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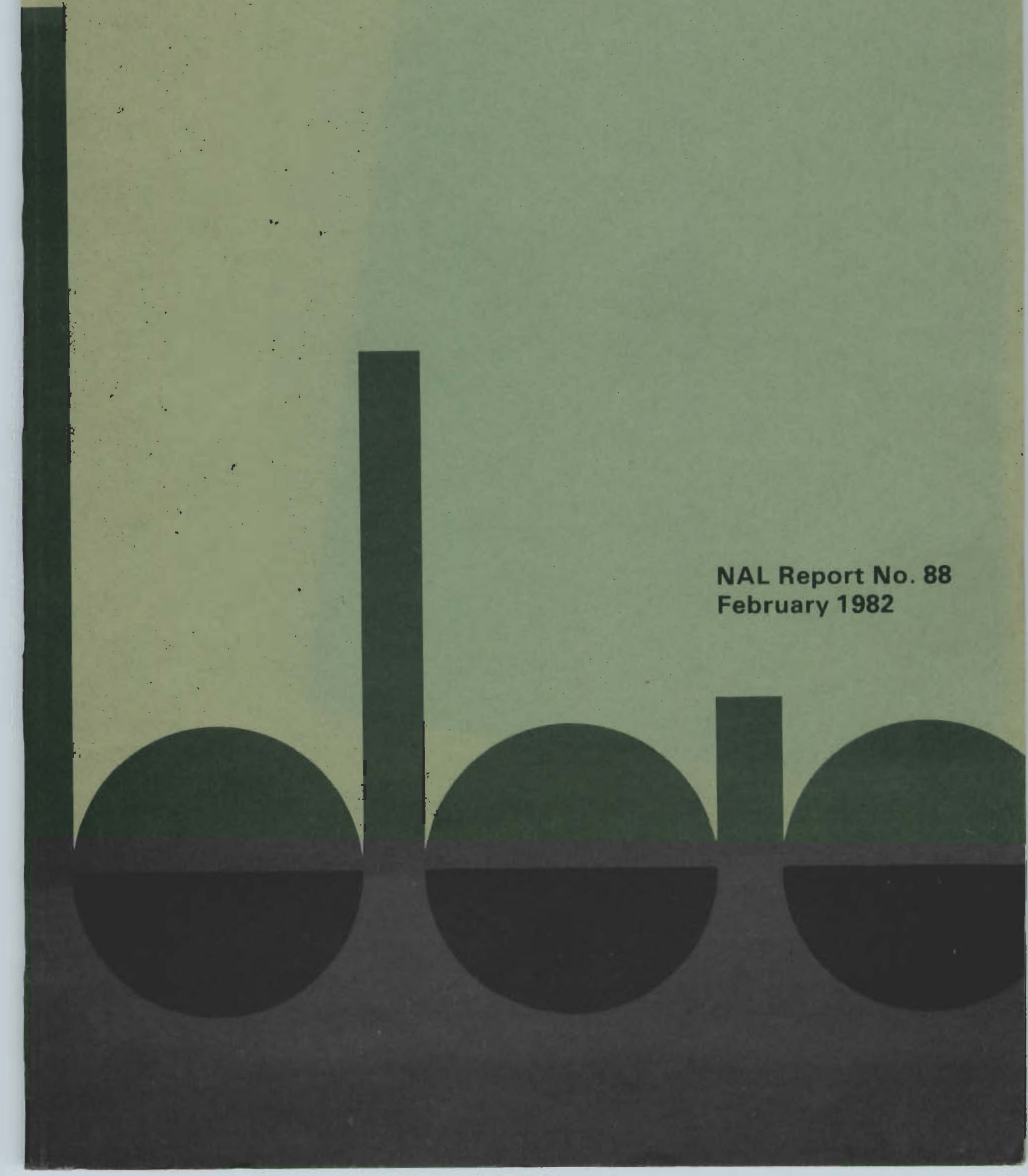
Aircraft noise in Australia: A survey of community reaction



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AIRCRAFT NOISE IN AUSTRALIA:
A SURVEY OF COMMUNITY REACTION

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SOCIO-ACOUSTIC RESEARCH SECTION

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ABSTRACT

A major socio-acoustic investigation was undertaken to assess the impact of aircraft noise on residential communities in Australia. In a social survey, personal interviews were conducted with 3,575 residents around the commercial airports in Sydney, Adelaide, Perth and Melbourne and the Air Force base at Richmond. From the responses to the questionnaire, subjective reaction to aircraft noise was measured in terms of GR (General Reaction), a composite of a number of ratings of dissatisfaction, annoyance and fear as well as reports of activity disturbance and complaint disposition. A score of GR $\geqslant 8$ was used to define whether or not respondents were 'seriously affected' by aircraft noise. Noise measurements were made at several sites around each airport either by tape-recording overflights or by the unmanned logging of noise levels over periods of two weeks. The noise exposure at each of the dwellings in the social survey was estimated in terms of 20 different indices.

Analysis showed that 'equal-energy' indices such as NEF were more highly correlated with community reaction than other types of index including 'peak-level' indices. However, it was found that the standard weighting given to night flights is too high, and that there should be a weighting applied to flights during evening hours. Attitudes towards the aviation industry, personal sensitivity to noise, and fear of aircraft crashing were found to be important in modifying the extent to which a person will be affected by a given amount of aircraft noise. Demographic variables such as age, sex, occupation and education were found to be of generally minor importance in explaining subjective reaction.

Estimates are given of the number of residents around each airport who are seriously or moderately affected by aircraft noise. From the dose/response functions derived in this study it is suggested that a revised NEF value of 20 can be regarded as indicating an 'excessive' amount of aircraft noise. However, questions relating to noise regulation and land-use planning around airports in Australia can be answered only by translating the present scientific assessment into a socio-political context.

CHAPTER 1

OVERVIEW AND SUMMARY

1.1 Overview of Study

1.1.1 Introduction

In preparing this report the authors were presented with the problem of having to write for two different types of reader. On the one hand, this study represents a thorough scientific investigation of the effects of aircraft noise, and will be of interest to scientists who demand full detailing of the methods and results. On the other hand, however, this report will be read by many who are not scientists, for whom the details will be irrelevant or even confusing. This first chapter is written primarily for the non-scientific reader, and provides a broad overview of the study and the major findings.

