of noise on man is permanent loss of hearing. Usually, hearing loss occurs only after prolonged exposure to intense noise, although single exposures to extremely loud noises have been known to cause permanent hearing damage.

Occupational exposure to intense industrial noise constitutes a definite risk of hearing loss which has been confirmed in many industrial noise and hearing studies. Industrial noises, as a group, range generally higher than noises encountered in other walks of life and the exposures are usually more sustained both on a daily basis and by years.

Present criteria for preventing this loss are limited to protecting hearing for frequencies ranging from 500 to 2,000 cycles per second which are considered essential for understanding everyday speech. Further, these criteria assume that noise exposure is limited to 8 hours a day, 40 hours per week, and that relatively quiet conditions prevail outside periods of noise exposure.

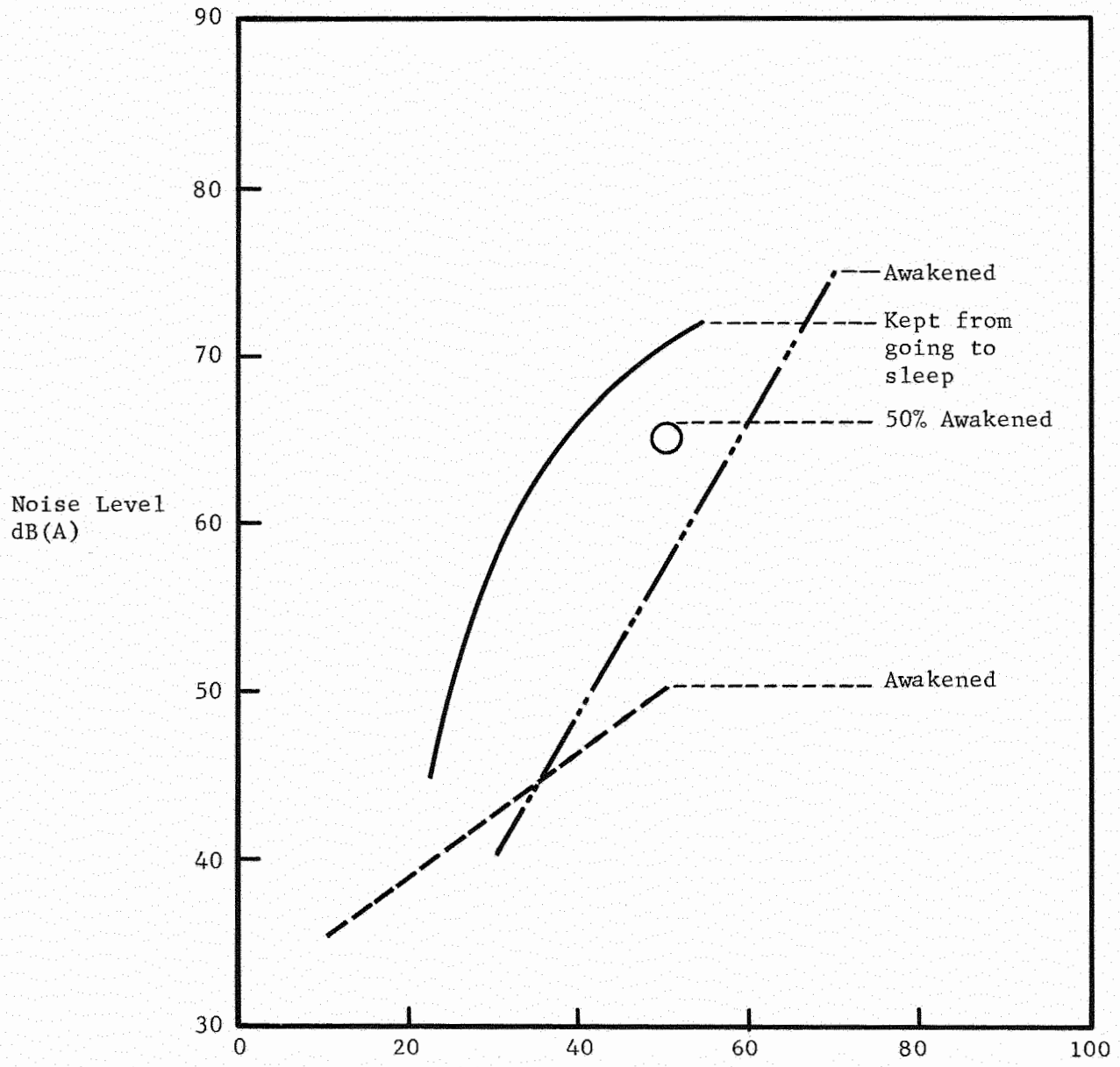
The criteria provide only limited and indirect protection for having frequencies above 2,000 cycles per second which is essential for enjoyment of some attributes of life other than understanding speech. Moreover, the presumption of relative quiet off-the-job is increasingly an illusion.

