Public Hearings on Noise in Alberta

Report and Recommendations

Alberta

ENVIRONMENT COUNCIL OF ALBERTA

PUBLIC HEARINGS

ON

NOISE IN ALBERTA

REPORT AND RECOMMENDATIONS

July 1982

Environment Council of Alberta

Copies of this
report may be obtained
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Lieutenant-Governor in Council
Legislative Building
EDMONTON, Alberta

Honourable J. W. Cookson
Minister
Department of the Environment
222 Legislative Building
EDMONTON, Alberta

Dear Sirs:

I have the honour to transmit, herewith, the Report and Recommendations of the Environment Council of Alberta on Noise in Alberta, as required under Section 7 (1) (i) of the Environment Council Act (Chapter E-13 R.S.A. 1980).

I have the honour to be, Sirs,

Your obedient servant,

Roy F. McBride
Chairman, Noise Panel
Environment Council of Alberta

PREFACE

The report begins with the Council's recommendations. Opposite each recommendation is a brief outline of the reason for the recommendation. Following these are the Council's proposals for alleviation of traffic noise.

The main part of the report, which follows immediately after the recommendations and proposals, contains much more detail. It should be read to understand the scope of the study, the development of the recommendations, the physics of sound, and the effect of noise on health of the individual. A glossary of selected technical terms appears in the Appendix. Points in the text of the report which were mentioned in briefs presented at the public hearings may be marked by footnote numbers. A list of briefs relating to each number is located at the end of each major section.

ACKNOWLEDGEMENTS

This report has resulted from the dedication and hard work of many people. Extensive background material and subsequent information programs provided the foundation for highly successful public hearings. Many individuals and organizations attended the hearings to express their concerns about noise and frequently offered commendable suggestions for improvement.

Representatives of provincial government departments dealing with noise shared their experiences and expertise with the Panel. Mr. John Throckmorton of the Occupational Health and Safety Division was particularly helpful in sharing his knowledge about noise in the workplace.

The Panel also benefitted from the experience of experts in other provinces: Mr. John Manuel, Noise Pollution Control Section, Ontario Ministry of the Environment and his staff; officials of Mississauga and Etobicoke; Dr. T.F.W. Embleton and Dr. J.D. Quirt, National Research Council; and Mr. Victor Dubroff, Health Unit, Burnaby, British Columbia. During a visit to the United States Environmental Protection Agency, Mr. Charles Elkins and Mr. Kenneth Feith of the Office of Noise Abatement and Control and other government staff members provided valuable information concerning their noise-control programs.

Of great importance to the successful completion of this report was the staff of the Environment Council of Alberta. Some two years ago, Mr. David Buchwald, Mr. Tom Cottrell and Ms. Mary Gordon, Research Staff, began to develop background material. Their work continued throughout the public hearings and finally to the writing of this report. Mr. Bill Flook and Mr. Ken Nelson of the Liaison Division handled the many details necessary for successful hearings.

On behalf of the Noise Panel, I would like to acknowledge and extend my sincere appreciation to the many people who contributed to this report. As Chairman of the Panel, I must express my personal thanks to my fellow panel members for their effort and co-operation.

Roy F. McBride
Chairman, Noise Panel

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CREATING QUIET IN ALBERTA

INTRODUCTION

Noise is any sound or combination of sounds which is disturbing, harmful, or unwanted. Of greatest concern are those sounds which threaten or affect the health or well-being of individuals.

The World Health Organization defines health as "a state of complete physical, mental, and social well-being, and not merely the absence of disease or infirmity." The Council accepts this definition and, therefore, considers noise to be a health hazard.

Noise is already a serious problem for some Albertans, particularly those who are located along major truck routes or busy highways or those who work in noisy occupations. However, with the growth of population and increasing industrialization in Alberta, it is expected that more people will be impacted more severely by noise in the future unless actions are taken now to prevent an increase in noise levels.

The major recommendation proposes a Quiet Communities Directorate, to be responsible for leadership in achieving a quiet environment.

Recommendations will be dealt with under the following headings: **Administration, Education, Co-ordination, Planning, Economic Programs,** and **Research.** The problems of **noise in the workplace, noise in energy-related developments, alternate recreation facilities,** and the general problem of **noise measurement** are dealt with separately.

ADMINISTRATION

Recommendation 1

That an agency be established within the provincial government to provide leadership in achieving a quiet environment in Alberta.

The Council believes that the key to creating quiet communities is to establish an agency whose sole responsibility would be noise control. The functions of this agency, identified as the QUIET COMMUNITIES DIRECTORATE, would be:

1) To develop a core of technical expertise about noise – its nature, hazards, and control – that would be available to the provincial government departments, municipalities, and the public at large.

2) To develop special programs to achieve quiet communities; for example, through education, economic programs, and development of a model municipal noise control by-law.

3) To liaise and co-ordinate noise concerns among jurisdictions and departments. A non-exhaustive listing by the Council identified five municipal departments, 18 provincial departments, and eight federal departments or agencies responsible for, or concerned with, noise matters. There is a need for a centre to co-ordinate action on noise among the three levels of government and among the various provincial departments.

The major responsibilities of the Quiet Communities Directorate would include:

1) education;
2) co-ordination among provincial government departments, and between the province, municipalities, and the federal government;
3) advice on land use planning and a referral centre for noise planning problems;
4) the development of a model municipal noise control by-law and other legislative measures;
5) the development of economic, research, and other programs intended to achieve quiet;
6) the design and development of alternative facilities for those who seek quiet;
7) the development and enforcement of standards and regulations.

(See Section 4.2.1.)

Recommendation 2

That the Quiet Communities Directorate be composed of three divisions: Technical, Operational, and Quiet Communities.

The nature of noise is complex and far reaching. To effectively deal with all aspects of noise, three separate divisions are required:

1) The Technical Division would be the centre of technical expertise on noise with responsibility for research, design, monitoring noise levels, equipment, and development of standards.

2) The Operational Division would:
   a) review subdivision plans referred by subdivision approving authorities;

b) provide liaison and co-ordination among provincial government departments and agencies and among levels of government;
c) design and promote facilities which provide quiet alternatives.

If enforcement becomes necessary, the development of procedures would also be the responsibility of this division.

3) The Quiet Communities Division would:
   a) develop education programs on noise designed to reach all sectors of the population;
   b) develop a province-wide municipal model noise control by-law and other legislative measures;
   c) design economic, research, and other programs that would assist in creating quiet communities.

(See Section 4.2.1.)

Recommendation 3

That the Director of the Quiet Communities Directorate be a member of the Alberta Planning Board and the Provincial Board of Health.

Co-ordination is essential to the overall effectiveness of the Quiet Communities Directorate. The Director, therefore, should be a member of the Alberta Planning Board, which reviews regional plans and receives appeals concerning subdivision approvals.

The Director should also be a member of the Provincial Board of Health, which is responsible for overseeing community health programs throughout Alberta.

(See Section 4.2.1.)

Recommendation 4

That an Interagency Quiet Communities Co-ordinating Committee be established and that the Director of the Quiet Communities Directorate act as chairman.

An Interagency Quiet Communities Co-ordinating Committee should be established, where all Alberta Government departments with a responsibility or concern for various aspects of noise at the provincial level would be represented. This committee would provide for information exchange about the various programs and approaches being adopted by the different departments, the identification of noise problems they are experiencing, and their successes in coping with them. In addition, the programs of the Quiet Communities Directorate could be co-ordinated with noise programs in the various departments.

(See Section 4.2.1.)

Recommendation 5

That a Quiet Advisory Committee be established.

A committee consisting of a few members of the general public could provide input, advice, and guidance on noise problems, the effectiveness of the Quiet Communities Directorate's programs, and the identification of areas where more attention should be focussed.

(See Section 4.2.1.)

Recommendation 6

That the Quiet Communities Directorate be located either in the Department of Municipal Affairs or the Department of Social Services and Community Health.

The case for location in the Department of Municipal Affairs relates to:

1) the importance of planning as a tool in creating quiet communities;
2) the need to review regional plans and subdivision approvals;
3) the development of a model municipal noise control by-law and its adoption by municipalities.

The case for locating the Quiet Communities Directorate in the Department of Social Services and Community Health is that noise is basically a health problem. The Health Services division is responsible for the network of local boards of health which cover the province in 27 autonomous health units. Approximately 125 inspectors in these health units are already responsible for environmental health concerns, ranging from eating facilities to septic tanks. Local boards of health usually are capable of conducting hearing tests. In addition some public health inspectors, as part of their training, receive instruction on monitoring and interpreting noise measurements.

Because so many of the needed technical capabilities already exist in the local boards of health, and with a network of provincial coverage already in place, locating the Quiet Communities Directorate in the Department of Social Services and Community Health appears to be a very practical solution.

(See Section 4.2.1.)

Recommendation 7

That the Quiet Communities Directorate have a separate vote in estimates yet be assigned to a department.

A separate vote would ensure that the responsibility for the control of noise and the creation of quiet is clearly identified.

It would also mean that the Legislature and Cabinet would review the mandate, performance, and expenditures separately, thus ensuring that the effectiveness of the Quiet Communities Directorate is assessed on a continuing basis. The department to which it is assigned would provide the normal housekeeping

facilities: financial control, personnel administration, and general administrative support.

(See Section 4.2.1.)

EDUCATION

Recommendation 8

That education programs be a major responsibility of the Quiet Communities Directorate.

Education is identified by the Council as the most important element of any program to achieve quiet in our communities. The Council further believes that much of the problem with noise is either lack of knowledge about its health dangers and how quiet can be achieved, or simple thoughtlessness. Education programs should be directed at these problems.

Though educational programs should be aimed at a broad spectrum of the population, certain high-priority target groups can be identified:

1) Those in decision-making positions – their program might be modelled after a very effective program developed in Ontario, consisting of courses ranging from one day to one week, tailored for people such as municipal planners, architects, municipal officials, and developers. These courses are essentially directed at those involved in the planning and development of new residential communities so that they become aware of the nature of noise problems, and of solutions to them.

2) Employers and workers in noisy occupations – for example, hearing testing, an integral part of any hearing conservation program, provides an opportunity for an important educational experience. At the time of testing, the audiologist or the audiometric technician has a unique opportunity to explain to the worker what is being tested and why, the impacts that cumulative exposure to noise can have, and the means of preventing hearing loss. Other techniques may include the use of various educational materials. An education program specifically geared to the farming community should also be developed.

3) Students in elementary and secondary schools – there is little awareness of the nature of noise, the danger of noise, or the need for protection from excessive noise among the general public.

The Office of Noise Abatement and Control in the United States Environmental Protection Agency developed educational packages for use at all grade levels in elementary and secondary schools, intended to provide a general level of awareness of the nature and problems of noise. The potential use of this or similar educational models in the schools of Alberta should be explored.

4) Students in technical training institutions or apprenticeship programs – an educational program would be part of pre-employment training for those who will work in noisy trades. These programs would identify problems that students will face during their working life and the ways to avoid noise-induced hearing loss.

5) General programs to increase public awareness of noise are also required.

(See Sections 4.2.1, 4.2.2, and 4.3.2.)

CO-ORDINATION

Co-ordination is an important function of the Quiet Communities Directorate because at present the responsibility for noise control is divided among a number of different jurisdictions and agencies.

Federal Liaison and Co-ordination

At the provincial level, there is little possibility of influencing the noise levels of products such as vehicles, construction equipment, aircraft, and appliances since most are manufactured outside the province or the country. The federal government has the legislative authority to request that such products be quieter when manufactured or imported. The federal government is also responsible for the regulation of many noise-producing facilities such as railways and aircraft, as well as being a major employer through institutions such as the post office. As an employer, the federal government provides a different standard of noise protection to its employees than is required of other Alberta employers. This is an unsatisfactory situation since all Albertans should be provided with the same level of noise protection whether they work in a provincially or federally regulated industry.

(See Section 4.2.3.)

Recommendation 9

That the Quiet Communities Directorate work with the federal government to achieve quieter manufactured and imported products.

Recommendation 10

That the Quiet Communities Directorate work with the federal government to reduce the noise generated by aircraft and railways.

Recommendation 11

That the Quiet Communities Directorate work with the federal government to provide the same level of protection to federal employees as is provided to other Albertans.

Provincial Co-ordination

As pointed out in Recommendation 1, some 18 departments and agencies in the provincial government have a concern with or a responsibility for certain aspects of noise. In most instances, these concerns and responsibilities should remain where they are, since they are frequently built into other programs or services provided by these departments. For example, the Department of Transportation, in the development of new highways, has considerable skill in designing, locating, and constructing highways so that their noise impacts can be reduced.

The Public Works section of the Department of Housing and Public Works is concerned with reducing noise levels in provincial government offices through such techniques as insulating or designing of air-conditioning equipment. These skills and functions should remain with these departments, but could be assisted and co-ordinated by the Quiet Communities Directorate.

Recommendation 12

That the Quiet Communities Directorate provide a readily identified single responsibility centre for noise complaints.

Public complaints about noise are presently directed to many different departments, such as the Department of Environment, the Department of Transportation, or the Energy Resources Conservation Board. Having the Quiet Communities Directorate receive all complaints would be advantageous to the public, even though appropriate action would frequently be provided by other departments or agencies.

(See Section 4.2.1.)

Municipal Co-ordination

Many aspects of noise are local. Noise is not transportable, and many of its effects are contained within the bounds of local government jurisdictions. Hence much of the basic responsibility for the control of noise should rest at the local level.

However, local authorities need to know the context within which their programs are set so that their standards are neither too high nor too low; local authorities should have some centre to which they can refer difficult technical problems relating to noise and obtain competent advice. Co-ordination between the provincial and local levels is essential to the success of any program for the control of noise and the creation of quiet communities.

PLANNING

The Council believes that the most effective way to control noise is through prevention. This means separating noise sources and the people who could be annoyed or disturbed by them, or the attenuation of noise before it impacts on sensitive receivers. One of the key ways to achieve this, identified by many briefs at the hearings, is through planning. The Council concurs in this view. Noise at present is not one of the factors that is explicitly taken into account in the preparation of regional plans, in subdivision approvals, or land use by-laws. The Council believes that noise levels can be forecast with the same level of accuracy as traffic flows, aircraft movements, or truck loadings. The Council therefore believes that noise should be considered in land use planning as explicitly as topography and traffic flows.

Recommendation 13

That Section 92 of the Planning Act be amended to include a provision for noise attenuation as part of a development agreement.

Section 92 of the Planning Act (RSA 1980 cP-9) presently gives a municipality the right to enter into agreements with developers to install such utilities as pedestrian walkways and off-street parking. When noise attenuation is needed to protect a residential subdivision, a municipality should be able to enter into an agreement with a developer to install or pay for the installation of noise-attenuation devices or employ design techniques where necessary, to achieve an acceptable level of quiet.

(See Section 4.6.3.)

Recommendation 14

That Section 8 of the Subdivision Regulation be amended to include noise from adjacent land uses.

Section 8 of the Subdivision Regulation under the Planning Act, 1977 presently reads: "In making a decision as to whether or not to approve an application for subdivision approval, the subdivision approving authority shall consider, with respect to the land that is the subject of the application..." following which is listed a large number of factors such as topography, soil characteristics, potential flooding, etc. A phrase should be added to this section to the following effect: "...the noise levels generated in the vicinity of the land that is the subject of the application." In this way, noise would be identified as a specific factor that must be taken into account before a subdivision is approved.

(See Section 4.6.3.)

Recommendation 15

That Section 6 of the Subdivision Regulation be amended to add the Director of

Section 6 of the Subdivision Regulation presently reads: "Upon receipt of a completed application for subdivision approval, the subdivision approving authority shall send a

the Quiet Communities Directorate to the list of authorities that review subdivision applications before approval.

copy of it to..." and then lists a large number of agencies and departments, such as school authorities and public utilities. The Director of the Quiet Communities Directorate should receive copies of the subdivision applications from the subdivision approving authorities. This would provide an opportunity for the Quiet Communities Directorate to identify any noise problems likely to occur in the subdivision, and provide comment to the subdivision approving authority on the seriousness of the problem and whatever potential solutions seem to be appropriate.

(See Section 4.6.3.)

The effect of these actions would be to ensure that the noise factor is explicitly considered in the planning approvals process. They would provide for early identification of noise problems in the development of new residential communities. As it is easier to prevent rather than rectify noise problems, these measures should lead to the avoidance of many of the problems that presently exist.

Model Municipal Noise Control By-law

Recommendation 16

That a model municipal noise control by-law be developed for use throughout the province.

Noise is a problem which is predominantly local in its impact and frequently confined within the limits of municipal boundaries. However, municipalities approach the control of noise in different ways, with varying degrees of success, and find it difficult to identify the appropriate technical approaches to control noise. In view of the similarity of the problem within the municipalities, it seems practical to have uniformity in noise control while recognizing local differences where practical.

The Province of Ontario has found the solution to these problems in the development of a province-wide model municipal noise control by-law. This by-law comes in two phases. Phase one is a subjective by-law, intended for smaller towns and communities that lack technical resources and generally have only moderate problems with noise. This phase of the model by-law is simple to enact, easy to enforce, and readily understood. Phase two of the model by-law is more detailed and technical, requiring sophisticated measurements of sound levels and some technical capability to administer and enforce. This phase of the by-law is intended for larger municipalities where noise problems are severe and technical capabilities are available in the city staff.

A municipality can, within limits and with proper approval, choose the phase of the model by-law that fits its needs, and can remove clauses or phrases that do not seem appropriate to its individual situation. The Council was able to discuss this approach with municipalities in Ontario that have adopted the model municipal noise control by-law and found them quite enthusiastic about its practicality and effectiveness. Some municipalities in Alberta requested such an approach at the public hearings.

(See Section 4.2.2.)

Recommendation 17

That, if a municipality adopts the model municipal noise control by-law in whole or in part, in the interest of uniformity the Director of the Quiet Communities Directorate must approve changes or modifications.

This policy would ensure that the approach to noise control does not vary too widely throughout the province. In cases of dispute, municipalities should have the right of appeal to the Minister responsible for the Quiet Communities Directorate.

(See Section 4.2.2.)

Recommendation 18

That training programs for municipal officials be part of the implementation of a model municipal noise control by-law.

One reason for the success of the Ontario approach is that the adoption of a model by-law was accompanied by seminars, workshops, and short courses which explained to civic authorities the nature of the provisions of the by-law and the actions that would be required, and made suggestions for its effective implementation. This educational component is an important reason why the model by-law has proven to be so effective and why so few problems have occurred with its implementation.

(See Section 4.2.2.)

The recommended model municipal noise control by-law for Alberta should be designed to meet specific conditions in this province. The Council believes this would be an appropriate task for the Quiet Communities Directorate.

ECONOMIC PROGRAMS

Economic programs seek to reward the creation of quiet and penalize the production of noise through some economic reward or penalty. They normally do not stand by themselves but are part of other programs.

An economic program developed by the Environmental Protection Agency seems to hold great promise – the "Buy Quiet" program. In essence, this program is educational, directed at purchasing agents for city, state, and federal

governments as well as purchasing agents for private companies. It is based on the fact that there is a wide variation in noise produced by different brands of appliances, equipment, machines, or vehicles. Quite frequently the quietest piece of equipment is no more expensive than one which is noisier. The Buy Quiet program urges purchasing agents at all levels of government to include quietness as one of the specifications for any equipment purchased.

Recommendation 19

That the Quiet Communities Directorate be responsible for the implementation of a "Buy Quiet" program.

In Alberta, between municipalities and the provincial government, a considerable amount of equipment is purchased each year. If government purchasing agents indicated that they would give preference to quieter machines, this would provide a useful incentive for manufacturers to develop quieter equipment. If other provinces and the federal government were to join in this approach, the impact would be substantially enhanced.

Much equipment today is noisy because there is little or no incentive to make it quieter. If manufacturers knew that quieter equipment would have some advantage in the market, they would begin to adopt production methods that would reduce noise. The Council believes that a Buy Quiet program has important potential benefits for Alberta at relatively low cost.

(See Section 4.5.2.)

Land Economics

Recommendation 20

That the Quiet Communities Directorate become a centre of expertise in noise-related land economics.

Frequently, during the planning process the avoidance or reduction of noise is rejected by a developer as being too costly either because his land will be sterilized by leaving it empty to provide for noise attenuation by distance, or because the provision of berms and noise barriers to protect potentially subdividable land is too expensive. Similarly, the acquisition of homes along truck routes through existing residential areas is resisted or rejected by municipal councils because of the cost involved.

The land economics approach to these problems is to determine if other alternatives are available which would reduce noise and at the same time would not escalate the cost of housing or land acquisition. The principal methods used to achieve this objective are: changing the land use in areas adjacent to noise sources to less sensitive uses such as commercial or light industrial developments, and permitting

higher density development adjacent to noise sources, in conjunction with special building designs (barrier buildings) which reduce noise for the residents of the high-density buildings as well as the residents in the remainder of the subdivision. The Quiet Communities Directorate would work closely with municipal authorities to identify where these approaches are appropriate solutions to particular planning problems.

Edmonton Municipal Airport

At the public hearings, the Edmonton Municipal Airport was identified as the single most disturbing noise source in the province. The major contributors to the noise problem are the Boeing 737 jets.

Recommendation 21

That the City of Edmonton give serious consideration to prohibiting regular use of the Edmonton Municipal Airport by large jet aircraft.

An approximately equivalent level of convenience to the commuting public could be provided by the use of quiet planes such as the Dash 7. Since the City of Edmonton owns the airport, City Council could achieve an acceptably quieter airport by prohibiting the use of large jets at the Municipal Airport. The City of Toronto has banned the use of all jets at its Island Airport. The Council does not believe that smaller business jets contribute sufficiently to the Municipal Airport noise problem to warrant their elimination.

(See Sections 3.1.3 and 4.5.1.)

Cost Sharing

Recommendation 22

That the provincial government share in the cost of noise attenuation or retrofit programs to the same extent that it shares in the cost of construction of provincial highways in municipalities.

Provincial highways are identified as a major noise source in Alberta. The Council believes that it is appropriate for the provincial government to share in the cost of noise attenuation or retrofit programs to the extent that it presently shares in other aspects of a highway construction program. In other words, if the present cost sharing for a particular highway is 50 percent provincial and 50 percent municipal, the provincial government should share 50 percent of the cost of any noise-attenuation facilities that the highway requires.

(See Section 4.5.3.)

Redevelopment

Recommendation 23

That the province make low-cost loans available to municipalities for redevelopment as a solution to noise problems.

Though retrofit can be quite effective technically, it is an extremely expensive approach, and one which should be viewed as a last resort. The Council believes redevelopment is an appropriate approach where truck routes or provincial

arterial highways cut through existing residential areas and create major noise problems. Though a change of use or an increase in density holds excellent promise of a long-term economic payoff, the so-called "up-front" costs are extremely high. This is because a number of properties must be purchased over a long period of time with potential problems of holdout or speculation, designs must be developed for the new uses that will replace those fronting on the noisy arterial, and the project must eventually be constructed. Such a project could take several years. However, one of the reasons that redevelopment is a preferred alternative is because the potential returns from the upgrading of land uses should be sufficient to cover the cost of the property and the special sound treatment required.

The Council believes that the province should make low-cost loans available so that a municipality is not inhibited by a shortage of funds from proceeding with redevelopment as a solution to noise problems, where this is the most cost-efficient solution to the problem.

(See Section 4.5.3.)

Compensation

Recommendation 24

That a greater reduction in assessment be made available for residential properties located next to a noise source.

Some municipalities already provide for a reduction in assessments of up to 15 percent if residential properties are located next to noise sources such as truck routes and arterial highways. The Council believes that this is a helpful approach and should be extended.

An equitable approach would be a 0.4 percent reduction in assessed value for each dBA Leq(24) over 55 dBA, with a doubling in the rate for each 5 dBA increase in sound levels. That is, up to 60 dBA the maximum assessment reduction would be 2 percent; to 65 dBA, the maximum assessment reduction would be 6 percent; to 70 dBA, 14 percent; to 75 dBA, 30 percent; and so on. The Council believes this would have two effects: it would compensate the homeowner for the loss of amenity value which is represented by a noisy situation; and it would create an incentive for the municipality to provide solutions to noise problems and thus prevent a reduction in assessed values.

(See Section 4.5.3.)

Recommendation 25

That the province compensate municipalities for assessment reductions resulting from a provincially supported highway.

In those locations where the assessment reduction is due to a provincially supported highway, the province should contribute to the municipality in the amount of tax revenue lost, in proportion to its cost sharing on the construction of the highway. However, the Council believes that the funds supplied by the province as compensation for lost assessment should be locked in; that is, they should be used for the construction of noise-attenuation devices or other approaches which would reduce noise levels and not for general revenue purposes.

(See Section 4.5.3.)

Recommendation 26

That when reduced assessments are allowed, a notice to this effect must be placed on the title.

Homeowners who take advantage of reduced assessments should also provide information on the noisy conditions to prospective purchasers through a notice on the title. The notice on the title would indicate that the building is located in a noisy area and that its assessed value has been reduced because of this fact.

(See Section 4.5.3.)

RESEARCH

Though much is known about noise, there is still much to be learned. The Council identifies the following as major areas where knowledge is lacking.

Extra-Auditory Effects

Recommendation 27

That medical research into the extra-auditory effects of noise be given high priority in Alberta's medical research programs.

There are tentative links between exposure to noise and major health effects such as cardiac and blood circulation problems and other stress-related symptoms. However, these links are neither clear nor well established. The Environmental Protection Agency provided funding to major medical research centres to identify these links and some very valuable results have been achieved. Unfortunately, further funding will not be made available in spite of the important advances made, particularly in establishing that it is a worthwhile area of research. We cannot rely, as we frequently do, on benefitting from American research. The health effects of noise are a frontier of medical knowledge. Alberta's growing medical research capabilities could allow us to become a world leader in this area.

(See Section 4.3.3.)

Monitoring

There is little baseline data about noise levels in most Alberta communities. To establish the current situation, but more particularly to trace the future success or failure of noise-control programs, long-term monitoring of noise levels is required. These noise surveys should establish noise contours in major Alberta communities. Subsequent surveys, perhaps every two years, would identify the extent to which noise impacts have increased, decreased, or remained stable.

(See Section 4.3.3.)

Recommendation 28

That long-term monitoring of urban noise levels be carried out.

Hearing testing programs in industry can also provide a useful data base. Through analysis of records of audiometric testing, it would be possible to establish with some accuracy which Alberta industries are noisiest and where workers are protected inadequately. The potential for improving or modifying programs to protect hearing is directly related to the availability and accuracy of such records.

(See Sections 4.3.1 and 4.3.3.)

Recommendation 29

That long-term baseline data on the hearing capability of employees in Alberta industry be acquired and analyzed.

Loud Music

There is considerable controversy and little evidence about whether prolonged exposure to loud music, particularly amplified music, leads to hearing loss. Specific studies are essential to identify whether a problem exists and to determine its nature and scale.

(See Section 4.3.3.)

Recommendation 30

That studies be conducted to determine the effects of prolonged exposure to loud music.

Loss of Hearing in Higher Frequencies

At present, hearing conservation programs are directed at the speech frequencies (generally 500 to 3000 Hz). Loss of hearing in the higher frequencies (4000 to 8000 Hz) is considered significant primarily as a diagnostic device (the early warning notch). Loss of hearing in the higher frequencies, while not incapacitating, reduces the quality of the sound we hear. Research is required so hearing conservation programs can begin before some hearing loss has been experienced.

(See Section 4.3.1.)

Recommendation 31

That procedures be developed to protect hearing in the higher frequencies.

Building Standards

Recommendation 32

That studies be conducted to determine if the present sound transmission class ratings are adequate for multi-family dwellings and to assess the technical and economic implications of improving the standards.

Noise-attenuation standards for multi-family dwellings were established in 1941 when the National Building Code was first adopted. Forty years have passed since this standard was established and a number of countries have since adopted much higher sound transmission class (STC) ratings. Research is required to identify whether the 1941 standard is adequate for present day building conditions, whether higher standards are technically and economically feasible, and if so, the most appropriate method of implementation.

(See Section 4.4.3.)

NOISE IN THE WORKPLACE

Recommendation 33

That the primary responsibility for control of noise in the workplace remain with the Occupational Health and Safety Division.

The responsibility of the proposed Quiet Communities Directorate would relate primarily to problems of environmental noise. The control of noise in the workplace is also an important task and is presently the responsibility of the Occupational Health and Safety Division.

Alberta has as yet seen little evidence of the impact of occupational noise-associated hearing loss. This is because both the work force and the industries in Alberta are young, and because noise-induced hearing loss is not a sudden or dramatic ailment but the result of the accumulation of exposure to excessive noise over a working lifetime. The way to prevent noise in the workplace from becoming a major problem is to take action now.

The Council received briefs from a number of organizations, including representatives of the major labour unions in the province, which maintained that the standards presently established by the Occupational Health and Safety Division are not sufficient to protect the workers of Alberta from hearing damage. Having considered this point very seriously, the Council is satisfied that the regulations that presently exist are sufficient to protect workers' hearing in the speech frequencies. The problem is not inadequate standards, but inadequate extension and enforcement of existing standards.

The best estimates that the Council received indicated that only 10 percent of Alberta workers are included in hearing conservation programs. This situation exists for several reasons:

1) Noise has not had a high priority in safety programs in many occupations. It has been considered one of the normal aspects of the occupation about which little or nothing can be done. This attitude is changing among both workers and employers as more knowledge becomes available.

2) With small budgets and a centralized operation, the most cost-effective method of establishing hearing conservation programs is to deal first with the large industries in the major urban centres.

3) Many of the major occupations in Alberta, such as the oil and gas and construction industries, are highly mobile. The companies move from site to site and the turnover rate among workers is high. These are the most difficult industries and occupations to reach with a hearing conservation program.

Though the Council appreciates the difficulty in enforcing and extending coverage, the current situation is dangerous to health and well-being and must be corrected. The Council therefore makes the following recommendations for extending coverage of hearing conservation programs.

(See Sections 3.2.1 and 4.3.1.)

Recommendation 34

That the Occupational Health and Safety Division explore the possibility of utilizing local health inspectors to enforce the regulations on noise in the workplace and develop hearing conservation programs.

Public health units and public health inspectors already provide blanket coverage throughout the province. Public health inspectors, due to the nature of their work, must visit small and widely scattered industrial and commercial operations. The addition of noise as one of the health hazards that they should consider would be an efficient use of an existing network.

(See Section 4.3.1.)

Recommendation 35

That noise counselling be a mandatory part of any audiometric testing program.

Audiometric testing provides a unique opportunity to tell workers about the nature and dangers of noise, the cumulative nature of noise exposure, and how to prevent hearing loss. Since all licensed audiometric technicians must take courses where the importance of counselling is stressed, it is probable that most hearing tests feature counselling. However, it would provide greater security if counselling were identified in the regulations as a requirement of any hearing test.

(See Section 4.3.1.)

Recommendation 36

That the Occupational Health and Safety Division develop hearing conservation programs to meet the needs of workers in industries with varying work locations.

The Council appreciates the difficulty that this recommendation presents and is mindful of the problems experienced by the Workers' Compensation Board in British Columbia in trying to follow employees as they move from job to job and from location to location. However, to say that it is administratively impossible to track such workers is to condemn a substantial number of Albertans to major hearing loss at the end of their working careers.

There are several government documents which presently follow workers from job to job and from location to location. One of these documents could include individual audiometric tests, which are essential for the protection of the worker from the cumulative impacts of noise in the workplace.

(See Section 4.3.1.)

Recommendation 37

That for particularly noisy industries, employers be required to develop a plan for noise abatement in the workplace.

The development of a plan to abate noise in the workplace should be left to the employer, who is most familiar with the operations and their financial impacts, and should be responsible for identifying how, over a period of time, a quieter workplace can be achieved. The plan should be reviewed and approved by the Occupational Health and Safety Division. Such a program is presently being undertaken by the Workers' Compensation Board in British Columbia and seems to be effective and successful.

(See Section 4.3.1.)

Recommendation 38

That employees working in noisy taverns and discotheques be provided the same protection as any other worker in a noisy workplace.

One of the more conspicuous exceptions to hearing protection programs has been identified as the employees of noisy taverns and discotheques. These employees deserve the same level of protection as any worker exposed to noise in Alberta industry.

(See Section 3.4.1.)

ENERGY-RELATED FACILITIES AND NOISE

Recommendation 39

That noise levels be measured at the property line of an energy development.

The Energy Resources Conservation Board (ERCB) has an interim directive (ID-80-2) which should be revised. The Council suggests that Recommendations 39, 40, and 41 be

considered when the regulation is redrafted. The directive stipulates that noise emanating from an energy resource development facility, such as a pumping station or drilling rig, shall not exceed a certain dB level when measured 15 metres from a nearby residence. This requirement has been an effective temporary measure and has reduced the noise conflict between the energy industry and residences. However, there are a number of difficulties with this approach, some at the technical level in relation to the measurement of sound, and some because of the possibility of residences being located in the noise-affected area after the fact.

(See Section 3.2.2.)

Recommendation 40

That permissible noise levels be lowered for permanent facilities.

There should be a difference between the noise levels that are tolerable for a temporary disturbance such as a drilling rig, and a permanent disturbance such as a pumping station. As a result, the Council believes that improved noise standards are required for permanent facilities.

(See Section 3.2.2.)

Recommendation 41

That, in rural areas, a noise standard of 5 dBA Leq (24) above ambient noise levels be adopted.

Many energy-related facilities are located in rural settings. Rural areas normally have very low noise levels and the residents expect that these levels will be preserved. In cities it is normal to consider that a noise problem begins at 55 dBA. However, such levels would be completely out of place in many rural areas where the ambient noise level is 35 to 50 dBA, or lower. What seems to be required is a measure of intrusive noise level; that is, the extent to which the energy-related development raises the ambient noise levels. The Council suggests that a permanent energy-related facility be no more than 5 dBA Leq (24) above the ambient noise level in the rural location, measured at the property line of the facility.

(See Section 3.2.2.)

ALTERNATE RECREATIONAL FACILITIES

Recommendation 42

That the provision of quiet and non-quiet public facilities be explored.

There has been a considerable trend in recent years to provide alternate facilities for smokers and non-smokers in public places. The Council believes that there are opportunities for exploring a similar approach in providing quiet and non-quiet public facilities. This approach applies particularly to parks, campgrounds, and recreation lakes, and could be achieved

through design or by having a designated quiet area in one part of the park, separated from other areas where noise is less objectionable. Entire parks or recreation lakes could be designated as quiet parks or quiet lakes where motor vehicles or power boats would be prohibited. Alternatively, noisy pursuits such as trail bike riding could be zoned into one particular part of the park. Approaches such as these have been tried in the development of Kananaskis Country and their extension to other areas and situations is recommended.

(See Section 3.4.2.)

NOISE MEASUREMENT

Recommendation 43

That the use of dBA Leq be accepted as the standardized noise descriptor.

One of the problems in the noise field is the variety of noise descriptors used, each designed to fit a specific problem or situation. Standardization of noise descriptors is desirable for consistency and comparability. The National Research Council concluded that dBA Leq is the most appropriate standard noise descriptor.

(See Sections 3.2.2 and 3.6.2.)

ALLEVIATION OF TRAFFIC NOISE

The most frequent and persistent problem identified at the hearings was traffic noise. The Council does not believe there is one solution to traffic noise. Resolution of this problem will require many programs applied in a consistent and co-ordinated way. Each program will make a small contribution, and combined they can provide substantial relief.

Following is a summary of the Council's proposals relating to the reduction of traffic noise.

Reduce noise at the source, particularly from trucks.

This is primarily a federal responsibility but the province can persuade and lobby for higher noise standards. Through a Buy Quiet program, which creates a demand for quieter products, a direct impact can be achieved.

(See Sections 3.1.1 and 4.5.2.)

Adopt municipal noise by-laws under Section 16(1) of the Highway Traffic Act.

Through the adoption of municipal noise by-laws under Section 16(1) of the Highway Traffic Act (RSA 1980 cH-7) and adequate enforcement, noisy faults can be identified and the owners can be required to rectify the problems.

(See Section 3.1.1.)

Develop vehicle testing facilities.

Testing facilities should be available in major municipalities, so that suspected vehicle faults can be accurately and precisely identified.

(See Section 3.1.1.)

Fines for noise infractions or for ignoring instructions to rectify noise faults in vehicles should be sufficiently high to ensure compliance. Low fines tend to be regarded as just another cost of keeping cars on the road, and do not lead to a solution of noise problems.

Adequate enforcement of the Highway Traffic Act.

Adequate enforcement of the Highway Traffic Act will help reduce squealing tires, stunting, and other poor driving practices that produce excessive noise.

(See Section 3.1.1.)

Use techniques to reduce noise on heavily travelled roadways.

Several approaches which will help reduce noise on heavily travelled roadways are: using special road surfacing to reduce tire noise, decreasing the number of traffic signals, and promoting free, steady traffic flow with little need for gearing up or down.

(See Section 4.4.1.)

Improve land use planning.

Noise should be taken into account explicitly as a factor in land use planning. Heavily travelled traffic routes and good residential areas are incompatible, and they should be separated. Where they cannot be separated, the use of depressed roadways, berms, noise fences, and special surfacing for roads should be considered part of the essential cost of constructing new highways or reconstructing old ones. The costs of these facilities should be shared between the province and the municipality in programs similar to those used for other highway construction costs.

(See Section 4.6.1.)

Use barrier buildings.

In particularly difficult situations, the use of barrier buildings should be considered. The province should make low-cost loans available to municipalities to meet the formidable front end costs of this solution. However, the possibility of higher density or higher value reuse holds promise that such redevelopment would recover the costs of land acquisition and replotting.

(See Sections 4.5.2 and 4.5.3.)

Introduce assessment reductions.	As an incentive to municipalities to avoid or overcome traffic noise problems and as a partial compensation to residents who suffer from traffic noise, an extended scheme of reduced assessments should be provided, on a sliding scale with the greatest reductions available to those who suffer the most from noise. Reduced assessments should only be available for residentially zoned areas. (See Section 4.5.3.) None of these approaches is sufficient by itself to solve the traffic noise problem. Each problem area will require a unique solution, tailored to that particular situation. The development of unique solutions to individual problems should be a principal task of the Quiet Communities Directorate, which at the same time should strive to achieve actions that will reduce problems with traffic noise overall.

The Council wishes respectfully to place these recommendations and this report before you.

Environment Council of Alberta
Panel on Noise in Alberta

R.F. McBride, Chairman

A.D. Crerar, Vice-Chairman

D.E. Lewis, Q.C., Member

J.E. Wilson, Member

Introduction

REPORT

SECTION ONE

Fifty years ago in Alberta, quietness was taken for granted. Today, with much larger populations, more trucks and cars, airplanes, mechanized industry, and electronic amplifiers, quietness is no longer the norm.

A significant number of Albertans are exposed to excessive noise levels. Quietness can no longer be taken for granted. Careful planning is needed to avoid the increasingly serious problems caused by noise.

In May 1980, the Organization for Economic Co-operation and Development (OECD),* of which Canada is a member, convened a conference on noise abatement policies. The conference president stated

> *...during the last twenty years, the quality of the noise environment has steadily deteriorated, mainly as a result of rapid urbanization, the growth in mobility, and the rapid development of mechanized activities in OECD countries. Currently, 15 percent of the population of OECD countries, that is about 100 million people, are exposed in their daily environment to levels of noise which are regarded as unacceptable (more than 65 dBA), and more than half the population of these countries is exposed to a level of noise higher than that corresponding to a level of comfort (more than 55 dBA) (OECD 1980:1).*

A report on the state of the world environment from the United Nations identifies noise pollution as a significant and growing environmental problem which "...not only threatens health, disturbs or annoys, but can also impair the efficiency of work, [and] damage structures..." (Tolba 1979:9).