The introductory chapter of the report (Chapter 2) outlines the basic aims of the study, namely, to evaluate the Noise Exposure Forecast (NEF) system which is the official index used to measure aircraft noise in Australia, and to determine the 'dose/response' relationship between aircraft noise exposure and community reaction to the noise. This chapter also defines the scope of the study and reviews previous research.

Previous studies have usually focussed on the way in which aircraft noise interferes with or disturbs everyday activities such as conversation, TV viewing, sleeping etc. One of the most consistent findings has been that there are large variations among individuals in the amount of annoyance caused by a given amount of noise. Thus, one person can be almost oblivious to the aircraft flying over his house while his neighbour is in a state of continuous rage about the noise. Regardless of the measurement index used, the amount of aircraft noise can explain only a small part of this variation in subjective reaction among individuals.

It has been well-established by previous investigators that much of the variation in reaction arises because of 'psycho-social' factors including:

i) the person's attitudes towards and beliefs about aircraft and the aviation industry,

ii) the extent to which the person is afraid that a plane might crash in the neighbourhood.

Apart from a number of student projects, the only aircraft noise studies previously conducted in Australia were those by Mather (1970) and R. Travers Morgan (1974). Both studies were carried out around Sydney airport and neither provided a detailed evaluation of the NEF index in comparison with other possible measures of aircraft noise exposure.

1.1.2 The social survey

Details of the social survey procedures are discussed in Chapter 3. The survey was conducted on a random sample of residents in noise-affected areas around the commercial airports in Sydney, Adelaide, Perth and Melbourne and the Air Force base at Richmond, N.S.W. The survey sample was organized by noise zone in order to obtain a representative spread across areas exposed to different amounts of noise. In addition, a number of 'control' areas were selected from between aircraft flight paths to provide baseline data on the reaction of residents with little or no noise exposure. The sample dwellings were randomly chosen within each selected area and one respondent was chosen at random from the adult members of each household.

A total of 3,575 people were interviewed by trained personnel during the period February-August, 1980. The overall response rate was 81.6% and the refusal rate 7.1%. The numbers of respondents (and the response rate) for each airport were as follows: Sydney - 1515 (76.4%); Richmond - 311 (83.6%); Adelaide - 710 (89.8%); Perth - 682 (83.7%); Melbourne - 357 (85.4%).

The questionnaire used in the survey was developed after careful consideration of procedures used in previous research. A pilot survey of 160 residents was conducted around Sydney airport to test the wording of the questions. The final questionnaire consisted of 45 questions and averaged about 30 minutes. It was designed so that the questions follow a natural sequence from general questions on the neighbourhood to questions about personal characteristics, questions on noise, and then specific questions about aircraft noise. A copy of the questionnaire is given in Appendix A and a summary of the structure is given below:

Qs. 1 - 6	Attitudes towards neighbourhood
Qs. 7 - 9	Questions on health
Q. 10	Questions on everyday annoyances
Q. 11	Time spent at home
Q. 12	Perception of survey purpose
Qs. 13 - 16	General questions on noise
Qs. 17 - 28	Aircraft noise: perception and reaction
Qs. 29 - 39	Aircraft noise: behaviour and attitudes
Qs. 40 - 45	Demographic information

1.1.3 Measurement of noise exposure

The methods used for estimating the noise exposure at each residence in the survey are described in Chapter 4. The first step in this process is to calculate the amount of noise produced by each type of aircraft at each house. One problem which arises here is that the "amount of noise" can be calculated in a number of different ways. In this study, the "amount of noise" was calculated using three different units:

a) Maximum dB(A) - This unit represents the maximum loudness of the aircraft in a comparatively simple way.

b) Effective Perceived Noise Level (EPNL) - This also takes account of the duration of the noise, and measures loudness in a more complicated way. In practice, measurement of EPNL requires a mini-computer.

c) Sound Exposure Level (SEL) - This unit is similar to maximum dB(A), except that it takes account of the duration of the noise.

All three units can be calculated from standard tabulated values, if the distance from the residence to the aircraft is known.

In order to check the accuracy of these standard values for the areas in the survey, noise measurements were taken at several points around each airport. EPNL and maximum dB(A) were measured in Sydney and Richmond, and maximum dB(A) only at the other airports. The results showed that the standard values are generally quite accurate,especially for aircraft which are landing. The most significant deviations from the standard values are:

a) Noise levels are lower than the standard values when the aircraft is some distance to the side of the observer - that is, when the angle between the aircraft and the horizon is low.

b) When taking off on runways which are not preferred for take-off, all aircraft appear to climb much more steeply than is usually assumed. This could occur because aircraft usually take off into a headwind and tend to have lighter loads when they use non-preferred runways. Their noise level, as heard on the ground, is therefore lower than the standard values.

c) DC10, F27 and F28 aircraft are all several decibels louder than is assumed in the standard values.

The results of these measurements were taken into account to produce "corrected" values of the three noise units for all types of aircraft.

The next stage in the estimation of noise exposure is to combine noise levels from individual aircraft into an overall index representing the amount of "noise exposure" at the residence. This is even more complicated than calculating the noise from a single aircraft, because the number of aircraft which operate per day, as well as their noise level, has an effect on the way people react to the noise, and there is no general agreement on exactly how the noise from different aircraft should be combined.

The official unit of noise exposure in Australia, which is known as the Noise Exposure Forecast (NEF), is one of a group of units called "equal-energy" indices. These units calculate the total amount of noise energy arriving at the residence per day, independent of whether this comes from a few loud aircraft or many quieter aircraft. On the other hand, units known as "peak level" indices take account only of the loudest aircraft heard. That is, they assume that the "noise exposure" from a few loud aircraft is greater than that from many quieter aircraft, even when the overall amount of noise energy is the same.

For the present study, several "equal-energy" and "peak level" units were calculated, as well as other types of noise measurement unit. A total of 20 different units measuring the amount of "noise exposure" were calculated for each residence in the survey. For this calculation, the distance from each house to the aircraft flight-path was measured from aerial photographs, and the number of aircraft flying per day was found, normally by counting airport flight-strips recording each aircraft movement, over a six-month period.

1.1.4 Measurement of subjective reaction

Chapter 5 describes the psychological scaling procedures used in measuring the extent to which people are affected by aircraft noise. Almost all previous studies have measured reaction either by a single rating of annoyance, or in terms of the number of activity disturbances caused by the noise. Both procedures are suspect, the first because it offers no indication of the reliability or consistency of the person's response, and the second because it gives an inaccurate overall measure of subjective reaction.