Noise Interference With Sleep: Noise disturbs sleep not only in ways of which the subject is aware, but also in ways of which he is unaware. Noise which is not sufficient to arouse a person may impair the quality of sleep by shifting him from a deep stage of sleep to a shallower stage, or deprive him of that portion of sleep which is connected with dreaming and which is thought to be most important for rest.

The effects of noise on sleep have been observed by studying brain wave patterns of subjects exposed to steady artificial noise and to conventional transient sounds such as the noise from aircraft or trucks. Other experiments have been performed in which the actual awakening of subjects was the means of observing sleep disturbance effects of noise. Further information on sleep disturbance by noise comes from community annoyance surveys.

The results of several well-documented studies of the effects of noise on sleep are displayed in Figure 1. While there is a wide scatter in the data, it is apparent that noise disturbs the sleep of people in a gradually increasing way and that 20 percent or more suffer some form of sleep disturbance if the noise exceeds 45 dB(A).

Noise Interference With Communication: Excessive noise interferes with communication by preventing the intelligent reception of voice sounds in ordinary



SLEEP DISTURBANCE BY NOISE

Figure 1

conversation, classroom lectures, over the telephone, and reception of radio and television programs. In some situations, excessive noise can also result in definite safety hazards; e.g., by inability of a truck driver or a factory worker to perceive audible warning signals.

The speech interference effects of noise have been thoroughly studied and are well documented. The criteria which have been developed are expressed in terms of the "Speech Interference Level" (SIL) of the interfering noise and may be expressed in dB(A).

The ability to understand speech in the presence of interfering noise depends not only on the magnitude and frequency of the noise but also on the magnitude of the voice of the speaker and the distance between the speaker and listener. The noise levels that permit reliable conversation at various distances when the speech is conducted at normal voice level are shown in Table 2.

Table 2

NOISE LEVELS THAT BARELY PERMIT RELIABLE CONVERSATION AT VARIOUS DISTANCES AND A NORMAL VOICE LEVEL

Distance Between Speaker and Listener	Level of the Interfering Noise
Feet	dBA
1	75
2	70
3	66
4	64
5	62
6	60
10	56
20	50

A typical listener distance for normal conversation in a family residence rarely exceeds ten feet. On this basis, frequently occurring interfering noise in excess of 56 dB(A) inside residences is unacceptable from a communication standpoint. Also, an interfering noise in excess of 75 dB(A) is unacceptable in any situation where normal conversation is desired.

Noise Induced Physiological Stress: Exposure to noise has been found to cause widespread activation of the autonomic nervous system resulting in changes in heart rate, respiration rate, gastric activity, pupil size, and sweat gland activity. Many studies have

been made to assess the significance of these affects and at what noise levels they occur. The stimulus sound levels used in these studies range well above noise levels which interfere with sleep and speech communication. Present data indicate that the threshold of stress response is about 65 dB(A) and becomes pronounced at 80 to 85 dB(A).