In 1974, the provincial government recognized that the subjective nature of noise made it difficult to control and manage. The Minister of the Environment requested the Environment Conservation Authority (now the Environment Council of Alberta) "to examine the nature of noise legislation that may be advisable for Alberta and make recommendations to the Minister."

The Authority's Science Advisory Committee established a group to assess the problem. This resulted in the two-volume report *Noise in the Human Environment* (Jones 1979), which was published by the Council in 1979 and widely distributed.

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*The OECD is an international organization founded in 1960 to stimulate economic progress and world trade. The members are: Austria, Belgium, Canada, Denmark, Finland, France, the Federal Republic of Germany, Greece, Iceland, Ireland, Italy, Japan, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. The goals are:

> *to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;*
>
> *to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development;*
>
> *to contribute to the expansion of world trade... (OECD 1980:np).*

In May of 1981, the Government of Alberta, by Order-in-Council, requested the Council to:

1) Inquire into all aspects of the effects of noise on the environment within the province of Alberta, giving particular attention to
   a) noise sources and problems,
   b) the effects of exposure to noise on health and the human environment, and
   c) technological and other practices that may be adopted to control noise levels and resolve problems.

2) Hold public hearings at suitable locations throughout the province, and report to the Minister of the Environment and the Lieutenant-Governor in Council on completion of the report of the findings.

The Panel assigned to this task consisted of:

Roy F. McBride, Chairman – Mr. McBride served as a mine electrician, mine manager, and training co-ordinator for Manalta Coal Ltd. between 1958 and 1979. He is a lifelong farmer and a veteran of the Royal Canadian Air Force.

Alistair D. Crerar, Vice-Chairman – Mr. Crerar is the Chief Executive Officer of the Environment Council of Alberta. He is an economist and planner.

D. Edwin Lewis, Q.C. – Mr. Lewis is a lawyer and former Western Counsel of Imperial Oil Ltd. He is past president of both the Calgary and Alberta Chambers of Commerce and is presently Chairman of the Glenbow Museum. He is also a director of a number of companies.

Joan E. Wilson – Ms Wilson built a small group interested in controlling litter into a major environmental interest group, the "Clean Calgary Committee." She has studied psychology and journalism.

1.1 THE PUBLIC HEARINGS

Hearings were held at six locations in the province. At all locations, evening sessions were included to facilitate the participation of those unable to attend a day session. Additional hearings were scheduled in Edmonton to accommodate the number of people wishing to be heard. The schedule was:

Calgary	June 25, 26
Edmonton	June 9, July 7, 8
Edson	June 17
Grande Prairie	June 11
Lethbridge	June 23
Red Deer	June 15

One hundred and fourteen briefs were received during the hearings and 42 briefs after the hearings had been completed, for a total of 156. (See the Appendix for a list of briefs presented.)

Sources of Briefs Presented at the Hearings

Percent	Source
52	Individuals
17	Industry
17	Local Governments
10	Environmental and Community Groups
4	Labour Organizations
100	Total (114 briefs)

Over 80 percent of the 42 supplemental briefs were from individuals.

1.2 INFORMATION PROGRAM

The public hearings were preceded by an extensive information program. Reports and brochures were prepared by the Environment Council's Science Advisory Committee, the Council's research staff, the Occupational Health and Safety Division of Alberta Workers' Health, Safety and Compensation, and a consultant.

Noise in the Human Environment, Vol. I deals with Canadian problems in a variety of areas including community reactions, law, noise-control devices and techniques, planning, building design, and transportation noise.

Noise in the Human Environment, Vol. II discusses noise associated with vehicles, appliances, construction, and industry. There is a physical description of noise and a section on the noise environment of man.

Noise in Alberta describes sound, noise, and the Alberta soundscape.

Noise is a Health Hazard discusses the effects of noise on health, including physiological, psychological, and behavioural aspects.

Noise in the Workplace provides a detailed analysis of noise in the industrial setting.

Administration and Regulation of Noise in Alberta reviews existing responsibilities of the municipal, provincial, and federal governments in dealing with noise.

Economic Aspects of Noise in Alberta discusses the impacts of noise on the economy and people of Alberta.

Brochures were also prepared for distribution in connection with the hearings.

Transportation Noise discusses vehicle, railway, and airplane noise; certain control techniques; and various government responsibilities.

Planning Considerations reviews the role of land use planning in noise control.

Noise Around the Home discusses noise sources and problems in the domestic setting.

Economic Aspects summarizes the report *Economic Aspects of Noise in Alberta.*

Public Hearings on Noise, Make Your Concerns Known describes the public hearings and the Noise Panel members.

In addition, several films on various aspects of noise were obtained for the information program.

Prior to the hearings, the Council staff met with and made presentations to any group interested in noise. The meetings included seven with health units, 12 with regional planning commissions, eight with civic or public groups, and three with professional organizations.

The Council advertised the hearings through a campaign which utilized radio, newspapers, and posters. Contacts were also made with a variety of professional, business, labour, and government organizations.

1.3 OTHER SOURCES OF INFORMATION

The Noise Panel was very interested in the experiences and activities of other jurisdictions. These agencies were frank and helpful in the assessment of their programs and provided viewpoints which were useful to the Panel in the development of this report.

CANADA

Provincial

Alberta - Meetings were held with representatives of:
- Department of Social Services and Community Health
- Department of Transportation
- Department of the Environment
- Occupational Health and Safety Division
- Workers' Compensation Board
- Energy Resources Conservation Board

British Columbia - The Panel met with a health unit representative from Burnaby, B.C. during the Canadian Acoustical Association conference in Edmonton, during October of 1981.

Ontario - The Panel interviewed representatives of:
- Ministry of the Environment
- Ministry of Transportation and Communications
- Ministry of Labour

The experience of local governments in Ontario was discussed during visits to the Borough of Etobicoke and the City of Mississauga. Valuable information was obtained about the Ontario Model Municipal Noise Control By-law, building design, and land use planning, and the significance of transportation noise and its control.

Federal

The Panel met with representatives of:
Department of Transport
Consumer and Corporate Affairs Canada
Canada Mortgage and Housing Corporation
National Research Council Canada

UNITED STATES OF AMERICA

The Panel met with representatives of the Environmental Protection Agency (EPA), Washington, D.C. In the past 10 years, the Office of Noise Abatement and Control, with offices and research staff throughout the U.S., has gained considerable knowledge and experience in noise problems and their correction.

A great deal of information was obtained, including details of their educational programs, noise labelling procedures, Buy Quiet program, quiet community program, quiet truck program, and regulating procedures.

A discussion with the Federal Aviation Administration (FAA*) provided information on aircraft and airport problems and their control.

OTHER

The Panel also attended the Canadian Acoustical Association conference held in Edmonton during October of 1981, to familiarize themselves with the latest developments in noise control and abatement.

In order to obtain an understanding of the enforcement problems of noise control, the Panel met with representatives of the City of Calgary Police force.

Mr. Lyle Lorenz, Superintendent of Schools, County of Stettler, reviewed the educational material provided by the EPA.

Mr. R.G. Winkelaar, M.A., Director of Audiology, Foothills Provincial General Hospital, provided assistance with the medical aspects of hearing and loss of hearing.

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*FAA - Federal Aviation Administration (U.S.)
The FAA is responsible for regulating aviation in the U.S. As well as administering safety regulations, aircraft registration, air navigation facilities, air space management, and civil aviation abroad, the FAA administers programs to assist public agencies in airport system planning, including programs designed to control airport and aircraft noise. For example, the FAA currently has a pilot program for funding Airport Noise Control and Land Use Compatibility (ANCLUC) planning studies under the Planning Grant Program (PGP).

1.4 A DEFINITION OF NOISE

Doing something about noise depends on a common understanding of what is meant by "noise." For the purpose of this report, the Environment Council has chosen the following definition of noise in order to ensure consistency and promote that understanding.

> *Noise is defined as any sound or combination of different sounds which are disturbing, harmful, or unwanted. The essence of this definition is that noise is all sound which threatens or affects the health and well-being of people.*

Within this definition, noise can include: very loud workplace sound which will impair hearing and cause deafness given sufficient exposure, such as in a steel fabricating plant or engine repair shop; the dull roar from a heavily used truck route that distresses nearby residents; a noisy party which annoys and disturbs those next door; a neighbour's dog barking in the middle of the night; and the sound of a trail bike in an outdoor recreation area used by hikers who are seeking peace and quiet.

The Council believes that programs to control noise must not be hampered by a restrictive definition. Society is not static – people are in constant movement from their homes, along travel routes to their workplace, at their workplace, in vacation spots, and in their neighbourhoods. All kinds of noise can affect individuals in all these settings. The cumulative impacts must be fully considered.

Since noise is sound which affects the health and well-being of people, an understanding of what is meant by "health" is a prerequisite to understanding the effects of noise. The definition of health as contained in the constitution of the World Health Organization and which is accepted by the Council for this report is: "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity" (United Nations 1964:497).

Impacts of Noise

REPORT

SECTION TWO

The terms of reference for the public hearings established a very broad context within which to consider noise. Identifying and describing the impacts of noise on people and their environment sets the stage for evaluating the severity of the problem, determining sources of noise, and delineating appropriate controls.

In describing how exposure to noise affects people, the implications for personal health become prominent. Noise also has an economic impact. This section describes the health and economic consequences of exposure to noise in our society.

2.1 AUDITORY EFFECTS

The auditory effects of noise are those effects concerned with hearing and the ability to understand speech. The extent to which noise affects these abilities and their importance to our personal health and well-being are critical.

2.1.1 The Importance of Our Hearing

The sound of the world around us – our soundscape – is an important part of our daily lives. Being able to hear allows us to perceive our soundscape and influences all of our activities. While many of our activities tend to be strongly visual, of the five senses, "Hearing is our major social and learning sense. The ear is a magnificent microcosm of creation. It may be small in size but it is mighty in its impact on the totality of human life" (Terry 1979:10).

Hearing influences our ability to communicate with family, friends, associates, rivals, and enemies. It bears directly on the quality of our lives. As pointed out by Dr. J. Oshiro in Brief 49 during the public hearings, "For those who hear, it would be unthinkable to live without sound, for sound has been with us since the beginning of creation and awareness of sound has been with us since our awareness as human beings [*sic*]."

Hearing is a 24-hour sense. Our ears receive sound continuously and transmit signals to the brain whether or not they are perceived. Sarah Burns, an audiologist, stated in Brief 11 that our ears are constructed as a passive system unlike sight which is an active system. Hearing does not depend on having to either focus or turn the ears to perceive a particular sound. Also, our ears are particularly vulnerable to damage because unlike our eyes which have eyelids that can be closed against too much light, our ears do not have earlids that can shut out too much sound.

The ability to hear permits us to be fully aware of and relate to other people and our environment. To lose hearing is to sever this contact and become isolated.

2.1.2 Hearing Loss Caused by Noise

Loss of hearing caused by exposure to noise is defined as an increase in the amount of energy needed to hear. Loss of hearing occurs when high-energy sound numbs and damages the hair cells inside the cochlea, or inner ear (see Section 5.6). More sound energy is needed to activate the hair cells because their sensitivity has been reduced. The threshold of hearing in a normal young person is set at 0 decibels (dB) (see Section 5).

Determining the level at which a hearing loss becomes a handicap is difficult. For example, a loss in hearing sensitivity of 10 dB is not generally considered a serious impairment. However, when a person notices or is affected by such a loss, a handicap exists. The Workers' Compensation Act (RSA cW-16) identifies noise-induced hearing loss as a compensable disease. Many jurisdictions in North America consider a loss of 25 dB or over as a significant handicap (Wiens and Kinley 1980).

The effect of noise on our hearing usually occurs initially in frequencies from 4,000 to 6,000 Hz. Since this range is above those frequencies crucial for hearing and understanding speech, a person may not initially be aware of having impaired hearing. Continuous exposure to intense noise will damage hearing more severely, gradually affecting perception of the lower frequencies critical to speech. By the time a hearing loss is detected, irreparable damage has been done to the hair cells. Maximum loss from noise will generally occur within five to ten years of exposure, unless conditions of exposure change (Throckmorton 1980).

A temporary loss of hearing sensitivity is known as "temporary threshold shift" (TTS). It can be caused by a single exposure to loud noise, such as a rifle shot. It can also be caused by exposure to continuous noise, which results in a gradual drop in hearing sensitivity. This happens, for example, when you must turn up the volume of your car radio in order to hear it satisfactorily at the end of a long road trip.

The extent of TTS varies in relation to the level of noise and the duration of exposure. Brief 46 mentioned that recovery time also depends on the duration of exposure. Full recovery from TTS after eight hours of exposure to noise may take as long as 24 hours (Hall 1981), longer than the 16 hours of rest most people have between work periods.

Permanent loss of hearing, known as "permanent threshold shift" (PTS), appears to occur from repeated episodes of TTS without sufficient rest between them. Brief 46 and Throckmorton (1980) state that most PTS, particularly in the speech frequencies, results from repeated, long-term exposure to noise. Research to date indicates that little or no risk occurs in the speech frequencies at levels of noise below 85 dB (Hodge and Price 1978).

People differ in their sensitivity to noise and their susceptibility to loss of hearing. Since it is impossible to predict accurately who is or is not susceptible, people working in noisy jobs must have their hearing tested regularly to know if it is being affected. Noise-induced hearing loss can be stopped only by preventing exposure to damaging noise.

2.1.3 The Effects of Hearing Loss

Kenn Blom stated succinctly in Brief 29 that a shadow hangs over hearing loss. People are ashamed and afraid of having poor hearing and will find subtle ways to hide or compensate for the problem. Mr. Blom added that "this affliction, which may have to a greater or lesser degree affected many of us, sits in a cloister, along with impotency and other personal hangups."

Following the earlier analogy with sight, people wearing glasses experience no stigma about their visual deficiency. They are not bothered by experiencing a great blur when they

remove their glasses. Yet a stigma persists against being hard of hearing. Wearing a hearing aid is considered strange and socially unacceptable. Our society has not accepted and individuals have not adjusted to the disability of not being able to hear at normal levels of sound.

People with impaired hearing are cut off socially from other people and physically from their soundscape. The greatest impact on people who have become deaf as adults is the social and psychological effect on their lives. Their ability to communicate is reduced or cut off, and they cannot participate fully in their social environment. Brief 151 described people with hearing loss as being in a world of their own, suffering great loneliness, and becoming very frustrated.

"Humanitarian Helen Keller, who was both blind and deaf due to a childhood disease, said that of the two handicaps she felt the loss of her hearing most keenly because it shut her off from human social interaction" (Perham 1979).

People with hearing impairment may also antagonize others and suffer reciprocated frustration and anger. Other people often feel the person with poor hearing is not paying attention, is ignoring conversation, or gives inappropriate replies to questions and comments.

Symptoms of impaired hearing due to noise may be exhibited by people who talk loudly, mumble, speak in a mushy style, or turn the television louder than other family members like. Briefs 6 and 151 described hearing loss as being characterized by a decreased ability to understand speech, particularly in a noisy environment, poor discrimination of the pitch of sound, often a continuous, annoying ringing (called tinnitus) in the ears, or painful hearing. Similarly, a person with poor hearing may wonder why others seem to be mumbling or shouting, or why they may be angered by the conversation. Trying to compensate for poor hearing by lip reading can also be very frustrating if someone cannot fully understand what is being said.

Noise-induced hearing loss is permanent and cannot be medically corrected. Operations, treatments, or the use of a hearing aid will not totally compensate for the loss. Hearing aids, which generally only amplify sound, cannot recapture full hearing in the same way that glasses usually correct poor vision. Brief 63 stated that improvements have been made in hearing aids in the last few years, however, and using them can provide some benefit.

Loss of hearing contributes to more problems than just poor communication. Brief 46 from the Sheet Metal Workers International Association, Local 8 stated that safety on the job often depends on workers being able to hear verbal instructions, special signals, or the sound of machinery and equipment. During the public hearings, the Alberta Federation of Labour (AFL) referred in Brief 107 to studies on the relationship of noise to hearing conservation and accidents. In one case the AFL cited, the rate of injuries declined dramatically – between 40 and 50 percent – after implementation of a hearing conservation program. "The noisiest jobs generally have the highest rate of accidents and injuries" (Throckmorton 1980). The AFL feels this aspect of noise has been neglected and deserves more attention.

A person's job or occupation may also be directly affected if that individual has impaired hearing. The problem can take different forms. For example, an employee may be moved to

a different job if a safety hazard exists or if the job is not being done properly. An employee may be denied possibilities of promotion or transfer to a better position because of impaired ability to communicate. The hearing loss may also be used as an excuse by the employer to discharge the person involved, possibly to avoid compensation payments. Such events would add to the stress and frustration already being experienced due to the noise-induced hearing loss.

2.1.4 Noisy Working Conditions

The predominant cause of noise-induced hearing loss is noisy conditions in the workplace. The toll of exposure is greater, however, if a person both lives and works in noisy surroundings.

Estimates vary of the number of workers in Alberta exposed to occupational noise considered hazardous to hearing. The traditional estimate is that about 10 percent of all workers are exposed. This level amounts to a conservative figure of 125,000 workers plus about 60,000 farmers (Throckmorton 1981).

A study of the economic aspects of noise commissioned by the Environment Council estimates that in 1980, 30 percent of the provincial labour force, or nearly 300,000 workers in agriculture, the oil and gas industry, construction, and manufacturing were exposed to noise over 80 dBA for an eight-hour day (Wiens and Kinley 1980). Although at present "it is not known how many workers in Alberta are affected by hearing loss and to what degree" (Wiens and Kinley 1980:30), an estimated 29,000 workers or about 12 percent of the work force exposed to over 80 dB for an eight-hour day will suffer hearing loss of 25 dB or more due to noise over a 20-year working life (Wiens and Kinley 1980). It has been estimated that at least 60 percent of the labour force has some degree of hearing loss, although not necessarily in the speech frequencies.

Hearing loss may be severe among farmers. Prolonged exposure to noisy machinery has probably caused substantial hearing loss in an entire generation of farmers, as stated in Brief 68.

The AFL stated that noise in Alberta is affecting far more workers than is indicated in either the traditional estimates or the Council's study of economic aspects of noise. The AFL estimated that 493,000 workers are exposed to noise over 80 dBA over an eight-hour day. This includes workers in transportation; communication; public administration and service; and mining and logging, which were excluded from the economic study. Assuming 40 years of exposure rather than 20, the AFL estimates that more than 54,000 workers exposed to noise levels over 80 dBA will incur a loss of hearing. Although the methods of estimation are different, the results of the studies are similar. Both estimate that between 10 and 12 percent of the labour force will suffer from impaired hearing.

Discrepancies in the estimated number of workers exposed are caused in part by different industries being included in the respective analyses and the identification of occupations considered to be noisy. The crux of the problem is that comprehensive data is not available on levels of noise in the workplace or how many workers are exposed to dangerously noisy

conditions. As well, few workers have had their hearing tested and even existing data has not been fully analysed.

Occupational noise is felt to be the most common and prevalent health hazard in the workplace (Throckmorton 1981). It is also felt to be the "most significant cause of hearing loss in all industrialized nations" (Alberta Association of Industrial Safety Councils 1981:1).

Loss of hearing from long-term exposure to noise is the most obvious effect on our health, and was claimed in Brief 3 to be the most apparent problem resulting from noise in industry. Brief 107 pointed out that if 10 percent of the labour force is going to have damaged hearing, hearing loss must be at epidemic proportions. In the U.S., an "industrial insurance survey reported that hearing loss is the largest compensable health problem today" (Howard 1979). Even though noise-induced hearing loss is not a visible disability, it can be a substantial handicap. Its severity is generally beyond the comprehension of people with adequate hearing.

Both large and small businesses have noisy working conditions and workers suffering a loss of hearing. Large industry may be more aware of the problem of noise levels and noise-induced hearing loss. Some large industries do test employees' hearing, and provide hearing conservation programs. The difficulty is that the majority of workers are employed either by small business or are self-employed. In 1978, approximately 900,000 workers in Alberta were employed on 60,000 worksites, 78 percent of which had under 10 employees. Brief 29 raised the question "when we look to the fact that approximately 70 percent of these worksites were not provided with any occupational health inspectional services at all, how much of a problem is noise?"

Despite the lack of comprehensive data, it is clear that noise levels in the workplace are high for many workers. Improvements are necessary to lower the levels of noise, and make conditions quieter, safer, and healthier for workers. In order for control programs to succeed, surveys are required on the levels of noise, the extent and severity of exposure, the number of workers who have or will suffer impaired hearing, and the degree of damage.

2.2 EXTRA-AUDITORY EFFECTS

Reactions to noise and the effects it has on our health other than physical hearing loss are called "extra-auditory" effects. These include annoyance, stress, interruption of sleep, interference with speech (causing annoyance), the body's physical reactions, and effects on our relations with other people.

The effects of noise depend on both the characteristics of the sound and how it is perceived. For example, loud sound can contribute to stress and certain adverse reactions even if it is tolerated, as in a noisy job, or chosen, as in a discotheque. Unwanted sound (noise), whether loud or soft, will cause stress and adverse reactions, whereas soft, wanted sound (music) will not.

Extra-auditory effects of noise arise at work, home, and play. The severity of these effects relates to the amount of time spent in noisy surroundings and the amount of quiet time between periods of exposure.

There is a substantial collection of scientific literature which deals with the effects of noise on our health. It is well established that sufficient exposure to noise impairs hearing. The degree of harmful influence on other aspects of our health, however, is not as clear. It is known, for example, that noise causes annoyance and certain physiological reactions, but the extent of adverse consequences resulting from these is uncertain.

A review of much of the literature available on the relationship of noise and health was carried out by Taylor et al.(1980). Research papers were examined on the basis of several criteria for scientific validity in order to differentiate between "justifiable and unjustifiable" conclusions about the effects of noise. To quote from their report:

> *The synthesis of the evidence from methodologically adequate studies shows that the only strong evidence of an effect of noise on health is for noise-induced hearing loss. For non-auditory health outcomes, there is no clear evidence to support the hypothesized effects, but equally there is in general no clear evidence to reject them. There are two main reasons for the lack of clear evidence. The first is that specific human health outcomes are investigated in only a few studies. It is uncertain what, if any, implications for human health can be drawn from animal-based research or from studies measuring physiological outcomes with unknown health consequences. The second reason is that few studies use powerful research designs with the result that causal inferences are normally not possible.... We recognize that we are applying stringent criteria in assessing the evidence, but we maintain that they are vital criteria and that it is only by using them that valid conclusions can be drawn about the true causal effects of noise on human health (Taylor et al. 1980:94).*

The Edmonton Local Board of Health also undertook a substantial review of current literature on the health effects of noise and submitted that review as Brief 98 at the hearings. The Board found that "nausea, headaches, instability, argumentativeness, sexual impotency, changes in general mood, anxiety and other effects have been associated with exposure to noise, but all are difficult to assess." In short, the findings of research on the adverse extra-auditory effects of noise on health are not conclusive. More work needs to be done before definitive conclusions can be drawn (Hall 1981).

The Environment Council recognizes that the scientific evidence may not show a strong relationship between noise and adverse extra-auditory effects. However, the Council feels it cannot ignore the briefs presented at the public hearings by people describing how noise affects them.

> *...one cannot assume that the lack of data represents the absence of risk. This is particularly true when one considers that the methods to which many people object (permanent effects found in studies on animals, temporary effects on humans, correlated and cross-sectional studies in industry) are the same as those used to demonstrate the relationship of hearing loss to noise (Dunn 1979:221).*

Lack of conclusive proof of the adverse extra-auditory effects of noise on health should not limit any initiatives to solve noise problems. The following quotation illustrates this position:

> *Dr. William H. Stewart, former Surgeon General [United States], in his keynote address to the 1969 Conference on Noise as a Public Health Hazard, made the following point: 'Must we wait until we prove every link in the chain of causation? I stand*

> *firmly with [Surgeon General] Burney's statement of 10 years ago. In protecting health, absolute proof comes late. To wait for it is to invite disaster or to prolong suffering unnecessarily. I submit that those things within man's power to control which impact upon the individual in a negative way, which infringe upon his sense of integrity, and interrupt his pursuit of fulfillment, are hazards to public health.' It is finally clear that noise is a significant hazard to public health. Truly, noise is more than just an annoyance (Environmental Protection Agency 1978:23).*

The same sentiment was expressed in different words by Faye Donkin in Brief 9 during the public hearings:

> *People 15 years ago were not aware that smoking had caused cancer...so we waited until we had a few people die of cancer to say, 'Oh, definitely.' And so, the United States put a little thing [warning] on their packaging of cigarettes. Do we wait again...to take action?...Let's try to do something about noise pollution before it is too late.*

Section 2.2.1 gives a general description of the extra-auditory effects of noise as they are currently understood. It also outlines the views expressed by people at the public hearings concerning the problems they suffer due to noise. Details of the sources and locations of noise that cause these effects in Alberta, and the levels of noise, are given in Sections 3.1, 3.3, and 3.4.

2.2.1 General Reactions

During the public hearings, many people stated that noise is a hazard to their health and described the extra-auditory effects.[1] People are concerned about the consequences of noise for themselves, their children, their home life, and the value of their homes. A feeling expressed in Briefs 29 and 49 was that people consider noise to be a growing problem over which they have little direct control. Frustration was expressed with both the problem and the lack of solutions.

They are also upset by the conflicts between people that result when opinions differ about what is noise and what is just sound, or even music. Noise can be particularly distressing and disturbing to those people who are less able to cope – the ill, elderly, or disabled.[2] The fact that noise causes annoyance and stress was suggested in Brief 31 as sufficient evidence to relate it to health problems.

Brief 95 summarized the sentiments of many participants at the hearings:

> *My reactions to noise are agitation, resentment, anger, sleeplessness, fear, irritability, headaches, tension, chronic complaining. And I have observed many of the same reactions in others, plus hearing damage, indifference, apathy, selfishness, can't tolerate their work conditions. They are afraid of harassment or in fear of losing their job if they do complain.*

2.2.2 Annoyance

Annoyance is a very common reaction to noise and has important psychological ramifications. It is "probably the most pervasive phenomenon" (Throckmorton 1980) with respect to

complaints by people about noise in their environment. Brief 8 stated that a high level of annoyance is one of the criteria for judging the severity of the effects of noise, especially in a community setting. Annoyance is a psychological effect that is subtle and difficult to quantify, yet inescapable.[3]

Reactions of annoyance to noise depend on several factors. The characteristics of sound influence rather strongly our perceptions of noisiness (Dunn 1979). How sound is perceived, its source, our expectations for a particular soundscape, and what we happen to be doing when the sound is heard influence our feelings of annoyance.

Loudness of sound appears to determine annoyance more strongly than other factors. An increase in the loudness of noise will increase annoyance reactions. A 10 dB jump in loudness, for example, doubles annoyance for moderately intense noise. As well, a varying sound that is increasing in loudness is perceived to be noiser and more annoying than steady or decreasing sound. Briefs 116 and 152 stated that annoyance is also related to the intrusiveness of the noise.

Single-frequency tones, sound in narrow-frequency bands, and high-frequency sound are more annoying than wide bands of frequencies and lower frequency sound. A concentration of sound energy in the speech frequencies (see Section 5) is perceived to be noisier than sound outside those frequencies. The longer noise lasts, the more annoying it becomes.

People's attitudes toward the source of a noise appear to be an important factor in determining "levels of annoyance not totally predictable by the loudness of sound" (Dunn 1979). The connotation of a noise may cause greater annoyance than its physical characteristics alone. Motorcycles, for example, are a major source of complaints about traffic noise. This reaction results in part from the loudness of certain motorcycles, but also from inconsiderate operation and a generally negative attitude toward motorcycles and their riders. Unappealing and frightening noise sources also produce annoyance reactions.

Noise-exposure patterns and reactions of annoyance vary for different kinds of noise. Assumptions should not be made that a community survey of annoyance at traffic noise is applicable to other kinds of noise.

Surveys of community reaction to noise, conducted in Edmonton in 1972 (Bolstad Engineering Associates Ltd. 1973) and Calgary in 1974 (Dunn and Jones 1974), revealed that the most frequent noise complaint concerned traffic. Aircraft noise was the second most frequent source of complaints and train noise the third. These reactions vary, however, depending on the respondent, the area of the city, and the dominating noise source. For example, in an area where noise from airplanes is the major source and noise from traffic is minor, people are more aware of airplane noise. To illustrate, a survey of the reaction of people to noise in an area adjacent to both Toronto International Airport and Highway 401 found that generally a greater percentage of people are annnoyed by the noise from aircraft compared with traffic. The Calgary survey found that a much higher percentage of people are annoyed and disturbed by motorcycles as a component of traffic than cars and trucks, which in turn showed a much higher percent annoyance than aircraft.

Even though severe irritation draws protest, as mentioned in Brief 152, and as noise levels rise, so do the number of complaints, there is not a good correlation between the level of annoyance in a community and action taken to register complaints (Hall 1981). The number of complaints volunteered is not a reliable indicator of community reactions of annoyance because not everyone complains and different people complain for different reasons. A fairly good correlation exists, however, between measured levels of noise and the level of annoyance as determined through surveys. A survey of noise in Toronto found that 24.5 percent of people are highly annoyed by road noise of 70 dBA Leq(24). This level of noise is a general predictor of high annoyance at traffic noise over a wide area with expressways and arterial routes (Hall 1981).

The expectations people have for a particular soundscape influence how they feel about noise. Brief 152 mentioned that the degree to which sound is contrary to expectations is related to its annoyance value. Rural residents are accustomed to a generally quiet environment and will react strongly to and be more annoyed by noisy intrusions that urban residents might readily accept. People at home usually expect conditions to be quieter at night than during the day and are therefore more annoyed by noise at night. Noisy intrusions at night would probably pass unnoticed during the day. A dripping tap is not loud, but can be intensely annoying if heard at 2:00 a.m.

In parks, "man-made noise... regardless of intensity, is considered more adverse and interfering than natural noise" (Dunn 1979:226). Annoyance will occur particularly when the noise is not related to the activity of the listeners, penetrates their "space," and interferes with their enjoyment of an activity. However, people engaged in noisy recreational activities such as shooting, riding motorcycles, or driving snowmobiles are not irritated by the noise they produce. That is, the capability of listeners to control a noise source also influences whether or not the noise will be annoying. Sound that cannot be controlled is generally more irritating. People can become highly annoyed at traffic and aircraft noise, both of which are beyond their direct control. In the same way, people will be aggravated more by noise from activities they perceive to be of no benefit to them. The noise of a neighbour cutting the lawn at an abnormal hour, or the noise coming from a loud party next door will be both an annoyance and interference.

Assessing annoyance due to noise is very complex. It involves the characteristics of the noise, the ways noise affects a person's expectations and attitudes, and the social and economic conditions and influences in a person's life (Dunn 1979).

During the public hearings, annoying noise sources identified included aircraft, traffic, outboard motors, air conditioners, industry, off-road vehicles in natural park areas, loud music from bars and dance halls, and noisy parties. The background noise from air conditioners and word processing equipment in offices was described in Briefs 70 and 126 as a concern. Conversations in open-plan offices can be very irritating for someone not involved in the discussion. Low-level background music was mentioned in Briefs 95, 109, and 134 as a substantial annoyance in professional offices, hotel lobbies, stores, and public places.

Very often, annoyance due to noise results from inconsiderate people who fail to realize how the noise of their activities disturbs others. Brief 134 stated that people suffering most from noise are not normally the ones who make or authorize the noise.

2.2.3 Physiological Reactions

Our bodies react in a variety of ways to environmental stimuli. Physiological reactions involve a change in a person's state of physical well-being. Body functions such as heart rate, blood pressure, rate of metabolism, blood chemistry, and muscle tension are involved.

Research literature indicates that noise causes a variety of physiological reactions. However, the degree to which these reactions have an adverse impact on health is not certain (Dr. Fred Hall: 1981, personal communication). The reactions of the body to noise are strongly related to annoyance and stress.

During the public hearings, three briefs[4] described how the body reacts to noise and summarized research information, in particular Brief 98 from the Edmonton Local Board of Health.

Research frequently shows that an increase in blood pressure results from exposure to surprisingly low levels of noise (Throckmorton 1980, Dunn 1979). The body does not adapt or get used to this stimulus – that is, each time someone is exposed to noise, increased blood pressure will result. To date, however, chronically high blood pressure (hypertension) among people in urban areas has not been related to exposure to noise (Throckmorton 1980). Annoyance has also been shown in one study to have reasonable correlation with blood pressure (Dunn 1979).

Some evidence shows an increased incidence of cardiac problems and other ailments among workers in factories with high levels of noise. People with circulatory problems may be more susceptible to noise-induced loss of hearing. As well, people who are ill may suffer more adverse reactions to noise than healthy people. Changes in heart rate and missed heart beats have appeared in some experimental work with animals exposed to noise (Dunn 1979). Brief 98 and Throckmorton (1980) state that changes in the levels of hormones, cholesterol, sugar, uric acid, and other chemicals in the blood have also resulted from exposure to noise. These effects occur at a level of noise well below that required to impair hearing.

Our bodies can react strongly when exposed to noise. Defence mechanisms such as increased blood flow and tense muscles are alerted to battle noise as a stress agent. "Either the body successfully overcomes the influence of the noise-induced stress or breaks down from exhaustion. This exhaustion may show itself in a variety of psychosomatic syndromes such as ulcers and kidney problems." (Throckmorton 1980).

The public does not generally realize that a relationship exists between being exposed to intense noise, as might occur in a noisy job, and the possibility of being sick.[5] People may be apathetic about noise problems and, unaware of the potential hazard, they say "You get used to noise." But that does not happen. You do not get used to noise. The body reacts through such extra-auditory effects as annoyance, stress, or altered physiological states as well as through loss of hearing.

2.2.4 Stress

Stress due to noise is closely related to both annoyance and the physiological reactions of the body. Annoyance probably influences the nervous system. In some people, this

influence may reach a point where physiological stress contributes to ill health (Throckmorton 1980). Scientific evidence is uncertain, however, about the pattern of the relationship among annoyance, stress, and the body's physiological reactions. More research is needed to determine if noise affects the nervous system leading to physiological reactions and resulting in stress, or if a person's attitude toward a particular noise causes stress which in turn leads to physiological reactions.

It is also difficult to state how much noise in an already stressful situation will produce negative health effects.

> *What is important is the long-term effect of sufficiently intense noise occurring intermittently in the everyday environment, where other stresses and arousal agents are present, in general where noise is not under the control of the unwilling listener.... If noise is an arousal agent, its effect may be extremely adverse in combination with many other arousal agents, or when already highly anxious people are subjected to it (Dunn 1979:218).*

Stressors in our environment may all work together to affect us; noise is one of these, although evidence of its extra-auditory contribution is inconclusive.

During the public hearings, people described how noise is a major stressor in their lives and how they react. Twelve briefs stated that traffic noise is disturbing and causes stress,[6] whereas six pointed to stress from aircraft noise.[7] Eleven briefs mentioned that noise affects the central nervous system and makes people nervous, disturbs psychomotor reactions and behaviour, and causes apathy, fear, moodiness, nausea, loss of balance, and stress.[8] Brief 9 stated that stress-related diseases such as ulcers, birth defects, and alcoholism can originate with noise. Brief 11 noted that people experience stress reactions from intermittent noise over 100 dB if the noise is annoying.

Although people at the hearings discussed these reactions, it is uncertain what part noise plays out of a person's total activities. However:

> *If one could show that functioning under a high noise environment produced an increase in mental illness, one would have strong support for environmental noise being an effective stressor, either in and of itself, or through its ability to interfere with an individual's ability to 'cope' (Dunn 1979:220).*

Although environmental noise was mentioned most often by people as the cause of stress, workplace noise was not ignored. People working in noisy jobs were said to experience stress and lower productivity, exhibit lower morale, and become very fatigued.[9] Briefs 46 and 107 tied nervousness, mistakes, and accidents on the job to noisy conditions. A clinical psychologist having several years experience working with automotive workers in Oshawa felt that the noise in the plants and the monotony of the jobs were the two most significant problems workers face (Harry Eerkes: 1981, personal communication). These factors create high levels of stress for workers and contribute to stress-related problems such as alcoholism, drug abuse, and family and marriage breakdowns.

Loud music in pubs and taverns was described in Brief 90 as particularly detrimental to employees, causing hearing loss as well as annoyance and stress. Hearing loss, however, does

not occur as rapidly from loud music as it does from other types of workplace noise because of the constant variation in the intensity of the sound and the recovery time provided during intermissions. But with sufficient exposure, musicians and employees will suffer hearing loss, particularly in the higher frequencies.

Two students from Mount Royal College submitted Brief 138, in which the college library was specifically identified as being much too noisy for students to work. The noise from audio-visual equipment and students socializing around study tables, combined with lack of supervision and poor design and construction of facilities, was both irritating and stressful to students genuinely trying to study.

Even though the scientific literature is uncertain about how stress arises due to noise, the message from the public hearings is clear. People experience annoyance and stress from noise and want the level of noise affecting them reduced.

2.2.5 Sleep Interruption

Noise very often disturbs people while they sleep. They will be awakened, the pattern and quality of sleep will be changed, or the body's biological alerting mechanisms will be aroused (Throckmorton 1980). Sleeping appears to be the activity that is interrupted by very low levels of noise (Dunn 1979). As with other extra-auditory effects, the scientific literature is not clear about the effect of noise on sleep and the impact of not sleeping soundly.

The degree to which noise is an interruption and its effect depend on many factors: age, sex, stage of sleep a person is in when disturbed, motivation, prior conditioning, background noise level, the extent of the noise intrusion, the source of noise, its meaning, and a person's mental and emotional state at the time.

Most data indicates that: middle-aged people are the most susceptible to being awakened or experiencing a shift in the stage of sleep; the elderly awaken more easily than youngsters and infants; young children, although difficult to arouse, may be frightened when awakened by noise; and women awaken more readily than men (Dunn 1979). People who are sick or depressed are particularly sensitive to noise during sleep. A person motivated to respond to a particular noise, such as an alarm clock or a baby's cry, will be awakened easily.

Time and stage of sleep are important factors. People are more likely to be awakened by noise early in the morning when they are usually in a light stage of sleep. People will also have trouble going to sleep because of noise. The onset of important stages of sleep can be delayed. Consequently, it is critical for most people to have quiet early in the night and early in the morning. This factor is highly relevant to the need for the timing of a quiet atmosphere outside our homes so that people can get adequate good-quality sleep. Brief 44 pointed out that for those people who work shifts and often must sleep during the day, noise is a very serious problem.

Different types and levels of noise influence how noise interrupts sleep. In studies of traffic noise with peaks of 80 dBA, low-density traffic at an average of 61 dBA was found to

disturb sleep more than higher density traffic averaging 70 dBA (Dunn 1979). Intermittent lower level noise is more disturbing than steadier noise at a higher level. Noise of 55 to 65 dBA changed sleep patterns in 50 percent of the subjects in studies cited in Brief 11 and by Throckmorton (1980). Brief 11 also stated that generally people will awaken if exposed to noise over 65 dBA.

Interruption of sleep due to noise is thought to have little effect on pursuit motor reaction time, but can affect the ability to estimate time. Evidence suggests that being deprived of sleep affects one's ability to organize and structure material, be creative, retain learning, and resolve stressful situations (Dunn 1979). The effect of noise is greater if it both causes stress and disturbs sleep.

Thirty-two briefs presented at the public hearings mentioned the interruption of sleep by noise.[10] How often this occurs and its impact on health depend on many factors. Prolonged lack of sleep will become a health problem, however, aside from its effect on a person's disposition.

Sleep may be interrupted by many sources of noise, depending on local conditions. Three briefs stated that aircraft noise disturbs sleep,[11] and 18 briefs identified traffic noise as the culprit.[12] People mentioned that Speedway Park in Edmonton (Brief 3), air conditioners,[13] and in Briefs 44 and 45 an asphalt plant near Lethbridge, awaken them and prevent a good sleep.