In this study reaction was measured by means of a combination of the responses given in many different questions. The measure is called GR (for General Reaction) and comprises ratings of "how much affected" and "how much dissatisfied" the person feels, as well as three separate ratings of annoyance, and a rating of fear caused by aircraft noise. GR also includes information about activity disturbances experienced and about complaint actions the person may feel like taking. Scores on GR range from 0 - 10 and provide a reliable and accurate measure of a person's overall subjective reaction to aircraft noise.

The meaning of scores on the GR scale was determined by examining how they were related to responses on other 'peg' questions. For example, at what points on the scale do the majority of people claim that aircraft noise affects their health, select aircraft noise as the feature most worth improving in their neighbourhood, report that aircraft noise disturbs sleeping, or rate their neighbourhood as 'very bad' for aircraft noise? From this examination it was decided that those scoring 8 or more on the GR scale could be considered to be "seriously affected" by aircraft noise. A GR score of at least 4 was taken to define "moderately affected". These classifications were used in the dose/response analysis.

The questionnaire also included items designed to measure a number of psychological factors known to play an important modifying role in determining how much a person will be affected by aircraft noise. One of these was a scale to measure how sensitive the person is to noise in general - this was made up of ratings of annoyance from other noises in everyday life. There was also a scale of attitudes based on agreement or disagreement with ten statements about the airport, the airlines, government officials, aircraft manufacturers etc. The effect of these and other 'modifying variables' is discussed in Chapter 6.

1.1.5 The relationship between exposure and reaction

Chapter 6 discusses the relationship between calculated values of noise exposure and respondents' reaction to the noise (known as the 'dose/response' relationship). As has been found in numerous previous studies, this relationship is very loose - for a given level of noise exposure the degree of reaction, as measured on the GR scale, varies greatly. In fact, the amount of noise exposure explains no more than 13% of the variation in people's reaction to the noise.

There are two possible ways to condense all these varying responses into a single graph. One can either take the line of best fit through all the individual responses (known as the use of individual data) or one can average all responses in an area, and then take the line of best fit through these averages (known as the use of clustered data). A decision must also be made as to whether one is interested in describing respondents' average scores on the GR scale, or only the proportion of respondents who are seriously affected or moderately affected by the noise. The choice of exposure index also affects the relationship. Figures 6.1 and 6.2 show the various graphs of the dose/response relationship using two different measures of noise exposure: NEF3 - the best estimate of the true value of NEF; and $NEF3_{,6}$ - an index which was found to provide a more accurate estimate of reaction than NEF3. It can be seen, for example, that using clustered data, 36% of residents are seriously affected by aircraft noise when NEF3 = 35, whereas at NEF3 = 20, 12% are seriously affected.

As could be expected, reported disturbances to activities and reported effects of aircraft noise on health both increase with increasing exposure to aircraft noise. Overall, the most important disturbance from aircraft operations was flickering of the picture on a TV set, but for those seriously affected by the noise the most important disturbance was to sleeping. The amount of annoyance caused by other neighbourhood noises, such as traffic, dogs and cats, etc., showed no relationship with the amount of aircraft noise.

Much effort has been expended in other studies in an attempt to explain why individuals with the same noise exposure show such great differences in their reaction to the noise - for example, why one person may describe himself as completely unaffected by aircraft noise while his neighbour reports that it disturbs many activities, affects his health, etc. It appears likely that there are personal characteristics which control, or modify, the way noise affects individuals. The most important of these which were found in the present study are:

i) Negative attitudes to the airport, the airlines, the government's effectiveness in controlling noise pollution, etc.

ii) Fear that an aircraft will crash in the area.

iii) Sensitivity to noise in general.

These three factors appear to account for nearly 60% of the variation in values of GR between individuals, compared with 13% of this variation which is accounted for by noise exposure. The figure of 60% may be an over-estimate, due to uncertainty about whether reaction to the noise is affected by these characteristics or vice-versa. (These problems are discussed in detail in Section 6.6.2). However, it is clear that psychological characteristics such as these are very important in determining the extent of an individual's reaction to aircraft noise.

1.1.6 Other results from the survey

Various results other than dose/response relationships are discussed in Chapter 7. The results investigated concern potential sources of bias in interpreting dose/response relationships, the effects of various personal characteristics on reaction to the noise, and the consistency with which respondents answer almost-identical questions at various places in the interview schedule.

The three potential sources of bias investigated are:

a) The possibility that people in households with many members may react to aircraft noise in a different way to people in smaller households. This is a potential problem because people in smaller households had more chance of being interviewed, due to the sampling procedures used.

b) The possible effect of an aircraft crash which occurred at Sydney Airport the day after the Sydney survey began.

c) The possibility that some respondents were aware of the purpose of the survey from the beginning of the interview.

Of these potential sources of bias, no significant effect of a) or c) on the other analyses performed in the study was found. It is possible that b) had some effect, since respondents who mentioned the crash during the interview had significantly higher reaction to the noise than others. Overall, however, the effect is small, and it is not clear whether people's reaction to the crash influenced their reaction to aircraft noise or vice-versa.

Of the personal characteristics investigated, only previous knowledge of the noise problem in the area had a strong relationship with reaction to the noise. It would appear that people who knew about the amount of aircraft noise in an area before they moved there have considerably lower reaction than others. However, this result must be treated with caution, as it could be that respondents who give high ratings for their reaction to the noise feel obliged to "explain" this reaction by stating that the noise was unexpected.

Demographic characteristics (age, sex, occupation, education, home ownership) showed very little effect on reaction to aircraft noise. The most important of these was age, which accounts for only 1.2% of the individual variation in reaction, compared with noise exposure which explains about 13%. Other variables which showed little or no relationship with reaction are the length of time the respondent has been living at the address, the amount of time spent at home, and the type of dwelling - that is, the number of walls which allow noise to enter the building.

Analysis of responses to three questions about the health effects of aircraft noise showed a confusing pattern of response. There was no evidence of "bias" - that is, of respondents systematically mentioning health effects caused by aircraft noise when they knew aircraft noise was the main focus of the interview, but not beforehand. In fact, three times as many respondents answered in the opposite way, giving a health effect in early questions, but not in response to an almost-identical question later in the interview. This confirms the importance of the approach used in this study, namely, having many different questions including some almost identical items to obtain accurate measures of people's reaction to aircraft noise.

1.1.7 Evaluation of noise exposure indices

The various units of noise exposure are compared in Chapter 8. Many possible units were tested by examining how closely they related to the extent of community reaction to the noise. In this case, "reaction to the noise" was evaluated by the percentage of people who are seriously affected by the noise.