IV. Sources of Noise in California

There are so many sources of noise in California that it would be tedious, if not impossible, to discuss them individually. Roughly, they can be divided into the 11 broad categories listed below:

1. Transportation
2. Industrial
3. Construction
4. Logging and Lumbering
5. Petroleum Production and Refining
6. Mineral Production
7. Agricultural
8. Public and Private Utilities
9. Public Services
10. Building Service Equipment
11. Routine Activity of People and Things

1. Transportation

Noise generated by transportation modes is the major cause of complaints about noise. Aircraft noise constitutes the principal noise offense to people who reside near airports, but surface transportation noise offends a much larger number of people. Continued expansion of conventional air and surface transportation, together with an increasing proliferation of snowmobiles, minibikes, powerboats and other mechanically powered vehicles will greatly increase transportation noise unless effective countermeasures are taken.

Aircraft: Aircraft noise is a major problem because jet aircraft are inherently noisy. A typical long-range, four-engine jet transport on takeoff spreads an unacceptable noise level contour 34,000 feet long from the end of the runway and 6,000 feet wide. On landing, the same aircraft generates an unacceptable noise contour 11,000 feet long and 1,500 feet wide. This is a total of approximately eight square miles of land outside the airport being exposed to a generally unacceptable level of noise.

The Federal government and aircraft manufacturers are expending considerable effort to develop quieter aircraft engines and to quieten some of those now in use; however, the amount of noise reduction foreseen will not be sufficient to solve problems for some airports now surrounded by residential communities.

Rail Transportation: Rail transportation noise is generated by train engines, the interaction of trains and tracks, whistles, and braking sounds. Engine noise is produced by combustion engine intake and exhaust systems, generators, gears, and electric motors. Non-engine noise is generated by the clanking of wheels passing over rail joints, flat spots on the wheels, the squeal of wheels rounding curves, and the application and release of brakes.

Motor Vehicle: Motor vehicle noise is generated by the vehicles themselves and by the interaction of the vehicles and their environment. The principal noises of motor vehicles stem from the exhaust, the engine intake, valving and gearing, the fan, and aerodynamic noise generated by passage of vehicles through the atmosphere. There is a great variation in the frequency and intensity of noises generated by the many different kinds of motor vehicles, and these variations are complicated by the state of maintenance of the vehicles and the manner in which they are operated.

The modern passenger automobile usually makes much less noise than other types of motor vehicles. Even at speeds up to 50 mph, they produce little exhaust noise except at low frequencies. The combination of wind, gearing, and tire noises, produces an identifiable spectrum at speeds over 40 mph at distances over 100 feet. At higher speeds, the combination of sounds provides identifiable cues at distances up to one mile in quiet backgrounds. The most persistent element of the automobile noise at these distances is the sound of tires.

The sports car is a different sort of noise generator. With its small, high speed engine and typically small muffler, this type of vehicle generates a distinctive sound under high torque conditions, such as during rapid acceleration from a traffic light.

Motorcycle noise is also distinctive. In addition to noise from intake, exhaust, and gearing systems, motorcycles radiate considerable noise directly through the engine walls.

Buses tend to radiate less noise than other heavy vehicles because their engine compartments are sealed. Bus noise, however, usually increases with use because of damage to these seals. Some engine enclosures are so badly distorted that noise radiates almost as freely as if there were no engine compartment.

As a class, trucks make more noise than other motor vehicles. Diesel trucks are the worst offenders. A single, large diesel truck may produce more noise than 30 passenger automobiles. Under most conditions of operation, exhaust noise predominates, but at low speeds under heavy acceleration, engine and transmission noise may be louder. At high speed on level roadways, tire noise predominates. Other sources of noise from trucks include chassis, brakes, sheet metal parts, loose pins, and cargo.

2. Industrial

Industrial noise comes from a great many sources. It can be reduced by structural enclosure; however, a wholly enclosed industrial plant can generate noise which may penetrate residential and commercial areas. The intakes and discharges from fans, compressors, and engines often penetrate the walls of industrial buildings. Ducts and piping outside buildings radiate noises generated inside. Inadequately insulated walls and roofs transmit noise. Sheet metal walls, for example, vibrate in response to inside noise and become effective noise radiators. Out-of-door industrial activities also constitute sources of noise. These include storage operations, steel and scrap yards, and truck and rail freight handling yards.