2.2.6 Speech Interference

Included within the category of noise is sound which is loud enough to interfere with normal levels of conversation. Sound is too loud when people must shout to be heard. Although the interference of noise with the ability to understand speech (speech discrimination) is considered an auditory effect, this aspect is described here because of its relationship to annoyance and stress.

Noise interferes with communication in three ways (Dunn 1979). First, noise impairs hearing. Second, noise interferes with reception of the strict word message. Third, noise distracts the attention and concentration of the listener. Such distraction masks the unspoken portion of a message – the emotional content, facial expressions, and intonation. A complete message is not received. Brief 81 suggested that, as a result, the message may be interpreted wrongly, such as a person feeling insulted instead of hearing a joke. Noise which interferes with speech discrimination can create dangerous working hazards and cause accidents if messages or signals are not heard.

For children, exposure to noise that disrupts speech discrimination can have an unfavourable impact on learning and the development of auditory skills. Language and reading skills can also be affected if children cannot hear due to noise since reading achievement depends on the ability to discriminate between all the sounds heard (Throckmorton 1980:4).[14]

When referring to environmental noise, "interference with speech is one of the more important causes of community annoyance" (Dunn 1979:216). Talking is considered the daily activity most susceptible to interference by noise.

A variety of factors influence the degree to which noise interferes with speech. The level of noise, the pattern of noise events, the activities of the listener, and the distance between the talker and listener all determine intelligibility. Interrupted background noise generally is not as interfering as steady noise, although not in all cases (Dunn 1979). People with hearing loss and those using hearing aids will experience greater problems with speech interference in noisy environments. Evidence shows that some people who can perceive speech normally in quiet surroundings have considerable difficulty when levels of background noise are high.

Brief 8 stated that a level of 55 dBA is generally considered the point beyond which speech interference problems occur. At 60 dBA, it is possible to carry on a satisfactory conversation at a distance of two metres. Over this level, noise from traffic, for example, interferes with normal levels of conversation at home both outside and inside with the windows open.

Noise from aircraft,[15] traffic,[16] and some commercial activities were identified during the public hearings as interfering with speech. Twenty-four people stated that noise interferes with normal talking, television viewing, and radio listening.[17] Interference with speech is felt to be particularly aggravating when people are trying to enjoy an evening together.

2.2.7 Social Relations

The discussion of the effect of noise has so far focussed on the individual – it affects one's state of well-being, behaviour, and disposition. Noise can also influence relationships among people. Social difficulties can arise from the level of noise, inconsiderate behaviour by others, and differing preferences about desirable sound.

The presence of moderately high levels of noise will affect the degree to which people relate socially to others. Evidence shows that noise over 80 dBA causes people to increase the distance at which they feel comfortable with others (Dunn 1979). When stressed by noise, people frequently show less consideration toward other people. Noise has also been attributed to making people exhibit more aggression toward others.

In noisy surroundings, people appear to be less willing to help others in need. Dunn (1979) cites laboratory studies which test the willingness of people, when exposed to various levels of noise, to help another person who drops an armful of books and papers. The percentage of subjects helping under low noise of 48 dB was 72 percent, under moderate noise of 65 dB, 67 percent; and under high noise of 85 dB, 37 percent.

Another study tested the willingness of bystanders to help a subject who dropped a load of books while wearing and not wearing a cast under low and high noise conditions. When the subject dropped the books and was not wearing a cast, 20 percent of people helped under ambient noise of 50 dB, but only 10 percent responded when a lawn mower emitting 87 dB was working nearby. When the subject was wearing a cast, 80 percent of bystanders helped with low noise levels (50 dB), but only 15 percent helped when the lawn mower was working.

Inconsiderate behaviour by some people toward others, along with different opinions about desirable sound, are noise problems which lead to deteriorating relations. During the public hearings, 12 people commented that unthinking people create difficulties because

of the noise they make.[18] The most dramatic example, as portrayed in Brief 131, involved two people who lived next door to each other. One person, who liked to read quietly in the garden, was severely disturbed by a very inconsiderate neighbour who had noisy parties and played loud music outside. When the first person protested, he was threatened with violence. He now lives in fear and apprehension of retaliation. Brief 86 mentioned that while the most immediate solution to such a noise problem seems to be to talk to one's neighbour, "in the event that this does not work, what is your recourse?"

Noise may also promote social alienation. A feeling was expressed in Briefs 38 and 81 that people seem to be psychologically isolating themselves in order to escape the noise around them. A quotation from Brief 38 illustrates: "Deafness...is partly physical and partly mental, and I think our society is going more and more into mental deafness as self defence against our environment." This phenomenon is becoming increasingly obvious on the street as greater numbers of people are carrying either large, loud, portable stereos known to some as "boom boxes," or small radios or tape players strapped to their belts with earphones in their ears.

These items are a current market craze, with mushrooming sales. Portable stereos represent a new, potentially disturbing noise source that will lead to increasing social conflict in the future. The Sony Walkman type of earphone stereo can represent a retreat from the noise environment into a personal soundscape that cures the individual's problem but leaves the environmental noise problem unanswered.

2.3 ECONOMIC IMPACTS

The effects of noise in the human environment have been discussed up to this point in relation to personal health and social relationships. However, noise also generates substantial economic impacts. In economic terms, noise problems have benefits and costs; solutions to these problems also have benefits and costs. As a problem, noise confers both benefits and costs on people. For example, noisy airplanes may cost less to manufacture and be less expensive for airline companies to buy. These savings would mean lower operating costs passed on as lower fares to air travellers – a benefit. When the noisy airplane takes off, however, the people living below the take-off and landing paths are subjected to the racket from the noisy planes, resulting in lower real estate values for their homes – a cost.

Controlling noise also confers on people both benefits and costs at the same time. The cost to modify airplane engines to reduce noise might mean higher costs to airline companies reflected in higher fares for travellers – a cost. Because the noise of airplanes would be reduced, the value of homes below the flight paths would increase – a benefit.

In preparing for the public hearings on noise, the Environment Council found little information available on the economic aspects of noise pertinent to the Alberta economy. Consequently, InterGroup Consulting Economists Limited was hired to investigate this topic and prepare a detailed report. The information that follows is a summary of their report, *Economic Aspects of Noise in Alberta* (Wiens and Kinley 1980).

Determining economic damages due to noise is difficult because of insufficient data and imprecise methods of estimation. Nevertheless, because the economic impacts of noise are

localized in area, calculating economic losses due to noise is easier and more direct than calculating losses from many other environmental contaminants. The study by InterGroup found that economic impacts of noise arise in the workplace, from road and air transportation, construction and industrial activities, and from noise sources around the home. Table 1 summarizes the costs of noise for some areas of impact.

In the workplace, InterGroup found that the costs arising from auditory and extra-auditory effects on workers in Alberta total about $65 million per year. This figure represents the cost of hearing impairment suffered by workers; absenteeism and sickness; higher compensation assessments due to claims for hearing impairment accidents; lower productivity and morale; higher costs of medical care, insurance, and safety; a higher rate of turnover among workers; and other factors less easily measured, such as higher stress and lower individual well-being. Additional costs are imposed on the public in order to support programs of medical care and rehabilitation for workers with hearing and health problems. A reliable estimate of these costs cannot be made at present.

These losses occur mainly in agriculture, resource extraction industries, construction, heavy equipment operation, and manufacturing. If workers in transportation, communication, public administration, and service are included, as suggested in Brief 107, the economic impact of noise in the workplace would be even higher.

Around the home, environmental noise from a variety of sources affects the real estate value of residential property. The value of property near noisy streets and under airplane flight paths is lower than similar property in quiet areas. This difference indicates the loss of satisfaction homeowners and renters feel due to noise. People who value quiet will either not buy a house in a noisy area or will only buy the quietest home available within their price range.

It is possible to determine only rough estimates of the economic impact of road transportation noise in Alberta. Although noise surveys have been conducted in Calgary and Edmonton, the data is incomplete because of their rapid growth rates. Nevertheless, through indirect methods of estimation, it is likely that traffic noise damages, as reflected in reduced property values, are at least $350 million throughout the province. Assuming a 4 percent discount rate and a 20-year lifetime for housing stock, annual noise damages due to traffic would be about $26 million.

This value is lost by property in areas which are already noisy due to existing truck routes and arterial roads with high rates of traffic flow. As well, the value of property declines in existing quiet neighbourhoods when roads are expanded from two lanes to four, or designated as new truck routes.

To obtain more accurate figures, noise levels would have to be monitored along major streets and arterial roads in Edmonton, Calgary, and other larger centres in Alberta. The number and type of dwelling units exposed to the noise, the degree of exposure, and the relative property value would have to be determined. Surveys could also be done in residential areas next to roads in Edmonton and Calgary where noise-attenuation barriers have been built in an attempt to reduce the noise impact. These latter surveys would show whether or not the value of dwellings was enhanced after construction of the barriers.

Table 1. Noise Costs

Noise Problem/Source	Annual $ Loss (millions)	Impact
Industrial Workplace	65	hearing loss, sickness, stress, absenteeism, higher compensation assessments, accidents, lower productivity, higher turnover of workers
Traffic	26	lowered capital value of residential property
Airports and Aircraft	12 to 17	lowered property value
Around the Home	3 to 5	noise stress in terms of accident rates, and the value of a noisy compared to quiet apartment
Construction/Industrial	1.5	lowered property value
Total	107.5 to 114.5 million/year	

The noise from air transportation in Alberta lowers the value of residential property in a fashion similar to road noise, although it affects substantially fewer people. By comparing property values, the estimated damage due to aircraft noise is between $12 million and $17 million per year. This estimate does not include the impact on schools, hospitals, and commercial property, the value of which are affected less by noise.

These losses occur in areas near airports, with noise levels measured according to the noise exposure forecast (NEF) scale. This scale predicts decreasing levels of noise exposure moving away from an airport. Similar NEF values are joined to indicate noise contours around the airport. NEF contours are calculated according to the direction and projected number of take-offs and landings, types of aircraft, time in the air, and time of day. Adding 35 to the NEF values approximates the corresponding noise levels in dBA Leq. Areas outside the NEF 25 contour are generally considered acceptable for residential development.

The Edmonton Municipal Airport clearly affects more dwellings and people than any other airport in Alberta. Thirty-nine percent of the dwellings in Alberta within NEF 25 contours are adjacent to this airport. Over 60 percent of these are apartments. Wiens and Kinley (1980) cite a University of Alberta study which concluded that "in 1976, consumer valuations of Edmonton property affected by aircraft noise were $13 million less than they would have been had noise levels not exceeded 20 NEF" (Wiens and Kinley:55).

In addition to lowered value of residential property, "...aircraft noise imposes considerable costs on airport users and users or potential users of land adjacent to airports and airport access routes" (Wiens and Kinley 1980:54). The need to build airports out in the country increases the costs for major access facilities, generates more road traffic noise for some areas, and greatly increases travel costs to the airport for passengers and employees. In addition, considerations given to reduce potential noise impacts and protect the airport can increase the cost of buying land for the airport zone. "Because of the requirements for airports to have a 'noise right-of-way', land assembly costs increase with noise levels. For example, a reduction of 10 NEF would release 50,000 acres from the right-of-way at a potential saving of $100 million at current land costs in urban fringes of Alberta" (Wiens and Kinley 1980:54). Although incalculable, another loss is the cost incurred by individuals who move to escape the noise.

Noise in the domestic environment both inside and outside the home causes economic losses for people in their own homes and for their neighbours. Greater concentrations of people in apartments and townhouses, along with more appliances, tools, and pets; poor construction of buildings; and more cars packed into residential parking areas create domestic noise problems with far-reaching implications. "For example, it can encourage individuals to seek privacy by migrating to low-density suburbs, thereby incurring greater costs for transportation, infrastructure development and municipal services" (Wiens and Kinley 1980:57).

The economic impact of domestic noise is estimated to be between $3 and $5 million per year (Wiens and Kinley 1980). These figures are based on the cost of noise stress in terms of accident rates, extrapolated from an American study plus the discounted value of a noisy apartment compared to a quiet one as determined in the 1974 Calgary noise survey. This loss is an estimate only and is probably understated since no specific studies have been done.

Construction and industrial noise which affect people offsite also have a detrimental effect. Edmonton and Calgary have a high level of construction activity and it is conceivable that perhaps one percent of the population is affected. Through a comparison of property value in a fashion similar to the evaluation for road noise, the capital loss on residential property exposed to construction noise is estimated to exceed $20 million, or $1.5 million per year (Wiens and Kinley 1980).

Industrial noise has been less of a problem because usually wide areas separate residential and industrial land uses. Cumulative small increases in the ambient noise level due to the expansion of industrial operations and plant capacity, however, are generating more concern among residents. For example, Brief 145 described how progressive increases in the "background roar" from Refinery Row in the Gold Bar area of Edmonton are a concern for residents who view the noise as an intrusion and fear decreasing value of their homes.

Footnotes for Section 2.2 Extra-auditory Effects

1. Briefs 3, 4, 5, 6, 8, 9, 11, 13, 14, 15, 16, 17, 18, 19, 22, 24, 25, 27, 29, 31, 34, 38, 44, 45, 46, 47, 49, 52, 53, 54, 57, 60, 61, 62, 69, 70, 74, 78, 81, 84, 86, 90, 91, 92, 93, 94, 95, 97, 98, 100, 101, 102, 107, 108, 109, 110, 116, 120, 123, 124, 125, 127, 131, 132, 134, 136, 138, 146, 147, 148, 150, 152, 154, 155.

2. Briefs 57, 84, 124, 125.

3. Briefs 8, 19, 29.

4. Briefs 9, 11, 98.

5. Briefs 6, 38, 49, 84, 109, 119, 146.

6. Briefs 8, 34, 91, 93, 101, 108, 116, 123, 125, 132, 152, 154.

7. Briefs 3, 5, 62, 94, 136, 150.

8. Briefs 24, 25, 29, 44, 46, 95, 97, 107, 146, 152, 154.

9. Briefs 14, 46, 49, 53.

10. Briefs 3, 5, 8, 11, 13, 17, 22, 24, 25, 27, 34, 44, 45, 60, 62, 69, 84, 90, 91, 92, 93, 95, 98, 101, 108, 111, 114, 116, 120, 125, 132, 136.

11. Briefs 5, 62, 136.

12. Briefs 8, 13, 17, 22, 27, 34, 60, 69, 90, 91, 101, 108, 111, 114, 116, 120, 125, 132.

13. Briefs 24, 25, 92.

14. Briefs 6, 31, 97.

15. Briefs 94, 102, 150.

16. Briefs 11, 91, 108, 148.

17. Briefs 4, 5, 6, 8, 11, 13, 18, 22, 27, 33, 49, 60, 62, 74, 81, 91, 93, 94, 102, 108, 116, 148, 150, 155.

18. Briefs 3, 19, 42, 75, 81, 86, 92, 97, 107, 124, 131, 134.

Noise Sources

SECTION THREE

REPORT

It has been established that noise is a problem in Alberta because it has unwanted and often harmful effects on people. There is also a growing realization that noise problems are expensive.

Section 3 reviews in detail the specific sources of noise problems which exist in Alberta, namely, transportation (road, railway, and aircraft), work-related, domestic, and recreation noise.

3.1 TRANSPORTATION NOISE

Noise from air and surface transportation pervades our communities. It affects our health and reduces property values. Sixty percent of all the briefs submitted (94 out of 156)[1] made specific reference to transportation noise. Of these, 81 briefs[2] were particularly concerned about noise from road traffic. Twenty-nine briefs[3] mentioned aircraft noise and 13[4] identified noise problems associated with railways. Although most of the briefs pertaining to aircraft and railway noise came from Edmonton and Calgary, other areas of the province appear to have their share of concerns regarding road transportation noise. (Twenty-six of the 81 briefs which dealt with traffic noise came from areas other than Edmonton and Calgary.)

This magnitude of concern is not surprising in light of noise problems documented elsewhere in the world. A background report prepared for the May 1980 Conference on Noise Abatement Policies organized by the Organization for Economic Co-operation and Development (OECD) documents the present and future state of the noise environment in member countries (OECD 1980:11-19). Table 2 shows the percentage of population exposed to aircraft and road traffic noise in various OECD countries. It is interesting to note that the estimated number of Canadians exposed to aircraft noise, though lower than in the U.S., is significantly higher than estimates for Japan and Europe, particularly in the upper noise ranges (over 65 dBA). This difference is surprising given the generally low population density of Canadian cities and the abundant space available compared with Japan and Europe. The conclusion appears to be that in mature industrial countries where noise is recognized as a serious problem, steps can be taken in spite of difficulties of land cost and space to protect people from excessive noise. Table 2 also indicates that approximately "15 percent of the population are exposed to an outdoor noise level [from road transportation] greater than 65 dBA [daytime Leq], corresponding to approximately 100 million inhabitants for the whole of OECD" (OECD 1980:15). Approximately 50 percent of the population of the OECD countries is exposed to road traffic noise levels exceeding 55 dBA. While the 65 dBA noise level is regarded as an absolute upper acceptable limit, the 55 dBA level is used by a number of countries as a target level for permissible maximum noise. The fact that approximately half of the OECD population currently exceeds this target level signals a significant problem.

The concerns about transportation noise voiced at the public hearings are also consistent with the findings of the Edmonton and Calgary noise surveys. Both studies clearly identified various locations where residents are exposed to high noise levels. In Calgary, the survey concluded that "occupants of houses along the major arteries which have been widened are subjected to something approaching intolerable conditions..." (Dunn and Jones 1974:12).

Table 2. Population Exposed to Aircraft and Road Traffic Noise in Selected Countries or Regions in the Mid-1970s

Aircraft Noise % of national population exposed to given levels (a) (b)				Noise Level in Leq (dBA) outdoor measures		Road Traffic Noise % of national population exposed to given noise levels (b)										
United States (c)	Canada (d)	Japan (c)	Europe (e)			United States (a)	Japan (f)	Belgium (f)	Denmark (f)	France (f)	Germany (f)	Nether-lands (f)	Norway (a)	Spain (f)	Sweden (a)	Switzer-land (f)	United Kingdom (g)
13	2	3	3	> 55	Sleep can be disturbed if windows are open	40	80	68	50	47	72	–	22	74	38	66	60
5	1	1	1	> 60	Sleep and conversation can be disturbed if windows are open	18	58	39	–	32	46	30	12	50	24	28	27
2	1	0.6	0.2	> 65	Sleep and conversation can be disturbed even if windows are closed	6.4	31	12	20	14	18	7.4	5	23	11	12	11
0.6	0.3	0.2	0.05	> 70	Sleep and conversation disturbance; possible complaints	1.8	10	1	–	4	4	1.6	2	7	4	1	4
0.2	0.1	0.1	0.01	> 75	Possible long-term danger for hearing ability	–	1	–	–	0.5	–	0.1	–	1	1	–	1

(a) Expressed in Leq over 24 hours.

(b) Data refers to various years in the early Seventies for different countries. Since many measurements and surveys do not give results in Leq, equations relating Leq and other indices have been used. The margin of error due to national estimates, different years, and to this transformation is probably very important, especially at lower level of noise (± 10%).

(c) For all airports.

(d) For 5 major airports (Edmonton, Montreal, Ottawa, Toronto, Vancouver).

(e) For 34 airports. Broad assumptions were made concerning densities around some airports.

(f) Expressed in Leq over the period 6-22 h.

(g) Expressed in Leq over the period 6-24 h., England only.

Source: OECD 1979: Table 16

The major conclusion of the Edmonton survey was "that noise from vehicular traffic is of greatest concern to citizens [and] that there are sufficient numbers in the vicinity of the major truck routes and arterial roads to be serious [*sic*]" (Bolstad 1973:19). Another concern to residents in Edmonton was "aircraft noise in the vicinity of the Industrial Airport and associated flight paths" (Bolstad 1973:19).

The evidence and concerns expressed at the public hearings regarding road, railway, and aircraft transportation noise follow.

3.1.1 Road Transportation Noise

Vehicular noise is widely recognized as the major contributor to the public's total noise exposure (EPA 1980:24). Evidence from the public hearings indicates that Albertans are no exception. Of all the sources, noise generated by motor vehicles (cars, buses, trucks, motorcycles) received the greatest attention (81[2] out of 156 briefs).

The vehicular noise source of greatest concern was identified to be the major urban transportation arteries which impact on neighbouring residential areas. Within the vehicular flow, trucks were most often identified as the primary problem and many briefs presented opinions on the effectiveness or ineffectiveness of truck routes. Other particularly noisy elements in the general traffic flow were specified: vehicles with poorly maintained, inappropriate, or non-existent mufflers; motorcycles; buses; and emergency vehicles using sirens excessively. Various characteristics of the road surface, tires, and their interaction were also identified as contributing to vehicular noise levels. Other factors included location and frequency of traffic signals and speed controls, and poor driver attitudes which lead to squealing tires and other exhibitionist activities. These concerns were repeatedly emphasized at all hearing locations. It is probably safe to conclude that vehicle transportation noise problems extend far beyond the specific neighbourhoods and communities which participated in the public hearings, impacting on a large proportion and broad distribution of Albertans.

The Road Network Planning Problem

Traffic noise is commonly the feature of a neighbourhood most disliked by the most people (Benwell and Repacholi 1979). Participants at the public hearings from neighbourhoods and communities across Alberta identified many residential areas perceived to be severely impacted by noise from major arterial roads and truck routes.

Table 3 lists specific areas where traffic noise is a problem. The briefs pointed out that throughout Alberta, highways and arterials are absorbing more and more traffic. For example, in Brief 13 residents from Willow Park in Leduc reported that the addition of lanes on Highway 2 and the new access roads resulted in a 5 to 8 dBA increase in both peak and average noise levels between July 1979 and May 1981. Their 1981 survey showed that peak noise levels remain near 80 dBA throughout the night. As another example, the City of Edmonton Transportation Systems Design Department in Brief 8 reported that the City has created several very noisy corridors by encouraging traffic or forcing trucks to use specific routes. The result has been increased noise levels and increased annoyance, speech interference, economic cost, and stress — all leading to a continual demand for noise reduction.

Table 3. Areas with Road Transportation Noise Problems Identified at the Hearings

Location	Area	Problem/Source
Edmonton	Calder[5]	97 St., 127 St., 127 Ave., 137 Ave., St. Albert Tr., 113A St., 132 St., 153 Ave.
	Hermitage/Beverly[6]	Santa Rosa Road
	Strathcona[7]	99 St.
	Lansdowne/Malmo[8]	Whitemud Freeway
	McKernan[9]	114 St.
	Other[10]	125 Ave., and downtown streets
Leduc	Willow Park[11]	Highway 2
Fort Saskatchewan[12]		Highways 15 and 21, some internal roads
Calgary	Hillhurst/Sunnyside[13]	Memorial Drive, 10 St. NW, and 14 St. NW, Centre St.
	Briar Hill/Houndsfield[14]	16 Ave. N
	Bowness[15]	Trans-Canada Highway, hotel traffic
	Southwest Area[16]	Glenmore Trail, Crowchild Trail
	Richmond Hill[17]	33 Ave. SW
	Downtown[18]	All streets
Grande Prairie[19]		84 Ave.
Edson[20]		Highway 16, other truck routes
Red Deer[21]	Normandeau	Niven Street
	Other	Truck routes
Lethbridge[22]		Trucks going to asphalt plant

A number of briefs[23] reported that environmental deterioration of residential areas is attributable to the establishment of truck routes and increasing traffic on them.

Once-quiet residential neighbourhoods are finding that they are no longer quiet and new residential areas are being built in areas with known or projected vehicle noise problems. The City of Calgary Transportation Department in Brief 83 reported that they have incorporated a design noise level guideline of 60 dBA Leq(24) into the design of both new residential developments and transportation corridors. However, a general need exists throughout the province for noise considerations to be more appropriately incorporated into all land use planning and transportation planning decisions. It also appears that traffic flow controls, such as stop lights, need to be evaluated for their potential to generate noise.[24]

Other Aspects of Vehicle Noise

Many participants at the public hearings stated that the causes of vehicle noise problems go beyond inadequate land use and transportation planning to include a number of technical and behavioural factors.

Various types and conditions of road surfaces, tire tread designs, and their interaction[25] are significantly increasing noise levels. On high-speed roads, "rolling" or tire noise is a greater problem than engine and exhaust noise. Even on lower speed roads, the presence of pavement faults causes trucks and their boxes to bounce and rattle.[26]

Particularly noisy types of vehicles within the general traffic flow were identified as trucks,[27] motorcycles,[28] and buses.[29] It was also reported that the inappropriate use of sirens on emergency vehicles[30] and the Jacobs brake on trucks[31] cause noise problems during the night.

Poor vehicle maintenance, lack of mufflers, and faulty or inappropriate mufflers[32] were often vehemently cited as being particularly bothersome. For example, Brief 36 reported that in some areas of the province school buses operate with straight pipes rather than mufflers, creating considerable noise in residential neighbourhoods.

Deliberately noisy driving behaviour such as squealing tires and revving engines[33] also contributes to road noise.

Industry's Viewpoint

Representatives of trucking associations,[34] truck manufacturers,[35] and a motorcycle association[36] acknowledged being aware that their vehicles draw considerable criticism because of noise. They discussed in technical detail the noise problems of the engine, cooling fan, exhaust, air intake, transmission, and chassis, and described their efforts to reduce noise emission. It seems clear that trucks and motorcycles from the manufacturers or dealers are meeting federal standards. The increase in noise problems is attributed mainly to the increasing number of vehicles, as well as failures or improper repairs such as exhaust system leaks, failed thermostats on clutched fans, incorrect mufflers, improper fan blade

replacements, and removal of engine noise reduction panels. It was also suggested that lack of noise-related training for drivers results in poor driving habits.

The vehicle fleet (trucks and cars) is steadily increasing in Alberta and is expected to double in the next 20 years (Table 4). Evidence indicates, however, that individual cars, trucks, and motorcycles are becoming quieter with improved technology. Tire noise remains a problem and becomes predominant at speeds of 60 to 65 km/h. Another less technical, but very difficult problem is how to reduce noise which results from individual tampering and poor attitudes.

Controlling Vehicle Noise

The factors contributing to vehicle noise are diverse, with some perceived to be more easily remedied than others. In fact, the easiest solutions have probably already been developed and it will get progressively harder to solve the remaining components of the problem.

The most obvious approach is to alter the noise-producing components of the source – the vehicles and tires. For example, several truck manufacturers explained that the main sources of truck noise are continually being studied and redesigned to lower their noise emissions.

In addition, two types of regulations can control noise at the source: the first regulates permissible noise emissions of new vehicles; the second attempts to regulate the continued maintenance of vehicles to certain standards and the manner in which vehicles are operated. The first is primarily within the federal jurisdiction, although provincial support for more stringent regulations where appropriate and encouraging research into such technical fields as tire design and road surfacing could produce considerable results. The second area, regulating the use of vehicles, lies within provincial and local jurisdictions. Either through provincial regulations or local by-laws (as provided for under Section 16(1) of the Highway Traffic Act (RSA 1980 cH-7)), noisy vehicles and inconsiderate drivers can be removed from traffic. Regular vehicle testing, currently found in some jurisdictions, can check for adequate mufflers. However, unless the proportion of faulty or modified vehicles is large, testing would probably not reduce average noise levels significantly, but might reduce intrusive peaks (EPA 1980). Strong enforcement for those with poor driving practices could be beneficial. If enforcement is supported with meaningful fines, considerable improvements could be expected. An important point to be considered is the difficulty individual communities would experience in fully reducing vehicle noise unless standards are applied over a large area. This may be achieved by the development and widespread use of a model municipal noise control by-law as described in Section 4.1.

Perhaps the most publicized and controversial approach to controlling vehicle noise is using acoustical barriers[37] such as berms and walls. These can be used both in early planning and design stages and as retrofit measures to give relief to existing residences from mounting traffic noise. An apparently effective variation of the acoustical barrier used in urban redevelopment situations is designing the first row of buildings facing a noise source to form a "barrier block" for acoustical shielding.

Table 4. Number of Vehicles Registered in Alberta

Year	Passenger Cars	Trucks	Total
1969	482,375	197,893	680,268
1970	503,925	205,739	709,664
1971	525,524	214,120	739,644
1972	552,854	227,008	779,862
1973	582,167	246,440	828,607
1974	620,480	273,548	894,028
1975	690,330	318,932	1,009,262
1976	704,743	319,193	1,023,936
1977	760,861	335,568	1,096,429
1978	855,419	370,600	1,226,019
1979	949,233	405,679	1,354,912
1985 (projection)*	1,142,944	515,114	1,658,058
1990 (projection)	1,363,785	620,550	1,984,335
1995 (projection)	1,584,627	725,985	2,310,612
2000 (projection)	1,805,469	831,421	2,636,840

Source: Alberta Treasury 1980:125.

*Trend line projection.

Other noise-control techniques exist which only provide protection for interior living areas: arranging rooms and corridors so that noise-sensitive areas are furthest away from traffic noise, and providing good acoustical insulation at the time of construction. Detailed discussions of these technologies are found in Section 4.

The approach most often mentioned at the public hearings focussed on land use and transportation planning to separate the public from noise. This approach encompasses a range of techniques including site planning, incorporating noise considerations into land use plans and subdivision decisions, careful municipal truck route planning, and traffic control planning to minimize noise by managing speed and interruptions of flow.

The transportation planning departments of both the City of Edmonton and the City of Calgary presented substantial briefs[38] addressing these techniques and outlining current transportation planning practices and problems. Both acknowledged a growing demand by neighbourhood groups for relief from road noise. They also noted that city-wide noise control policies and programs must be shared with other departments, such as the planning and building departments. There also must be co-ordination with provincial transportation planning and development activities, primarily through Alberta Transportation's programs regarding arterial roads and major corridors. The point was made that the planning agencies (local or provincial) should also consult affected residents to develop effective mitigative solutions.

3.1.2 Railway Noise

Railway noise is not a major problem in Alberta. However, it does seriously disturb certain communities and neighbourhoods adjacent to rail facilities. A total of 13 briefs[39] made reference to railway noise problems (see Table 5). Canadian National (CN) in Brief 1 described their efforts to date to reduce noise levels.

CN stated that "railways are noisy by nature and can be bothersome to people who live nearby." In fact, railways generate a variety of noises. Idling engines emit mostly low-frequency sound with the frequency rising as engine speed increases. On moving trains, the engine, exhaust muffler, fans, electrical generator, wheel/rail interaction, and whistle can be very noisy and can cause severe vibration. Rail yard noise results from such activities as coupling and uncoupling train cars, and switching, marshalling, and classifying trains.

Brief 147 stated,

> *Most traffic seems to consist of freight trains of over 100 cars, with typically five or six power units; when these trains are accelerating, the noise level outdoors is best described as shattering and is disturbing indoors too (especially at night); the accompanying low-frequency vibrations contribute further by rattling loose objects (including some window panes).*

Very positive comments were received, however, from the Calder area of Edmonton which a decade ago had serious problems with the hump yards. Now only a few complaints are expressed about shunting noise, vibration, and the occasional whistle in the yard. Brief 3, in fact, commends CN for its mitigative measures, citing them as "an example of what industries can do if they are trying to be co-operative."

Table 5. Areas with Railway Noise Problems Identified at the Hearings

Location	Area	Problem/Source
Edmonton	Calder[40]	Yard activities
	Hermitage[41]	Railway elevated
	Strathcona[42]	Shuffling trains in the southside depot
	Oliver[43]	General train traffic
Fort Saskatchewan[44]		CN mainline through the centre of town - 24-hour problem assembling trains
Fort McMurray[45]		Shunting trains at night Loading and unloading trains Ground tremors from rail yard activities
Calgary	Canyon Meadows[46]	General train traffic Whistle blowing at controlled crossings Railway crossings
	Bowness[47]	Train traffic through community accelerating, long trains Engine exhaust
Kipp[48]		Proposed move of rail yard from Lethbridge to Kipp

Controlling Railway Noise

A strong message was received from all rail-oriented briefs. While trains are recognized as inherently noisy, most problems can be avoided with good management and planning. Brief 147 poetically stated: "the passage of the passenger train, The Canadian, is rarely noticed; freight trains are rarely missed."

As with road noise problems, control measures with the highest priority focus on the source. CN has had considerable success in this regard in the Calder yard. The measures employed include: a noise-containing shed over the main retarder; noise barriers on both sides of the group retarders; reducing source noise by modifying equipment and buying quiet equipment if possible; eliminating night work where practical; meeting with community leaders, city administrators, and acoustical consultants to correct specific problems; and keeping employees continually aware of quieter operating practices.

At the local government level, Edmonton and Medicine Hat have prohibited the blowing of train whistles within city limits, except for certain specified crossings. Other communities are considering similar action. Banff National Park officials are asking the Canadian Transport Commission to ban the blowing of train whistles between the park's west boundary and the Banff townsite. Representatives from the Transportation Department, City of Calgary in Brief 83 reported that a by-law similar to Edmonton's is being considered. Brief 72 suggested that quieter alternatives to whistle blowing, such as the dropping barriers, little bells, and flashing lights activated by the "beautiful LRT" should be used to increase quiet and safety.

Berms and barriers can also effectively reduce rail noise, providing the railway is not elevated and adequate consideration is given to potential noise problems in all land use planning and development decisions.[49] As the Oldman River Regional Planning Commission pointed out in Brief 47, however, the province should develop criteria suitable for and readily applicable to most land use planning tasks. The research program of the Freight Development Branch, Canada Department of Transport is developing NEF contours for areas adjacent to railways. Their studies may provide the opportunity to develop complementary provincial, regional, and local land use planning procedures for areas of high railway noise exposure.

3.1.3 Aircraft Noise

Aircraft noise has a number of well-defined characteristics. Helicopters generally produce a throb from the propeller blades, a sound which may carry long distances due to its low frequency. The roar from jets results from air being forced through the engines and exhausted at tremendously high speeds. This noise is at its peak during take-off, while during landing the high-pitched fan noise dominates. The impact of aircraft noise depends on the distance between the source and receiver, as well as the intensity of the sound at its source. Major concern, therefore, is focussed on areas close to airports where air traffic is under take-off power and where aircraft are relatively close to the ground.

Twenty-nine briefs focussed explicitly on noise generated by aircraft[50] (see Table 6). The major issues relating to aircraft are helicopter noise in Calgary and jet noise from both the Calgary International and Edmonton Municipal airports. Helicopter noise was repeatedly

Table 6. Areas with Aircraft Noise Problems Identified at the Hearings

Location	Area	Problem/Source
Edmonton (Municipal Airport)	Calder[51]	B737 jet traffic
	Queen Mary Park[52]	B737 jet traffic, small jets and small propellor aircraft
	Prince Rupert District[53]	B737 jet traffic, small business jets Helicopter traffic
	Oliver[54]	Aircraft generally
	McKernan[55]	B737 jet traffic
	Downtown area[56]	B737 jet traffic
	Garneau[57]	B737 jet traffic
Calgary	General city area[58]	Helicopters and aircraft
	Vista Heights[59]	Large jet traffic (B737 and B727)
	Brier Hill[60]	Helicopters
	Southwest Area[61]	Helicopters and small planes used for reporting traffic conditions
	Bowness[62]	Jets taking off, helicopters
Edson[63]		Helicopters Forestry spray planes
Warburg[64]		Low-flying aircraft Sky-diving activities
Other[65]		Helicopters in remote areas Small planes over bird nesting areas

identified[66] as the most distracting source of aircraft noise in Calgary. As Brief 60 explained, part of the problem appears to occur because the heliport "is located on the south side of the river about two blocks east of the 10th Street bridge." Also, helicopter traffic appears "to be heaviest on weekends when they are used for transporting construction material to various sites in the downtown area." Thus, noisy activities are increased at a time when most people are home wanting and expecting quiet. The problem is poor timing and possibly the use of an inappropriately noisy technique in the construction industry. Among the solutions suggested were relocation of the heliport away from downtown[67] and banning the use of helicopters within city limits except for emergency services.[68] Brief 94, the one Edmonton brief which identified helicopter noise problems at the Edmonton Municipal Airport, suggested that the minimum height that helicopters must achieve before leaving the airport be increased.

The jet noise problem was most clearly related to the Edmonton Municipal Airport, although two Calgary briefs also mentioned disturbance from aircraft noise.[69]

It must be noted that the level of concern results not just from the fact that air traffic has increased but, as Brief 5 points out, because "during the past 35 years residential areas adjacent to the airport have increased very considerably and many more multiplefamily units have been developed." The criticisms about jet noise primarily focus on increasing traffic volumes, particularly noisy craft, and problems with flight scheduling.

Three briefs[70] provided estimates of volumes of aircraft movements to illustrate the widely expressed feeling[71] that traffic volumes at the Edmonton and Calgary airports are steadily increasing (Table 7).

The Edmonton briefs generally agreed that commercial jets are the primary contributors of jet noise, although small jets and propeller aircraft were also mentioned. For example, Brief 94 reported that the noise from a Lear jet is even harsher than that from a 737. Briefs 101 and 103 reported that Time Air's Dash 7 flights are significantly quieter than PWA's Airbus service. De Havilland Aircraft of Canada Limited, manufacturers of the Dash 7, attributed the reduced noise levels to various design features including propeller configuration, reverse flow engine, and ability to handle steep approaches and take-offs. In comparing the certified noise levels of various airplanes, de Havilland indicated that on take-off, the Dash 7 is about 19 dBA lower than required minimum levels and 10 dBA lower on approach, while most other aircraft are very close to the minimum requirements.

Flight scheduling was also repeatedly criticized. Briefs 3 and 94 acknowledged that scheduled take-offs and landings are restricted at night, but pointed out that charter flights and private jets are not restricted and "aircraft activity is common during these (2300 to 0700 hours) sleeping hours." Brief 94 also noted the problem of heavy scheduling of traffic during the supper hour (between 1700 and 1830 hours). With jet noise every 10 minutes, difficulty in enjoying a summer barbeque or patio dinner was reported.

Controlling Aircraft Noise

Three briefs[72] strongly recommended closing the Edmonton Municipal Airport as the only solution to jet noise problems. The arguments basically focus on decreased noise, increased

Table 7. Aircraft Movements in Alberta

Year	Calgary International	Edmonton Municipal
1976	124,159	136,545
1977	134,486	164,271
1978	143,949	168,570
1979	165,193	188,727
1980	184,885	188,005
1985 (projection)*	257,046	258,387
1990 (projection)	333,125	322,075
1995 (projection)	409,205	385,763
2000 (projection)	485,284	449,451

Source: Alberta Treasury 1981:100.

*Trend line projection

safety, more cost-effective use of land, and subsequently improved road patterns in the city. However, the proponents also recognized that the problem is one of land use planning — incompatible land uses have been permitted to establish too close to each other.

One planning technique frequently used in the vicinity of airports is the noise exposure forecast. Contour maps of NEF values (Figure 1) identify the range of various degrees of noise impact. Brief 11 pointed out that in the vicinity of the Edmonton Municipal Airport, residences, at least five hospitals, a number of extended care facilities, and numerous schools are within the NEF 25 contour. The actual impact of jet noise on these institutions is unknown although Brief 3 reported that school classes are interrupted by aircraft noise. Brief 3 recommended that new residential developments not be permitted within at least a mile of the NEF 25 or higher contour. Another approach is to soundproof facilities disturbed by jet noise. A U.S. Federal Aviation Administration study concludes that it is feasible and practical to soundproof schools, hospitals, and public health facilities located near airports (FAA 1977).

Various forms of traffic management at both the Calgary International and Edmonton Municipal airports were suggested to eliminate the noisiest jets, and to regulate flight patterns, traffic volumes, and schedules.[73] For example, Brief 62 recommended that a northern take-off be used more frequently at the Calgary International Airport, especially by the noisier jets. This practice would reduce the noise impact on the residences south of the airport. Similarly, for the Edmonton Municipal Airport, Brief 94 recommended that Calgary-bound jets which must take off to the north should complete their arc over the west end to reduce the period of jet noise over the city. Brief 103, pointing out an Ontario example of traffic management, reported that the City of Toronto has banned jets from the Toronto Island Airport. The inference drawn was that similar restrictions on jet traffic should be considered in Alberta. (See Section 4 for a discussion of the economic implication of such an approach.)