The results show that the Noise Exposure Forecast system used in Australia for measuring aircraft noise is among the best available systems. It appears to be definitely superior to "peak level" and other alternative types of unit. However, the efficiency of the Noise Exposure Forecast in predicting the amount of reaction to aircraft noise can be improved in the following ways:

a) The penalty applied to aircraft flying between the hours of 2200 and 0700 should be reduced. In NEF, one flight during these hours is considered to be equivalent to about 17 flights at other times. In the index having the closest relationship with reaction, one "night" flight is considered to be equivalent to about 2 "day" flights.

b) A penalty should be introduced for aircraft flying in the "evening" - between the hours of 1900 and 2200. One flight in these hours appears to be equivalent in its effect on residents to about 4 flights in the "day" hours.

c) Noise from aircraft which are at the airport itself rather than flying overhead should not be included in the unit. (For practical reasons, this noise is not included in current NEF calculations performed by the Department of Transport, Australia.)

Other minor improvements can be made to the efficiency of the NEF unit, but the practical effect would be very small, and the resulting unit would be more complicated and difficult to interpret.

1.1.8 The aircraft noise problem in Australia

Chapter 9 provides a comparison of standard NEF with revised NEF (i.e., NEF with a reduced noise penalty for night flights but with an additional penalty for evening flights). The dose/response functions for the various airports are less scattered when the revised index is used. Generally, the estimate of noise exposure tends to be smaller when it is calculated in terms of the revised NEF. In Perth, particularly, the revised NEF is consistently 5-10 dB below the standard NEF estimate. This explains why community reaction in Perth appears unusually low - it is not that Perth residents are any less affected than in other cities, but that standard NEF overestimates their noise exposure because the weighting for night flights is higher than it should be.

Noise exposure contours around each airport were derived using a procedure of estimating values on a grid pattern. Contours for 25 NEF (standard) and for 20 and 25 NEF (revised) are plotted around the five airports and are illustrated in Chapter 9. Also, estimates were made of the population affected by aircraft noise around each airport. These were as follows:

	Seriously Affected	Moderately Affected
Sydney	78,800	231,300
Richmond	1,200	4,400
Adelaide	16,600	65,200
Perth	4,600	16,600
Melbourne	5,800	19,900

In terms of actual numbers of residents affected, the aircraft noise problem in Sydney is far worse than anywhere else in Australia. This does not mean that the noise problem around other airports can be ignored. It is suggested that residents inside the 20 NEF contour (revised index) can be regarded as being exposed to an 'excessive' amount of aircraft noise. However, the issue of what should be done regarding land-use planning and noise regulation around airports calls for socio-political decisions based on a reasonable interpretation of the scientific data reported in this study, in the wider context of the needs of urban communities.

1.2 Summary of Findings

1.2.1 Relationship between exposure and reaction

a) The relationship between NEF, as it is usually defined, and the percentage of the population which is seriously affected by aircraft noise is shown in Figure 6.2 (b) (Section 6.3). The percentage of the population which is moderately affected is also shown. For example, at NEF = 35, 36% of residents are seriously affected by the noise, and 73% are at least moderately affected. At NEF = 20, 12% are seriously affected, and 38% at least moderately affected.

b) A comparatively small proportion (about 13%) of the variation in individuals' response to aircraft noise can be explained by the amount of noise present.

c) A large proportion of the individual variation in reaction to aircraft noise is due to psychological factors. In particular, negative attitudes towards the airport, airlines, etc., fear that an aircraft will crash in the area, and high sensitivity to noise in general can all act to make reaction much stronger than it would otherwise have been.

d) Overall, the most important disturbance related to aircraft noise is flickering of the picture on a TV set. However, for those seriously affected by the noise, the most important disturbance is to sleeping.

e) Demographic characteristics - age, sex, occupation, education and home ownership - have little effect on reaction to aircraft noise. The most important of these is age, which explains only 1.2% of the variation in reaction, older people tending to be less affected. No evidence was found of any relationship between reaction to aircraft noise and the proportion of time spent at home.

f) Whether or not an individual takes active complaint action against aircraft noise is a poor guide to the extent to which he is affected by the noise. Willingness to take complaint action appears to be related to socio-economic variables.

g) Estimates of the total number of residents who are seriously affected by aircraft noise around each airport in the study are:

Sydney	-	78,800
Richmond	-	1,200
Adelaide	-	16,600
Perth	-	4,600
Melbourne	-	5,800

1.2.2 The most appropriate noise exposure index

a) "Equal-energy" indices, e.g. NEF, show a significantly stronger relationship with reaction to aircraft noise than other types of index tested, including "peak-level" indices and indices which are independent of the number of overflights per day.

b) The penalty given in NEF to aircraft flights at night (viz., 12.2 dB) is too high. However, a penalty should be included for flights in the evening. The optional penalties found were 3dB for night flights and 6 dB for evening flights. However, in a practical index it may be more appropriate to give a 6 dB penalty to all flights between 7 pm and 7 am.

c) Noise from aircraft which are on the ground at the airport itself or are taking off on other runways has far less effect on residents than noise with the same total energy from aircraft flying over their residence.

d) The index referred to as N70 - the number of aircraft per day whose level exceeds 70 dB(A) - gives information on reaction in addition to that given by NEF, although the increase in one's ability to predict reaction is not large. None of the other indices tested has this property. If desired, values of N70 could be given for a noise-affected area in addition to NEF.

1.2.3 Noise exposure estimation

a) Aircraft noise levels, in units of EPNdB, derived from noise certification trials are generally in close agreement with measured levels. (Noise levels derived from certification trials are used in computer predictions of NEF made by the Department of Transport, Australia.) The overall error (that is, the R.M.S. error) in predicting NEF at any one point is about ± 3 dB, but only about 25% of this error can be removed by using more accurate aircraft noise levels.

b) Aircraft whose noise levels do not agree with assumed levels are the McDonnell-Douglas DC10, Fokker F27 and Fokker F28. All these aircraft show measured levels typically 3 - 6 EPNdB above their assumed values.

c) Height-versus-distance profiles for aircraft on departure from non-preferred runways seem to be much steeper than the profiles usually assumed. This could be due to the fact that non-preferred runways are used only when a strong head-wind is present, or to a tendency for aircraft using these runways to be carrying lighter loads.

d) When noise levels are measured in terms of maximum dB(A), there is a tendency for assumed levels of common aircraft types - particularly the Boeing 727 and McDonnell-Douglas DC9 - to be too high. That is, the assumed difference between EPNL and maximum dB(A) is smaller than the measured difference, by about 3 dB.