3. Construction

Diesel engine operated equipment is the major source of noise generated around most construction sites. Such engines are used to drive generators, compressors, trucks, bulldozers, loaders, scrapers, power shovels, and other excavating equipment. Air compressors generate noise from both intake and discharge openings and also radiate noise directly from cylinder walls. Pumps produce a number of sounds which are radiated from the pumps themselves and also from piping serving the pumps. The noises of piledrivers, riveting machines, jack hammers, elevators, cement mixers, and excavating equipment characterize many construction activities. Residential construction involving the use of hammers, power saws, electric drills, and concrete equipment is an annoyance in many communities.

4. Logging and Lumbering

Logging operations involve the use of diesel powered equipment, chain saws, hoisting and conveying equipment, and, occasionally, blasting. Sawmill noise is produced by saws and planers and other lumber shaping equipment, the clanking of hoisting and conveying equipment, and the operation of yarding and loading equipment.

Logging operations generally are conducted in remote areas; however, the conveyance of logs to market or to lumber mills involves the use of rail or diesel truck transportation which produce transportation noise as discussed above.

5. Petroleum Production and Refining

Petroleum production operations typically are conducted in unpopulated areas, hence are not a major source of noise offense. A few are conducted in residential areas but these are normally required to blanket derricks and to control other loud noise sources.

Petroleum refining operations are often located in the vicinity of populated areas. Principal sources of noises include pressure reducing valves in pipes, steam turbines, gear boxes, compressors, electric motors, diesel engines and maintenance equipment.

6. Mineral Production

Mineral production includes both surface and underground mining, sand and gravel pit operations, and crushed rock operations. Noises generated from these sources include sounds emanating from rock crushers, screens, conveyor belts, diesel engines, electric motors, dump trucks, power shovels, rock drills, and blasting. Most primary mineral operations are conducted in regions removed from public residence and are not usually sources of complaint. Rock and sand distribution plants frequently are located in close proximity to residential areas and can be the source of unacceptable noise.

7. Agricultural

Agricultural noise is generated by a host of soil preparation and crop harvesting equipment, pesticide applicators, and conveying and elevating equipment. Most agricultural noise sources are located at points removed from residential areas and are not a major source of noise complaint.

8. Public and Private Utility

Public and private utilities engage in construction activities producing the same kind of noises discussed under Construction Noise. They also operate hydroelectric, steam and diesel electric generation plants, compressors, pumps and pipelines, all of which generate noises similar to those discussed under Industrial Noise. Some of these facilities are located in or near residential areas and for such installations, noise control measures more exacting than for plants in industrial areas should be required.

9. Public Services

Public services include police and fire department activities, ambulances, rubbish collection and disposal, and the maintenance of streets, sewers and water systems. Except for warning devices such as sirens, public service operations and equipment should generate no more noise than their transportation, industrial, and construction counterparts.

10. Building Service Equipment

Building Service Equipment includes heating, ventilating, and air conditioning facilities, water and waste water systems, elevators, and escalators. The most common city noise source in the air conditioning category is the modern high efficiency cooling tower, which contains two noise sources – fans and water spray. The water spray noise may be particularly annoying in residential areas where, even with the fan off, the spray noise has been found objectionable.

The increasing use of window or through-the-wall packaged air conditioning units leads to the generation of noise outside. In addition to their inherent noise characteristics, as these units age the rattling of loose metal parts and window frames becomes an added annoyance factor.

The intakes and discharges from major air conditioning systems for apartments, hotels, offices, and various commercial buildings are just as annoying as their industrial counterparts.

11. Routine Activity of People and Things

Many noise sources in this class involve man in his leisure activities and include radios, television sets, musical instruments, and home workshop tools.

Outdoor activities in residential areas include the use of power mowers, power hedge trimmers, and power operated chain saws, which often produce excessive noise. People talking, whether in the street or in neighborhood yards or buildings can often be a source of annoyance to neighbors. So can arguments of happy but noisy people. Children at play, barking dogs, yowling cats and other pets often produce more noise than is acceptable to their neighbors.