Early in 1982, the *Draft Edmonton Area Aviation Master Plan 1981* was released. The plan places considerable emphasis upon the noise problem of the municipal Airport, including noise exposure forecasts for various situations. These forecasts were mapped; some are illustrated in Figure 1. Figure 1 shows the 1977 noise exposure forecast contained in the City of Edmonton Land Use By-law and demonstrates the significance of increasing or decreasing large jet traffic. If large jet traffic were removed from the airport, noise levels would be reduced substantially. In this case, almost all residences would be found outside of the 30 NEF contour.

The hearings identified widespread public dissatisfaction in neighbourhoods adjacent to several of Alberta's major airports. Internationally, this is a common problem despite efforts over the last 10 years to reduce aircraft noise at the source. The OECD Conference on Noise Abatement policies recommended that "in order to speed up a reduction in noise levels, the retirement or retrofit of non-acoustically certificated aircraft is needed" (OECD 1980:ix). For immediate relief from aircraft noise, the OECD recommended that site-specific measures be pursued, such as altering flight paths, imposing strict curfews, changing take-off and landing flight procedures, applying land use controls, and soundproofing houses (OECD 1980:x). The use of these techniques in Alberta is discussed further in Section 4 which explores the noise control options in this province.

3.2 WORK-RELATED NOISE

Worksites are a major source of noise in Alberta. Workplace noise affects not only workers on the worksite, but in many cases, residents near the worksite. Noise may still be considered an indication of progress to some, but its impacts on the workplace and its intrusion into our homes and recreational areas are increasingly condemned.

The Environment Council received 59 briefs[74] which referred to noise problems associated with work activities. More specifically, 38 briefs[75] addressed the on-site issues of workplace noise and 31 briefs[76] identified broader concerns about the impacts of noise beyond the worksite.

Industrial noise affects people both on-site and off-site, although the severity of exposure, and the short- and long-term effects differ. On-site noise affects the entire work force to

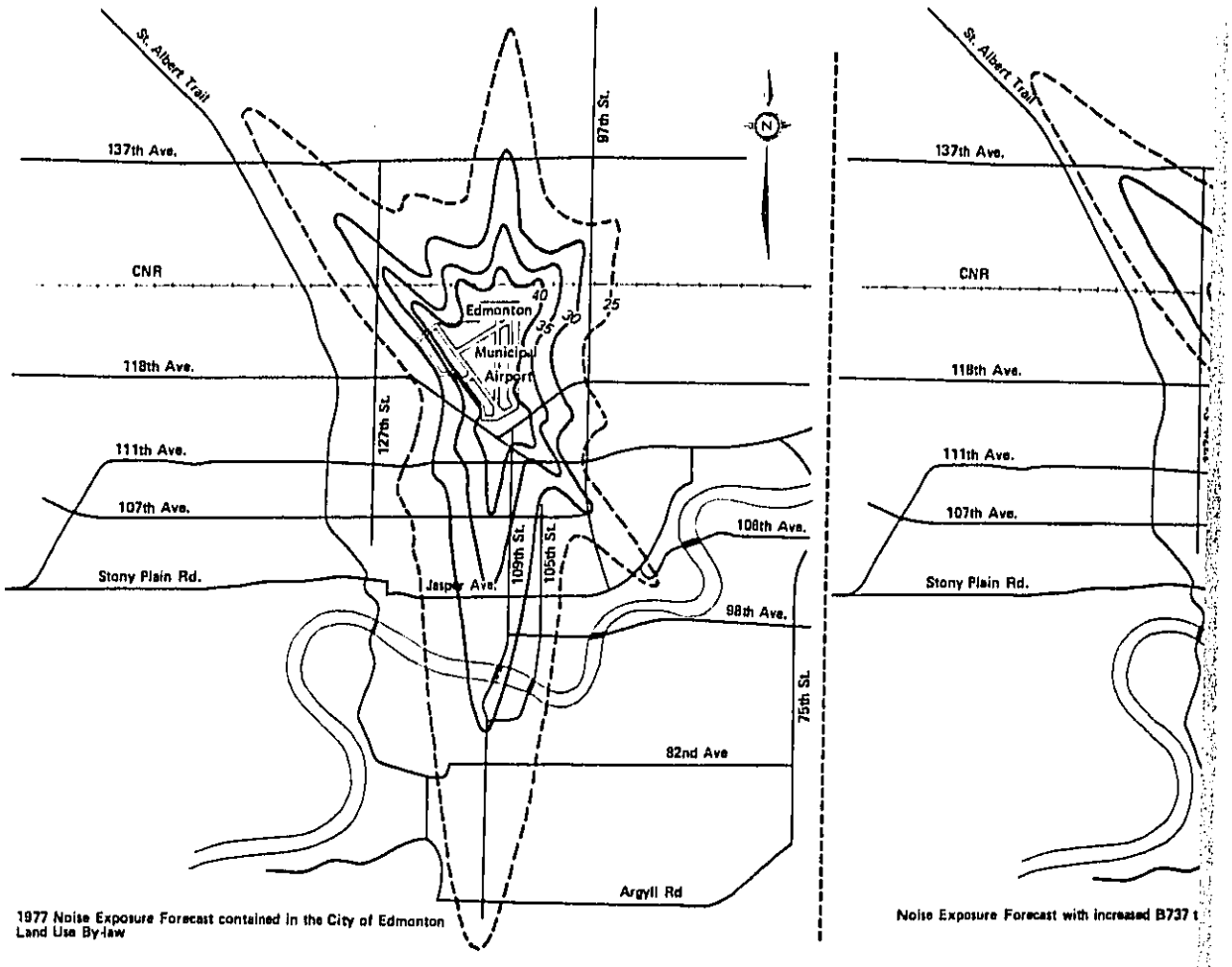
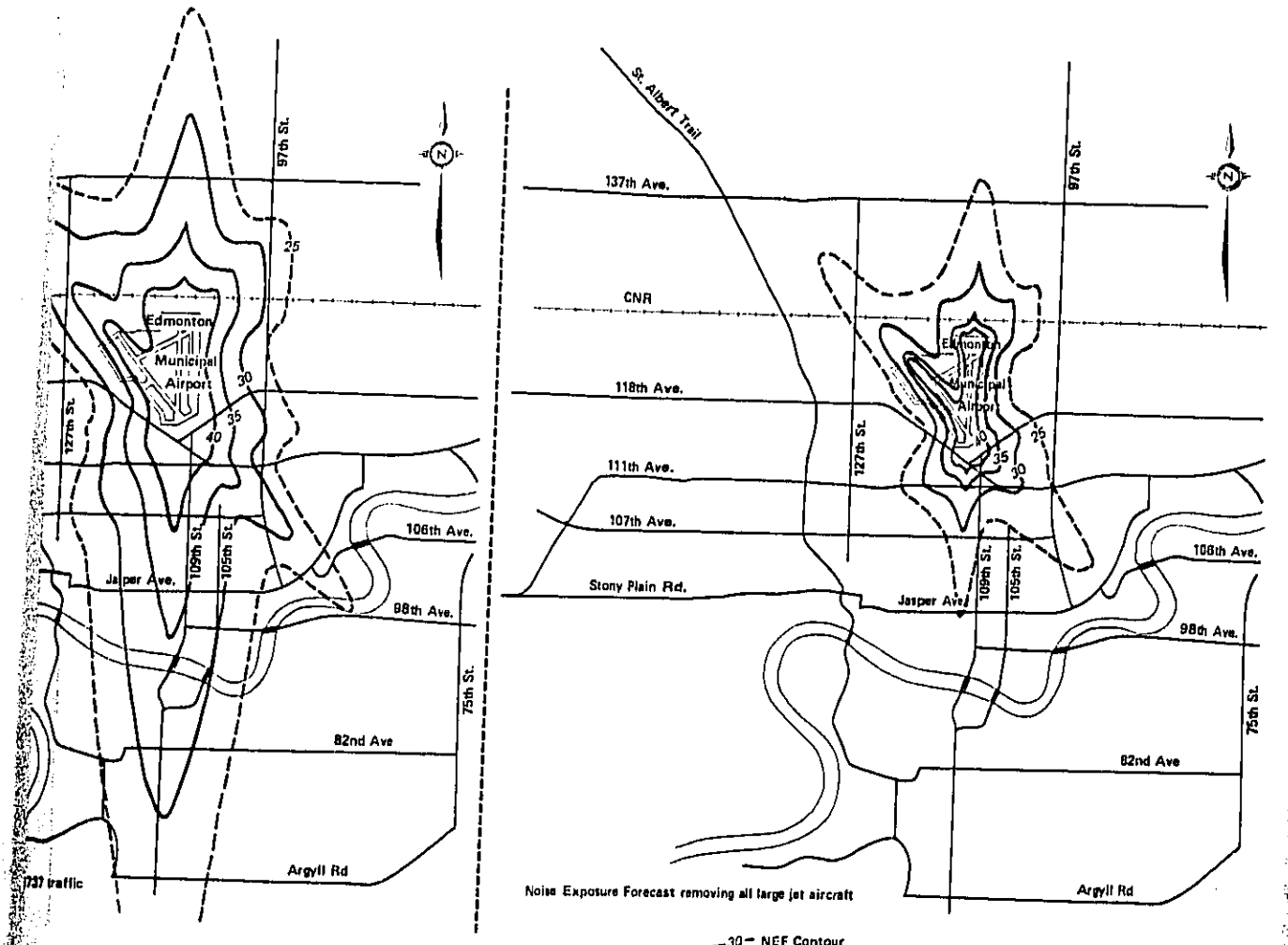


Figure 1. Noise Exposure Forecasts for the Edmonton Mu

Source: Matson 1981



Municipal Airport

some degree. The number of on-site workers exposed to noise levels high enough to result in hearing loss can be determined with reasonable accuracy. Industrial noise also disturbs people off-site, primarily those in houses located next to industries. Workers on site generally have more prolonged and consistent exposures to higher noise levels than people disturbed off the site. On-site exposure not only causes hearing loss, but there is increasing evidence linking noise to accidents, absenteeism, and the whole range of extra-auditory effects discussed in Section 2. Off-site, the noise is generally associated with annoyance, and in more severe cases, loss of sleep and interference with communication. Because of these differences in the impacts of industrial noise as well as differences in the range of control approaches, on-site and off-site problems are discussed separately.

3.2.1 On-Site Noise

Noise is widely recognized as the most prevalent health hazard in the workplace (Throckmorton 1981). An American industrial insurance survey revealed that hearing loss is the largest single compensable health problem (Howard 1979). It is not surprising then, that of the 38 briefs dealing with on-site workplace noise, 16[77] specifically addressed hearing loss and other physical effects such as tension and digestive problems. These concerns were raised by individual workers, labour representatives, industrial employers, and health professionals.

Individual workers and representatives of labour organizations provided information on the magnitude of the problem. The following noisy worksites and occupations were described:

electrical generating stations[78]
sheet metal workshops[79]
foundries and heavy fabrication industries[80]
mining[81]
oil and gas exploration[82]
agriculture and related industries[83]
construction[84]

The severity of noise-related problems that workers in these occupations are exposed to was demonstrated in Brief 59 which pointed out that hearing loss is a common disability among sheet metal workers and boilermakers. In fact, such hearing loss is colloquially known as "boilermaker's disease." Until recently, rural residents apparently had been unaware of health problems due to noise in farming and the agricultural service industries. Brief 68, however, pointed out that there is evidence that farmers are now beginning to use hearing protection. Briefs 10 and 67 reported that truck drivers are commonly hard of hearing in the left ear from driving with the window open, thus being exposed to high noise levels over long hauls.

Other workplaces were reported to have identifiable noise problems which are not likely to lead to hearing loss but which apparently cause noise-related problems:

University of Calgary (outdoor radio broadcasting)[85]
Mount Royal College Library[86]

schools[87]
hospitals[88]
open-plan offices[89]
offices and institutions with noisy air conditioning[90]
post office[91]
bars and discotheques[92]

As the Alberta Federation of Labour pointed out in Brief 107, there are numerous work situations in all employment sectors with unacceptable noise levels (see Table 8).

The Council received a variety of estimates of the total number of people in Alberta exposed to hazardous noise levels in the workplace (see Section 2.1). It is estimated that 10 to 12 percent of the total work force may incur a hearing loss over 20 to 40 years of exposure to occupational noise. While most of the people who presented briefs recognized the existence in Alberta of regulations to protect workers from the effects of noise, many believed that the regulations are not adequately enforced.[93] For example, Brief 29 reported that only 30 percent of all worksites in Alberta have occupational health inspection services. Brief 107 stated that only about 45,000 workers, or less than 10 percent of the total work force, are covered by hearing conservation programs.

Brief 29 also pointed out that because a majority (78 percent) of worksites in Alberta have less than 10 employees, the provision of adequate pretesting, monitoring, and noise-attenuation programs tends to be costly for small-scale employers to administer and difficult to enforce from a government perspective. These problems emphasize the need to identify the resources that are required to ensure adequate enforcement of current regulations to protect all workers from the impacts of noise (see Section 4.2).

The Council heard evidence that both employees and employers need to be aware of, and are recognizing their responsibilities to reduce the impacts of noise. For example, in Brief 59 a union representative acknowledged the potential role of labour groups to encourage greater use of hearing protection. The brief included the following admission: "The union has been lax, as we have not promoted and encouraged the protection from noise among our members to our full potential." However, it also pointed out that employers generally and the various government departments having jurisdiction over this problem have not adequately supplied workers with hearing protection and encouraged them to use it. Alberta Power Limited in Brief 106 recognized that employees in generating stations are exposed to noise levels in excess of the eight-hour allowable limit. They are attempting to alleviate the noise problem by using engineering techniques, buying quieter equipment, enclosing work stations, providing and encouraging the use of protective equipment, administering a hearing conservation program (since 1968), and discussing with employees the effects and hazards of noise. The City of Calgary, another major employer, described in detail in Brief 85 its hearing conservation program which includes working with various city departments to quieten noisy work areas and encouraging purchase of the quietest equipment available. They also have direct employee programs such as routine audiometric tests and provision of hearing protectors. Brief 29 identified "joint job safety committees," which consist of management and labour developing safety strategies together, as being able to assist in providing noise control and protection. However, three briefs[94] emphasized that the provincial government should assume greater responsibility for ensuring that its own regulations

Table 8. Recent Examples of Noise Levels Found on Selected Alberta Worksites

Mail room	84 - 86 dBA
Typewriter	72 - 76 dBA
Mag Card typewriter	80 dBA without cover, 76 dBA with cover
Lawn mower, push type (4 cycle)	92 - 96 dBA variance of speed
Lawn mower, push type (2 cycle)	90 - 94 dBA variance of speed
Tractor mower, pull type	90 - 94 dBA in tractor cab
Kitchen	From 72 dBA in baking area to 86 dBA in pot-washing area
Wood-working shop	100 - 107 dBA
Jackhammer breaking concrete	108 dBC
Car wash	78 - 92 dBA (inside car entrance to exit respectively)
Road grader	97 dBA
Caterpillar D9	102 dBA
Front-end loader (tractor)	100 dBA
Carbon arc welding	96 - 102 dBC
De-barker	100 dBA
Chipper shredder	120 - 130 dBA
Re-saw (trim blade)	105 - 122 dBA
High-speed cut off saw	95 - 105 dBA
Planer	97 - 110 dBA
Standard sander	90 dBA

Source: Brief 107:2-3

are enforced, and as well provide greater leadership in the education of workers and employers about the hazards of noise. Both labour and management should work together to achieve safe levels of noise in the workplace (see Section 4.2).

While many briefs questioned the enforcement of current occupational noise regulations, only one argued the basic inadequacy of permissible exposure levels. The AFL stated that the current permitted exposure to noise levels of 85 dBA (over an eight-hour period) is neither healthy nor safe. Instead, the AFL recommended that workplace noise should never exceed 80 dBA. Crucial to achieving such a goal would be noise level monitoring of all permanent worksites suspected of having noise levels in excess of 80 dBA. On non-permanent worksites, the AFL recommended that there be an inventory and assessment of the noise emissions of all machinery, tools, and equipment. They would be subsequently retrofitted to meet the 80 dBA maximum. In essence, the AFL would like to see more emphasis in the regulations on limiting noise emissions, rather than the onus being on the worker to wear hearing protection.

A number of briefs[95] stressed that engineering controls at the source should be the highest priority approach to reducing workplace noise. For example, Brief 102 pointed out that in the forestry industry, noise abatement kits are available for skidders from such companies as Caterpillar and Clark, and similar technologies should be available for construction equipment. In Brief 64, an acoustical consultant who advises industries on engineering noise-control designs outlined various control principles and techniques. From his experience, if the noise source can be identified, there is an almost 100 percent chance it can be successfully controlled. The AFL also provided numerous examples of effective source controls. Preferable to retrofitting source controls, however, is ensuring that adequate acoustical protection is designed and built into work environments before operations begin. Brief 59 argued that it is of utmost importance that approval from a government body be required for industrial buildings and designs prior to construction.

3.2.2 Off-Site Noise

In the 31 briefs[96] which identified the off-site problems resulting from workplace noise, it is evident that there are two primary sources: noise from stationary worksites, and noise from road and rail traffic generated by the work activities.

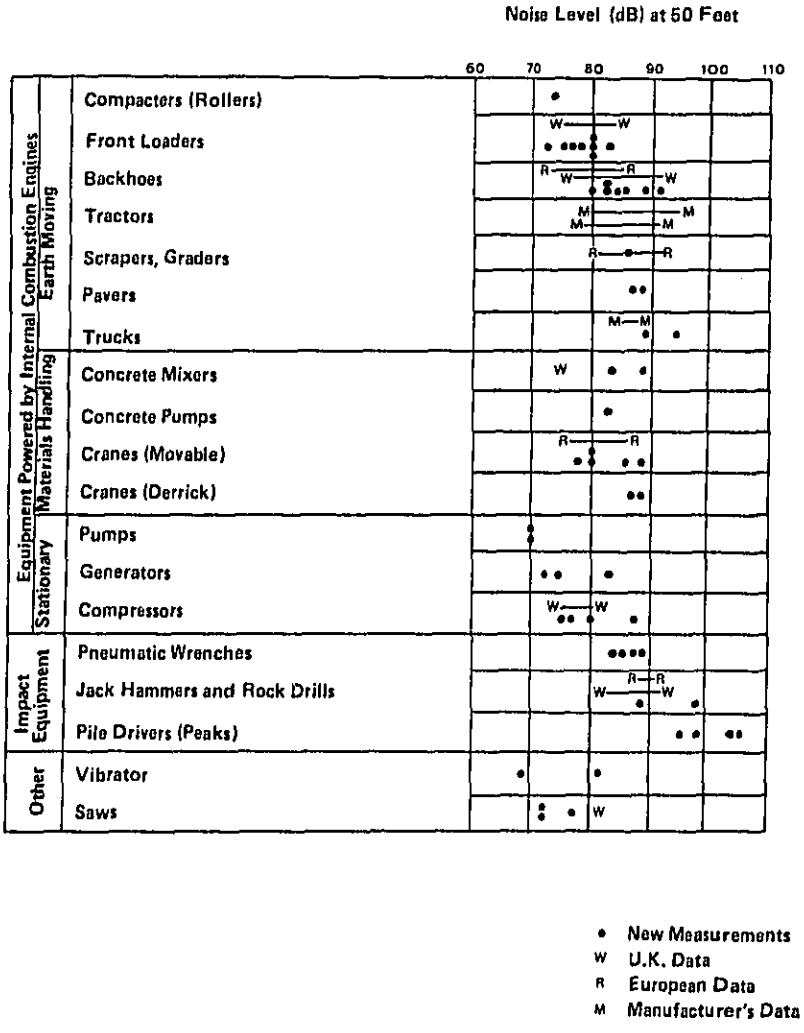
Noise from construction sites received the most complaints. Nine briefs[97] identified a variety of construction activities such as road, residential, and industrial construction, which disturb neighbouring residents. Brief 102 reported that in certain areas of Edmonton, noise from construction of apartment buildings is continuous. As Table 9 indicates, much of the equipment used on construction sites produces very high levels of noise. Back-up beepers found on most construction equipment were also identified as particularly annoying.[98]

While construction noise is largely related to urban growth, the oil and gas industry was reported to be introducing noise problems into the rural environment.[99] Brief 115 identified two typical forms of noise from oil and gas operations: high-intensity noise from well drilling operations, and continual 50 to 70 dBA noise levels during operation constituting long-term intrusion into previously quiet environments. "In the heavy oil areas of north-eastern Alberta, up to 64 wells per section are being considered.... In the bitumen areas of Cold Lake a well every two acres is a possibility." The conclusion is that the rural ambient noise levels are rising much higher than the original levels. Brief 115 expressed particular concern about the new hydraulic pumps (HEP units) used in the heavy oil areas.

Oil refinery facilities, particularly in Refinery Row in the Edmonton area, also appear to cause cumulative additions to the background noise in adjacent residential neighbourhoods. Brief 145 stated that "The roar is the sum of individual industrial noises...particularly attributable to compressors, fans, pumps, flare stacks, valves, and the plumbing generally associated with handling and processing of fluid hydrocarbons and their products."

Other industrial and commercial activities which have impacts on neighbouring residential areas or communities include blowdowns at power generation stations,[100] asphalt plants,[101] a rapeseed plant,[102] industrial vacuum sewage trucks,[103] shopping centres,[104] and even home occupations involving high-power hand tools.[105]

Table 9. Noise Levels Generated by Construction Equipment



- • New Measurements
- W U.K. Data
- R European Data
- M Manufacturer's Data

Source: Reif and Vermeulen 1979: Table 3

A number of these and other industrial noise generators also create increased truck and rail traffic. Brief 4 pointed out that new industrial activity in Fort McMurray has resulted in more rail traffic and hence more noise. In Red Deer, Brief 32 reported that servicing trucks going to the Dow Chemical plant generate noise. In Lethbridge, Briefs 44 and 45 expressed concern about the gravel trucks going to the asphalt plant. Brief 70 identified cement trucks working on construction as a problem, and Brief 108 reported significant noise problems from trucks supplying a wholesale food outlet.

Currently, outside of land use planning restrictions, which at most can separate incompatible land uses, the only restrictions on off-site industrial noise are the guidelines set up by the Energy Resources Conservation Board (ERCB). They establish "maximum permissible noise levels applicable to energy resource industry operations, in particular, drilling rigs, compressor stations, pumping stations, and gas well flaring" (ERCB 1980). Brief 115 considered the ERCB's permissible noise levels of 65 dBA daytime and 50 dBA nighttime as measured 15 metres from existing residences, to be inadequate. Brief 115 recommended that the permissible levels be "reduced to below 25 dBA, being about 5 dBA higher than the dominant atmospheric sound." Brief 145 reviewed the two most recent ERCB decisions applicable to the Refinery Row area and concluded that the decisions illustrate a lack of concern regarding troublesome noise, despite the guidelines.

Many energy-related facilities are located in rural settings. Rural areas normally have very low noise levels and the residents expect that these levels will be preserved. In cities it is normal to consider that a noise problem begins at 55 dBA. However, such levels would be completely out of place in many rural areas where the ambient noise level is 35 to 50 dBA or lower. What seems to be required is a measure of intrusive noise level; that is, the extent to which the energy-related development raises the ambient noise level. The Council suggests that a permanent energy-related facility be no more than 5 dBA Leq(24) above the ambient noise level in rural locations.

The ERCB guidelines have been useful in the absence of any other regulations dealing with industrial noise. However, one disadvantage is that noise measurements are taken near existing residences rather than at the property line of the development. This means that an industrial site could violate the standard in the future, if new residences are built in the noise-affected area. It would be more useful if the location for measurements was standardized at the boundary of the property. Another disadvantage is that the directive does not distinguish between temporary and permanent facilities. There should be a difference, as residents will very likely tolerate a higher level of inconvenience if they know it to be temporary in nature. Also, permanent facilities tend to expand, sometimes becoming a more significant noise source. Therefore, a distinction should be made between noise levels from permanent and temporary facilities, with more stringent rules for the permanent facilities.

The ERCB also investigates specific noise problems in response to complaints. However, the Council believes that the ERCB's maximum permissible noise level is inadequate given as a dBA measurement because individual readings do not accurately represent an acoustical environment. The standard should be an Leq measurement (see Section 5.5). As well, the actual permissible level should reflect a minimum increase over rural ambient sound levels. Typical ambient sound levels in rural Alberta are 25 to 35 dBA Leq (Bolstad 1977) and the

introduction of industrial noise levels of 50 dBA Leq, while perhaps complying with current levels, would certainly be disturbing.

The Canadian Petroleum Association (CPA) in Brief 77 claimed that the oil and gas industry, particularly in Alberta, has maintained a position of leadership in industrial noise awareness and control. Restricting its comments to noise emanating beyond plant boundaries from industry-related activities or facilities, the CPA reported that noise abatement measures are employed at virtually all facilities. The brief also asserted that "the industry is fully aware of and willing to accept the possible additional cost in improving and incorporating new noise abatement technology into facilities developed in sensitive areas." Current individual noise-control efforts include: siting criteria for plant facilities which include noise considerations, in-house noise seminars, standard design specifications for noise limits on equipment, equipment enclosures, and special research projects to respond to specific noise concerns.

Like transportation noise, off-site industrial noise problems are closely related to land use and transportation planning issues. Several briefs[106] stressed the need for land use planning to adequately separate industrial and residential areas. One approach may be to incorporate controls into the Subdivision Regulation under the Planning Act, 1977. Residential subdivisions should be restricted in the vicinity of noise generators (see Section 4.5).

Where industrial activities such as construction must temporarily disturb residential areas, local jurisdictions can control the routing of heavy equipment and operational hours through a municipal by-law, such as the model by-law suggested in Section 4.1. Also, consideration must be given to the type of equipment used and the provision of incentives for use of quieter equipment.

3.3 DOMESTIC NOISE

In their homes, people sleep, eat, relax, and socialize with other family members and friends – all activities which usually require a quiet environment to be fully enjoyed. As the preceding sections demonstrate, many residential areas in Alberta are exposed to unacceptably high noise levels from surface and air transportation and industrial sources. There are also a great many other noise sources around the home. Many complaints stem from annoying neighbourhood activities such as neighbours' dogs barking, wild parties, and loud music. Our own use of noisy machines such as large and small appliances, power tools, lawn and garden equipment, air conditioners, and ventilating systems also creates substantial noise.

Forty briefs[107] identified various aspects of noise resulting from activities around the home. Twenty-nine[108] of these expressed concerns about the noise from neighbours' activities disturbing privacy. Eighteen[109] briefs identified noise problems caused by a variety of consumer products used around the home.

3.3.1 Neighbourhood Activities

Inconsiderate and irresponsible behaviour resulting in noise is the cause of much neighbourhood discord. Briefs referred to neighbours' barking dogs,[110] noisy parties,[111] loud music,[112] public broadcasting systems,[113] and the Calgary carillon.[114] Alderman Lee from the City of Calgary in Brief 83 reported that he has even had complaints about the noise made by children playing in parks.

Unlike most other types of noise sources, determining what levels are too noisy in these circumstances is subjective; our own children, dogs, or parties do not seem as noisy as our neighbours'. Reducing or eliminating these noise problems requires behavioural changes which encompass greater consideration for neighbours.

The most common control approach is for local governments to adopt by-laws prohibiting specific noises or nuisances. Many municipalities in Alberta have by-laws which prohibit such things as broadcasting on public streets, train whistles, barking dogs, or simply "any unusual or unnecessary noise likely to disturb persons in his neighbourhood" (Grande Prairie By-law C502, 1974:1). The Red Deer by-law (No. 2626/79) has broad prohibitions against community, industrial, and construction noise. Rather than establishing maximum acceptable sound levels, the Red Deer by-law defines loud noise as "an unnecessary noise, an unusual noise or a noise which annoys, disturbs, injures or endangers the comfort, repose, health, peace or safety of others" to be determined by the court which hears a prosecution. The Calgary noise by-law (1974) is the most extensive municipal noise by-law in Alberta. It places restrictions on domestic sources, prohibiting such things as the operation of power lawn mowers, model aircraft with internal combustion engines, engine-powered snow clearing devices during nighttime hours, and allowing animals to disturb neighbours. A model municipal noise control by-law, which could easily be adapted to suit individual municipal concerns while encouraging consistent province-wide control of domestic noise problems, is needed (see Section 4.1). Table 3-1 from the Ontario Model Municipal Noise Control By-law illustrates the wide range of noisy activities which a municipality may regulate or control (see Table 10).

Enforcement of such municipal by-laws is usually the responsibility of police or by-law enforcement officers. For example, Staff Sergeant Charlebois of the Grande Prairie RCMP detachment reported that most noise complaints concern noisy parties – they receive an average of three to five calls a night on the weekends and the occasional call during the week. The detachment's enforcement policy is to visit the source of the problem, ask that the parties be quietened, and, if necessary, issue a ticket for creating noise under By-law C502(1974). While the municipal by-law appears adequate in Grande Prairie, Brief 131 from an Edmonton resident reported that the police appear reluctant to do anything about noisy neighbours and that the eventual fines are "laughable" and ineffectual.

In Calgary, it has been necessary to supplement noise by-law enforcement with other legislation such as the Criminal Code and measures such as strong police action in order to deal with large noisy parties. In Red Deer, even though the maximum fine provided for in the by-law is $500, the highest fine issued to date has been $300, with the normal fine about $150. McLaren (1979:22) concludes that "...municipalities rarely appropriate adequate finances to underwrite enforcement. Consequently, enforcement is either non-existent or left to the grudging initiative of existing agencies, whose time and energy are already stretched to the limit." Enforcement of this kind depends on adequate manpower and finances, which in turn is dependent on political desire to pursue certain standards. As suggested by the Calgary police department, one potentially effective way of expressing such desire is to increase fines substantially.

It is important to stress that enforcement of local noise control usually depends upon public involvement through complaints. It follows that simplicity and publicity are required

Table 10. Table 3-1 of the Ontario Model Municipal Noise Control By-law

3. Prohibitions by Time and Place

No person shall emit or cause or permit the emission of sound resulting from any act listed in Table 3-1 if clearly audible at a point of reception located in an area of the municipality within a prohibited time shown for such an area.

TABLE 3-1

PROHIBITIONS BY TIME AND PLACE

		Prohibited Period of Time	
		Quiet Zone	Residential Area
1.	The detonation of fireworks or explosive devices not used in construction.	At all times	At all times
2.	The discharge of firearms.	At all times	At all times
3.	The operation of a combustion engine which, (i) is, or (ii) is used in, or (iii) is intended for use in, a toy or a model or replica of any device, which model or replica has no function other than amusement and which is not a conveyance.	At all times	At all times
4.	The operation of any electronic device or group of connected electronic devices incorporating one or more loudspeakers or other electro-mechanical transducers, and intended for the production, reproduction or amplification of sound.	At all times	C
5.	The operation of any auditory signalling device, including but not limited to the ringing of bells or gongs and the blowing of horns or sirens or whistles, or the production, reproduction or amplification of any similar sounds by electronic means except where required or authorized by law or in accordance with good safety practices.	At all times	D & E
6.	The operation of any powered rail car including but not limited to refrigeration cars, locomotives or self-propelled passenger cars, while stationary on property not owned or controlled by a railway governed by the Canada Railway Act.	At all times	B
7.	The operation of any motorized conveyance other than on a highway or other place intended for its operation.	At all times	B
8.	The venting, release or pressure relief of air, steam or other gaseous material, product or compound from any autoclave, boiler pressure vessel, pipe, valve, machine, device or system.	At all times	A

Table 10 cont.

	Prohibited Period of Time	
	Quiet Zone	Residential Area
9. Persistent barking, calling or whining or other similar persistent noise making by any domestic pet or any other animal kept or used for any purpose other than agriculture.	At all times	A
10. The operation of a commercial car wash with air drying equipment.	At all times	D & E
11. Yelling, shouting, hooting, whistling or singing.	At all times	A
12. The operation of a power assisted hang glider or parafoil	At all times	D & E
13. The operation of any item of snow making equipment.	At all times	E
14. All selling or advertising by shouting or outcry or amplified sound.	At all times	D & E
15. Loading, unloading, delivering, packing, unpacking, or otherwise handling any containers, products, materials, or refuse, whatsoever, unless necessary for the maintenance of essential services or the moving of private household effects.	D & E	D & E
16. The operation of any equipment in connection with construction.	D & E	D & E
17. The operation or use of any tool for domestic purposes other than snow removal	C	B
18. The operation of solid waste bulk lift or refuse compacting equipment.	C	B
19. The operation of a commercial car wash of a type other than mentioned in item 10.	C	A

Prohibited Periods of Time:

A 2300 one day to 0700 next day (0900 Sundays)
B 1900 one day to 0700 next day (0900 Sundays)
C 1700 one day to 0700 next day (0900 Sundays)
D All day Sundays and Statutory Holidays.
E 1900 one day to 0700 next day.

Source: Ontario Ministry of the Environment 1978:Table 3-1

for the complaint mechanism to be effective. The OECD, in identifying this principle, explains that the public requires easy access to the enforcement agency and needs an assurance that action will be taken.

3.3.2 Consumer Products

Probably the loudest noises around the home come from our own use of mechanical devices. Such noise may not generate the degree of annoyance and stress that noise from neighbours, industry, or transportation does, due to the fact that we control our exposure. However, users often are not aware of the effects of noise on their health, and if they are aware, they do not have a choice of quiet products or adequate protection. Household noise can prevent speech communication, mask warning signals such as a child's cry, and irritate other family members.

Table 11 summarizes noise levels of various common appliances. Many briefs contained complaints about excessive noise from vacuum cleaners,[115] refrigerators,[116] appliances,[117] lawn mowers and other garden equipment,[118] snow blowers,[119] air-conditioning units,[120] plumbing,[121] and TV commercials[122] which seem to be louder than regular programming.

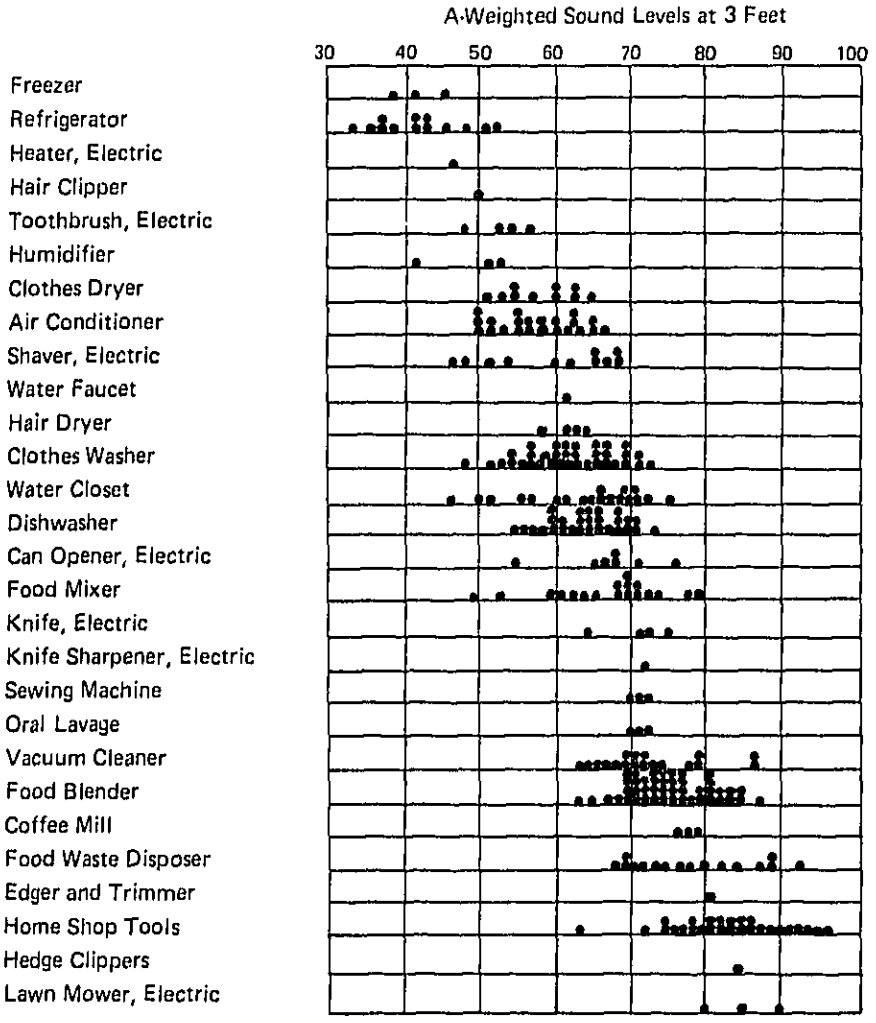
Air conditioner noise, which primarily comes from the fan and compressor, was the most frequently identified domestic noise source. Not only can noise reduction be achieved by modifying design, suspension, speed of rotation, and compression enclosure, but mounting location also appears to be a critical control factor. Three briefs[123] objected to the exterior siting of air-conditioning or cooling tower units, some on the roofs of large buildings, others on a side facing bedroom windows in other buildings. Brief 92 reported having to forfeit fresh air throughout the summer because windows had to be closed to keep out the motor noise from a neighbour's window air conditioner. It appears, though, that a reduction in excess of 10 dB can be achieved by selecting an appropriate mounting location (Reif and Vermeulen 1979:168). This might best be achieved through building codes and basic training of installation crews.

While neighbours' use of certain equipment contributed to some of the concern, most of us commonly use machines around the home which are themselves noise sources. Reducing noise emissions from these devices depends on increased awareness on the part of both manufacturers and consumers.[124]

Several briefs[125] identified the need for regulating the noise emissions of home equipment, as well as the need to promote greater consumer awareness through product labelling. Brief 97 advocated making quiet an attractive selling point for electrical appliances. A combination of both these approaches is recommended by the OECD (1980:209) and is also the Environmental Protection Agency's strategy for dealing with the consumer product noise problem (EPA 1980:74-79).

Because of jurisdictional conflicts, it appears that initiatives for new product regulations would be most effective if they came from the federal government. While Consumer and Corporate Affairs Canada has one regulation which applies to the noise emissions of toys, there appears to be no current interest in extending such regulation to other consumer

Table 11. Noise Levels Generated by Common Appliances



Source: Reif and Vermeulen 1979: Table 1

products. In the U.S., the EPA has begun work on regulations to limit the noise emissions from lawn mowers, but higher priority is being placed on regulating the noise emissions of surface transportation, aviation, and construction equipment.

The provinces can require specific noise labelling of products. The EPA's labelling program was promulgated in 1979 to provide "accurate and understandable information on the noise generating or noise reducing characteristics of products so that consumers can compare different brands" (EPA 1980:75). Figure 2 gives examples of standard EPA labels. Even if little progress in this direction is made in Canada, manufacturers in the U.S. are being encouraged to establish their own labelling programs. Success in the U.S. will probably spill over into Alberta due to the availability of American products in Canadian markets.

3.4 RECREATIONAL NOISE

Transportation, work-related activities, and some neighbourhood activities are generally recognized throughout the world as the major sources of noise problems. Not so widely identified, but of obvious concern since they were mentioned in 40 briefs at the public hearings, are noise problems resulting from recreational activities.[126]

Recreation can take many forms -- some make noise, and others are highly sensitive to the intrusion of noise. For example, recreational equipment such as motorcycles, snowmobiles, electronic amplifiers, and radios brought into parks by certain groups disturb others who have gone there for more peaceful types of recreation. As one brief stated, "to find an hour to be alone is one thing, to find an hour of quiet is quite another."

Nine[127] briefs identified motorcycles as a recreational noise source, eight[128] briefs commented on snowmobile noise, and 16[129] objected to electronic amplifiers and radios. These and associated recreational noise sources create problems in both urban and rural recreation areas. Special sporting events[130] were also identified as noise generators in certain areas.