CHAPTER 2

INTRODUCTION

2.1 Background and Aims of Study

In its report in 1970 the House of Representatives Select Committee on Aircraft Noise recommended that:

> "there is a need for a social survey in Australia to obtain factual data on the magnitude of unrest and disturbance attributable to aircraft noise. It is recommended that this should be conducted in the areas surrounding Sydney Airport as being the area of greatest exposure."

The Aircraft Noise Social Survey (ANSS) Ad Hoc Working Group was established in 1977 to review the need for a major survey. This group comprising representatives from the Australian Bureau of Statistics, the National Acoustic Laboratories, the Department of Transport and the Department of Defence, decided that a social survey should be conducted around the commercial airports in the cities of Sydney, Perth, Adelaide and Melbourne, and also around the Air Force base at Richmond (N.S.W.).*

Early in 1979 the National Acoustic Laboratories formed a Socio-acoustics research team to undertake the task of conducting the social survey as well as a noise assessment study. A pilot survey of 160 residents around Sydney airport was carried out in June, 1979, with a view to testing the questionnaire and developing psychological scaling procedures for assessing subjective reaction to aircraft noise. An additional survey of 100 Sydney residents was conducted to further elucidate the nature of subjective reaction. The main survey was carried out between February and August, 1980.

The primary aims of this study were:

1) To investigate the effects that aircraft noise has on residential communities around Australian airports.

2) To evaluate the index presently used to estimate aircraft noise exposure in Australia, namely, the Noise Exposure Forecast (NEF). In particular, to determine whether other noise exposure indices or a modified NEF index may be more suitable for predicting community reaction.

3) To provide scientific data which can form the basis of guidelines and standards for land-use planning around Australian airports. In particular, to quantify the "dose/response" relationship between aircraft noise exposure and subjective reaction to the noise.

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* The study was financed jointly by the Department of Defence and the Department of Transport, Australia. Funds to cover the cost of interviews in Melbourne were provided by the Environment Protection Authority of Victoria.

4) To assess the extent of the aircraft noise problem around the various airports studied.

2.2 Scope of the Survey

The five airports included in the survey were chosen so as to give a representative picture of the aircraft noise problem in Australia. (See Figures 3.1 to 3.5 for maps of the various airports). As can be seen from Table 2.1 the airports differ in a number of respects. Sydney, Perth and Melbourne are international airports, Adelaide is a domestic airport and Richmond an Air Force base. Sydney and Melbourne have significantly larger numbers of aircraft operations than the other airports. Different types of aircraft predominate at the different airports although the Boeing 727-200 is the most common commercial aircraft overall. While all five airports have procedures for noise abatement, only Sydney and Adelaide have a formal curfew which restricts jet aircraft operations in the hours 2300-0600. Also, the distribution of aircraft traffic over day, evening and night hours varies widely for the different airports (see Figure 4.1). Finally, the airports differ in the composition and density of the surrounding residential population. For example, while Sydney has high and medium density housing in high noise areas close to the airport, Melbourne has medium and low density housing and has no residential areas with high noise exposure. It is the variations across the airports included in the study which will enable a systematic investigation of the many factors involved in community reaction to aircraft noise.

	SYDNEY	RICHMOND	ADELAIDE	PERTH	MELBOURNE
Type of airport	International	Air Force	Domestic	International	International
Average daily operations (F27+larger)	277	74	72	52	208
Most common aircraft types	Fokker F27, Boeing 727	Hercules Transport (C130)	Boeing 727, Fokker F27	Fokker F28, Boeing 727	Boeing 727, Douglas DC9
Curfew	Yes	No	Yes	No	No
Density of surrounding population	High + Medium	Medium + Low	Medium	Medium + Low	Medium + Low

TABLE 2.1 Differences among the five airports included in the survey.

2.3 Previous Research

2.3.1 Early studies

The first serious studies of the effect of aircraft noise on a residential population were conducted in the United States in the 1950's and reported in 1961 (Borsky, 1961). The major study consisted of interviews with 3635 respondents around 8 major commercial airports. This research was motivated largely by complaints, and the interview concentrated on assessing the degree of the respondent's annoyance, which was seen as the reason for complaints. Annoyance was assessed by the number of activities which were said to be disturbed. Noise exposure was estimated by a number of units, most of which are no longer used (e.g., the mean number of seconds per hour during which a Speech Interference Level of 60dB is exceeded).

This work set a pattern for most subsequent studies in that it involved face-to-face interviews where the purpose of the interview was concealed, at least initially. Respondents were questioned about their attitude toward the airport and other factors considered relevant to their response, as well as about their direct reaction to the noise.

Because results were not analysed in terms of correlations, only the existence of effects, and not their strength, could be directly determined. The expected increase in annoyance with exposure was found, annoyance increasing both with the level exceeded by 10% of aircraft and with the number of noise events above a given level. Annoyance was also related to "sociopsychological variables", such as fear of aircraft crashing and negative attitudes towards the airport. Little relationship was found between annoyance and demographic variables, such as age, sex and socio-economic status.

Similar results were reported in a study conducted around Heathrow Airport in 1961 (McKennell, 1963). The design and analysis of the study were very similar to Borsky's with the exception that the use of correlational analysis allowed quantitative estimation of the strength of relationships. Correlations between the annoyance scale used and various measures of noise exposure ranged from about 0.35 to 0.45, indicating that only 12 - 20% of the variance in individuals' annoyance could be accounted for by the measures of noise exposure which were employed. This result has been verified in numerous subsequent studies for a range of noise exposure measures.

Correlations between annoyance and "personal factors", such as fear of aircraft crashing, beliefs about the preventability of the noise, etc., proved to be of about the same magnitude as correlations with noise exposure. This was taken to indicate that reaction to aircraft noise has a large "psychological" component. Correlations between annoyance and demographic variables were again very low.

McKennell also studied a separate sample of complainants. Although these people were found to have higher annoyance than the "average" respondent, there were still many non-complainants who seemed to be just as annoyed as complainants. The main differences between complainants and these non-complainants appeared to be in demographic variables, particularly those associated with socio-economic status. Complainants tended to rank higher on the social scale than others.