V. Technological Noise Control

General Principles

In all cases of noise offense there must be a noise source and a noise receiver, and between them a path of noise transmission. In a final sense the latter is air but structures provide intermediate paths.

Examination of these elements reveals four basic procedures that may be taken to reduce noise inflicted on receivers.

1. Control the Noise at the Source:
   This may be accomplished in many ways including:
   a. Redesign the source. Most noise sources can be redesigned to radiate much less noise.
   b. Substitute a less noisy source.
   c. Enclose the source with sound absorbent material.

2. Interrupt the Airborne Path:
   a. Impose solid barriers between noise sources and noise receivers. Earthworks along California freeways reduce noise inflicted on nearby residences up to 12 dB(A). Depressed freeways are even better, providing up to 15 dB(A) reductions.
   b. Separate noise sources from noise receivers by distance sufficient to attenuate the noise to acceptable levels. Each time the distance is doubled, noise is reduced four to six decibels – a very substantial noise reduction.

3. Interrupt the Structure-Borne Path:

   Structures frequently conduct vibration long distances from primary sources of noise and, by inducing vibration in the air, become secondary sources of noise. Control can be obtained by preventing transmission of vibration. This can be done in a number of ways:

   a. Install insulation between equipment and structures to reduce transmission of vibration.
   b. Acoustically treat interior surfaces of structures enclosing noisemaking sources to reduce their tendency to vibrate in response to airborne noise.
   c. Carpet floors to reduce impact noises which may be transmitted to ceilings below.

4. Enclose the Receiver:
   The same results can be achieved by enclosing receivers of noise as by enclosing noise sources; however, requiring that people live in acoustical enclosures should be considered a last resort in protecting them from noise.

Application

Considering all factors of cost and benefit, direct and indirect, it is clear that major emphasis should be placed on controlling noise at the source – as with any other pollutant. It is technologically and economically feasible to make major reductions in noise from a number of bothersome sources in the very near future; e.g., exhaust from diesel trucks and air compressors. Considerably more time will be required to quieten a few sources, most notably the jet airplane. Noise abatement programs should take this distinction into account by including both short- and long-range components, including a time-phased reduction in noise output from various noise sources.

The pace of urbanization of our society seems likely to continue for some time to come. This leads, for example, to predictions that there is no way to achieve satisfactory air quality in the Los Angeles Basin just by improvements in technology of reducing emissions of air pollutants. The same may very well be the case as regards community noise in many urban areas. This means that we must begin to think of noise control in much broader terms than just quietening individual sources and building noise barriers.

As just one, albeit important, example, consider mass rapid transit. A single car of the new Bay Area Rapid Transit System, carrying 72 seated passengers at 70-80 miles an hour, will make no more noise than one or two passenger cars at 65 miles an hour. A ten-car rapid transit train, carrying 720 passengers at over 70 miles an hour, will make no more noise than one or two buses carrying 40 to 80 passengers at 55 miles an hour. It is obvious that modern rapid transit vehicles produce much less noise than other types of transportation vehicles, and their use should not be overlooked as a means of reducing transportation noise. This, of course, is additive to other advantages of mass rapid transit, such as decreased air pollution and congestion and conservation of energy resources.

VI. Criteria for Noise Control

Criteria Based on the Harmful Effects of Noise: Criteria for noise control can be based on one or several objectives depending on the goal desired. With respect to the harmful effects of noise on people, these objectives can be arrayed as shown in Table 3.

Table 3

Harmful Effects	Noise Levels at Which Harmful Effects Occur
Prevention of Hearing Loss	75-85 dB(A)
Prevention of Extra Auditory Physiological Effects	65-75 dB(A)
Prevention of speech interference	50-60 dB(A)
Prevention of interruption of sleep	35-45 dB(A)

Criteria Based on What People Want: Another approach is to base noise criteria on what most people would like to have in the way of a noise environment; however, this is not so precise. People have lived with increasing noise for so long that many have lost any rational basis for judging what they might want if they had an appropriate basis for judgment. A person's reaction to noise is not determined by the noise alone but also by the environment in which the noise occurs. People who live in industrial areas accept more noise than those who live in nonindustrial areas and apparently without complaint; however, it is likely they would demand less noise had they a different basis for judgment. This is suggested by the fact that vigorous complaints arise when industrial noise sources are introduced into previously quiet residential areas. The same is true of other noises which are incompatible with the particular environment they may happen to penetrate.