3.4.1 Recreational Equipment

Motorcycles are both a popular mode of transportation and a form of recreation. Evidence presented by the motorcycle industry in Brief 65 shows that modern highway machines are relatively quiet. Trail bikes, however, are inherently noisy. Noisy highway motorcycles result mainly from altered exhaust and muffler systems or improper operation. Adequate enforcement of present laws could eliminate the problem. More difficult to control are trail bikes, which are not licensed for operation on roadways. Their operation must be strictly limited to certain off-road areas adequately removed from other noise-sensitive uses. Source controls should also be introduced on off-road motorcycles, as has been done for on-road vehicles.

Snowmobiles were frequently mentioned[131] as a source of recreational noise problems. Evidence was presented in Brief 23 from the International Snowmobile Industry Association that technology has been developed and implemented to reduce noise levels "...from over 100 dBA to a maximum of 78 dBA and a "typical mode" maximum of 73 dBA." They also

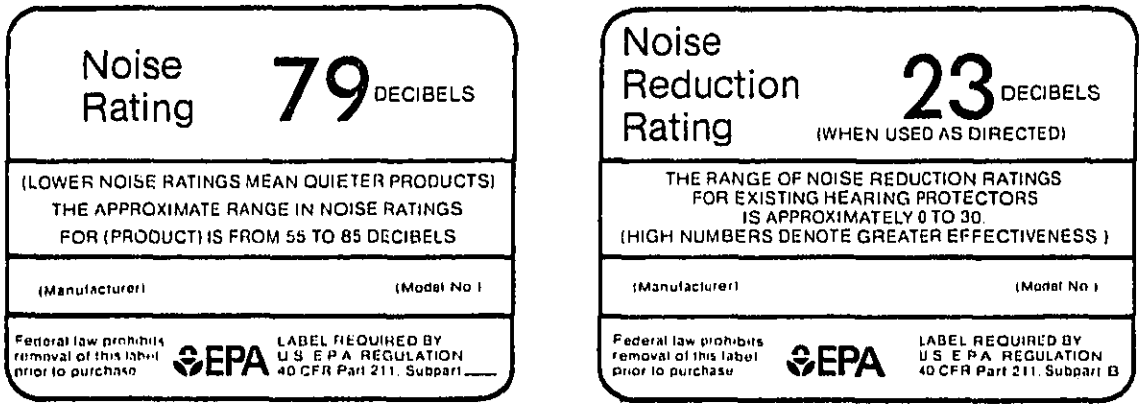


Figure 2. EPA Noise Labels

claimed "it would take some 256 current snowmobiles, all operating at wide-open throttle, to develop the sound energy equivalent to a single circa-1968 model." If these quieter machines are maintained to ensure continued quietness, the noise impact on the environment by this type of recreational vehicle should be reduced as older, noisier machines are phased out.

Amplified music was the focus of the greatest of the recreational concerns. The potential harm caused by high sound levels from amplified music raises issues for employees (including musicians), patrons, and neighbours.

Patrons of establishments with loud music go there as a matter of choice and in most cases they escape long-term exposure. However, employees of such establishments must accept repeated and continuous exposure or lose their jobs. The provincial noise regulation (Alta. Reg. 314/81) requires that all workers be protected from hazardous noise. Therefore, employers should be required to implement hearing conservation programs for these employees.

The possibility exists for patrons of discotheques to suffer noise-induced hearing loss. However, there is little evidence of any ill effects, probably due to the short duration of the exposure. In any case, if an improved situation can be created for employees and musicians, it will concurrently protect patrons.

Protection of neighbours from entertainment noise is normally covered by municipal by-laws. Regional variations in effectiveness can be found. As with other aspects of noise, for example, domestic noise, a consistent provincial regulation would be preferable.

3.4.2 Parks and Campgrounds

The problem in parks and campgrounds is that many recreational activities produce noise levels irritating to other users. For example, many people who presented briefs objected to noise from trail bikes,[132] snowmobiles,[133] stereos and radios,[134] motorboats,[135] inconsiderate behaviour,[136] and logging operations[137] in public parks.

In England and the U.S. many parks and campgrounds have special areas where quietness is a condition of use. Those who wish to have music or noise are guided to other areas. Such separation of obviously conflicting usages, where freedom of choice is available with full knowledge of the implications, lessens confrontation and probably increases the personal enjoyment of all. In Alberta, some restrictions exist on the use of motorboats on some lakes.

3.4.3 Public Sports Facilities

Large recreational events also generate considerable noise. Speedway Park in Edmonton was identified in Briefs 3 and 12 as a particularly annoying noise source. At the time of the hearings, it was located in an adjoining municipality and those most seriously affected by the noise lacked an effective framework through which to seek redress. This jurisdictional problem has probably been solved by the expansion of the City of Edmonton through

annexation and the subsequent applicability of the Edmonton noise by-law (No. 5112) to the Speedway Park area. The best way to deal with such problems, however, is through prevention by good planning. Such facilities and the associated major traffic arteries must be separated from residential areas.

In summary, the primary approaches to controlling recreational noise focus on source controls where appropriate, planning to separate noisy activities from quieter ones, and providing adequate choice so that noisy and quiet recreationalists will not interact. Advances are being made in reducing noise emissions at the source although there are problems with major types of recreation equipment, such as trail bikes, which have not yet been solved. Planning decisions involving existing or potential recreational noise sources must ensure adequate separation of those facilities from noise-sensitive areas. Further, while recreation planners at all levels (municipal, provincial, and federal) are currently separating some conflicting recreationalists, greater emphasis may be needed in this direction. People should be able to choose a quiet or a noisy campsite. The key is freedom of choice – the ability to find the type of recreational area that is preferred.

3.5 THE NOISE FUTURE FOR ALBERTA

The international experience, as pointed out previously, indicates that noise levels are increasing in space and time. This is largely due to increased urbanization and associated increases in transportation by road and air. At present, noise in our cities is increasing at a rate of about one decibel per year.

Researchers estimate that in the U.K. the number of city dwellers exposed to high levels of traffic noise will increase by 600,000 between 1975 and 1985. French authorities project an increase of 1.5 million in those exposed to high noise levels from 1978 to 1985. In the U.S. from 1973 to 1978 the percentage of the population exposed to road traffic noise greater than 65 dBA increased from 6.4 to 10 percent. It has been estimated that the total acoustical energy has more than doubled in the OECD countries in the past 20 years. Increases in noise levels have tended to be less in built-up areas where noise levels are already high. The increases have been greater in areas which were formerly quiet, such as suburban residential areas (OECD 1978, 1980).

Similar patterns have been experienced in some heavily populated regions of Canada. However, the noise-control program implemented in Ontario has resulted in a certain stabilization and, in some cases, a drop in noise levels despite continued growth.

The public hearings have shown that Alberta's noise problems are at an early stage compared with international situations. The trends, however, are similar.

Transportation noise was identified as a concern in 60 percent (94 briefs) of the presentations received. Fifty-two percent (81 briefs) raised the issue of road noise, 19 percent (29 briefs) discussed aircraft noise and 8 percent (13 briefs) pointed out that railway noise is a problem. (A number of briefs addressed more than one transportation noise issue.)

Quieter vehicles may assist in reducing the impact of vehicle noise but may not be a long-term solution to the problem. Even if the per vehicle noise decreases, it will undoubtedly be

compensated for by the increase in fleet size. A trend line projection suggests that car registrations in Alberta will increase from about 925,000 to about 1.8 million from 1980 to 2000, nearly a doubling. Similar figures for trucks are about 400,000 at present to around 800,000 nearly 20 years from now. It appears that land use planning will be the most effective method of reducing the impact of vehicular noise.

Aircraft noise received major comment in Edmonton and Calgary. Complaints in Edmonton were due to the existence of a major airport in the centre of the city and the considerable jet traffic it attracts. In Calgary, the emphasis was upon helicopter noise.

Aircraft noise can be lessened by source controls and by reducing the amount of conflicting land use. The long-term solution, however, must recognize the potential growth rate of the province. Simple projections suggest that the Edmonton Municipal Airport could be faced with about 450,000 aircraft movements in the year 2000 as opposed to under 200,000 now. Calgary is in a similar situation with possibly 485,000 aircraft movements by 2000. Changing economic circumstances may preclude this situation from happening, but the possibilities need to be acknowledged and appropriate planning measures considered.

Alberta's population is growing. By the year 2000 it may approach 3.7 million with perhaps 850,000 in each of the Edmonton and Calgary census metropolitan areas (Table 12). A doubling of the gross provincial product can reasonably be expected in the same time period (Table 13).

Conventional urban planning theory recognizes that many smaller centres tend to grow and become large urban areas, and that larger areas continue to expand due to their more comprehensive economic base. In a sense, the large centre is a predictor for the small centre.

Hearings were held in the two large metropolitan areas of Edmonton and Calgary and in the smaller urban areas of Grande Prairie, Edson, Red Deer, and Lethbridge. Over 80 percent of the attendance was in Edmonton and Calgary. In these centres, noise problems have reached a level which is severe enough to stimulate the organization of protest groups.[138] Their focus is on transportation noise, one of the most rapidly growing noise problems and one of the most difficult to control.

Similarly, the OECD experiences with mature economies provides a forecast of Alberta's future challenges. The patterns are clear from provincial trends as well as from national and international experience that our sound environment is deteriorating. Alberta's various regions are simply at different stages of development in the recognition of problems and solutions. If stabilization or possible reduction of noise is to be achieved in the future, a start must be made now or these goals will be extremely difficult to accomplish.

The solutions to these problems and the creation of quiet are discussed in the following sections.

Table 12. Alberta Population (in thousands)

Year	Edmonton CMA *	Calgary CMA *	Province **
1971	496.0	403.3	–
1972	505.8	414.8	–
1973	515.6	426.2	–
1974	527.8	440.0	–
1975	540.5	454.7	–
1976	554.2	469.9	–
1977	568.7	487.9	1,900.7
1978	582.0	505.4	1,962.8
1979	594.9	522.7	2,027.5
1985 (projection)	669.0	608.8	2,464.1
1990 (projection)	732.0	684.0	2,871.1
1995 (projection)	795.1	759.2	3,280.5
2000 (projection)	858.2	834.4	3,688.7

* Source: Statistics Canada 1972. Projection by trend line analysis

** Source: Alberta Treasury 1979:17, series 5

Table 13. Alberta Gross Domestic Product

Year	Dollars * (millions)
1973	9,269
1974	9,820
1975	10,621
1976	11,268
1977	11,811
1978	12,827
1979	14,024
1985 (projection)	18,278
1990 (projection)	22,112
1995 (projection)	25,945
2000 (projection)	29,779

* in 1971 constant dollars

Source: Alberta Treasury 1980:58

Footnotes for Section 3.1 Transportation Noise

1. Briefs 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 15, 16, 17, 18, 19, 20, 21, 22, 24, 27, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 42, 44, 45, 47, 48, 51, 56, 57, 58, 60, 62, 65, 66, 67, 69, 70, 72, 76, 79, 80, 82, 83, 84, 87, 88, 90, 91, 93, 94, 95, 97, 101, 102, 103, 104, 108, 110, 116, 117, 119, 120, 122, 123, 125, 126, 127, 128, 129, 132, 136, 137, 139, 140, 141, 142, 143, 147, 148, 149, 150, 152, 154, 156.

2. Briefs 3, 4, 8, 10, 11, 12, 13, 15, 17, 18, 19, 20, 21, 22, 24, 27, 30, 32, 33, 34, 35, 36, 37, 38, 39, 40, 42, 44, 45, 47, 51, 56, 57, 58, 60, 62, 65, 66, 67, 69, 70, 72, 76, 79, 80, 82, 83, 84, 88, 90, 91, 93, 95, 97, 101, 104, 108, 110, 116, 117, 119, 120, 122, 123, 125, 126, 127, 129, 132, 137, 139, 140, 141, 142, 143, 147, 148, 149, 152, 154, 156.

3. Briefs 3, 5, 7, 9, 11, 12, 16, 17, 31, 38, 39, 57, 60, 62, 69, 70, 80, 84, 94, 101, 102, 103, 122, 126, 136, 143, 147, 148, 150.

4. Briefs 1, 3, 4, 15, 30, 48, 72, 83, 84, 122, 126, 128, 147.

5. Brief 3.

6. Brief 15.

7. Briefs 17, 110, 139, 140.

8. Briefs 18, 91, 116, 132.

9. Brief 101.

10. Brief 104, 108, 143.

11. Brief 13.

12. Brief 30.

13. Brief 60.

14. Brief 90.

15. Briefs 79, 147.

16. Briefs 80, 82, 156.

17. Brief 152.

18. Brief 119.

19. Briefs 21, 22, 27.

20. Briefs 36, 37, 38, 39, 40, 42, 120.

21. Briefs 32, 33, 34.

22. Briefs 44, 45, 51, 123.

23. Briefs 21, 30, 33, 34, 123, 140.

24. Briefs 19, 34, 58, 69, 95, 97, 101, 108, 142.

25. Briefs 3, 70, 132, 142, 156.

26. Briefs 3, 13, 156.

27. Briefs 3, 34, 37, 39, 40, 42, 44, 45, 57, 58, 66, 70, 80, 82, 83, 84, 93, 108, 116, 126, 129, 132, 139, 140, 142, 156.

28. Briefs 35, 51, 57, 60, 62, 66, 84, 88, 93, 97, 117, 125, 142, 147, 152.

29. Briefs 36, 88, 116, 126.

30. Briefs 82, 88.

31. Briefs 27, 57, 93.

32. Briefs 3, 4, 10, 19, 34, 35, 51, 60, 62, 72, 83, 88, 97, 126, 127, 129, 137, 141, 142, 148, 149, 154.

33. Briefs 3, 10, 70, 117, 137, 141.

34. Briefs 56, 58.

35. Briefs 67, 76.

36. Brief 65.

37. Briefs 3, 8, 11, 12, 13, 18, 21, 22, 27, 30, 32, 34, 35, 47, 82, 83, 93, 97, 104, 108, 123, 143.

38. Briefs 8, 83.

39. Briefs 1, 3, 4, 15, 30, 48, 72, 83, 84, 122, 126, 128, 147.

40. Brief 3.

41. Brief 15.

42. Brief 122.

43. Brief 126.

44. Brief 30.

45. Brief 4.

46. Brief 72.

47. Brief 147.

48. Brief 48.

49. Briefs 15, 47.

50. Briefs 3, 5, 7, 9, 11, 12, 16, 17, 31, 38, 39, 57, 60, 62, 69, 70, 80, 84, 94, 101, 102, 103, 122, 126, 136, 143, 147, 148, 150.

51. Brief 3.

52. Brief 5.

53. Brief 94.

54. Brief 126.

55. Brief 101.

56. Briefs 102, 143.

57. Brief 150.

58. Briefs 57, 70, 80, 148.

59. Brief 62.

60. Briefs 69, 60.

61. Brief 84.

62. Brief 147.

63. Briefs 38, 39.

64. Brief 136.

65. Brief 31.

66. Briefs 60, 69, 70, 80, 148.

67. Brief 60.

68. Brief 147.

69. Briefs 62, 147.

70. Briefs 3, 94, 103.

71. Briefs 3, 5, 62, 94, 103.

72. Briefs 3, 5, 122.

73. Briefs 3, 5, 16, 62, 94, 101, 122, 147.

Footnotes for Section 3.2 Workplace Noise

74. Briefs 1, 4, 6, 9, 10, 11, 12, 14, 19, 26, 28, 29, 30, 32, 33, 36, 37, 38, 40, 41, 42, 44, 45, 46, 49, 53, 54, 55, 57 59, 62, 63, 64, 67, 68, 70, 71, 74, 77, 84, 85, 88, 89, 90, 102, 106, 107, 108, 115, 122, 124, 125, 126, 138, 143, 145, 146, 147, 155.

75. Briefs 1, 6, 9, 10, 11, 14, 26, 28, 29, 33, 36, 38, 40, 42, 46, 49, 53, 54, 55, 59, 62, 63, 67, 68, 70, 71, 74, 77, 85, 88, 90, 106, 107, 122, 124, 138, 147, 155.

76. Briefs 4, 12, 19, 29, 30, 32, 36, 37, 38, 41, 42, 44, 45, 57, 63, 64, 68, 70, 77, 84, 88, 89, 102, 106, 108, 115, 125, 126, 143, 145, 146.

77. Briefs 6, 14, 26, 28, 29, 38, 42, 46, 54, 55, 59, 63, 85, 106, 107, 155.

78. Brief 14.

79. Briefs 46, 59, 63.

80. Brief 155.

81. Briefs 40, 63.

82. Briefs 63, 77.

83. Briefs 6, 29, 38, 68.

84. Briefs 63, 77.

85. Briefs 62, 147.

86. Brief 138.

87. Brief 33.

88. Briefs 11, 124.

89. Brief 74.

90. Brief 122.

91. Brief 28.

92. Briefs 36, 53, 54, 74, 90.

93. Briefs 14, 29, 55, 59, 63, 106, 107, 155.

94. Briefs 59, 107, 155.

95. Briefs 38, 59, 64, 77, 102, 107, 146.

96. Briefs 4, 12, 19, 29, 30, 32, 36, 37, 38, 41, 42, 44, 45, 57, 63, 64, 68, 70, 77, 84, 88, 89, 102, 106, 108, 115, 125, 126, 143, 145, 146.

97. Briefs 32, 37, 38, 57, 84, 102, 106, 126, 143.

98. Briefs 38, 63.

99. Briefs 77, 115, 146.

100. Brief 106.

101. Briefs 44, 45.

102. Brief 125.

103. Brief 36.

104. Brief 89.

105. Brief 88.

106. Briefs 12, 30, 57.

Footnotes for Section 3.3 Domestic Noise

107. Briefs 3, 4, 19, 20, 24, 25, 30, 37, 41, 42, 51, 53, 62, 66, 70, 72, 73, 78, 79, 83, 84, 86, 87, 88, 89, 92, 93, 95, 96, 97, 99, 100, 101, 102, 109, 120, 123, 124, 131, 153.

108. Briefs 3, 4, 19, 20, 30, 37, 51, 53, 62, 66, 70, 72, 73, 78, 79, 83, 84, 86, 87, 88, 95, 99, 100, 102, 109, 120, 123, 124, 131.

109. Briefs 24, 25, 30, 41, 42, 83, 84, 87, 89, 92, 93, 95, 96, 97, 101, 109, 124, 153.

110. Briefs 3, 4, 30, 83, 84, 120.

111. Briefs 3, 4, 20, 30, 37, 51, 73, 84, 87, 88, 99, 131.

112. Briefs 3, 30, 66, 70, 72, 73, 79, 86, 87, 88, 95, 99, 100, 109, 131.

113. Briefs 53, 62, 78, 124.

114. Brief 78.

115. Briefs 84, 124.

116. Brief 93.

117. Briefs 42, 84, 95.

118. Briefs 19, 30, 84, 101.

119. Brief 30.

120. Briefs 24, 25, 83, 89, 92, 93, 109, 153.

121. Brief 87.

122. Brief 41.

123. Briefs 24, 25, 153.

124. Briefs 19, 95, 97, 101.

125. Briefs 93, 95, 97, 101.

Footnotes for Section 3.4 Recreation Noise

126. Briefs 3, 4, 12, 23, 29, 30, 31, 32, 33, 36, 38, 42, 43, 50, 51, 52, 53, 54, 56, 57, 63, 65, 68, 74, 81, 83, 86, 88, 90, 91, 95, 101, 109, 121, 127, 131, 135, 142, 147, 152.

127. Briefs 29, 50, 51, 65, 91, 109, 121, 131, 152.

128. Briefs 4, 23, 29, 38, 57, 88, 101, 121.

129. Briefs 29, 33, 36, 38, 53, 54, 56, 74, 81, 83, 88, 90, 95, 109, 135, 142.

130. Briefs 3, 12, 83.

131. Briefs 4, 23, 29, 32, 38, 57, 88, 101, 121.

132. Briefs 50, 52, 65, 91, 109, 131, 152.

133. Brief 101.

134. Briefs 109, 131.

135. Briefs 30, 109, 127, 147.

136. Briefs 56, 131, 152.

137. Brief 53.

Footnotes for Section 3.5 The Noise Future for Alberta

138. Briefs 3, 5, 13, 17, 18, 60, 66, 101.

Creation of Quiet

REPORT

SECTION FOUR

A number of factors about noise make control feasible. First, the identification of noise sources is usually straightforward. Second, the effectiveness and cost of control technologies, whether at the source, along the pathway, or at the receiver, are reasonably well defined. Third, these control approaches have a basis in well-established scientific disciplines. Considerable background and expertise in controlling noise exists in the medical, architectural, engineering, economic, and planning disciplines. This combined expertise should be effectively utilized in Alberta.

An effective noise control program must recognize that noise is a by-product of growth. As Alberta grows, so does its potential noise problem. Section 3 demonstrates that serious noise problems exist in the province now[1] and that they are growing.[2] In the future, noise will probably affect more people in additional locations unless preventive action is initiated.

This section discusses possible approaches to solving the noise problems previously identified. It emphasizes prevention rather than "Band-Aid" solutions. Details of a possible administrative structure are provided. Suggestions are made for the development of health, education, and research programs; improved use of engineering controls; introduction of economic incentives for quieter communities; and amendment of current planning processes and provisions.

4.1 RIGHT TO QUIET

Canada has a written constitution that sets out the powers of the federal government and the provinces. At the same time, it recognizes certain common-law rights, based primarily on English precedents in the English provinces. This separation of powers complicates the law as it relates to noise, as certain noise sources are controlled by the federal government and others by the provincial governments.

The common law recognizes relief from noise as it relates to one's property in the form of an action for nuisance. The remedy is usually an injunction, but damages by way of money have been granted in some cases. Plaintiffs have been successful in actions based on noise from both domestic and industrial sources. Courts have granted remedies for damage and annoyance based on noise caused by steam hammers, generators, foundry operations, quarrying, movement of motor vehicles, and operation of aircraft, among others. The concept of "reasonable user" is applied and the definition varies from location to location. The variability adds to the difficulty of success and an action can be very difficult and costly if unsuccessful.

Dean J.P.S. McLaren of the University of Calgary, Faculty of Law, has researched this phase of the law in an article appearing in *Noise in the Human Environment* (McLaren 1979). The article should be read if one is interested in the law as it relates to noise, as it outlines the difficulties inherent in such an action. Further, the common-law rights are being superseded by statutes and regulations in our modern society, and will probably be curtailed even further as Alberta becomes more populated.

In the early days in Canada and Alberta, noise controls were left in the main to municipalities to administer because of the local nature of noise in the community. The major

problems centred on disputes between neighbors, and could be covered by local by-laws or convention. The interest in noise expanded as provinces became more populated, and the provincial governments' concerns followed growth, land use, and transportation needs. Similarly, the federal government has an interest in noise, particularly in areas of inter-provincial trade, transportation, and communication. Now, concerns and jurisdictions overlap. The problems this causes can only be solved by analysis of noise sources and jurisdictions and co-ordination of control. The old common-law principles are no longer satisfactory to meet the problems of modern society or the individual. In the interest of the well-being and health of the individual, noise must be considered by all levels of government which, through liaison, must meet the problems as they arise.

4.2 ADMINISTRATION

The report *Administration and Regulation of Noise in Alberta* (Gordon 1980) describes how noise is currently administered in the province. As the report points out, a morass of responsibilities exists, at all three levels of government with many agencies involved. They include:

Federal

Canada Mortgage and Housing Corporation
Canadian Transport Commission
Consumer and Corporate Affairs Canada
Department of the Environment
Department of Justice
Department of Transport
National Research Council Canada
Standards Council of Canada

Provincial

Department of Advanced Education and Manpower
Department of Agriculture
Department of Consumer and Corporate Affairs
Department of Education
Department of Economic Development
Department of Energy and Natural Resources
Department of the Environment
Department of Government Services
Department of Housing and Public Works
Department of Labour
Department of Municipal Affairs
Department of Recreation and Parks
Department of Social Services and Community Health
Department of Tourism and Small Business
Department of Transportation
Energy Resources Conservation Board
Occupational Health and Safety Division
Workers' Compensation Board

Municipal
- By-law enforcement departments
- Local boards of health
- Planning departments
- Police departments
- Transportation departments

This multiplicity of government departments and agencies involved in controlling noise suggests a need for intergovernmental co-ordination and co-operation. The need for a more effective system was reflected in the many complaints about administration and enforcement registered at the public hearings.[3] Despite the present extent of government involvement, more effective legislative and administrative controls of noise are considered necessary to provide citizens with an opportunity to enjoy a quiet environment.[4]

Effective noise-control approaches must include planning, engineering, education, and economic programs (see Sections 4.2 to 4.5). To be most effective, these programs must utilize existing expertise and facilities within the various departments at all levels of government and must be co-ordinated.

This section establishes the administrative framework required to instigate and co-ordinate these programs. Subsequent sections will provide detailed discussions of recommended health, education, economic, and planning programs.

4.2.1 Provincial Responsibilities and the Quiet Communities Directorate

At the provincial level, at least 18 departments and agencies have administrative and regulatory interests in noise problems. Those with the most active noise-related programs appear to be the Department of Municipal Affairs, the Occupational Health and Safety Division, the Workers' Compensation Board, the Department of Social Services and Community Health, the Energy Resources Conservation Board, and the Departments of Transportation, Environment, and Agriculture. The noise-related responsibilities of the remaining departments and agencies tend to be minimal and are incidental to their other activities.

Alberta Municipal Affairs, which administers the Planning Act (RSA 1980 cP-9), can incorporate noise considerations into land use planning throughout the province. The most substantive noise-related regulations pursuant to the Planning Act are the Airport Vicinity Protection Area regulations. Various other departmental activities pertaining to noise problems include: review of subdivision proposals, preparation of municipal plans and land use by-laws for communities not included in regional planning commissions, review of regional plans, the Alberta Planning Boards' subdivision appeal authority, and provision of advisory services to municipalities regarding by-law development (see Section 4.5 for specific land use planning recommendations).

The Occupational Health and Safety Division administers the Occupational Health and Safety Act (RSA 1980 cO-2) and the Noise Regulation (Alta. Reg. 314/81) pursuant to this Act. The regulation deals with exposure limits, hearing conservation programs, audiometric testing, and responsibilities of employers, employees, and audiometric technicians. Several

branches within the Occupational Health and Safety Division have specific noise-related responsibilities. The Occupational Hygiene Branch measures noise levels and establishes whether a noise problem exists with respect to the regulation. If the noise level exceeds permissible criteria, the branch attempts to persuade the employer to improve conditions. The Medical Services Branch focusses on the workers and promotes occupational hearing conservation programs. The Research and Education Branch has a training program that focusses on preventing noise in the workplace, a farm safety program aimed at heightening awareness of noise hazards on the farm, and has produced various publications about noise.

The Workers' Compensation Board (WCB) provides compensation for hearing loss and impairment suffered by workers who are covered by WCB benefits. The WCB averages 75 to 100 long-term exposure hearing loss claims a year as well as many short-term hearing problems which require medical aid and restitution for lost time.

Alberta Social Services and Community Health administers the Public Health Act (RSA 1980 cP-27), which provides the legal mechanism to regulate noise in the public domain through Provincial Board of Health regulations. The Act provides for local boards of health to be administered by public health inspectors. These professionals are charged with the resolution of environmental health problems. There are about 120 public health inspectors in 27 health units throughout Alberta. While the inspectors do not normally handle community noise problems, greater emphasis should be placed on utilizing their familiarity with noise and related health problems.

The Energy Resources Conservation Board regulates noise from energy resource industry operations through Interim Directive 80-2. It stipulates that noise level readings shall be taken 15 metres away from any occupied permanent dwelling and establishes maximum municipal daytime and nighttime levels. Enforcement of these guidelines is related to the licensing and inspection activities of the Board.

Alberta Transportation has considerable expertise in noise-control technologies applicable to roadways. The department responds to complaints related to roadway noise, receives and reviews subdivision referrals for proposed subdivisions within half a mile of a highway, provides financial assistance for construction of noise-attenuation facilities along new roadways, and maintains long-range planning and research programs related to highway development. (See Sections 4.4 and 4.5 for specific recommendations regarding highway planning and associated financial programs.)

Alberta Environment is specifically directed in the Department of the Environment Act (RSA 1980 cD-19) to prevent noise and control noise levels resulting from commercial or industrial operations. Although this is potentially very strong legislation, no regulations have been developed under this Act and none are anticipated in the foreseeable future. The department's main activity regarding noise problems is to respond to complaints which find their way to the department. Complaints received have related to noise from air conditioners, industry, activities at industrial warehouses, heavy equipment truck routes, equipment backup warning signals, aircraft, and rail yard activities. The department attempts to negotiate a mutually acceptable solution between the complaining and offending parties.

Alberta Agriculture provides financial assistance to the noise-related farm safety program of Alberta Workers' Health, Safety and Compensation. The department's Farmers' Advocate also receives and responds to noise-related complaints. Most of these issues involve the effects of compressor station and construction noise on the dairy and poultry industries. Successful resolutions are achieved either by compensation or operation changes.

Quiet Communities Directorate

The most obvious problem with controlling noise at the provincial level is the lack of co-ordination of activities of various departments and agencies. Such co-ordination could be achieved by establishing a small agency identified as the QUIET COMMUNITIES DIRECTORATE.

The intent is that the Directorate would develop a core of technical expertise on noise control and be able to advise provincial departments, municipalities, and the general public on these matters. The Directorate should be responsible for developing noise standards regarding such things as acceptable noise levels in building design and community planning. The Directorate should also act as the basic referral point for all provincial activities with noise concerns as well as a single responsibility centre for noise complaints. It should be a resource group to which municipalities could submit subdivision plans or other plans for comments on potential noise problems. In addition, it would be responsible for co-ordinating noise concerns and programs among the various jurisdictions.

The Quiet Communities Directorate should consider its responsibilities to be as follows:

1) education;
2) co-ordination between provincial government departments, and between the province, municipalities, and the federal government;
3) advice on land use planning and a referral centre for noise planning problems;
4) the development of a model noise control by-law and other legislative measures;
5) the development of economic, research, and other programs intended to achieve quiet;
6) the design and development of alternative facilities for those who seek quiet;
7) development and enforcement of standards and regulations.

The Directorate should have an administrative director and a small staff of perhaps 10 or 12 people. Its internal structure could consist of three divisions. The first division could be responsible for developing technical expertise on noise measurement, equipment, and monitoring. The second division could be operational, responsible for reviewing all referrals, co-ordinating interdepartmental activities, designing and developing alternate facilities (particularly those with provincial assistance), and co-ordinating enforcement of noise regulations. The third division could be responsible for developing education programs, a model municipal noise control by-law, and economic programs to assist in achieving quiet communities (see Figure 3).

To ensure interdepartmental co-ordination and consistent provincial direction, the Director of the Quiet Communities Directorate should head an Interagency Quiet Communities Co-ordinating Committee. This committee should consist of representatives of all provincial departments and agencies with responsibilities and concerns in noise control.

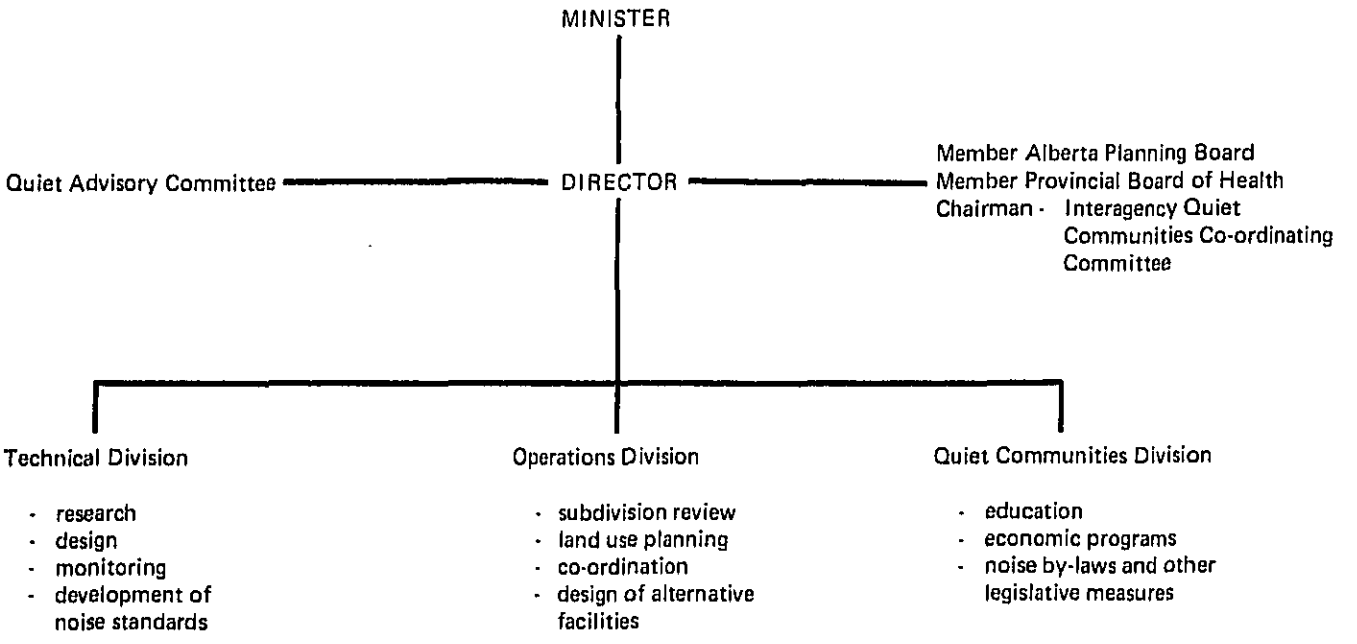


Figure 3. Organization of the Quiet Communities Directorate

The Director should also be a member of the Alberta Planning Board and the Provincial Board of Health. This would ensure that noise considerations are adequately incorporated into important land use planning and health-related issues.

It is important that the Directorate maintain public contact about noise problems, the effectiveness of programs, and future activities. Hence, a small Quiet Advisory Committee should be established with members from the general public.

The Quiet Communities Directorate should be assigned to a provincial department in order to have access to normal housekeeping facilities such as financial control, personnel administration, and general administrative support. However, the Directorate should be readily identifiable and should not be incorporated into the department's general programs. This can be accomplished by assigning a separate budget vote to the Directorate. The Legislature and public will then be able to identify program objectives, review the manpower and budget devoted to the program, and decide whether or not it is effective. Separate votes already exist within departments, for example, within the Department of Social Services and Community Health for the Alberta Alcoholism and Drug Abuse Commission.

Preferably the Directorate would be located in either the Department of Municipal Affairs or the Department of Social Services and Community Health.

The case for location in Municipal Affairs relates to:

1) the importance of planning as a tool in creating quiet communities;
2) the need to review regional plans and subdivision approvals;
3) the development of a model noise by-law and its adoption by municipalities.

The case for locating the Directorate in the Department of Social Services and Community Health is that noise is basically a health problem. The Community Health Services division is responsible for the network of local boards of health which cover the province in 27 autonomous health units. The 120 to 125 inspectors in these health units are already responsible for environmental health concerns, ranging from eating facilities to septic tanks. Public health nurses at local boards of health usually are trained to conduct hearing tests. In addition, some public health inspectors, as part of their training, are capable of monitoring and interpreting noise measurements.

Because so many of the needed technical capabilities already exist in the local boards of health, and with a network of provincial coverage already in place, the Environment Council sees a preference for locating the Quiet Communities Directorate in the Department of Social Services and Community Health.

4.2.2 Municipal Responsibilities

Currently at the local level a wide variety of local noise by-laws exist, which for the most part attempt to control individual noise makers or nuisances, such as barking dogs or noisy parties. These by-laws reflect specific community concerns but are frequently plagued by technical difficulties and a lack of enforcement.

Several participants at the public hearings suggested that a model by-law be developed. It would provide much-needed guidance to municipalities and could be easily adapted to suit individual needs and concerns while encouraging consistent province-wide control of domestic noise problems.

A successful example is the Ontario Model Municipal Noise Control By-law, which the Council found to be very effective. The by-law is in two parts. "...Part I is a simple qualitative (subjective) by-law... suitable for smaller municipalities with less complex noise problems.... Part II is a comprehensive by-law with both qualitative and quantitative portions..." (Ontario Ministry of the Environment 1978:5). Subject to the approval of the Minister of the Environment, municipalities may select elements of the by-law most suitable to them. It therefore provides a consistent regulatory framework which allows local governments to decide what level of noise control is appropriate for their area. The review of this by-law by McLaren (McLaren 1979) criticizes various aspects. However, the Noise Panel travelled to Ontario and discussed the by-law and its effectiveness in practice with both municipal and provincial government representatives. All felt it was accomplishing the objective of providing local responsibility for noise control while ensuring a consistent provincial approach.

Two important elements are essential to the effective implementation of a province-wide model municipal noise control by-law. First, in order to insure a consistent approach, all adaptations should require the approval of the Quiet Communities Directorate. However, in cases of dispute, municipalities should have the right of appeal to the minister. Second, it is essential that the Quiet Communities Directorate develop a strong educational program to inform municipal officials about the details of such an approach. One reason for the success of the Ontario model by-law is that seminars, workshops, and short courses accompany the development of the by-law. These sessions explain to civic authorities, including by-law enforcement officers, the nature of the provisions and the actions required of them, and make suggestions for effective implementation. This education component is an important reason why the model by-law is so effective and why so few problems have occurred with its implementation. The same educational requirement was emphasized by senior Environmental Protection Agency officials in Washington, D.C., as necessary for success when a new program is introduced.

4.2.3 Co-ordination of Federal Responsibilities With Provincial Activities

Jurisdiction over noise concerns is very complicated. Under the Constitution, the power to control noise seems to belong to whoever controls the source of that noise. The federal government, for instance, has jurisdiction over interprovincial transportation, communication in general, navigation, and interprovincial works or undertakings designed for the advantage of Canada or two or more provinces. Noise coming from federal lands can also be controlled by that body. The extent of federal jurisdiction illustrates the need for co-operation and liaison because many of these sources will be within a province and consequently affect people living there.

Co-ordination of noise control between jurisdictions has been identified as an important function of the proposed Quiet Communities Directorate. Evidence at the public hearings identified three major areas for which such co-ordination is particularly desirable.

The first involves occupational health criteria for all Alberta employees, whether under federal (such as post office or airport employees) or provincial authority. For example, Labour Canada has a regulation (SOR/71-584) specifying a maximum noise exposure limit of 90 dBA per eight-hour period, whereas Alberta's occupational health and safety Noise Regulation (Alta. Reg. 314/81) specifies 85 dBA for an eight-hour period. Brief 28 from a post office employee not only identified the inequity for federal employees, but also pointed to the fact that provincial labour officials are unable to assist with noise monitoring and attenuation in areas of federal authority. Negotiations with the federal government are required to provide the same level of protection to federal employees as is provided to other Albertans.

A second area of jurisdictional conflict concerns interprovincial transportation, such as aircraft activities and railways. Negotiations with the appropriate federal authorities are required to ensure that the noise levels from these facilities conform to provincial standards.

Third, federal/provincial co-operation is required to ensure greater efforts to reduce the noise-producing potential of all manufactured and imported products. The federal government should be encouraged to establish noise standards for new products, at either the time of manufacture or import. Such standards are presently used by the federal Department of Transport for some classes of motor vehicles. Application of this approach to other manufactured goods could help reduce general noise levels.

4.3 HEALTH, EDUCATION, AND RESEARCH PROGRAMS

The development of health, education, and research programs must be a primary strategy for solving noise problems in Alberta. These approaches received considerable attention at the public hearings: 25 briefs[5] related to health programs and problems, and 55 briefs[6] discussed education and information needs. Discussion of these programs follows.