2.3.2 More detailed studies of exposure and reaction

After this initial work it was felt that two aspects of the aircraft noise problem should be studied in greater detail. These were:

a) How can noise exposure be measured in such a way that it provides the best description of likely reaction to the noise?

and b) what are the factors, apart from noise exposure, which explain the large individual variation in reaction to aircraft noise?

Neither of these questions has yet been satisfactorily answered.

The first problem was studied in a second survey around Heathrow Airport in 1967 (MIL Research Ltd., 1971). In particular, this survey examined the relative effects of the number of noise events and their level, and the effect of the time of day at which a noise occurs. However, the results were rather inconclusive. It was assumed that a noise index should be approximately of the form (Energy-mean level of events) + K log(Number of events), with the value of K to be determined. The value K = 15 had been chosen from results of the first survey, although it was later pointed out (McKennell, 1969) that the data supporting this choice were by no means unequivocal. The second survey also failed to produce a clear result, since a very wide range of values of K gave indices with similar predictive abilities. The relative importance of overflights at night was also left unresolved. The only clear result of the analysis was that the relationship between night-time noise and disturbance at night was similar to that between day-time noise and overall disturbance.

A study around seven major airports in the United States (Tracor, Inc., 1971) investigated personal, or "psycho-social" variables which could influence reaction to aircraft noise. A number of variables were found, the most important being fear of aircraft crashing. The usefulness of some other variables tested seems doubtful, especially since their effects were highly non-linear, so that it is difficult to assign any meaning to the effect. Previous results concerning the relative sizes of correlation co-efficients, and differences between complainants and non-complainants, were substantially replicated.

2.3.3 Criticisms of the traditional survey methodology

Throughout the 1970's a number of criticisms of the techniques used in the above studies appeared. Many were concerned with the scaling procedures used to measure a respondent's "annoyance". Edwards (1975) argues that questions should be related directly to annoyance, rather than to activity disturbance which is presumed to result in annoyance. Two criticisms made by Gunn (1978) were:

i) in general, no explicit model of reaction to noise is put forward against which particular interview questions can be evaluated, and

ii) perhaps the word "annoyance" does not adequately cover the full range of human reaction to aircraft noise.

Noise measurement methodology was criticised by Rylander et al. (1972) and by Gunn et al. (1975) on the grounds that the exposure information generally supplied was insufficient to allow for the testing of a broad range of possible noise exposure indices.

Alexandre (1976) questioned the conclusion that "psycho-social" variables are important in determining reaction to aircraft noise. He argues that such things as fear of aircraft crashing could well constitute a part of overall reaction to the noise, rather than being a determinant of it.

In most recent aircraft noise surveys, estimates of response to the noise are based on answers to a single question. This asks directly about the extent of annoyance, in terms of a number of verbal categories (for instance, "not annoyed", "a little annoyed", "rather annoyed", and "very annoyed" (Rylander et al, 1972)). In addition, attention is concentrated on the number of respondents who fall into a category roughly equivalent to "highly annoyed". Data is generally analysed in terms of the proportion of respondents in a given area who fall into this category. Schultz (1978) argues strongly that this is the appropriate form of analysis and shows that if this is applied, results from a number of independent surveys show remarkable agreement.

In response to criticisms such as Alexandre's, and also because the technique of grouping response data tends to obscure individual differences in reaction, the effects of "psycho-social" variables are generally not as closely studied in recent surveys as in the earlier work. Indeed, it has been argued (Schultz, 1978) that measurable physical variables, such as house attenuation, could well explain much of the individual variation in reaction which was previously assigned to the effect of "psycho-social" variables.

Noise assessment, however, is still generally performed along lines similar to the early studies, although usually with more precision. The range of noise indices tested is usually small, and there is no obvious or stated reason for using one measurement index in preference to another. Often, only one index, or two very similar indices, are calculated (e.g., Grandjean et al, 1973 and Hall, 1979). The reason for this appears, in part, to be a general belief that the social survey instrument is too "blunt" to discriminate between noise exposure indices. With the exception of Rylander et al (1980), no researcher has been prepared to state, on the basis of survey results, that one index was found to be preferable to another. Such discrimination is thought to be more easily and accurately performed in controlled laboratory studies, or other special-purpose community studies.

2.3.4 Laboratory studies

Laboratory studies of the "noisiness" or "annoyance" or single noise events have been performed since the 1950's (Stevens, 1956). Results of these studies have been used to define a number of procedures which, when applied to a noise, give an indication of its annoyance. These range in complexity from simple frequency-weightings such as the A-weighting, to complex calculation procedures such as that used for the Effective Perceived Noise Level. A synthesis of these results by Scharf and Hellman (1978) shows calculation procedures to be superior to frequency-weightings, although the differences are usually small.

Borsky and Leonard (1973) conducted a laboratory study specifically to test differences in reaction to noise from Boeing 727 aircraft with and without acoustic treatment to the engine nacelles. Subjects were chosen from a previous survey of residents exposed to aircraft noise, and the laboratory was made to simulate a real living room. In this way, it was hoped that some of the difficulties associated with the artificiality of a laboratory setting would be overcome.

Rice (1977(a) and (b)) took this technique further, and asked subjects in a simulated living room to judge the difficulty of "... living with that amount of noise all the time ..." in their own homes. The main object of the study was to investigate the "trade-off" between the number of noise events and their level. It was found that some form of correction for the number of noise events was necessary, but that its precise nature could not be accurately specified, even using a controlled laboratory setting.

Recently, Shepherd (1981) has extended this laboratory technique to the point of asking subjects how annoying a certain pattern of aircraft noise would be if they heard it in their homes during day, evening or night periods. He found a difference in reaction equivalent to 7 - 12dB(A) for noise at night compared to that in the daytime, and a difference of 5 - 7dB(A) for evening noise. While such studies may provide useful guidance on specific questions concerning the form of noise exposure indices, it would seem that some corroboration from survey data is necessary before the results can be confidently applied to predict community reaction.

2.3.5 Previous Australian studies

Only two salient studies of reaction to aircraft noise in Australia have been reported - by R. Travers Morgan and Partners (1974) and Mather (1970). Both were conducted around Sydney Airport. The R. Travers Morgan study involved 1130 interviews conducted under three flight-paths. Noise exposure in 5dB steps was estimated from standard computer programs using the index NEF. Annoyance was measured by a scale of disturbances similar to that of McKennell (1963). Results concerning the relationship between exposure and reaction, and between "psychological variables" and reaction, were similar to those found by McKennell and by Tracor (1971). The results were not analysed in terms of the percentage of the population "highly annoyed".