Man is a creature of nature and probably would be most comfortable in a natural noise environment. It would be difficult to test this thesis in our present social-industrial world because any natural perspective has been lost. The question, then, dissolves into what is obtainable with respect to what people want or reasonably should have in the way of a noise environment.

A number of systems have been devised to provide answers to this question. By and large they are based on a noise criterion to which adjustments are made for duration, spectrum, and peaks of noise, the time of day, and the particular environment. The information underlying these systems come from surveys of people's reaction to noise. While it is obvious that such systems result in ranges of noise which are acceptable for different environments and different people, it is equally obvious that most people would prefer the more quiet end of the range for their particular environment. On this basis, *What People Want* is shown in Table 4.

Table 4

What People Want

Location	Noise Level dB(A)	
	Day	Night
Rural Residential	35	25
Suburban Residential	40	30
Urban Residential	45	35
Commercial	55	45
Industrial	60	50
Water Recreation Areas (Restricted)[1]	45	35
Water Recreational Areas (Open)[2]	55	45
Wilderness Areas[3]	30	20

[1]No internal combustion powered watercraft permitted.
[2]Internal combustion powered water craft permitted.
[3]No artificial man-made noise.

Criteria Based on What People Will Accept: People generally will accept a great deal more noise than they really would prefer and without undue complaint. This is evident from a number of studies conducted in cities and in the vicinity of airports. Social surveys conducted in Central London, near London Airports, and in several American cities are illuminating. Of thousands of people interviewed, about one-fourth of those present in any stratum of noise intensity seemed to be unperturbed. They apparently live happily next to elevated train routes, truck routes, airports, or other noisy activities. About one-tenth of those interviewed seemed to be disturbed by almost any audible noise not of their own making, regardless of the level. Of those in areas with a specific loud noise, about one-third said that they tended to get used to the noise and about one-fourth said the noise became more bothersome with time.

Because of this variation in the way people react to noise, it is not possible to determine fixed noise limits acceptable to all people under all circumstances. However, sufficient information is at hand to suggest limits within ranges which are acceptable to most people and for most environments. This information is derived from the same studies and systems used to determine what people want. The ranges of noise most people will accept without undue complaint are shown in Table 5.

Table 5

What People Will Accept Without Undue Complaint

Location	Noise Level dB(A) Day	Night
Rural Residential	35-45	25-35
Suburban Residential	40-50	30-40
Urban Residential	45-55	35-45
Commercial	55-65	45-55
Industrial	60-70	50-60

Community Responses to Noise: Numerous studies have been made to test community responses to noise. These studies show that people begin to complain when noise levels exceed the ranges shown in Table 5 and the vigorousness of complaint increases as the level of noise increases. The intensity of complaints for incremental increases in noise above acceptable levels are shown in Table 6.

Table 6

Estimated Community Response to Noise

Noise Level in dB(A) Above the Acceptable Level	Estimated Community Response
0	No observed reaction
5	Sporadic complaints
10	Widespread complaints
15	Threats of Action
20	Vigorous Action

Criteria for Noise Regulation:

Quantitative Limits: Qualitative or subjective judgments based on people's reaction to noise do not constitute sufficient basis for court judgment of offense. A noise regulation must be quantitative in order to be enforceable.

Limiting Criteria: A regulation should prevent the escalation of noise, therefore it must be limiting. The quantitative criterion should apply equally to all noises of a given class at a given location. The criterion limit of noise at a given location should be determined by the following factors:

1. The character of the location
2. The time of day
3. The character of the noise

Enforcement: If enforcement is to be practical and effective, observation and citation must be possible by many officers in the course of ordinary duties. The basis for enforcement must be a simple meter reading which relates to the effect of noise on people. The A-Band Sound Level is such a reading which can be taken by an officer after a minimum of training.