4.3.1 Occupational Health and Education Programs

Comments regarding health programs at the hearings were strongly oriented toward the area of occupational noise. Brief 29 reported that good health protection service consists of: prevention, cure, rehabilitation, extended treatment of chronic disorders, and research.

Several briefs specified prevention as an immediate need.[7] Prevention was broadly defined to include approaches such as requiring pre-job screening and regular on-the-job monitoring programs,[8] taking medical histories,[9] present hearing conservation programs,[10] administrative programs,[11] using mobile testing units,[12] and defining the role of public health inspectors and the local boards of health.[13]

Five briefs identified health education as basic to hearing protection.[14] Brief 40 specified that audiometric testing is an important component of such a hearing education program.

It was pointed out that providing occupational health services in small firms is difficult.[15] Briefs 46 and 59 identified an additional problem – some trades simply assume noise is part of the job. It was also emphasized in Brief 107 that hearing problems arising from various noisy occupations have been neglected, such as in the sheet metal industry.

The effectiveness of hearing protection equipment provoked many comments. For example, some workers prefer ear plugs,[16] while others consider them uncomfortable.[17]

Several briefs suggested that supplying hearing protection and encouraging its use is the employer's responsibility,[18] while others noted this should be a job requirement.[19] A concern was expressed in Brief 107, however, about how much personal protection an individual can wear. Workers are already encumbered with hard hats, safety boots, goggles, gloves, and other protective equipment. Hearing protectors represent one more defensive element in transforming the worker into the modern medieval knight.

Many health program needs were identified at the hearings: resources for health units,[20] more noise training for health inspectors and professionals,[21] increased utilization of occupational health nurses for small industries,[22] and the need for more research.[23] Co-ordination of health criteria with planning decisions was also specified as an important requirement.[24]

Occupational noise problems are clearly the responsibility of the Occupational Health and Safety Division. While the Noise Regulation (Alta. Reg. 314/81) is among the most progressive in Canada, a number of concerns must still be addressed.

Of evident widespread concern is the lack of broad enforcement of current occupational noise regulations. As previously stated, only a minority of Alberta employees are currently protected to the levels identified in existing regulations. Action is required to extend protection to all noise-exposed workers. Although the difficulties in enforcing and extending coverage are appreciated, the Environment Council would like to see more emphasis placed on achieving fuller application of hearing conservation programs to all employment groups.

A significant suggestion at the hearings was that the Occupational Health and Safety Division explore the possibility of utilizing local health inspectors to help enforce noise regulations and develop hearing conservation programs. This co-operation could be particularly important in monitoring hearing problems and noise levels in the many small and widely scattered commercial and industrial operations across the province. As the public health units already provide blanket coverage of the province, and as some public health inspectors have noise-related training, such an accord would mean greater efficiency in the current administration of occupational health programs.

Another major difficulty with current occupational hearing conservation programs is providing adequate programs for the highly mobile industries such as oil and gas exploration or construction. The size of the work force remains fairly stable within the industrial field, but individuals tend to move frequently among different employers. In British Columbia, the Workers' Compensation Board keeps centralized health records on all employees as they move from job to job. While the difficulties of implementing such a records system are appreciated, to say that it is administratively impossible to track workers from job to job is to condemn a substantial portion of the labour force to major hearing loss during their careers. A system of continuous record keeping would be invaluable to individual workers and provincial administrators responsible for monitoring hearing programs, and for occupational health research. Development of such a system should be investigated by the Occupational Health and Safety Division.

It was suggested at the hearings that the industries and worksites which are particularly noisy be identified as needing special attention to reduce noise levels. The Council believes that there should be a requirement for these employers to develop a plan for noise abatement on their premises. Such a program is currently being pursued in some parts of British Columbia and seems to be effective. The expectation is that the development of such plans will encourage employers, familiar with their own operations and knowledgeable about the feasibility of alternatives, to achieve the optimum noise environment. However, such plans should be reviewed by the Occupational Health and Safety Division.

A significant aspect of the new occupational noise regulations is that provisions are included for educational programs and a definition is given for the noise-exposed worker. A noise-exposed worker must be supplied with, and is expected to wear, proper protective equipment and be advised by various means of the hazards which exist.

Noise-exposed workers are also required to undergo audiometric testing. This testing is done, under prescribed conditions, by an audiometric technician. The testing program provides a record of the employee's state of hearing and an opportunity for the employee to be counselled about noise hazards by a qualified individual. It provides a one-on-one educational situation with the individual being tested being alerted to the significance of the test. Unfortunately, although counselling should be expected to occur as a part of the audiometric test, it is not mandatory. Appropriate amendments should be made to Section 8(1) of the Noise Regulation in order to guarantee that counselling does occur.

There is also some concern that the present occupational health program is oriented toward the protection of speech frequencies (500-3000 Hz) only. Hearing impairment at higher frequencies is used as a warning that a continuation of exposure will eventually affect the speech frequencies. A hearing loss which is medically diagnosed as noise-induced is designated as a notifiable disease if the average hearing threshold level at 1000 Hz, 2000 Hz, and 3000 Hz exceeds 35 dB bilaterally. The Director of Medical Services, Occupational Health and Safety Division is advised if a notifiable disease occurs. Patterns of notifiable diseases which are detected will likely provoke an investigation by the agency.

The Council believes that the objective of protecting speech frequencies only should be examined. The World Health Organization definition of health quoted earlier, "a state of complete physical, mental, and social well-being, and not merely the absense of disease or infirmity" is not met by this objective. Health is affected adversely by loss of hearing in frequencies higher than those protected by current regulations. Attention should be given to extending protection to a wide range of frequencies (WHO 1980).

In summary, more effective protection of workers from the hazards of noise is needed in Alberta. This is the responsibility of the Occupational Health and Safety Division. Co-ordination with the Quiet Communities Directorate is required. These objectives could be achieved by:

1) providing the same level of protection from noise for all employees in Alberta through a program of liaison and co-operation with all levels of government;

2) utilizing local boards of health and public health inspectors to monitor noise levels in occupational settings and to provide hearing conservation programs throughout the province;

3) making appropriate amendments to the Noise Regulation under the Occupational Health and Safety Act to provide mandatory counselling at the time of audiometric testing and greater protection for frequencies beyond speech frequencies, and to require the development of noise-attenuation plans by all industries identified as particularly noisy;

4) developing a records system to provide information on the mobile workers who may be exposed to high levels of noise with little consistent protection.

4.3.2 Environmental Noise Education

Education is one of the most important elements in achieving quieter communities. The development of educational programs is identified as a priority responsibility for the proposed Quiet Communities Directorate.

The objective of public education programs is to create a better understanding of the effects of noise on our health and how to avoid or correct noise problems. Such educational programs exist in Ontario and the U.S. and they provide useful models for the development of an effective program in Alberta.

A major education effort in Ontario was closely related to the development of the noise-control program and particularly the development of the model municipal noise control by-law. The effort began with three years of public seminars throughout Ontario. Each city was contacted at least three times during this program. In addition, there are Ministry of the Environment training programs consisting of four courses in Environmental Acoustics Technology. Certificates are issued at three levels of proficiency to students meeting the various course requirements. There are also several land use planning courses including a one-week course for planners, a three-day course for those who require general knowledge of the material (for example, planning directors) and a one- or two-day course for elected officials.

In the U.S., the Environmental Protection Agency, Office of Noise Abatement and Control developed extensive education and information programs oriented toward the general public. Their major educational programs include: the Quiet Community program, which emphasizes community involvement and demonstrates techniques for local noise control; the Each Community Helps Others (ECHO) program, which helps communities through the assistance of volunteer noise-control experts from other communities; and specific educational programs developed for all grade levels in the school system; as well as an apprenticeship program. The EPA also has an extensive list of publications covering a range of interests and educational backgrounds.

One of the first objectives of the Quiet Communities Directorate should be to identify and develop effective public education programs on noise. Priority should be given to reaching:

1) individuals in existing decision-making positions such as municipal planners, architects, and municipal officials,

2) employers and workers in noisy occupational settings,

3) students in pre-employment institutions such as apprenticeship programs and colleges,

4) students in the primary and secondary school systems,

5) the general public.

4.3.3 Research

A diverse information base exists on noise, its control, and its effects. A prominent research area involves the relationship between noise and human health. The occupational health information reviewed by the Council documents noise as a cause of hearing loss. Dunn's (1979) chapter in *Noise in the Human Environment* discusses a wide range of health problems associated with noise. It also discusses how noise influences task performance and social behavior.

While the documentation of extra-auditory and social effects may not meet all tests of scientific validity (Hall 1981) there is little doubt that a knowledgeable, prudent person would avoid noisy situations, especially over a long period of time. As some public hearing participants pointed out, the situation is similar to our understanding, 10 years ago, of the dangers of smoking.

There are tentative links between exposure to noise and major extra-auditory health effects such as cardiac and blood circulation problems and other stress-related symptoms. However, these links are neither clear nor well established. The EPA in the United States provided funding to major medical research centres to identify these links and some very valuable results have been achieved. Unfortunately, further funding will not be made available in spite of the important advances made, particularly in establishing that it is a worthwhile area of research. We cannot rely, as we frequently do, on benefitting from American research. The health effects of noise are a frontier of medical research, and with Alberta's growing medical research capabilities, the province could play a leading role in world research in this area.

Enough information now exists to justify noise-control programs in both occupational and environmental settings. Medical information is not all-embracing and will require more research, such as the review of long-term records of employees in noisy industries. However, other research fields are equally important, for instance, noise sources and the use of barriers and insulation. Where funds are limited, priorities must be established and the Quiet Communities Directorate should recommend which areas are most important to Albertans.

In order to evaluate priorities in the urban setting, it will be necessary to establish baseline data about noise levels in Alberta communities. This type of data will enable an assessment

of the current situation to be made. It is also necessary so future success or failure of noise-control programs can be traced. Subsequent surveys, perhaps on a two-year basis, could be used to assist in the assessment of program success.

Loud music, particularly in bars and discotheques, received comment at the hearings.[25] There is considerable opinion but little evidence about the role of such music in hearing loss. Unfortunately, the existence of noisy taverns can lead to a reluctance to introduce hearing conservation programs in other occupational settings. It is therefore important to obtain precise information on the significance of bars and discotheques to noise-induced hearing loss. If a problem or potential for a problem exists, then preventative programs can be implemented.

Any research program requires co-ordination with research programs elsewhere. Considerable information is available from the tri-annual *Noise Pollution Publication Abstracts.* The Quiet Communities Directorate should be responsible for provincial co-ordination. On a broader scale, this program will require liaison with other Canadian groups, particularly the Ontario Environment Ministry, the National Research Council and the Canadian Acoustical Association.

4.4 ENGINEERING CONTROLS

Controlling noise through engineering applications involves design and construction so that noise levels are lowered and problems reduced or eliminated. To lower noise levels, it is necessary to describe the noise problem, determine the criteria for reducing noise levels (including how much reduction is required), identify the noise-radiating mechanism, and select the appropriate control systems.

Engineering controls may be applied in three ways. The first is to reduce or eliminate mechanical vibrations at the source. The second is to interrupt the flow of sound waves along their pathway to the receiver by absorbing or reflecting the waves so that less sound energy is received. The third method involves protecting the receiver in some fashion to block out sound. Engineering solutions selected to deal with any specific noise problem may involve one or a combination of these approaches.

Solving noise problems through engineering controls involves various costs and benefits. Both may be either trivial or very high, depending on the source, criteria for reduction and the amount of reduction required. Simple, relatively inexpensive controls may achieve a substantial decrease in noise levels in certain cases. In other situations, only a slight decrease may be achieved at a fairly high cost. The methods selected will depend on both their technical and economic practicality. Engineering controls are an integral part of administrative, health, education, economic, and planning programs.

4.4.1 Source

The scientific literature on noise states repeatedly that a variety of technological alternatives exist to reduce noise at its source. Several studies show that compared to remedial or corrective measures, controls at the source are the most efficient, effective, and economical

means of dealing with noise problems (Bolstad 1973, Britton 1980, Cunniff 1977, May 1981, *Occupational Health and Safety News* 1981, Throckmorton 1981, Wiens and Kinley 1980). To draw a comparison with medicine, preventing illness is acknowledged to be more effective than curing a disease. The same is true of noise. Eliminating the cause is the most effective solution to noise problems wherever they occur.

The need to control noise at the source through technical means was also stated clearly during the public hearings. Thirty-nine briefs by individuals, municipal leaders, planning and health authorities, labour unions, citizens' groups, and industry all expressed a preference for controlling noise at the source.[26]

Workplace Noise

Section 2 of the Noise Regulation (Alta. Reg. 314/81) under the Occupational Health and Safety Act reads:

> *An employer shall ensure that no worker is exposed to noise in excess of the Occupational Exposure Limits set out in Tables 1 and 2 by first taking all reasonable steps to institute engineering, work practice or administrative controls, and, if such reasonable steps are not effective to keep noise exposure under those limits, then by supplying protective equipment to the worker in accordance with this regulation.*

The emphasis is clearly on controlling noise at the source. Currently, however, the provincial administrative system does not ensure compliance with this provision. It is not specified who is to determine where serious noise problems exist, how much noise reduction is required, what control methods are appropriate and can be achieved, or how and when controls should be implemented. It seems that methods to reduce noise at the source are frequently overlooked on the assumption that they are too expensive and impractical to implement. Employers may simply supply workers with hearing protection, rather than determine the feasibility of controlling noise at the source.

This situation should be changed. The priority of controlling noise at the source should be emphasized. Where noise levels approach or exceed set exposure limits, employers should be required to develop and implement a comprehensive plan of control. Such an approach would allow employers to use their ingenuity and initiative to solve noise problems. Only where the assessment of the plan and problems shows that noise is still high, or where measures to control noise at the source are clearly impractical or excessively expensive, should hearing protection be supplied (after implementation of whatever source controls are possible). The objective should be to reduce noise at the source to a level low enough so that hearing protection is not necessary.

Using engineering means to control noise at the source involves designing and producing quieter tools, equipment, vehicles, and other mechanical devices. Noise can also be reduced through proper plant design, layout of work areas, and the use of sound-absorbing material.

Reducing the noise of a mechanical device involves systematically finding the parts that vibrate and dampening or eliminating the vibrations. This goal may be achieved through

innovative design or by adding dampening devices to reduce vibrations and absorb sound energy.

In most cases, engineering controls produce the best results when implemented at an early design stage rather than being added on later (retrofitted). This principle applies to either an individual piece of equipment or a production line product (Cunniff 1977). As well, changes to reduce noise at the design stage are usually more cost effective and efficient, and often result in energy savings compared with devices or equipment where noise has not been considered. On large equipment, such as trucks, construction machinery, and airplane engines, noise arises from many sources. Controlling noise therefore involves engineering consideration in the design of many different components.

Some evidence presented during the public hearings indicates that these measures are not being taken in new shops in Alberta, although great success was reported in very large and noisy plants elsewhere. A new General Motors transmission plant in Windsor, Ontario was specifically engineered, designed, and equipped so that the plant would not be louder than 85 dBA in any area, and so that any piece of equipment would not be louder than 80 dBA (Dr. T. Embelton 1981: personal communication). The noise criterion was a critical element in the specifications for the plant and its equipment. Reduced noise levels were achieved at a cost of less than one percent of the total cost of the plant. It was possible to reduce noise levels for all operations but one to below 85 dBA.

Trucks

Developing quiet trucks is a key to reducing problems of noise from highways because trucks contribute a much greater portion of noise than cars, particularly in urban areas. Making trucks quiet is possible and, in fact, is advocated by some manufacturers.[27] Canadian Kenworth Company in Brief 67 and Western Star Trucks in Brief 76 stated they have successfully lowered the noise level of new trucks to 80 dBA. Both companies feel they can produce new trucks at 80 dBA or less and be competitive, providing current noise standards are lowered from 83 dBA to 80 dBA and providing other manufacturers do the same.

Noise reduction must deal with all sources of noise from vehicles. Engine, exhaust, and gear noise from trucks are the predominant sources at speeds less than 60 to 65 km/h. At higher speeds, noise from tire/road interaction predominates.

Truck noise can be lowered by design improvements and installing suppression devices. Many different features are available to reduce noise: clutched fans, dual mufflers, residential rather than commercial mufflers for trucks used in communities, heavier walls in engine blocks, air cleaners of the proper size, shields on exhaust manifolds, double-insulated oil pans and rocker arm covers, insulated engine housings and belly pans, and radial rib tires.

Considerable progress has been made in reducing exhaust noise. Installing improved and large-diameter mufflers or dual mufflers reduces noise with no significant loss of power or efficiency, and often affords improved fuel economy. Sealed engine compartments reduce noise, but can create cooling problems, limit access for maintenance, and increase fire hazard. Clutched cooling fans that operate only when needed (about 10 percent of the time) reduce

noise by as much as 3 dBA, and also lower fuel consumption. Engine, transmission, and axle manufacturers have reduced noise through new designs, quiet sets of gears, and add-on control packages.

Retrofitting existing trucks will reduce current noise levels. Consistently good maintenance and using good-quality replacement mufflers is also important. Using the proper mufflers is very important since exhaust noise is a predominant source at lower speeds.

Interior noise in trucks is a problem for operators. This can be reduced by putting insulation on firewalls, engine covers, under floor mats, on roof and back panels, and by sealing joints in the cab.

As the speed of vehicles increases, noise from the tire/road interaction becomes more important. The amount of noise produced by either trucks or cars is complicated by "the many variables of tread design, tire prints, the surface texture of the road, characteristics of vehicle exhaust, and type of engine" (Leong 1979:129), as well as degree of tread wear, axle loading, and vehicle speed. With most trucks, road noise predominates at speeds above 65 km/h. With most cars, road noise is important only over 80 km/h.

Road noise can be reduced mainly through preferential selection of road surfaces and tire designs. On existing roads, selecting appropriate tires is the easiest way to reduce road noise. Tires with a rib tread pattern are quieter than cross-bar or pocket tread patterns and radial-ply tires are quieter than bias-ply. The problem of road noise is very difficult to solve because the surface of the road, safety factors, and costs will determine the type of tires used. In a study by the U.S. Department of Transport, "the quieter, radial, rib tires were found to be the least expensive... over a 200,000 mile projection" (Leong 1979:145).

Railways

Like the noise from trucks, community noise problems with trains can be resolved most effectively by reducing noise levels at the source. CN has been quite successful at reducing the noise from their marshalling yards in Edmonton. A shed over the main retarder, electronic couplings, modified braking systems, different brake shoes, improved mufflers, and engine heaters so locomotives can be shut down at times have all been used.

Aircraft

Reducing aircraft noise is particularly dependent upon source controls, given that aircraft overhead spread noise over wide but predictable areas. High by-pass ratio turbo-fan engines have been developed and are being installed in new aircraft, making them much quieter. For example, Brief 103 described how the de Havilland Dash 7 turbo-prop airplane was specifically designed and built to be quiet. Hush kits to modify the engine and muffler systems are also available to reduce noise effectively in older aircraft.

Brief 103 also stated that it is possible to reduce noise at the Edmonton Municipal Airport and reduce the area within the 25 NEF by 52 percent, by replacing the Boeing 737s with the Dash 7s on a per seat basis. Because the Dash 7 is so much quieter than jet aircraft, its

use has been approved for commercial passenger service at Toronto Island Airport (City of Toronto 1981) and the Aspen, Colorado airport, where jet aircraft are banned.

Snowmobiles

The snowmobile manufacturing industry has been quite successful at reducing the noise produced by their products through innovative engineering and design changes, but only as a result of pressure from the public and government. Brief 23 stated that between 1968 and 1975, technological changes to snowmobiles reduced noise levels from over 100 dBA to 78 dBA, with some levels down to 73 dBA. This improvement was achieved through modifications to engines, muffling systems, and design of engine components.

Motorcycles

Manufacturers of motorcycles have also been successful at designing and building some quiet machines. Noise levels in some cases have been reduced considerably. Brief 65 mentioned that some new models are quieter than many cars. Noise of some larger motorcycles has been reduced to 70 dBA at 50 feet. However, motorcycles designed for both on and off-road use and strictly off-road machines are much noisier. Often, these machines are too noisy to be used in areas sensitive to noise. People using them on the streets, and in areas where recreational conflicts arise, still cause noise problems and disturb other people.

4.4.2 Pathway

Engineering techniques may also be applied along the pathway from the source to the receiver. If measures to reduce noise at the source are inadequate, too expensive, or technically too impractical to achieve desired levels of noise reduction, then pathway controls should be considered.

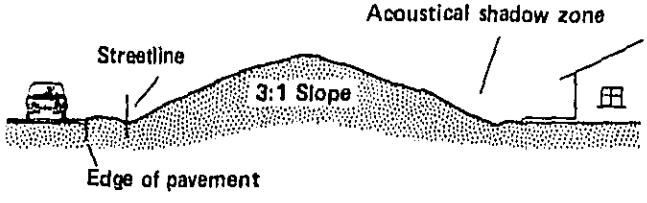
Berms and Barrier Walls

To reduce noise from road traffic and railways, pathway controls may involve building barriers to block sound waves or leaving wide strips of open space. Barriers may consist of berms (long mounds of earth) or steel or concrete walls built parallel to a road or railway either during or after construction (Figure 4). Designing berms and barriers into new facilities and subdivisions is preferable to retrofitting. Barriers must be designed properly and be located in new residential areas where they would be most effective.

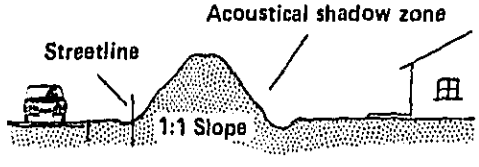
In most situations, berms and barrier walls may reduce noise by 6 or 7 dBA. On roads or freeways with high levels of noise, this amount of reduction may be insufficient to create a favourable soundscape in adjacent residential areas. The effectiveness of berms and walls can be reduced drastically by atmospheric conditions.

Berms and barrier walls are very expensive in relation to their limited effectiveness. Berms can usually only be incorporated into new road construction since they require a strip of land 60 to 100 feet wide at the base, depending on height and slope.

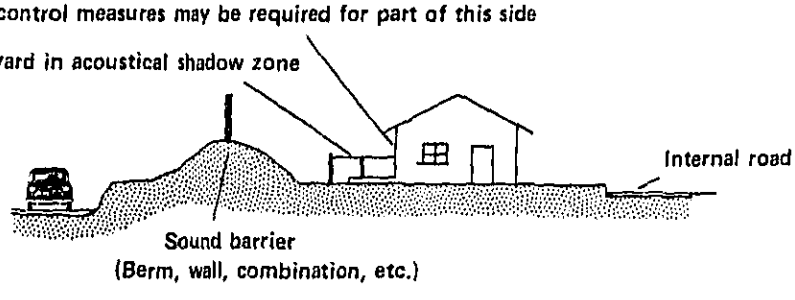
Height is the critical factor with berms and barriers. To be effective, they must be high enough to block the line of sight between the noise source and the receiver, allowing for the



With sufficient spaces, wide landscaped berms may be built



With limited space berms must be narrower and higher and reinforced with stone or other material to prevent erosion.



Sometimes concrete or steel walls on top of small berms are used to reduce noise effectively

Figure 4. Berms and Barrier Walls

Source: Berms - Edmunds et al. 1979, Barrier Walls - Manuel 1979

vertical exhaust stacks on large trucks. They also require maintenance, which normally involves ongoing costs for local governments. Barriers built on both sides of the road may be ineffective, as sound may be reflected over the opposite side. Trees and shrubs on top of berms also reduce their effectiveness. City officials, highway planners, and developers often prefer to use features other than berms and barrier walls to reduce noise.

Road Design

Features can be incorporated into highway design and engineering to reduce the level of noise reaching a residential area (Figure 5). Depressing the roadway, leaving a wide space for berm construction, putting in as few traffic lights as possible, using special asphalt surfaces, and minimizing the potential for bumps through high-quality construction are useful techniques. With four-lane roads, avoiding the use of a wide median strip will help to provide extra space between the travel lanes and any noise-sensitive uses beside the road. For truck routes through residential areas, the techniques outlined may be essential to reduce noise problems.

Barrier Blocks (Residential, Commercial, and Institutional)

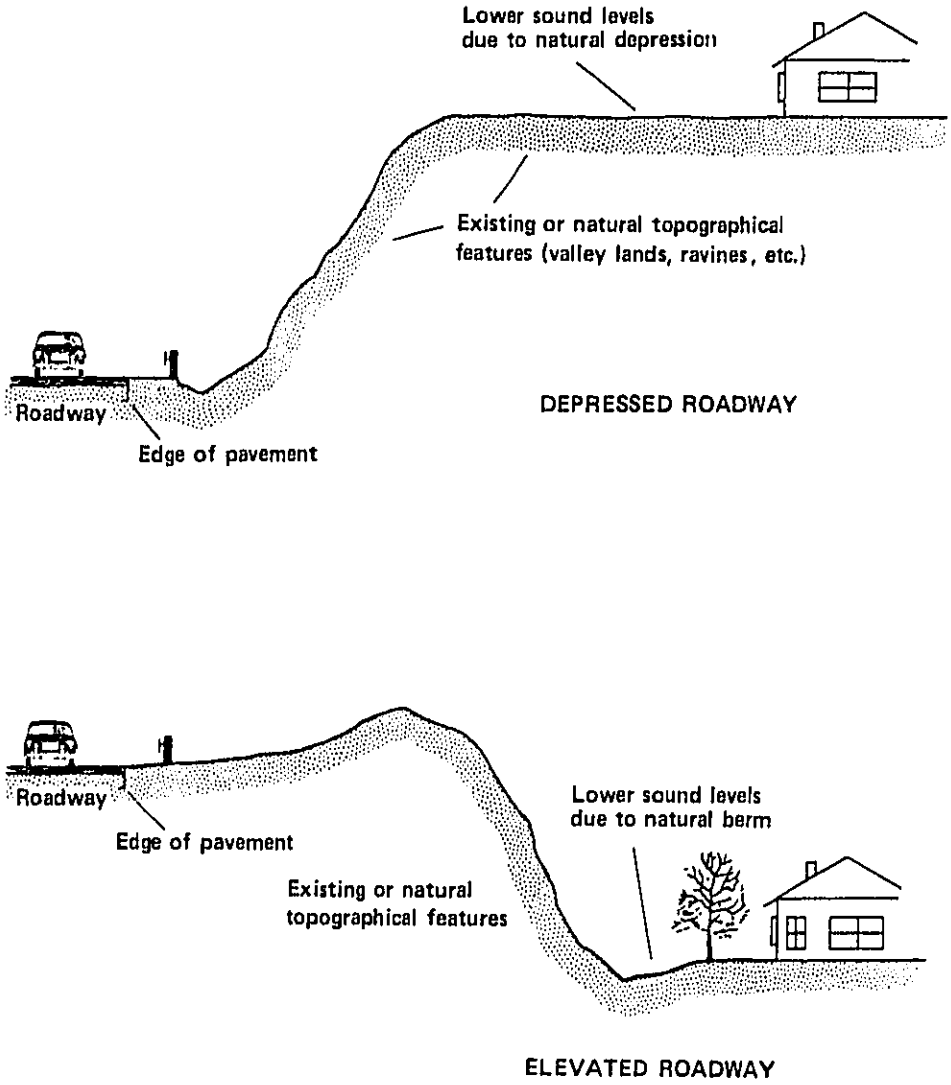
Barrier-block buildings can be built along a road, freeway, or railway to act as an effective noise barrier (see Figure 6). They make favourable use of adjacent land and may either be designed into the land use planning process for new development, or constructed during redevelopment schemes. Barrier-block buildings also hold out the possibility that, through increased density or an increased variety of uses, it might be economically attractive for private enterprise to undertake such developments.

Barrier-block buildings must be specifically designed to reduce noise on the side of the building away from the source. They must also include design features which reduce transmission of noise to the inside of the building. As few openings as possible should be placed on the source side and if included, should consist of triple-glazed, sealed windows, and insulated and specially sealed doors. The blank walls should be of heavy material such as brick or concrete, double cored, and possibly insulated.

Although these buildings shield community residents from the noise source, problems may arise. Residents frequently object to the height, density, shading, and increased local traffic which the barrier-block buildings create. However, as discussed in Section 4.4, in areas with particularly serious traffic noise problems, barrier blocks may be the only feasible solution.

Vegetation

Barriers of trees and shrubs have been suggested as a method of attenuating noise. However, a great deal of land is required for this to be effective. In Alberta, the value of narrow vegetation barriers relates more to psychological benefits than to noise-attenuation characteristics. Trees can aggravate the situation by acting as deflectors.



Road design may incorporate topographic features to depress or elevate the road to reduce the effect of noisy traffic.

Figure 5. Roads Designed to Reduce Noise in Residential Areas

Source: Edmunds et al. 1979

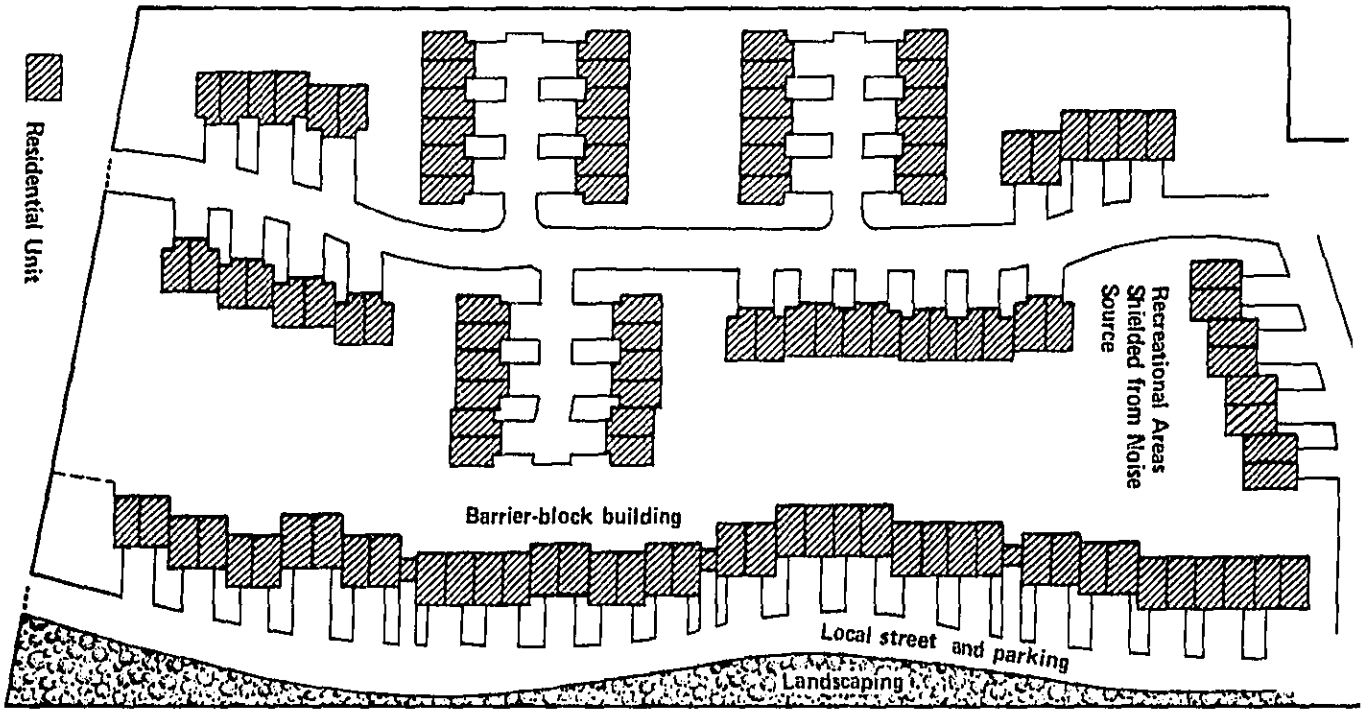


Figure 6. Effective Use of Residential Buildings as Barrier Blocks

Source: Manuel 1979

Workplace

In the workplace, controlling noise along the pathway may involve installing acoustic shields or walls between the source and the worker, or constructing enclosures or protective booths to isolate workers while they are operating noisy equipment. The maintenance of such protective devices is extremely important. For example, a half-inch hole in the acoustic insulation between the transmission and the operator inside a tractor cab can nullify most of the gain in quiet (Snellon 1976). Other measures include special shrouds or coverings around noisy machines, acoustic wall treatments inside plants or large baffles and silencers to absorb energy in noisy open shops.

4.4.3 Receiver

The third means of reducing noise problems is by protecting the receiver. In the workplace, this usually involves personal hearing protectors – earmuffs or ear plugs (Figure 7). The Noise Regulation requires that workers exposed to 85 dBA for more than eight hours must wear hearing protection supplied by the employer. Technical aspects of hearing protectors are described in detail in *Noise in the Workplace* (Throckmorton 1981).

At home, protecting the receiver from environmental noise involves the designing and constructing of residential buildings to attenuate noise and create quiet living space indoors. Different types of construction are required to create quiet conditions indoors, depending on the soundscape outside.

Building Standards

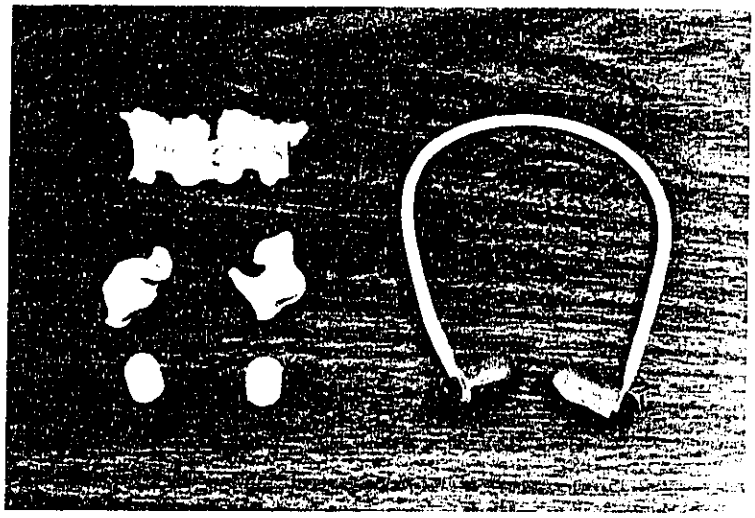
The national and Alberta building codes specify standards of construction to limit noise transmission through walls or floor/ceiling structures between units in a multi-residential building. The codes require a sound transmission class rating (STC) of 45 or better. This provision, passed in 1941, means that a dividing wall must be able to reduce levels of sound measured from one side of a partition to the other by 45 dBA. Table 14 lists various wall structures and their STC ratings. The higher the STC rating, the better the noise-control performance.

The STC 45 rating system is based on tests conducted in a laboratory of a variety of properly constructed walls. It does not take into account problems that arise at the building site, particularly during construction. Unfortunately, poor construction practices, inadequate building inspection, and obvious disregard by contractors for the wall requirement result in frame apartment blocks having inadequate noise attenuation. In concrete buildings, inter-unit noise is rarely a problem, as the mass of concrete attenuates noise well.

Two experts pointed out that the building codes are inadequate to ensure that proper noise attenuation occurs (Mr. L. Frank, in Brief 64 and Dr. David Quirt: 1982, personal communication).

Standard STC ratings of 50 to 55 have been adopted in New York City, Scotland, and Denmark and represent a reasonable objective for multi-family dwellings in Alberta. These

Ear Muffs



Ear Plugs

Figure 7. Hearing Protectors

Table 14. STC Ratings of Various Wall Structures

Wall	STC (dBA)
Single wood studs, single layer of 1/2" gypsum board on both sides, no insulation	34
Single wood studs, single layer of 1/2" gypsum board on both sides, 2-1/2" glass fiber insulation	37
Single wood studs, single layer of 5/8" gypsum board with resilient channels on one side, no insulation	38
Single wood studs, double layer of 5/8" gypsum board one side, single layer other side, resilient channels on one side	43
Staggered studs 24" O.C., single layer 1/2" gypsum board both sides, 2-1/2" glass fiber insulation	46
Single wood studs, 5/8" gypsum boards each side, resilient channels on one side, 2-1/2" glass fiber insulation	48
Single wood studs, 5/8" gypsum board both sides, resilient channels on both sides, 2-1/2" glass fiber insulation	50
Staggered studs, double layer of 1/2" gypsum board both sides, 2-1/2" glass fiber insulation	53
Double wood studs, single layer of 1/2" gypsum board both sides, 3-1/2" glass fiber insulation	56
Double wood studs, double layer of 1/2" gypsum board each side, 3-1/2" glass fiber insulation	63

Source:

1. Fiberglas Canada Ltd. 1977
2. Dr. David Quirt. Personal Communication, 24 March 1982

levels are already achieved in high-quality multi-family construction (high-rise units) where massive cement or masonry elements must be used. They can also be achieved with lighter frame construction if the components are properly designed and installed. If similar STC ratings were adopted in Alberta, even poor construction techniques (such as openings for electrical outlets that destroy the integrity of the units) could be tolerated. Action in this field should be pursued by the Quiet Communities Directorate with the National Research Council, which is responsible for the national building code.

In Canada, thermal insulation is a major consideration in the construction of outside walls. As a result, outside walls have insulation and an extra layer of siding that attenuate noise. A layer of brick veneer is particularly effective in attenuating noise.

Windows are the most vulnerable area for penetration of noise. Again, however, windows designed for thermal insulation serve to reduce noise. In order to keep out noise, windows must be sealed to prevent all air leaks. Thermopane windows are more effective than single layers of glass, while three layers of glass perform even better. The most cost-effective window for thermal and noise insulation is a one-half inch thermopane window located on the inside of a window cavity and a single pane on the outside of the cavity, with at least three inches of space between them. Layers of glass of different thicknesses also help to reduce noise.

In existing residential areas, creating quiet inside the living space can involve selecting from several different control methods. Options include constructing berms, barrier walls, or barrier-block buildings, retrofitting improved windows into existing buildings, and adding insulation to existing walls. In Brief 8, the City of Edmonton indicated it would consider adding insulation to houses over the long term in existing areas in order to meet minimum standards for noise levels indoors. While the cost per building of acoustic reinsulation is quite high, it may be the only option available in some cases. If it is necessary to have sealed windows or to keep windows closed against outside noise, central air conditioning must be added to provide adequate ventilation.

4.5 ECONOMIC PROGRAMS

It has been clearly established that noise has a substantial economic impact. Mostafa Tolba, in his 1981 annual report on major environmental problems from the United Nations Environmental Centre in Nairobi, pointed out that the economic impact of noise equals the economic impact of air pollution on a worldwide basis (Tolba 1981).

In Alberta, where population density is generally low and our major urban centres do not have the traffic densities or industrial operations to the extent experienced in older centres, the economic impacts of noise are nevertheless substantial. InterGroup Consulting Economists found that the total average annual damages from noise amounted to between $108 and $114 million per year, with a present value over a 20-year period of $1.46 billion (at a 4 percent real discount rate) (Wiens and Kinley 1980). However, in spite of this sizable economic damage, we have done little to combat noise or create quieter communities. Normally when people sustain losses that are substantial and continuing, they attempt to rectify the situation either through complaints, political action, or other means. There is little evidence that these approaches have been used to any substantial degree in Alberta.

This is due in part to the nature of noise itself. Those who suffer economic losses from noise tend to be either localized (resident near a truck route or beneath an airport flight path), or in an occupation where noise has traditionally been one of the inherent hazards of the trade.

Unlike air pollution, noise is not transportable. Therefore, if one is sufficiently removed from the source, there is no adverse impact. Conversely, air pollution is transportable and has the potential to endanger all citizens within a region. Further, air pollution is perceived as life-threatening whereas noise has been characterized as a nuisance. This impression is probably erroneous. In addition to hearing loss, which is a serious health hazard, noise is increasingly being linked to other health problems, particularly those associated with stress (Dunn 1979).