Mather's survey consisted of 296 interviews with residents of home units under the western flight-path in Sydney. Correlations between measures of noise exposure, annoyance and "attitudes" were found to be similar to those in previous studies. Percentages of respondents who were "highly annoyed" were again not given.

CHAPTER 3

THE SOCIAL SURVEY

3.1 Sampling Procedures

3.1.1 Sample size and structure

The survey covered all residential areas around Sydney, Richmond, Adelaide, Perth and Melbourne airports which had a nominal NEF greater than 25, together with dwellings lying outside the 25 NEF contour in the '20-25' NEF zone (see Figures 3.1 - 3.5).

The sample can be technically described as a two-stage clustered sample of the dwellings defined above, stratified by NEF zone and aircraft flight-path. One randomly-selected resident was interviewed at each dwelling included in the sample (see Section 3.3).

An area lying under a specific aircraft flight-path and within a 5-unit NEF zone (for instance, between 30 NEF and 35 NEF) is termed an "exposure zone". Since the number of dwellings in an exposure zone varies considerably between airports in the survey, it was necessary to adjust the number of dwellings sampled. Details of the sampling for each airport are given in Table 3.1.

AIRPORT	Number of Exposure Zones	Number of Sample Blocks per Zone*	Total Number of Sample Blocks	Number of Control Blocks	Number of Dwellings in Sample
SYDNEY	15	7	92	7	1542
RICHMOND	7	3	21	2	312
ADELAIDE	12	4	43	4	684
PERTH	15	3	42	3	688
MELBOURNE	4	5	20	2	352
				TOTAL (Target)	3580

TABLE 3.1 Composition of survey sample design.

* Because of the relatively small numbers of dwellings in the higher exposure areas, there were fewer than the target number of sample blocks in some zones.

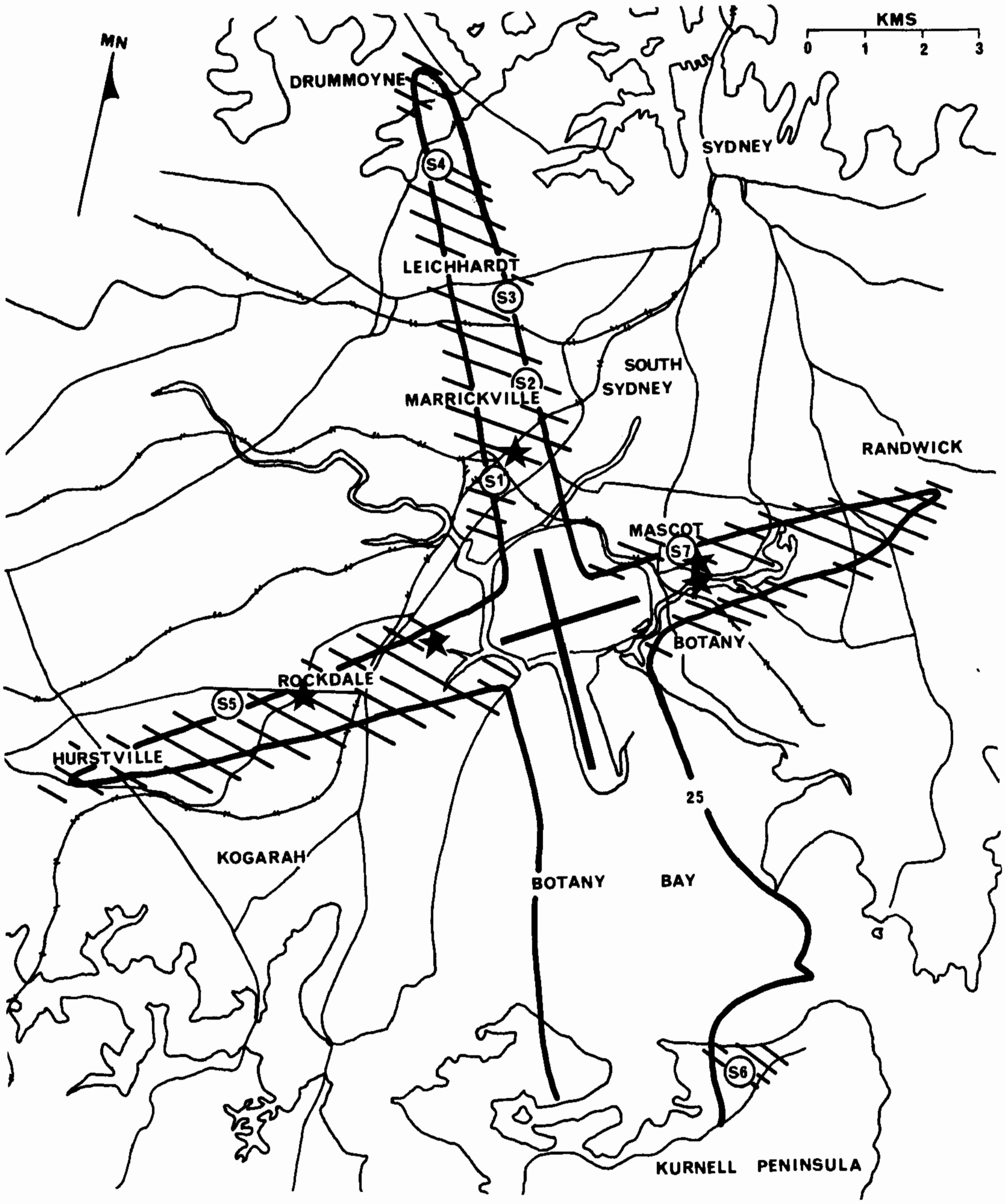

FIGURE 3.1 Sydney airport and surrounding areas. The solid line shows the nominal 25 NEF contour used for stratification. The sampled area is shaded. Noise measurement sites and code numbers are circled. Sites of Sydney Airport Noise Monitoring Centre terminals are shown by ★.