Application to Transportation Noise: Transportation is the dominant source of noise in almost all communities, hence local ordinances will be of little benefit unless they apply to transportation noise. The State and Federal Governments have set noise limiting criteria for most modes of transportation. Local ordinances should include equivalent criteria and local authorities should share in its enforcement.

Appendix A

Assembly Concurrent Resolution No. 165

RESOLUTION CHAPTER 249

Assembly Concurrent Resolution No. 165-Relative to noise pollution

(Filed with Secretary of State August 31, 1970.)

WHEREAS, The Legislature hereby finds and declares that there is an increasing and continuous bombardment of noise in the urban environment, and that the wilderness areas of our State are being affected by the irritating and harmful effects of noise also; and

WHEREAS, The great advances in technology have not brought an equally great reduction in the noise level of motor vehicles, aircraft, industrial equipment, or home appliances; and

WHEREAS, Studies indicate that some of the blame for the disorientation and frustration of today's urban life can be placed on the high noise levels that act as subliminal irritants, and, in addition to these mental symptoms, definite and measurable hearing loss has been found among those who work or play under noisy conditions; and

WHEREAS, In recognition of these declarations and findings and of the need for planning and regulation of the proliferation of noise, a study should be undertaken of the subject of noise; now, therefore, be it Resolved by the Assembly of the State of California, the Senate thereof concurring, That the State Department of Public Health is requested to prepare a report to the Legislature on the subject of noise, including the noise from industrial equipment, construction, motor vehicles, boats, aircraft, home appliances, electric motors, combustion engines and any other noise-producing objects, identifying the sources of noise pollution and recommending means of controlling the harmful effects of noise, including recommending standards of noise level emissions; and be it further

Resolved, That the department appoint an advisory committee consisting of representatives of public and private groups which have knowledge and interest in the subject matter, including representatives of those private industrial concerns which may be affected by the study, to assist in the study; and be it further

Resolved, That the department report its findings and recommendations to the Assembly not later than the fifth calendar day of the 1971 Regular Session of the Legislature; and be it further

Resolved, That the Chief Clerk of the Assembly transmit a copy of this resolution to the State Director of Public Health.

Appendix B

The Nature and Measurement of Sound

The Generation and Propagation of Sound: The generation and propagation of sound is easily visualized in a simple model. Consider a plate suspended in air bounded on both sides by layers of air. If we strike the plate it vibrates, moving rapidly back and forth. As it moves it compresses the air in the direction of its motion, and when it reverses direction it leaves a partial vacuum or rarefaction of the air. These alternate compressions and rarefactions cause small fluctuations in atmospheric pressure which are repeated in subsequent layers of air extending outward from the plate. When the pressure variations strike an ear drum, it vibrates in response to the changes in pressure. The disturbance is carried to the brain where it is interpreted as sound.

The Frequency of Sound: The frequency with which the variations in pressure occur give sound the quality we call "pitch". High frequency sound we call high pitched; low frequency sound, low pitched. Frequency is defined as the number of times the pressure variations occur in a second, usually expressed as cycles per second, abbreviated cps, and in more recent acoustical terms as Hertz or Hz. Human beings, generally, have the ability to hear sounds from 20 to 20,000 cycles per second. Middle C on a piano vibrates at about 260 cycles per second, high C at about 4,000. The frequencies of the human voice range from about 500 to 5,000 cycles per second.

The Measurement of Sound: Human sensitivity to sound is usually a function of three measurable physical qualities:

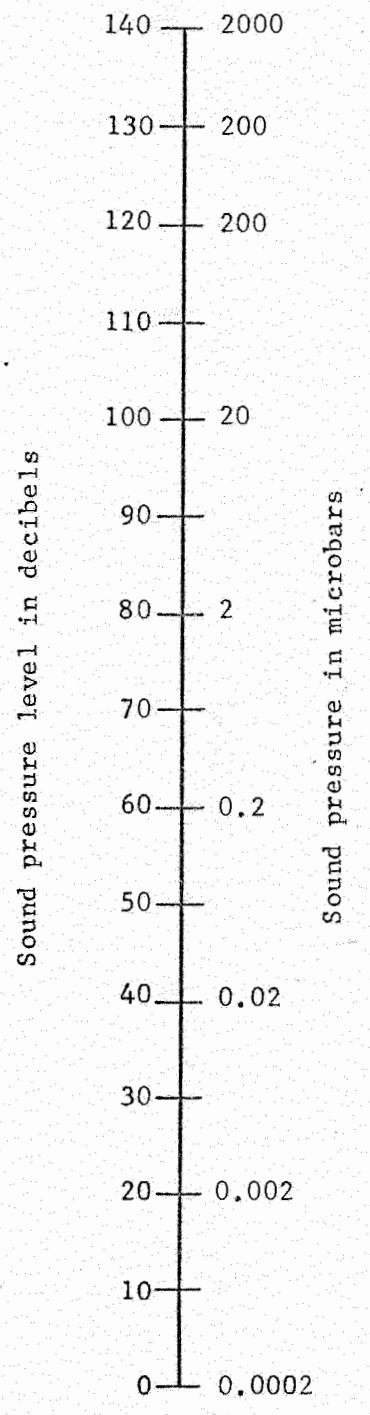
1. The "sound level" in decibels which relates to "loudness".
2. The "frequency" in cycles per second, which relates to "pitch".
3. The "duration" which is a measure of how long the sound persists. Duration is usually measured in seconds but may be expressed as percent of time; thus, a sound that persists for one hour a day or which occurs in intervals totalling one hour in a 24-hour period is on about five percent of the time.

Instruments are available to measure the physical qualities of sound but these measurements do not relate exactly to how people react to noise. Instruments measure sound-pressure levels and frequencies; people react to loudness and pitch. While loudness depends primarily on sound pressure, it is also affected by frequency. And, while pitch is most closely related to frequency, it also depends on sound-pressure. The reason for this is that the human ear is more sensitive to high frequencies than to low. Thus, a 2,000 cps tone of only 5dB sounds just as loud as a 20 cps tone of approximately 70dB; 20 cps at 70dB is quiet to the ear, 70dB at 2,000 cps is very loud.

The Magnitude of Sound: The magnitude of the variations in air pressure give sound the quality we call "loudness". The human ear is extremely sensitive to sound pressure variations which is best illustrated by another model. Consider that we live at the bottom of an ocean of air which extends outward some 200 miles. The pressure at the bottom of this ocean is 14.7 pounds per square inch which is approximately one 'bar', the unit of measurement for atmospheric pressure. The pressure variations induced by the passage of sound through the air are so small that they are measured in "Microbars" or one one-millionth of 14.7 pounds per square inch.* Herein lies the problem of noise. The human ear is so sensitive that it can detect sound pressure variations down to two ten-thousandths (0.0002) of a microbar, which is much less noisy than a quiet whisper. At the other end of the scale the ear responds to sound pressures up to 2,000 microbars - 10 million times the pressure of the weakest sounds we hear. This is far too great a range for normal arithmetical expression, thus it has become customary to express noise magnitude in decibels which are logarithmic ratios comparing pressures of interest to a reference pressure. The reference pressure commonly used in noise measurement is 0.00002 microbar - the weakest sound normal ears can hear. The relationship is shown in Figure 2.

*The microbar is exactly 1.0 dyne per square centimeter.

Figure 2. Relation between sound pressure and sound pressure level.



Because of these variations, a great deal of effort has gone into the development of systems which relate physical measurements of noise to subjective human response. Most of these depend on calculations based on sound pressure levels in various frequencies "weighted" to correspond to human response. Such calculations are impractical for routine noise assessment but they can be approximated by a single reading on the A-scale of a standard noise level meter.

Noise level meters are available having one or several "scales" which have been devised to measure particular qualities of noise. The most commonly used are C and A scales. The C scale gives an equally weighted response for all frequencies of noise. The A scale provides less weight to lower frequencies of noise, much as does the ear, and it correlates well with human response to noise. Because of this correspondence, the relative ease with which A scale noise measurements can be made, and to provide a common scale for comparison purposes, all noise levels cited in this report are given in dB(A).