4.5.1 Economic Theory of Noise Control

Economics involves making choices, often with varying degrees of knowledge and information. With adequate knowledge of economics, it should be possible for a rational person or organization to make appropriate choices if all the benefits and costs of those choices return to that person or organization. Such decisions are considered to be internalized.

In contrast to this is the situation where the impact of decisions falls elsewhere. These external impacts or externalities often receive inadequate consideration in day-to-day decision making. The best decisions are likely to occur when the benefits and costs are internalized.

For example, if one had a high tolerance for noise and a high regard for capital investment, one might deliberately choose to purchase a home adjacent to a truck route or freeway. In this case, the discount available for the residence might be considered sufficient to compensate the purchaser for the disturbance from noise at that location. The economist would say that this was merely the working of the market. The purchaser would have weighed the cost and the benefits and decided that the benefit of a lower price for the residence was worth, in his scale of values, the cost of the noise associated with that location.

A similar situation occurs with the Edmonton Municipal Airport. In this case, the City of Edmonton owns and manages the airport and all of the people who suffer from the noise of operations reside within the city. It would be possible for the City to substantially reduce the noise of airport operations by, for example, eliminating the use of jets, particularly the Boeing 737s used in PWA's Airbus operation.

If the City insisted that over a period of five years the Boeing 737s be eliminated from the municipal airport and be replaced by the quieter Dash 7 or similar planes, the number of flights required to replace that service would be approximately doubled. The resulting noise levels, however, would mean that very few people in Edmonton would have any cause for complaint about aircraft noise.

It is true that the Dash 7 takes 15 minutes longer to fly from Edmonton to Calgary. However, since the number of flights would have to double, the convenience to passengers would remain about the same. Where aircraft scheduling is presently on the half hour, it would be

every 15 minutes; where scheduling is an hour apart, it would be replaced by a half-hour service to move the same number of people with smaller planes. The increased level of flights would mean that the convenience of moving between these two major centres would be similar.

This equation demonstrates that the City of Edmonton has complete power to decide whether or not the inconvenience and harm suffered by the residents under the flight paths of the Municipal Airport are balanced out by the convenience to the airline and the air-travelling public.

In both the house purchase and airport examples, the costs and benefits of noise revert to the appropriate decision maker and the results are internalized. There may be, however, some difference in the ability of these two different decision makers to analyze the situation. The information base for the City's airport decision is very likely more accurate and comprehensive than the information base for a decision by the homeowner (possibly a first-time buyer). The City should be able to accurately assess whether the noise experienced by city residents is sufficiently compelling to warrant resolution of the problem. Recently, the *Draft Edmonton Area Aviation Master Plan 1981* has improved the information base upon which the City can make a decision. The plan clearly identifies the noise implications of expanding or reducing Boeing 737 operations at the Municipal Airport (Matson 1981).

In those cases where the decision is not internalized, the economic consequences are more substantial. This situation occurs when someone who previously had a quiet home on a little-travelled route finds that the noise level rises substantially due to expansion of the road or its designation as a truck route. The home was purchased in the belief that the area was sufficiently quiet to provide the utility or satisfaction that was sought. Subsequent actions, over which the homeowner had no control, changed the nature of the area. This person is in a lose/lose situation. If he wishes to relocate to a quieter area, he may not be able to obtain the price for his property that could normally be expected if the original level of quiet prevailed. If he remains at the location, the noise level may be unacceptable and he pays the cost in interrupted sleep, disturbed outdoor activities, and possible health deterioration. A break-even economic choice is impossible.

4.5.2 Cost Effectiveness of Various Approaches to Controlling Noise

Many methods exist to reduce or eliminate noise. The traditional approaches include source controls, retrofit, and land use regulations. Undoubtedly new approaches and techniques will be developed. Each can be rated on the basis of cost effectiveness; that is, the relative cost to reduce noise impact, measured by some standard such as dollars expended per decibel reduction.

Source Controls and a Buy Quiet Program

Controlling noise at the source recognizes that prevention of the problem is often the best solution. It is generally less expensive than control along the pathway or at the receiver. The unit cost for controlling noise in new cars, trucks, and motorcycles is relatively modest. However, the division of jurisdiction between the federal and provincial governments makes

it difficult to administer source controls. Alberta generally does not produce the machines or facilities which generate noise. Vehicles we use and construction equipment we require are purchased mainly from other provinces or countries. In the Environment Council's opinion, the chances are slight that the federal government will provide a solution to our noise problems in the foreseeable future through source control regulations. We assume that little reduction in the noise level of trucks will be forthcoming, particularly as the major supplier is the U.S., and as the role of trucks in our society will remain essentially unchanged. This means that the impact of individually somewhat quieter trucks will be largely eliminated by their increased numbers carrying greater volumes of goods.

However, the provincial government may be able to influence source noise levels by promoting a Buy Quiet program similar to that developed in the U.S. The American Buy Quiet program tries to bring to purchasing agents at local, state, and federal levels, the knowledge that products vary in their noise levels, and that it is only by asking for quieter products that the market will begin to supply them.

For example, alternatives exist now in the purchase of trucks. According to the Environmental Protection Agency, trucks off the assembly lines of some manufacturers have now lowered noise ratings from the 80 to 83 dBA level down to about 75 dBA. Simple modifications on some vehicles can drop noise levels by 5 to 6 dBA. If noise consideration becomes part of the purchasing decision by major purchasers, suppliers would very likely respond.

Although some quiet machines are more expensive than ordinary models, in many instances, they are price competitive or only slightly higher in cost than the noisier product. Obviously, as long as purchasing agents for governments do not specify that the quietest product will be given preference, the suppliers will ignore that particular factor in making bids on the equipment required. If provincial and municipal purchasing agents were even to indicate that quieter products would be given preference when pricing is uniform, there would be an incentive for manufacturers to produce a quieter product in order to be more competitive. For example, the total provincial government market for equipment is significant. The Alberta Government spent approximately $12 million on cars and light trucks and approximately $70 million on graders, caterpillars, and heavy equipment for the 1981 model year. If a program were developed which provided some competitive advantages to quieter products, the effects could be very positive. The impact, of course, could be multiplied if other provinces and the federal government followed Alberta's lead. The Council believes that a Buy Quiet program has important potential benefits for Alberta at relatively low costs. Its implementation should be part of the responsibility of the Quiet Communities Directorate.

Retrofit

The most expensive solution to noise reduction is probably retrofitting. There are many different forms of retrofitting, but in relation to traffic noise the concept refers to the attempt, after roads have been built or widened, to provide protection from noise, essentially as an afterthought to the planning and construction process. For example, it is possible to provide berms and barrier walls between a heavily travelled road and a residential population. This has the potential to reduce noise levels by as much as five or six decibels for the residences that are immediately adjacent to the noise source. It is also possible for homes originally

constructed with little noise insulation to have new noise-attenuation features added. Both of these approaches are possible and effective in varying degrees, but tend to be extremely costly. Berms, for example, by their nature require extensive land areas in order to reach the height needed to provide protection to residential dwellings. If this land is alongside a newly expanded throughway or major arterial, the acquisition of a number of residential units may be necessary, with associated high land costs. Due to the land cost factor, barrier walls are frequently adopted as an alternative. Barrier walls, however, are extremely expensive to build. While they provide privacy, they also create maintenance problems such as snow accumulation, corrosion from salt splash, and regular painting.

Land Use Considerations

When a road is widened or receives increased traffic and is bounded by sensitive uses such as single family residences, changes in land use should be considered. For example, if the single family zone that borders a heavily used arterial is changed to commercial, the less noise-sensitive commercial uses could act as a barrier between the remaining residential areas and the arterial street. While this is not a universal panacea, it might be an appropriate and effective solution in some situations.

Rather than changing the land use, a change in density may enable better noise-attenuating designs. Again, consider the example of a single family or relatively low-density residential area bordering a very heavily used and noisy street. If the density could be substantially increased, it might become profitable for a developer to purchase the properties, remove the existing houses and replace them with acoustically designed townhousing, apartment housing, or variants, in the high-density mode known as barrier-block buildings. Indeed, a condition of rezoning should be an agreement that the design of replacement housing will provide adequate sound attenuation. It then would be possible to shield both the residents in the high-density units and the people remaining in the adjacent residential areas from the effects of noise from the busy arterial (Figure 8). There are a number of examples of the successful application of these approaches in California and Toronto.

It must be noted that barrier-block buildings are not a universal solution. In some instances, the residents in the interior of the block would find a set of high-density units more distracting and unpleasant than the noise. In situations where major deterioration of the residences adjacent to the arterial has occurred, however, this may be the only effective solution.

This brief economic analysis of source controls, retrofit approaches, and land use considerations demonstrates the need for competent evaluation of the economic implications of the various control approaches. In particular, the Council expects the Quiet Communities Directorate to become a centre of expertise in noise-related land economics and to work closely with municipal authorities in identifying where these approaches are appropriate solutions to particular planning problems.

To illustrate how the economics of these various approaches may be evaluated, an example concerning traffic noise problems follows.

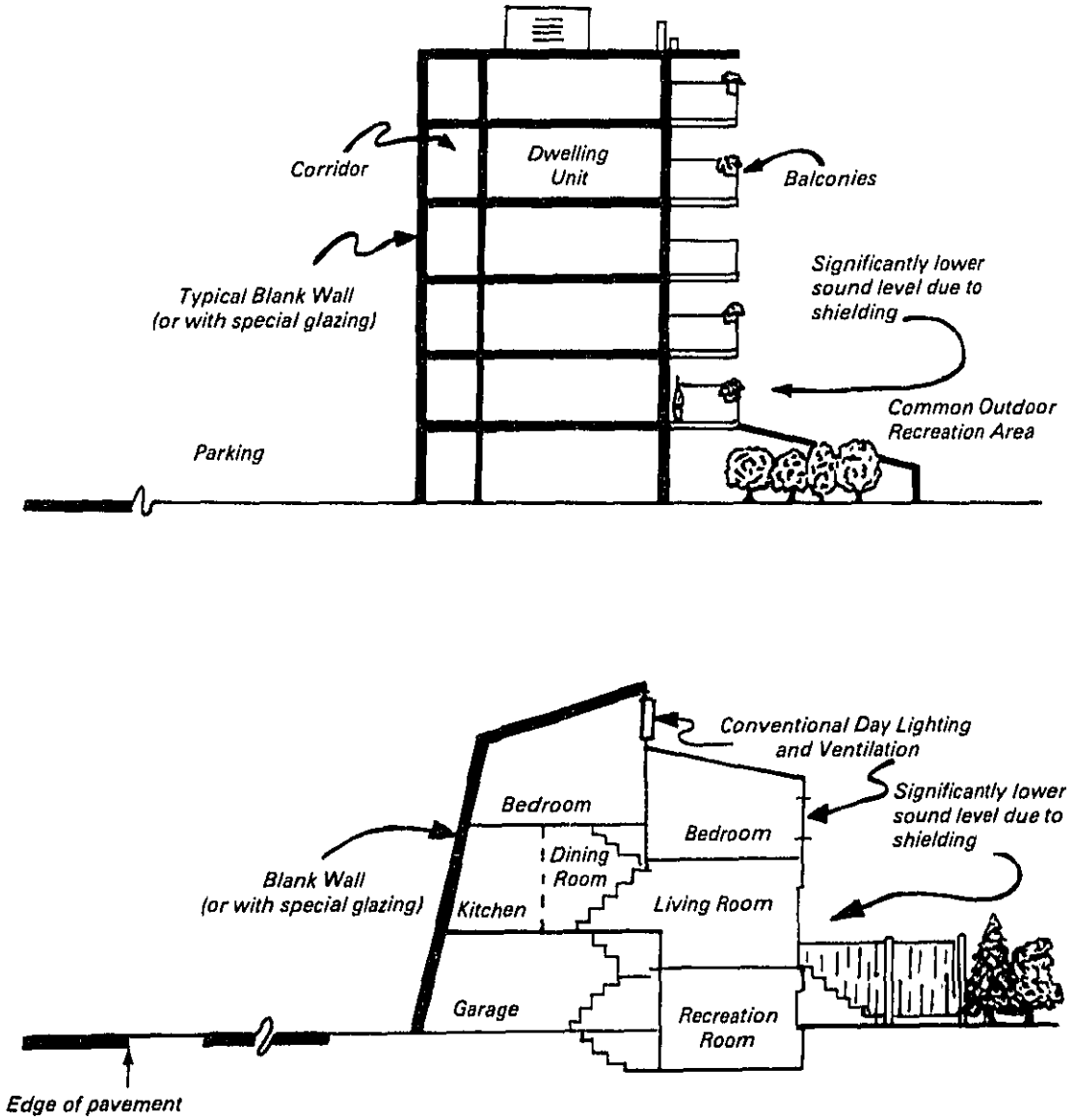


Figure 8. Designing Buildings to Attenuate Noise

Source: Manuel 1979: Figure 6

4.5.3 Case Study of Traffic Noise

Truck routes being a disturbing urban noise source was one of the most frequent complaints voiced at the public hearings (mentioned in 33 briefs).[28] The Council heard from residents along 99th Street and the Whitemud Freeway in Edmonton, along Glenmore Trail and Highway 1 in Calgary, and to a lesser extent (since traffic volumes are lower), from other municipalities such as Grande Prairie, Edson, and Red Deer. Possible control approaches include diversion, retrofit, and compensation and information.

Diversion

The residents' most common reaction is to ask that the truck route be relocated. This approach could provide an acceptable solution providing every effort is made, in the design of the alternate facility, to reduce noise generation by using topography, depressed roadways, berms, barrier walls, and careful allocation of uses bordering the new road.

This solution, however, requires that a new route be needed, not to solve noise problems, but because the existing route is inadequate or ineffective for new population levels or distribution. Constructing new freeways or truck routes simply to reduce noise levels on existing routes is not economically feasible. However, when a new route is being constructed to meet future traffic demands of a growing urban area, it would be foolish not to use the opportunity to solve old problems and prevent new ones from arising.

A more difficult problem is presented by situations such as 99th Street in Edmonton. Here, a north/south truck route to the city centre is required. Ninety-ninth Street was settled early in Edmonton's history, particularly the portions just south of the river valley, when today's volumes of cars and trucks were literally unthinkable. Low-rise apartments with only minimal sound insulation were constructed right up to the sidewalk. The result is that sleeping quarters are as little as 20 feet away from the travelled right-of-way.

What commends 99th Street as a truck route is its location in relation to southern industrial zones and the central business district, and most particularly, its relationship to the Low Level Bridge (recently increased in capacity). It fits in well with origin/destination demands, river crossings, and street capacities. The resulting noise problems are borne principally by the residents and landowners along its length. In this case, the alternatives are few and carry substantial penalties.

An increase in truck traffic on a street which already has significant truck traffic carries little penalty in terms of excess noise. This is due to the peculiar physics of noise. Once a street is well travelled (say 30,000 cars and trucks per day), doubling the traffic increases the noise level by approximately 3 dBA (Leong 1979). This increase would be detectable but would not necessarily be considered troublesome depending on the initial level of noise. The higher the initial level, the more a 3 dB increase would be noticed (Dick Winkelaar 1982: personal communication).

This characteristic of noise argues for the concentration of traffic on relatively few routes, where traffic volumes are already high and preferably where roadway and verge design has

provided for sound attenuation. As a principle of noise control, traffic and trucks should be concentrated on as few routes as possible. Those routes should be designed to high standards of noise attenuation. The alternative of diffusing traffic over many routes would bring little relief to already well-travelled routes, since the physics of noise works in reverse as well. The route with 30,000 vehicles per day would have to have its traffic cut in half (to 15,000 vehicles per day) before noise levels would be reduced by 3 dBA, again a barely detectable reduction in sound.

This is one of the more compelling arguments in favour of the traffic engineers' concentration on a system of expressways, major arterials, and designated truck routes. The more traffic is concentrated, the smaller the area and the fewer the people impacted by high noise levels. The more road traffic is diffused, the greater the area and numbers of people impacted by excessive noise.

Diversions of traffic to new routes can create problems. For instance, if trucks are diverted from the shortest route between origin and destination, fuel consumption will increase. It might also mean they would be diverted along a number of quiet roadways to reach alternate major arterials, thus disturbing a greater area and more people. As a result, priorities must be established and reviewed by traffic engineers and others, including the public.

Some partial measures could also provide relief. Barring trucks during the quiet hours, perhaps from 2200 to 0700 hours, would reduce noise impacts at the time when their intrusion is greatest. Again, however, there are penalties and spillovers. Many drivers prefer to travel at night because traffic volumes are lower, higher speeds can be maintained, and supplies can be delivered at the start of a business day. Trucks, therefore, are unlikely to stop movements; they would instead use the routes left available to them, with the result that the spillover effects mentioned previously might be increased during the quiet hours on alternative access routes. In addition, the increasing pattern of shift work in industry is of concern. It is estimated that about 15 percent of the work force now works at night and would receive little benefit from quieter nighttime conditions, yet would suffer the problems of a noisier daytime situation.

In summary, it is clearly preferable to divert traffic and trucks to available alternate routes, which are better designed to attenuate noise. The associated problems include:

1) very large volumes of traffic must be diverted if any substantial reduction in sound levels is to be achieved;
2) unwanted consequences arise from the diversion of trucks and traffic from their preferred route between origin and destination which must be carefully considered;
3) timing of construction of alternate routes depends on rates of growth of the city and of traffic, and on financial constraints. Noise relief, if it enters into consideration at all, would have very low priority as a reason for constructing a road or moving up its timing.

Retrofit

Retrofitting is the attempt to reduce noise after the fact. Although reasonably effective under certain conditions, it is usually an expensive solution, with the possibility of unwanted,

unexpected, or unpleasant side effects. When dealing with roads, the following retrofit methods are possible: berms, barrier walls, barrier-block buildings, and acoustical insulation. (See Section 4.4 for descriptions of these methods.)

The economic drawbacks of each method are:

Berms require extensive land areas to provide the effective height necessary for protection.

Barrier Walls are aesthetically unpleasant unless materials are carefully chosen, can be expensive to maintain, collect litter, and can deteriorate due to corrosion.

Barrier-Block Buildings have essentially blank, heavily sound-insulated walls and windows facing the traffic. They have the advantage of utilizing land adjacent to heavily travelled roads. They can be extremely effective sound barriers, both for the uses within them (usually multi-family dwellings, though office, commercial, or light industrial uses are also possible) and in protecting interior blocks from traffic noise. However, like berms and barrier walls, barrier-block buildings must be continuous to be effective. Any breaks between buildings, such as access roads, will act as sound tunnels, directing noise into the interior blocks. They are probably cost effective.

Acoustical Insulation can be very expensive. It has the advantage of also providing some thermal insulation value. Unfortunately, it does nothing to make yards or play areas more habitable.

A question that arises at this point is the extent of the Alberta Government's involvement and degree of obligation to assist with retrofitting. Transport between inhabited areas of the province has been acknowledged as the responsibility of the provincial government. Within cities, only a few routes are considered part of the provincial highway system — usually the numbered highways. The province provides financial assistance for the construction and maintenance of these routes. In the construction of new provincial highways through cities (such as the Yellowhead Trail in Edmonton or the Deerfoot Trail in Calgary), the province will provide funding for noise-attenuation features such as depressed roadways, berms, etc. This seems reasonable since designing noise-supression features into new roadways is cost effective and, if it is backed up with wise land use allocation by the city, can prevent noise problems from arising in the future.

The Council is in no position to recommend the level of cost sharing that is appropriate. This is an extremely complicated matter that must be the subject of continuous negotiation between the cities and the province. However, the Council believes that in principle, noise-attenuation costs should be treated in exactly the same way as any other element of design for new freeways, and the cost shared on that basis. The Council also believes the province has an obligation to insist that municipalities not permit uses along the highway that could create future noise problems.

The province should provide assistance through financial aid and, if necessary, enabling legislation to permit municipalities to engage in such things as redevelopment along noisy arterials. It could provide financial assistance through low-interest loans, in addition to

those already available through the Alberta Municipal Financing Corporation. These loans would enable municipalities to acquire land along particularly noisy routes if it can be established that, after acquisition of the land, the alternate use has the potential to recover the initial investment, for example, through development of barrier-block buildings.

Compensation and Information

An additional method of dealing with excess traffic noise combines social adjustment and compensation. It has been frequently noted that people have varying sensitivity to noise and indeed varying susceptibility to noise-induced hearing loss. In fact, some 20 to 25 percent of the population seem virtually impervious to noise – they show either little or no sign of impaired hearing or are not bothered by noise at high levels (Dunn 1979, WHO 1980).

This group presumably includes those with impaired hearing (some 10 to 15 percent of the population) as well as people with perfectly normal hearing who are disturbed only by the loudest noises. Those who have a high tolerance for noise are probably best suited to live in areas where ambient noise levels are high. Presumably, given enough time, such a selection would take place. The noise-sensitive would leave, the noise-tolerant would stay, and over time a balance would be struck between noise levels and noise tolerance.

Theoretically this is all very elegant. However, in real life, several factors intrude. First, noise parameters change over time. What was once a perfectly acceptable noise level may become intolerable due to increases in traffic or the number of trucks. Second, information gaps exist. People purchasing a home or renting an apartment may view it on the weekend or at mid-day when noise levels are not at their peak. It is only after moving in and experiencing a full week or month of noise patterns that the total impact of noise is accurately perceived. Similarly, if a purchase or rental occurs in the winter, the new resident may be shocked to open doors and windows wide on a balmy spring day and experience the level of ambient sound in the house and yard. Third, there may be financial constraints to adjustment. The homeowner may wish to move but may find that resale of the house is difficult or can only be achieved at a substantial discount below houses of similar quality and location which are not affected by noise. A renter may face even greater problems as alternate affordable accommodation may not be available.

These factors are presently at work. Houses in noisy locations are discounted. The City of Edmonton, for example, provides up to a 15 percent reduction in assessed values (and hence taxes) for residences next to maximum traffic routes with no service roads, and though *caveat emptor* is still the rule, house purchasers and renters are becoming increasingly wary of noisy locations. An increase in both compensation and the level and quality of information is required to speed the process and ease the pain of adjustment.

The Council believes that the existing 15 percent reduction in assessments and taxes is commendable and would like to see it extended substantially. We suggest that for each dBA rise in the sound level between 55 and 60 dBA, as measured in a backyard, a 0.4 percent reduction in property assessment should be allowed. Since the impact of noise increases as the volume increases, there should be a doubling of the permitted reduction in assessment

with each 5 dBA sound increase (Table 15). The high and rising impact of reduced assessment would direct the attention of the municipality to places with major noise problems and they would have a high and rising incentive to provide alternative solutions. It would also help compensate homeowners for the loss of amenity value.

This reduction in assessments would provide a worthwhile compensation to homeowners for the deleterious effects of noise, and would help them tolerate the noise levels to which they are subjected. However, there should be reciprocation on their part. The Council believes that the reduction in assessment should not be available unless the owners are willing to attach a suitable notice (flag) to their title identifying their property as one which suffers from noise that might be annoying to a prospective purchaser or tenant.

Such an approach would compensate the victims of noise, alert the city that problems exist, and provide an incentive for finding solutions. It would also provide an information base on noise levels to prospective purchasers and tenants as well as an incentive to those who are more noise tolerant since housing should be cheaper where noise levels are higher.

The Council believes that where reduced assessments are due to a provincially supported highway, the Alberta Government should contribute to municipalities a share of the tax revenue lost, proportional to its cost sharing for construction of the highway.

Assistance to municipalities for their noise-control programs should generally reflect existing levels of cost sharing. For example, where provincial assistance for road construction is 50 percent, the province should contribute 50 percent of the cost of noise-abatement programs for areas adjacent to the roads. However, in the case of compensating for the reduced revenues resulting from reduced assessments, the assistance should not be direct. Provincial aid should be directed into a special fund that would be available to cities to undertake the full range of noise-control programs, including retrofitting and construction of berms or barrier-block buildings.

In some municipalities, the source of excessive noise is a provincial highway. For example, Leduc residents living adjacent to Highway 2 suffer as much from excessive traffic noise as anyone in the major cities. They should be eligible for assessment reduction as outlined previously. Here, the provincial highway is largely responsible for the excessive noise they suffer and the provincial government should compensate the town for the loss of revenue from reduced assessments. However, these funds should be designated exclusively for noise reduction and attenuation investments.

One of the positive effects of such an approach would be that in the future when municipal councils are tempted to locate developments where noise problems are likely to occur, they would appreciate that consequences for future municipal revenues would follow, relative to the noise exposures that they permitted.

Cost Estimates of the Compensation Approach

The following cost estimates are provided to illustrate the economic impact of this recommended compensation program.

Table 15. Scale of Assessment Reductions

Noise Level (dBA)	% Reduction in Assessment for each dBA Increase*	Total Cumulative Assessment Reduction Possible
55 - 60	0.4% **	2%
60 - 65	0.8%	6%
65 - 70	1.6%	14%
70 - 75	3.2%	30%
75 - 80	6.4%	62%
80 +	12.8%	100%

* The doubling factor for each 5 dBA is that used by the Occupational Health and Safety Division.

** The initial figure of 0.4 percent is the figure identified by Nelson (1975) as cited in Wiens and Kinley (1980) as a reduction in average property value per unit of noise.

The *Urban Traffic Noise Policy Study* (Marshall Macklin Monaghan Ltd. 1980) prepared for the City of Edmonton estimates percentages of the city's population exposed to various levels of traffic noise (see Table 16). If each of the owners exposed to the levels of noise estimated in this study were to claim the full assessment reduction possible, the City of Edmonton's reduction in revenue would be as shown in Table 17.

Several assumptions here would tend to exaggerate the actual impact. It is assumed:

1) that all those exposed would in fact claim reductions, and particularly at low noise levels this is unlikely to be the case;
2) that in each category all claims would be for the maximum possible reduction.

On the other hand, no residences in Edmonton are estimated by Marshall Macklin Monaghan to be impacted by more than 75 dBA, which seems unlikely. They may be few in number but they probably exist. However, it is improbable that as much as 2.5 percent of the city's residential assessment would be exposed to claims for residential assessment reductions. There is, however, the possibility that the number of claims could increase if traffic noise levels increase in the future and no effective noise-reduction programs are adopted in the meantime.

In the case of the Edmonton Municipal Airport, where the control of noise levels is entirely within City Council's control, a similar program could be established based on NEF levels.

Table 16. Population Exposed to Traffic Noise in Edmonton, 1980

Noise Level (dBA, Ldn)	Number	% of City Population
55 - 60	16,500	2.9
60 - 65	44,000	7.8
65 - 70	28,500	5.0
70 - 75	22,500	4.0
Over 75	0	0
Total over 55 dBA	101,500	19.7

Source: Marshall Macklin Monaghan Ltd. 1980:Table 1.2

Table 17. Maximum Assessment Reductions Due to Noise

Noise Level (dBA, Ldn)	% of City Population Exposed	Maximum Assessment Reduction Possible	% Reduction of Total City Residential Assessment
55 - 60	2.9	2.0	.058
60 - 65	7.8	6.0	.468
65 - 70	5.0	14.0	.700
70 - 75	4.0	30.0	1.200
Over 75	0	0	0
Total over 55 dBA	19.7		2.426

Since this is entirely a City responsibility, no provincial aid is warranted. The potential reduction in residential assessments would help maintain the City's awareness of the social costs of maintaining existing use patterns at this facility.

In the Council's view, these potential impacts are of a scale sufficient to act as a spur to reduce noise, but are not punitive.

4.6 PLANNING PROGRAMS

Land use planning consists of identifying community goals and objectives and then developing ways of implementing the goals. In the initial stage of planning, all decisions of the past and the impacts of the present should be identified, mapped, tabulated, and assessed. In particular, contradictions between what is wanted and what has been achieved should be noted. For example, while the desire is normally for quiet in residential areas, changing transportation patterns may have resulted in high noise levels in areas adjacent to arterial roads.

A major difficulty in the planning process is that every actor in the urban area has somewhat different objectives from everyone else. People in an existing residential district may wish their area to remain unchanged, but with better facilities reasonably accessible. They might welcome a new regional shopping centre, a community recreation facility, or even places of employment if these facilities were 20 blocks away. They might also complain vociferously that it is difficult for them to get to work, to shopping centres, or to recreational areas because of the overcrowding of existing transportation routes. They might all be in favour of expansion or improvement of such roads. However, they may prefer that the expanded transportation route be some distance from where they live.

Many conflicts run through the whole fabric of a developing urban area. One has only to glance at the agenda of a local city council to appreciate the range of conflicts inherent in the different needs and desires of each resident of the community.

Nevertheless, the importance of these conflicts must be analyzed and the impact of alternative development decisions assessed. It is this activity, or process, that is generally called land use planning.

Planning in Alberta is institutionalized and formalized through the Planning Act (RSA 1980 cP-9). It provides for a variety of hierarchical plans ranging from regional plans to municipal plans, land use by-laws, area structure plans, and subdivision regulations. These land use by-laws and plans regulate the use and development of land and buildings. Although noise is not specified by the Act as a distinct issue to be addressed by these plans, noise-related policies are often implicit in such plans.

4.6.1 Noise Considerations in Land Use Planning

Since noise is associated with well-defined activities, it is possible to forecast consequences of land use decisions with a reasonable degree of accuracy in order to avoid or reduce future noise problems. However, noise forecasts frequently are not heeded in development and land use decisions. It is essential that problems associated with noise be given greater attention in the development and approval of plans at all levels of the planning hierarchy.

An important exception to this general neglect of noise in decision making is found in the Airport Vicinity Protection Area (AVPA) regulations pursuant to the Planning Act, 1977. These regulations are being developed by Alberta Municipal Affairs for most major airports in Alberta. They represent a consistent noise-related policy at the provincial level.

This policy is implemented by mandatory incorporation of AVPA regulations (when adopted) into official regional and municipal documents. Action is being taken well before problems arise. Most airports are at some distance from developing communities. With protective zoning in place, major noise disturbances from aircraft should not affect residential areas in the future.

However, there are numerous examples where in spite of the ability to forecast future volumes of noise, communities have considered noise to be of minor importance and have gone ahead to permit land use developments which are incompatible with high noise levels.

If a quieter community is an objective, it can be achieved. One of the principal methods of achieving it is through the planning process.

At the public hearing in Lethbridge, a comprehensive and competent brief (Brief 47) was presented by the Oldman River Regional Planning Commission. The Council was impressed by the material presented and by the directions suggested. The ORRPC called for a co-ordinating agency at the provincial level, which would have four major functions oriented toward making noise considerations a part of the planning process. These functions included:

1) technical expertise that would be available to planning agencies at the regional and local level throughout the province;

2) a referral service where subdivision applications and development permits could be referred for comments relating to potential noise problems;

3) a co-ordinating function between the provincial and local levels of government as well as between various departments and agencies of the provincial government; and

4) working toward the reduction of noise at the source, both on behalf of the provincial government and independently by working with the appropriate federal agencies such as the Canada Mortgage and Housing Corporation (CMHC), Department of Transport, and Consumer and Corporate Affairs Canada.

The Council agrees with the approach proposed by the ORRPC and believes these responsibilities should lie with the Quiet Communities Directorate.

In addition, the ORRPC recommended a number of specific planning needs concerning the development of noise criteria and amendments to existing legislation.

4.6.2 Need for Noise Criteria

Among others, the ORRPC stressed the fact that there are no province-wide criteria for homes, private outdoor space, recreation areas, and public areas with respect to noise. In the absence of such agreed-upon criteria, each municipality tends to have somewhat varying objectives. To partially overcome this problem, the Council suggests that a uniform model noise control by-law be developed similar to that presently in force in Ontario (see Section 4.1).

The details and development of the model by-law should be a principal task of the Quiet Communities Directorate. However, some general directions can be provided by provincial and international criteria which have been widely adopted.

The International Standardization Organization (ISO) is a committee of the United Nations that has adopted some widely recognized criteria for noise objectives. It is generally agreed that few people are disturbed or annoyed by noise levels below 45 dBA Leq, measured in the backyard or private outdoor space. Similarly, levels over 70 dBA Leq in private outdoor spaces are considered to be intolerable for residential areas. As an objective for residential areas, ISO suggests 55 dBA Leq. It is therefore possible to identify stages indicating the seriousness of noise problems and the action required.

The stages are:

Stage 1. Below 45 dBA Leq – there is no problem, nor is any action required;

Stage 2. Between 45 and 50 dBA Leq – no problems are identified, but consideration should be given to future problems;

Stage 3. Between 55 and 60 dBA Leq – noise problems begin to arise, but the seriousness is not sufficient to warrant major action;

Stage 4. Between 60 and 70 dBA Leq – a significant problem exists. As the levels increase between 60 and 70 dBA, increasingly vigorous action is required to reduce the impact of noise;

Stage 5. Over 70 dBA Leq – noise above these levels is intolerable and major action is required to reduce it.

Elsewhere in this report (Section 4.4) a scheme for compensation for the impact of noise is suggested, with increasingly reduced assessments related to increasing levels of noise experienced. The detailed levels and amounts are subject to further examination and definition. However, the principle is clear – as the noise level increases, action should be correspondingly vigorous, rising ultimately to a point where very strong action is taken.

The ORRPC also identified that "standards for traffic noise are required to evaluate the impact on existing and proposed neighbourhoods." An appropriate guide for action in this regard has been developed in Ontario and is set out by John Manuel, Supervisor of the Noise Pollution Control Section of the Ontario Ministry of the Environment (Manuel 1979). A set of tables illustrates how noise level forecasts vary with different vehicle per day flow levels, varying speeds, percentage of trucks in the flow, and different grades on the roadway. For example, from these tables it is possible to identify that with an average speed of 40 miles per hour with 40 percent truck traffic and a grade of between 0 and 3 percent, a traffic volume of up to 7,000 vehicles per day would cause no noise problems for residents further than 110 feet from the travelled roadway. In contrast, if the speed level were increased to 60 miles per hour and the traffic volume increased to 43,000 vehicles per day, yet fleet composition and grades remained the same, residences within 110 feet of the travelled roadway would experience intolerable noise levels of over 70 dBA. Residences 250 feet

away from the travelled right-of-way would experience 65 dBA. It may be possible to reduce outdoor sound levels for these residences to at least 60 dBA through design or construction methods. Those 570 feet away from the travelled roadway would experience 61 dBA. They would need to be warned of noisy conditions and could expect some relief from actions taken to improve the noise levels for those closer to the traffic route.

This information relating traffic and noise has been applied effectively in Ontario for more than five years. Although the by-law must be adjusted according to local conditions such as topography and other barriers, it nevertheless is a very useful reference for the impact of traffic on existing and proposed residential areas in Alberta.

The ORRPC also points out that "any noise standards which are developed by the province should be useable by anyone in the planning process, suitable for land use planning purposes and readily applicable to most planning tasks, involving the need for a quantitative noise measurement." This strong point was made not only by the ORRPC, but by other regional planning commissions and planning agencies both in formal briefs and informal meetings.

Currently, the only noise guidelines available to planners are CMHC handbooks regarding the siting and development of residential buildings in areas exposed to aircraft, road, and railway noise. However, as the ORRPC correctly points out, the guidelines have no legal status, resulting in frequent successful appeals to the Alberta Planning Board. For example, regional subdivision approving authorities cannot require soundproofing, a responsibility of municipal development approval authorities. But the lack of legal status does not undercut the utility of guidelines. As the CMHC airport noise handbook states, the intention is

> *...to draw attention to problems associated with aircraft noise; to support methods which seek to protect residential areas against the effects of aircraft noise; to encourage the co-operation of all levels of government to develop ways of alleviating the problems associated with such noise; to discourage the construction of new residential development on sites subject to high noise exposure and to introduce sound insulation in residential development on sites subject to some noise exposure at a lower level (CMHC 1979:3).*

Detailed specifications, clearly and simply described for easy use, are provided for set backs, insulation, site treatment, and screening. Clearly, if these objectives are reached, considerable progress will have been made in resolving Alberta's noise problem.

The guidelines will have considerable effect if they are adopted as provincial policy and supported by the Alberta Planning Board. Municipalities should also be encouraged to incorporate the guidelines into their land use and development control by-laws. The Quiet Communities Directorate could work toward the acceptance of guidelines by providing detailed technical advice to local planners or through inputs to the subdivision approval referral system (see Section 4.1).

4.6.3 Amendments to Legislation

A number of small amendments to the Planning Act (RSA 1980 cP-9) and the Subdivision Regulation would ensure that noise considerations are part of certain planning decisions.

First, it appears desirable to insert a clause in Section 92 of the Planning Act making it possible for municipalities to enter into agreements with developers to install or pay for the installation of noise-attenuation devices or designs that are necessary to achieve an acceptable level of quiet in a subdivision. Section 92 presently gives a municipality the right to enter into agreements with developers to install utilities, pedestrian walkways, and off-street parking. A similar provision is needed to enable municipalities to negotiate with developers regarding noise-attenuation devices or design alternatives where noise problems warrant such treatment. As suggested previously, an objective of 55 dBA Leq in outdoor residential settings would be an appropriate objective and would be useful to include in Section 92 as a guide for municipalities and developers.

Second, it appears desirable to amend Section 8 of the Subdivision Regulation to include noise from adjacent land uses. Section 8 of the Subdivision Regulation presently reads: "In making a decision as to whether or not to approve an application for subdivision approval, the subdivision approving authority shall consider, with respect to the land that is the subject of the application" and then lists many factors such as topography, soil characteristics, potential for flooding, etc. One factor that subdivision approving authorities shall consider is "the use of land in the vicinity of the land that is subject of the application...." The suggestion is that a phrase should be added to this section to recognize the importance of noise levels generated in the vicinity of the land that is the subject of the application. In this way noise would be identified as one of the factors that specifically must be considered before a subdivision is approved.

Thirdly, it is desirable to amend Section 6 of the Subdivision Regulation to require that subdivision applications be reviewed for noise problems by the Quiet Communities Directorate. Section 6 currently reads: "Upon receipt of a completed application for subdivision approval, the subdivision approving authority shall send a copy of it to:" and then lists a large number of agencies and departments such as the school authority, public utilities, the Deputy Minister of Environment, etc. If suitable review of existing or potential noise problems is to be provided at this stage of subdivision approval, the Director of the Quiet Communities Directorate should be one of the agencies to receive a copy. This requirement would provide an opportunity for the Quiet Communities Directorate to identify whether any noise problems are likely to occur in the subdivision, and to provide comment to the subdivision approving authority on the seriousness of the problem and potential solutions.

The above actions are intended to provide an opportunity for consideration of noise to be included in the planning process. Noise and its impact on future populations should be explicitly taken into account before new developments are approved. The suggested amendment under Section 8 of the Subdivision Regulation would identify noise as a factor to be considered before subdivisions were approved. The consideration of noise by subdivision approving authorities plus the comments from the Quiet Communities Directorate should be adequate to ensure informed decisions. The proposed amendment to Section 92 of the Planning Act supports and supplements the subdivision approval process, but enables municipal councils to take specific action to attenuate noise as part of a development agreement.

The approach to land use planning in Alberta is that the major decisions and the major responsibility for the future character of communities rest with the local and regional

governments. However, it is the province's responsibility to ensure that all relevant factors are considered before development is permitted to proceed and that individual regional plans are integrated with each other. Most problems are best handled at the local and regional level. There is, however, a provincial interest in considering noise so that local areas do not create future problems that would require provincial intervention to rectify or correct, for example, noise problems along provincial highways.

This action would generally rectify the greatest problem at present in planning for noise. Noise has not been considered an important factor and there has been little provision for its inclusion as one of the factors which constitutes a pleasant and enjoyable residential environment. The approaches identified should make a significant contribution to rectifying this deficiency in Alberta's existing planning process.

Footnotes for Section 4. Creation of Quiet

1. Briefs 3, 4, 5, 6, 7, 8, 9, 13, 17, 34, 62, 80, 82, 94, 97, 103, 139, 152.
2. Briefs 21, 22, 27, 30, 38, 62, 103, 120.

Footnotes for Section 4.2 Administration

3. Briefs 9, 33, 41, 45, 51, 58, 60, 63, 65, 79, 84, 88, 93, 97, 107, 131, 139, 152, 156.
4. Briefs 3, 9, 11, 13, 18, 26, 29, 35, 42, 44, 57, 59, 83, 84, 87, 104, 105, 111, 121, 124, 126, 139, 140, 152, 156.

Footnotes for Section 4.3 Health and Education

5. Briefs 2, 6, 11, 14, 24, 26, 29, 40, 46, 47, 49, 53, 54, 57, 59, 63, 77, 84, 85, 98, 105, 106, 107, 124, 151.
6. Briefs 1, 3, 6, 7, 8, 9, 10, 19, 26, 29, 30, 31, 33, 34, 38, 39, 40, 41, 42, 46, 49, 50, 51, 53, 54, 56, 57, 58, 59, 60, 63, 67, 75, 77, 81, 84, 85, 86, 88, 90, 91, 94, 95, 97, 98, 101, 105, 106, 111, 117, 122, 130, 138, 152, 155.
7. Briefs 26, 29, 57, 84, 107.
8. Briefs 29, 40, 49, 53, 63, 85.
9. Briefs 40, 46.
10. Briefs 11, 14, 63, 84, 85, 107.
11. Briefs 29, 107.
12. Brief 53, 85.
13. Briefs 29, 105.
14. Briefs 29, 40, 54, 59, 107.
15. Briefs 29, 49, 59.
16. Briefs 2, 106.
17. Briefs 14, 55, 59, 107.
18. Briefs 14, 46, 59, 63, 85.
19. Briefs 6, 11, 40, 63, 77, 84, 85.
20. Briefs 29, 49, 105.
21. Briefs 6, 11, 49, 57, 63, 105.
22. Briefs 54, 63, 85.
23. Briefs 49, 81, 107.
24. Briefs 29, 47.
25. Briefs 49, 63, 86, 90, 135.

Footnotes for Section 4.4 Engineering Control of Noise

26. Briefs 1, 3, 8, 14, 19, 23, 24, 25, 29, 30, 31, 38, 47, 49, 51, 52, 54, 59, 60, 64, 65, 67, 71, 76, 77, 83, 84, 93, 95, 97, 103, 106, 107, 126, 139, 142, 146, 147, 155.
27. Briefs 58, 67, 76.

Footnotes for Section 4.5 Economic Programs

28. Briefs 3, 8, 17, 18, 21, 22, 27, 33, 34, 36, 37, 38, 40, 42, 58, 66, 70, 80, 82, 83, 90, 91, 93, 108, 110, 114, 116, 120, 123, 132, 139, 140, 156.

The Physics of Sound

REPORT

SECTION FIVE—

Sound is a form of energy. It travels in waves of pressure through the air or some other medium such as water, wood, or steel. Sound waves cause a hearing experience by striking our eardrums and creating mechanical vibration in the middle ear. Hair cells in the inner ear pick up this action and relay it as nerve impulses to the brain.

5.1 FREQUENCY AND PITCH

Sound waves are generated when something moves or vibrates, disturbing the surrounding air. A common analogy is the example of waves created when a stone is thrown into calm water. In a similar fashion, sound waves move outward in uniform concentric spheres from the source (Figure 9).

When a vibration starts, it creates waves by compressing the air and raising the pressure. As the air rebounds from this compression, the pressure is momentarily lowered below what it was when the vibration started. Consequently, sound waves are alternating periods of high and low pressure moving out from the source. The amount of energy in waves depends on the force of vibration, just as a large stone creates larger waves in water than a small stone. Changes in pressure are greater with loud sound than soft sound.

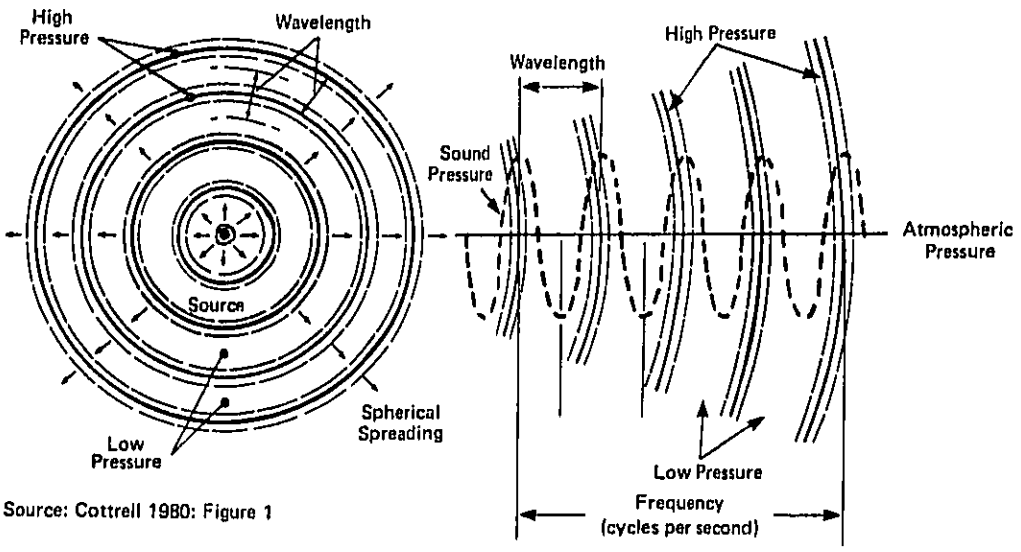
Sound waves flow as long as a source vibrates. The repetition of waves over time is called the number of cycles per second (cps), also referred to as hertz (Hz). One compression (raised pressure) plus one expansion (lowered pressure) equals one cycle.

Sound of one tone is waves of pressure with a fixed frequency of repetition. A tuning fork emits a single-frequency sound, for example, 128 cycles per second (or Hz). The frequency of a sound is heard as "pitch", a term with which most people are familiar. Frequency is a physical characteristic of sound waves, whereas pitch is the psychological perception of sound. Low-frequency sound is heard as low pitch; high-frequency sound is heard as high pitch.

5.2 INTENSITY AND LOUDNESS

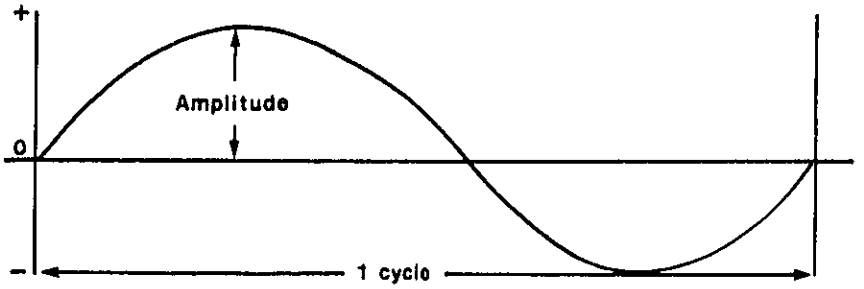
The intensity or energy in sound waves is related to the changes in pressure, and the extent of compression and expansion of air. The analogy for water might be the height of a wave going out from where the stone hit. The height of the sound wave form, or maximum extent of compression and expansion, is called the amplitude (Figure 10). At a given frequency, the higher the intensity of sound, or the higher the amplitude of a wave, usually the louder the sound will be perceived. As with frequency, intensity is a physical characteristic of sound waves. Loudness is how our ears perceive intensity – a subjective impression of the magnitude of sound.

The pressure of sound at any point can be measured in units called newtons per square meter (N/m^2), or pascals (Pa). The range of changes in pressure in sound waves is extremely wide, but the amount of pressure involved is extremely small. Our ears are very sensitive and are able to respond to these low pressures, picking up slight changes over a very wide range. To get some idea of the relative amount of power involved, think of an opera house filled with a crescendo of sound. The power involved is only about 1/100th of the power used in an average electric lamp (Jones 1980).



Source: Cottrell 1980: Figure 1

Figure 9. Characteristics of Sound Waves



Source: Throckmorton 1981: Figure 1

Figure 10. A Sound Wave

The lowest level of sound pressure which an "average" young person with normal hearing can perceive is .00002 N/m^2 or Pa. This value has been established by international agreement. Consequently, it is the reference sound pressure. Sound pressure which is high enough (loud enough sound) to cause pain in our ears is about 20 N/m^2 although it varies for each individual. The difference between .00002 N/m^2 and 20 N/m^2 is a factor of 10^6 or 1 million.

Because our ears can accommodate such an enormous range of pressure, a system other than a linear scale had to be developed to allow practical measurement of sound levels. Consequently, a logarithmic scale is used. An example of such a scale is the Richter Scale used to measure the magnitude of earthquakes.

Decibels (dB) are the units used to express sound levels in a logarithmic ratio between a measured sound pressure level (SPL) and the reference pressure level of 0 dB SPL (.00002 Pa). The entire range of pressure which our ears can accommodate from the threshold of hearing to the loudest point when sound causes pain is expressed on a scale from 0 dB to 120 dB. The logarithmic scale means that every time there is an increase of 10 dB it sounds twice as loud. The word decibel is derived from the word "bel," after Alexander Graham Bell's father.

Since measurement of sound pressure uses a logarithmic rather than a linear scale, measured pressure levels (dB values) of two different sounds can not be added directly. Combining two sounds of the same pressure raises the level by only 3 dB, rather than doubling it. Adding two sounds of different levels raises the total by less than 3 dB. The difference between the two levels determines the amount of increase. To illustrate: 70 dB plus 70 dB equals only 73 dB, not 140 dB; 70 dB plus 65 dB equals 71.2 dB; and 70 dB plus 60 dB equals 70.5 dB.

5.3 AIR-BORNE SOUND

Sound energy is propagated in waves, the behaviour of which are determined by the elasticity, temperature, and density of the medium. Air-borne sound is simply waves travelling through air to our ears, as occurs when someone speaks or a truck goes by. Propagation of sound waves through air is affected by geometric spreading, wind, air temperature, and absorption by the ground, buildings, etc.

Geometric spreading occurs when sound waves spread out in all directions from the source as a result of expansion of the wavefronts (Truax 1978). Waves from a point source, such as a stationary engine, spread out equally in all directions – a spherical shape. A linear source such as a busy highway or railway produces equal sound energy over unit length. In this case, sound waves spread out in a cylindrical fashion.

Moving wavefronts in both cases lose energy and perceived loudness. Sound from a point source will lose approximately 6 dB per doubling of distance. This is a considerable energy loss on the logarithmic scale. A level of 80 dB at 50 m would be only 74 dB at 100 m. Sound from a linear source, however, loses only about 3 dB per doubling of distance. These losses occur only under ideal conditions with no influence from wind, air temperature patterns, ground absorption, or barriers.

Sound waves in air of 0°C and normal atmospheric pressure at sea level travel at 331,5 m/sec. (1087 ft./sec.). At 20°C, the speed is 344 m/sec. (1130 ft./sec.). Sound waves travel even faster in air of high humidity. The perceived character of sound is influenced by its wavelength or frequency. It is important to know the wavelength when determining how to control sound.

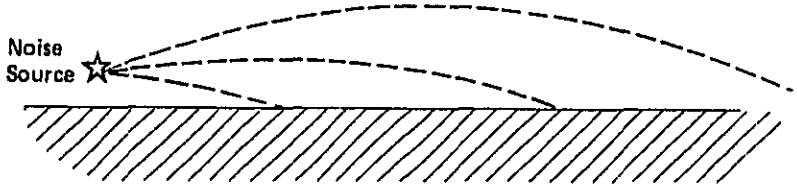
In addition to the loss of sound energy through spreading of wavefronts, a small amount of sound – roughly 1/10 dB/m – is absorbed by air (Jones 1980). Sound of higher frequencies is absorbed much more than lower frequencies. For most practical purposes outside, sound losses through absorption by air can be ignored except for high frequencies over large distances. High frequencies can be absorbed by air sufficiently in a concert hall, however, to influence the acoustics of the room, and perception of the music.

Outside, sound waves travel in complex patterns. Variations in air temperature over distance, in shadows, and from the ground up affect the speed and pattern of waves. On a typical sunny day on the prairie, air temperature decreases with a rise in altitude. When this happens, sound waves are bent away from the ground (Figure 11). As the distance from the source increases, the amount of sound decreases proportionally. A shadow zone is created where little if any sound enters. During a temperature inversion, however, as happens often in winter at sundown and before dawn, sound waves are bent back toward the ground causing more sound to be heard over a larger distance (Figure 11). Because of inversions, noise from traffic and railways is more obvious in winter and during the early hours of the morning than at other times.

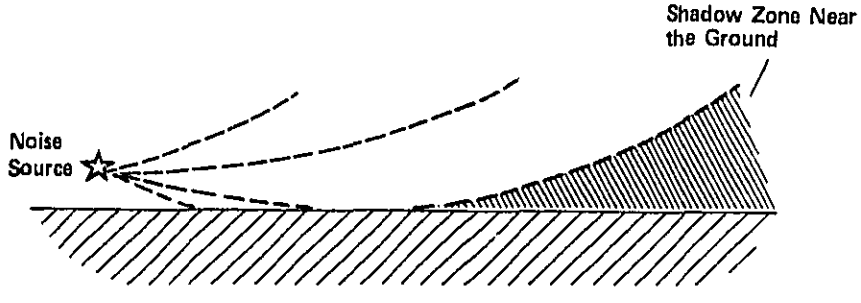
Air turbulence caused by wind also affects the flow of sound waves. The amount of sound absorbed by the ground depends on wind speed and direction. Wind speed tends to increase with rising altitude, which forces sound waves to bend down toward the ground downwind from the source. This means more sound over a larger distance. Upwind, sound waves are bent upward, meaning proportionally less sound, and creation of a sound shadow. Where the wind is strong, constant, and usually from the same direction, as in southern Alberta, this effect can be important in assessing sound levels heard in particular places. Such effects should be considered when planning where to locate a land use sensitive to noise in relation to a predominant source of noise.

The effects of temperature and wind can cause sound levels measured outside to be as much as 20 dB or two orders of magnitude different from those levels predicted due only to geometric spreading and air absorption. For sound levels over distances of a few hundred metres or more, these effects will be particularly important. As well, temperature and wind can reduce or eliminate the effectiveness of berms and barriers designed to reduce sound.

Topographical features such as slope, the type of surface on the ground, hills, and buildings also influence sound waves. Generally, the ground absorbs sound and rapidly attenuates intensity. Hard surfaces such as water, concrete, or old asphalt are hard acoustically. They reflect sound instead of absorbing it, so that considerable sound remains over large distances. Flat, spongy, grass-covered terrain and bare earth absorb a great deal of sound, particularly the higher frequencies, creating a sound shadow. Thick grass may attenuate up to 10 dB per 100 m at 2000 Hz (Truax 1978). Attenuation depends on how close the source and observer



Sound wave pattern during an inversion as happens in winter.



Sound wave pattern when air temperature decreases with altitude.

Figure 11. Patterns of Sound Waves

Source: Embelton 1981

are to the ground. Attenuation decreases with rising altitude. Since high frequencies are absorbed more by the ground than low frequencies, the latter will predominate at larger distances. For example, the drone of the diesel in a far-off train is heard more than the squeals of the wheels. Temperature and wind conditions will affect ground absorption. It can be increased or decreased depending on wind direction and patterns of temperature change.

Features such as hillsides also influence sound waves. In some cases, waves can be concentrated due to reflection off hillsides, producing higher intensities at some points than others. While it is commonly thought that trees and vegetation absorb sound, their effect is actually minimal. Trees often scatter sound waves, reducing the effectiveness of barriers specifically designed to attenuate sound.

Tall buildings along both sides of a street cause multiple reflections of sound, resulting in considerable reverberation, which reduces attenuation. This effect may also occur where noise barriers are built along both sides of a highway or road.

5.4 STRUCTURE-BORNE SOUND

Structure-borne sound is different from air-borne sound in that it is transmitted through structures, even though it has to pass through air to reach our ears. Structure-borne sound occurs when someone taps a pencil on a desk, a person in an apartment upstairs walks across the floor, or the large steel housing of an engine vibrates in a metal foundry. In these cases, propagation of sound waves depends on the type of material, what covers it, what it is attached to, the extent of vibration, and many other factors. The principles of propagation of waves are the same as in air, although the values are different.

When considering how to reduce sound levels, it is critical to know whether sound is air-borne or structure-borne. The method of controlling sound will be totally different in each case. If the wrong method is selected for a particular type of sound, a benefit may not be achieved.

5.5 MEASURING SOUND

As previously mentioned, loudness of sound is measured in units called decibels. Sound measured with a sound level meter, however, is usually expressed as dBA. The "A" refers to the fact that the electrical signal produced by the microphone of the meter is passed through the A weighting network (a particular electrical circuit in the meter) in order to filter the signal and discriminate against certain frequencies. This network mimics our ears, which do not hear all frequencies equally well. Sound below 500 Hz is not heard as well as sound at intermediate or higher frequencies. Hence, sound measured on the A scale (dBA) is considered to be a reasonably accurate representation of our perception of sound. Table 18 gives the levels of sound created by various objects and activities around us.

Sound level meters have three other weighting networks – B, C, and D. Each filters the electrical signal differently, creating a different response curve, depending on the type of sound being measured. The differences are mainly in the sensitivity to low-frequency

Table 18. Sound Levels Around Us

Common Sources	Decibel Level or Range	Typical Reaction
	0	Threshold of hearing
Very soft sound	10	Barely audible
Radio station broadcasting studio	20	
Rustling of leaves	20	
County home	30	Very quiet
Soft whisper at 5 feet	30	
Public library	40	Quiet
Quiet office or living room	40	
Moderate rainfall	50	Speech interference
Inside average urban home	50	
Quiet street	50	
Washing machine	47 to 73	
Light car traffic at 50 feet	55	
Normal conversation at 3 feet	60	Intrusive
Noisy office	60	
Noisy restaurant	70	Possible hearing damage with continuous exposure
		Telephone use difficult
		Steady sound becomes annoying
Loud singing at 3 feet	75	
Coffee mill	75 to 79	
Tractor at 50 feet	78 to 95	
Busy traffic intersection	80	
Electric typewriter	80	
Electric lawn edger	81	
	85	Hearing damage (8 hrs.)
Bus or heavy truck at 50 feet	88 to 94	Very annoying
Jackhammer	88 to 98	
Loud shout	90	
Freight train at 50 feet	95	
Modified motorcycle	95	
Jet taking off at 2000 feet	100	
Amplified rock music	110	Maximum vocal effort
Jet taking off at 200 feet	120	Threshold of pain
Air-raid siren	130	

Source: Cottrell 1980

sounds. A is most biased against low frequencies and C is least biased. The C network is used to measure impact or impulse sound such as a rifle shot.

Sound level meters measure sound only at any particular moment. In order to obtain the general level of sound over time, however, many instantaneous measurements must be taken, averaged statistically, and expressed in relation to the period of interest. The following notations are used to express sound levels measured in dBA.

Leq — the equivalent sound level, or the average intensity of sound over a given period. Leq is the level of sound of the continuous sound which would have the same energy as the actual time-varying sound over the period being considered. Technically, Leq is 10 times the logarithm of the time-averaged sound energy over a specified period. The number of hours during which sound is measured is often put in brackets. Leq(24) indicates energy averaged over 24 hours. Leq is the best simple measure used to predict the impact of intermittent noise of many different types. In Europe and Canada, measured community and industrial sound levels are commonly but not universally expressed as dBA Leq. The Council endorses the use of this measure in Alberta.

Ldn — the day-night equivalent sound level. Since people sleeping at home are more sensitive to disturbing sounds at night, sometimes 10 dB are arbitrarily added to levels measured between 2200 hours and 0700 hours to compensate for sleep disturbance. Therefore, Ldn requires different calculations for day and night, which doubles the workload to measure sound and makes the task more difficult. The U.S. often uses Ldn to measure community sound levels. The Council recommends against the use of Ldn in Alberta. Leq measurements are satisfactory for noise regulatory work, yet involve considerably less measurement problems than the Ldn system.

L_{10} — the level of sound which is exceeded by instantaneous measured values only 10 percent of the time. L_{10} usually reflects peak sounds in the environment where measurements are being taken.

L_{50} — the level of sound exceeded 50 percent of the time. This is the average level of sound in the environment.

L_{90} — the level of sound exceeded 90 percent of the time. This is a measurement of the ambient, background sound level.

The L_{10}, L_{50}, or L_{90} can be measured and calculated for any sound environment for any given period of time.

5.6 HOW OUR EARS HEAR

Our ears consist of three main parts: the outer ear, also called the pinna or auricle; the middle ear; and the inner ear. The outer ear on the side of the head is the visible part. It collects sound waves and funnels them through the ear canal to the eardrum (Figure 12).

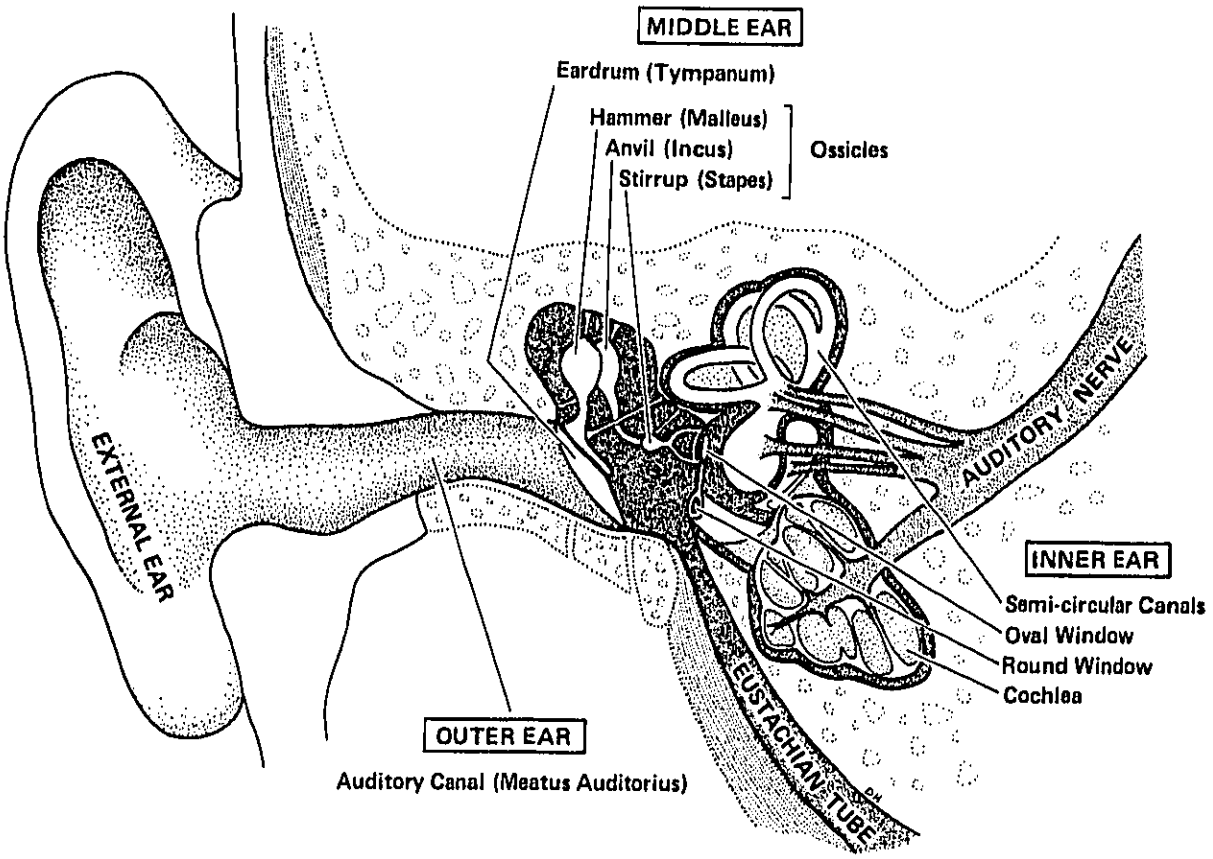


Figure 12. The Human Ear

The ear canal is about 2.5 cm long and 0.6 cm in diameter, but varies slightly with each individual. The eardrum picks up vibrations (sound waves) and transmits them to the middle ear.

The middle ear is an air-filled cavity which contains a chain of three, small, interconnecting bones (malleus, incus, and stapes) and the Eustachian tube. The chain of bones is held in place by tiny ligaments and muscles and transmits sound energy from the eardrum to the inner ear. The malleus, which is connected to the inside of the eardrum, picks up vibrations from the drum and passes them through the incus and stapes. The stapes protrudes through a hole called the "oval window" into the inner ear. Air for the air-filled cavity is vented through the Eustachian tube from the back of the throat. This tube allows pressure to be equalized on either side of the eardrum.

The eardrum and middle ear bones vibrate together in sequence with and proportional to the frequency and intensity of sound. Energy is amplified because the eardrum is larger than the oval window. As well, the three bones act as levers, which increases the energy. Without these bones, only 0.1 percent of the sound energy reaching the eardrum would actually be detected by the inner ear.

Three semi-circular canals (the balance mechanism) and the snail-shaped cochlea (the hearing mechanism) are the main parts of the inner ear. The cochlea is filled with a watery fluid, a series of membranes, and about 25,000 hair cells located within the Organ of Corti. The inner ear is the critical organ for balance as well as hearing.

The oval window is the entrance to the cochlea. Vibrations from the stapes are transmitted thus to the fluid and membranes inside the cochlea, then on to the hair cells which are attached to nerves. As the hair cells move in response to the vibrations, nerve impulses are sent to the brain, creating a perception of pitch of sound.

Hearing ability and sensitivity vary considerably with each individual. A young person with normal ears will hear sound over a frequency range from 20 Hz to 20,000 Hz. Some children can hear up to 24,000 Hz whereas middle-aged and older people may only hear from 50 Hz to 15,000 Hz.

Our ears are not equally sensitive to all sound from 20 Hz to 20,000 Hz. They are most sensitive at the mid-range frequencies from 500 Hz to 3000 Hz. For example, a 1000 Hz tone at a moderate intensity of 50 dB in quiet surroundings will be heard clearly by a person with normal hearing. Tones of 125 Hz or 8000 Hz at 50 dB, however, will be quite difficult to hear. This occurs because our ears are less sensitive at 125 Hz and 8000 Hz. As a result, low and high frequencies must have more sound energy to be audible. Our ears discriminate strongly against sound at lower frequencies, as does the A weighting network of a sound level meter. Figure 13 shows how the ear responds at different frequencies and intensities.

Sound from 500 Hz to 3000 Hz is in the critical range for understanding speech. Our ears are most sensitive to sound in this frequency range. This also means we must pay particular attention to protecting our hearing in this frequency range from the adverse effects of loud sound.

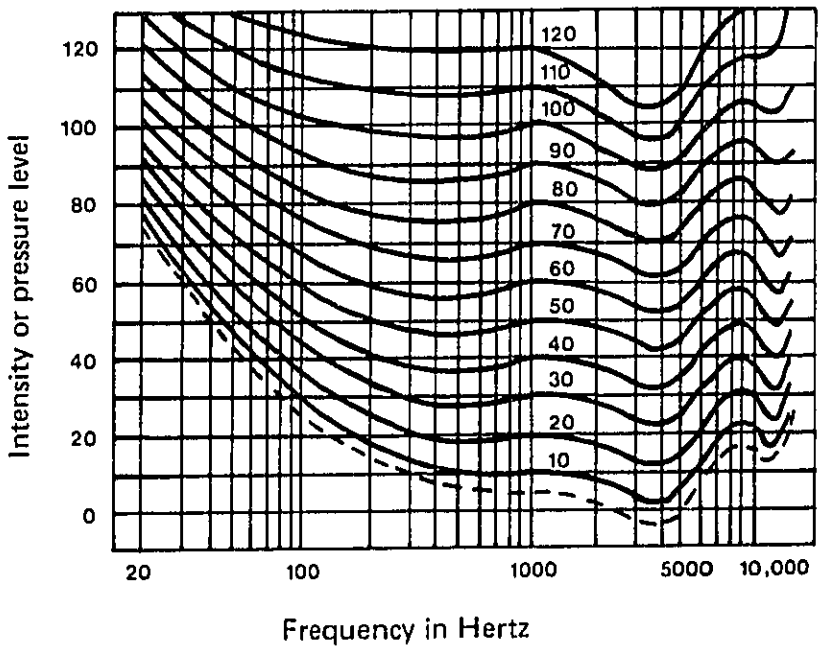


Figure 13. Frequency Response Curves for the Human Ear

Source: Throckmorton 1981:Figure 2

While loudness of sound is our impression of its intensity, short bursts of sound will not be perceived to be as loud as a continuous sound of similar intensity. Generally, the shorter the sound lasts, the less the apparent loudness (Jones 1980). As well, with continuous sound, our ears may "adapt," and the sound will not seem as loud after a while. As we get older, hearing sensitivity tends to decrease. This process appears to be partly natural, but may also be due to damage to hair cells from exposure to noise. Sounds must often be louder in order for the elderly to hear them; that is, the threshold of hearing rises. Hearing is said to be impaired if the threshold rises more than 25 dB at a particular frequency, although this does not necessarily mean a person's overall hearing ability at other frequencies is affected.

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Appendices

BRIEFS PRESENTED AT THE PUBLIC HEARINGS

Brief No.	Name	Representing
	Edmonton – June 9, 1981	
1.	Bob Johnson	Canadian National Railways
2.	Kay Shapko and Alfred Allin	Canadian Protectear Co. (Surrey, B.C.)
3.	V.D. Poole and Bill Glass	Edmonton/Calder Constituency Association (NDP)
4.	Margaret Gallo	Personal
5.	R.D. Ross	Queen Mary Park Community
6.	Ned Kramp	N.E. Alberta Health Unit
7.	Mark Lawrence	Alberta Department of Municipal Affairs
8.	Malcom Palmer	City of Edmonton, Transportation
9.	Faye Donkin	Ft. McMurray & District Health Unit
10.	Sgt. Adams	Edmonton Police Department
11.	Sarah Burns	Sarah Burns (Clinical Audiologist)
12.	Barry Clarke	Edmonton Regional Planning Commission
13.	D.D. Edmundson	Leduc - Willow Park Residents
14.	L. Anderson and R. Norbert	Personal

Brief No.	Name	Representing
15.	Joan Duiker	Personal
16.	Beverly Zubot	Personal
17.	Richard Nutter	Strathcona Community League
18.	Betty McFarland	Southwest Edmonton Residents Development and Transportation Association
19.	Hans Weissenbonn	Personal

Grande Prairie — June 11, 1981

20.	Sgt. B.M. Charlebois	RCMP
21.	Phil Pawlivsky	Personal
22.	Phil Pawlivsky	P.S. Naya
23.	W.T. Jobe, Jr.	International Snowmobile Industry Association
24.	Anonymous	Personal
25.	Anonymous (to Leamark Industrial Developments cc J.R. Cookson)	Personal
26.	Dr. David Naiberg (M.D.)	Personal
27.	Agnes and Koop Bosscha	Personal
28.	Monica Buechner	Personal

Brief No.	Name	Representing
	Red Deer – June 15, 1981	
29.	Kenn Blom	Public Advisory Committee on the Environment - Ad Hoc Committee On Noise
30.	Mayor Muriel Abdurahman	Town of Fort Saskatchewan
31.	Dr. Martha Kostuch, D.V.M.	Personal
32.	Tom Anderson	City of Red Deer
33.	Dr. Lou Lorincz	Personal
34.	G. Jonas, D. Seib, Joanne Edwards	Personal
35.	R.A. Wileman	Personal
	Edson – June 17, 1981	
36.	L.W. Collin	Collin Vacuum Service
37.	G.R. Kurceba	Town of Edson
38.	Ursula Martin	Personal
39.	Dorothy Cooper	Personal
40.	Michael Wynne	Personal
41.	Louis Joy	Personal
42.	G.R. Kurceba	Personal
43.	E.C. Millar	Royal Canadian Army Cadets

Brief No.	Name	Representing
	Lethbridge -- June 23, 1982	
44.	Al Duncan	Personal and Neighbours
45.	Dave Clifton	Personal
46.	H. Jim Munro	Sheet Metal Workers International Association Local No. 8
47.	Werner Fischer	Oldman River Regional Planning Commission
48.	Paul Szoke	Personal
49.	Dr. Jim Oshiro	Barons-Eureka-Warner Health Unit
50.	Dr. O.R. Wilkinson, M.D.	Personal
51.	W. Schmid	Personal
52.	Peggy Proto	Lethbridge Naturalist Society
53.	Roger Rickwood	University of Lethbridge
54.	Dr. G.R.C. Palmer, M.D.	Personal
55.	Ed. S. Strembicki	Energy and Chemical Workers
56.	Steve Ganger	Independent Trucking Industry
	Calgary -- June 25, 1981	
57.	Dave Davis	Alberta Public Health Association
58.	Keith G. Scott	Alberta Trucking Association
59.	Bob Hekkinen	Sheet Metal Workers International Association Local No. 8

Brief No.	Name	Representing
60.	Doreen Orman	Hillhurst/Sunnyside Community Association
61.	Jeff Kaster	100% Earth Ltd. Landscaping
62.	Mrs. M. Leckie	Personal
63.	Tom Moore	Audiology Consultants Ltd.
64.	Leslie Frank	Harford, Frank and Partners
65.	Jim Sibthorpe	Alberta Motorcycle Dealers Association
66.	Doreen Cunningham	Personal and Bow Crescent Neighbourhood
67.	John S. Lackie	Canadian Kenworth Company
68.	Stan Bell	Unifarm
69.	Stephen Nickols and Doreen Baker	Personal
70.	T.R. Haselden	Personal
71.	George Grant	Personal
72.	Dick Schuler	Personal
73.	Christina Caroll	Personal
74.	Bob Dewar	Personal
75.	E. Reiss	Personal

Calgary – June 26, 1981

76.	Bob Johnstone	Western Star Trucks Inc.
77.	Don Elves and Ian Scott	Canadian Petroleum Association

Brief No.	Name	Representing
78.	H. Heuer	Personal
79.	Isabelle Dade	Personal
80.	Bill McLennan	Personal
81.	Maryhelen Posey	Personal
82.	J.C. Stuijts	Personal
83.	Chris Andrews and Alderman Brian Lee	City of Calgary Transportation Department
84.	Amund Jonassen	The Clean Calgary Committee
85.	Carol Faulkner	City of Calgary, Occupational Health and Safety Division
86.	Stephen Silver	Personal
87.	Barbara Scott	Personal
88.	Beatrice Taylor	Personal
89.	Kathy Fedori	Personal
90.	Pierre Chardon	Highlander Hotel

Edmonton – July 7, 1981

91.	Brenda Wayne	Personal
92.	Sister Marie Raiwet	Personal
93.	Michael Norris	Personal
94.	Keith L. Maxwell	Personal
95.	Ruth Nolan	Personal

Brief No.	Name	Representing
96.	George Young	CITV
97.	Elly de Jongh	Personal
98.	Dr. J. Howell, M.D.	Edmonton Local Board of Health
99.	Mrs. Vera Moore	Personal
100.	Mrs. Bernice Sumka	Personal
101.	Frank L. Weichman	McKernan Community League
102.	Robert Burr	Personal

Edmonton — July 8, 1981

103.	A. Toplis	The de Havilland Aircraft of Canada, Limited
104.	D.G. Hussey	City of Edmonton Planning Department
105.	J.R. Elliot	Canadian Institute of Public Health Inspectors (Alberta Branch)
106.	Ernie Luders	Alberta Power Limited
107.	Ray Sentes	Alberta Federation of Labour
108.	John Popjec	Personal
109.	Hope Mestzies	Personal
110.	Ramona F. Whyte	Personal
111.	W.A. Williams	City of Edmonton Bylaw Enforcement Department
112.	Gordon Gaetz	Personal

Brief No.	Name	Representing
113.	Joan Uram	Personal
114.	G.L. Clampitt	Personal

Supplementary Briefs

115.	Larry Miller	Elk Point Surface Rights Association
116.	Peter Salmon	Personal
117.	Mr. A.J. Legvilloux	Personal
118.	Mrs. Linda Hope	Personal
119.	Mrs. C.E. Parsons	Personal
120.	Mr. and Mrs. W. Dann	Personal
121.	Mrs. Louise Burns	Personal
122.	Mr. R.V. Rasmussen	Personal
123.	Mr. Michael Sutherland	Personal
124.	Mr. Fred Meagher	Personal
125.	Residents of Pioneer Lodge, Lloydminster, Alberta	Personal
126.	Mr. R.K. Lenz	Personal
127.	Mr. David Fisher	Green Acres Trailer Park
128.	Mr. E.E. Rempel	Personal and Neighbour
129.	E.G. Knull	Pigeon Valley Women's Institute of Ma-Me-O Beach

Brief No.	Name	Representing
130.	Mrs. Donna Galarneau	Personal
131.	C.D. Wilson	Personal
132.	Katherine Yakimets	Personal
133.	Audrey Fiala	Personal
134.	B. De Land	Personal
135.	Mr. T.R. Betton	Personal
136.	Mrs. Vena J. Raugust	Protectors of Peaceful Environment (P.O.P.E.)
137.	Saverio J. Berte	Personal
138.	Asmina Sayani and Gulzar Jamal	Mount Royal College (Students)
139.	Mr. Peter de Vos	Personal
140.	A.W. Kachmar	Personal
141.	Staff Sergeant G.L. Gates	Calgary Police Force
142.	Reg Fryling	Personal
143.	Alan Duncan	Personal
144.	Dr. J.B. Railton	Trans Alta Utilities Limited
145.	Michael Day	Personal
146.	John G. Packer	Personal
147.	Dr. T.W. Swaddle	Personal
148.	Ken Pollock	Personal
149.	Anna M. Bray	Personal
150.	Professor N. Parker-Jervis	Personal

Brief No.	Name	Representing
151.	Ms. Lynne Bresnahan	Distinctive Employment Counselling Services of Alberta (DECSA)
152.	Drs. P.J. Vermeulen and H.G. Kariel	The Sierra Club of Western Canada
153.	Vincent Coady	Personal
154.	Mrs. C. Noack	Personal
155.	R.J. Pedrika	International Molders and Allied Workers Union Local 360, Calgary
156.	Joyce O. Walcott	Personal

GLOSSARY

Early Warning Notch

The initial stages of hearing loss occur in the frequencies between 3000 Hz and 8000 Hz, above the range critical for understanding speech. A notch between 3000 Hz and 8000 Hz on an audiogram tracing indicates both exposure to noise and susceptibility to that particular exposure. The notch acts as an early warning of impending hearing loss in the speech frequencies given continuing exposure to noise.

Infrastructure

The essential elements (basic framework) of a system or organization. For example, the permanent installations required for a community.

Leq

The equivalent sound level, or the average intensity of sound over a given period. (See Section 5.5.)

Ldn

The day-night equivalent sound level. (See Section 5.5.)

L_{10}, L_{50}, and L_{90}

Measurements of the levels of sound which are exceeded by instantaneous measured values only a specified percentage of the time. (See Section 5.5.)

Motor (psychology)

An organism's overt reaction to a stimulus.

Noise Exposure Forecast (NEF)

The noise exposure forecast is a quantitative forecast method used to evaluate the noise impact of aircraft operations on communities in the vicinity of airports. A series of equations are used to generate NEF contours around a given airport. Such factors as number of daytime and nighttime flights, and types of aircraft using various flight paths are considered. Based on a number of social surveys (Cunniff 1977) it is generally accepted that if a residential community is within an NEF 30 contour, community reaction ranges from sporadic complaints to widespread complaints. If it is within the NEF 40 contour, threats of legal action, strong appeals to local officials, and vigorous community action to reduce noise levels can be expected.

Psychomotor

Of or having to do with muscular activity resulting from mental processes.

Relating to the mental origin of muscular movement; that is, to the production of voluntary movements.