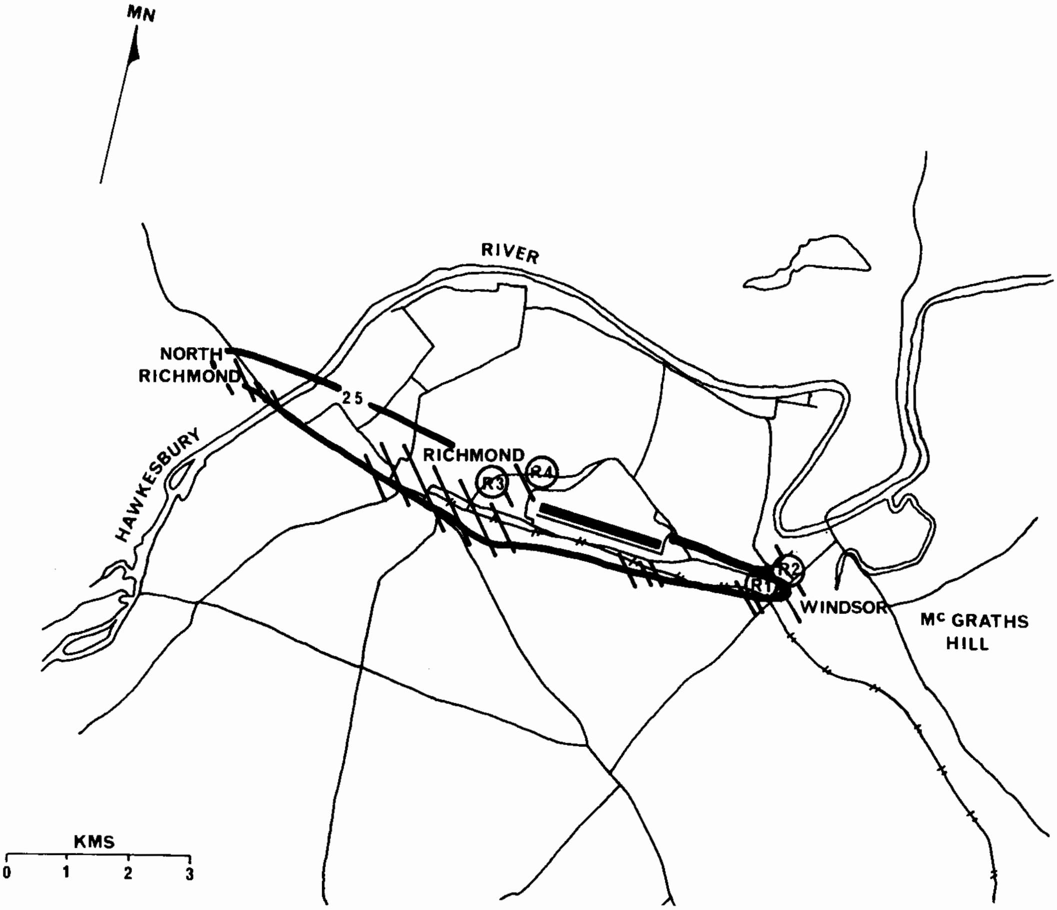

FIGURE 3.2 Richmond air base and surrounding areas. The solid line shows the nominal 25 NEF contour used for stratification. The sampled area is shaded. Noise measurement sites and code numbers are circled.

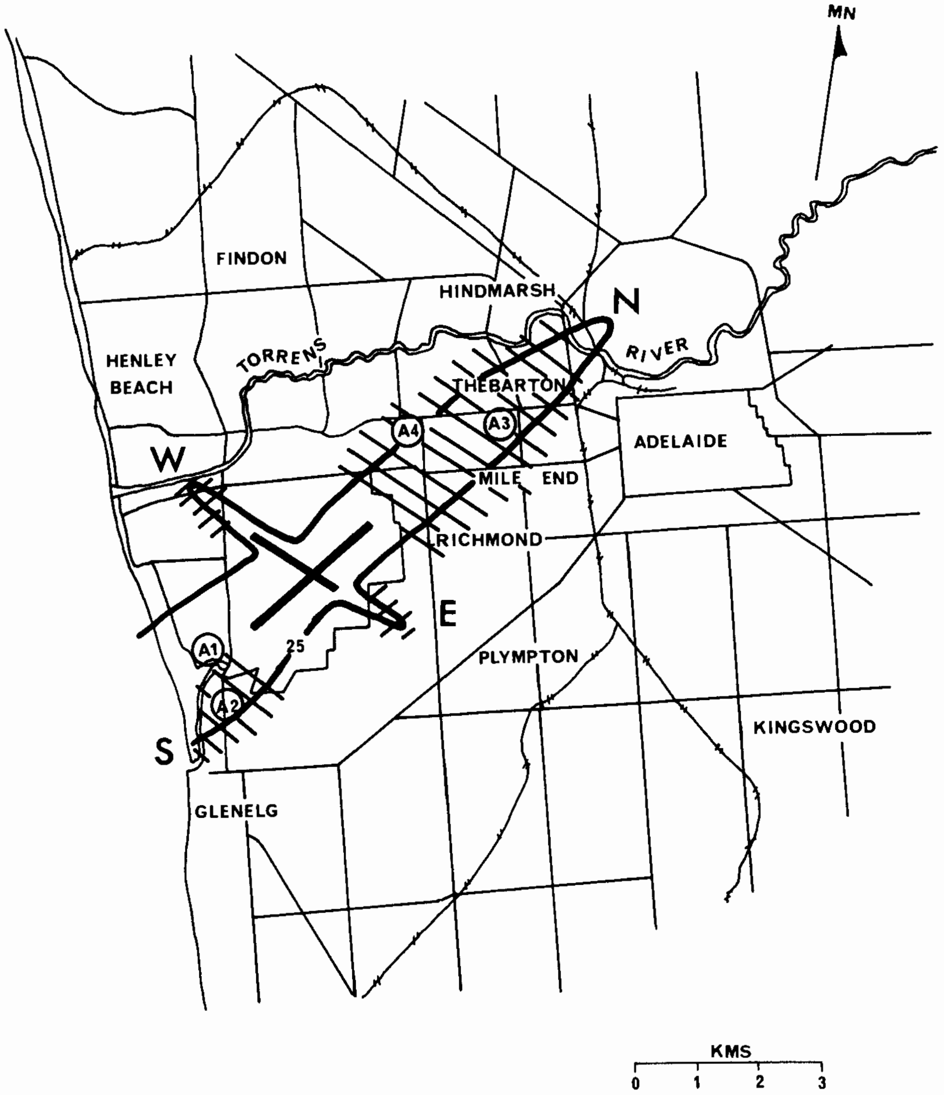

FIGURE 3.3 Adelaide airport and surrounding areas. The solid line shows the nominal 25 NEF contour used for stratification. The sampled area is shaded. Noise measurement sites and code numbers are circled.

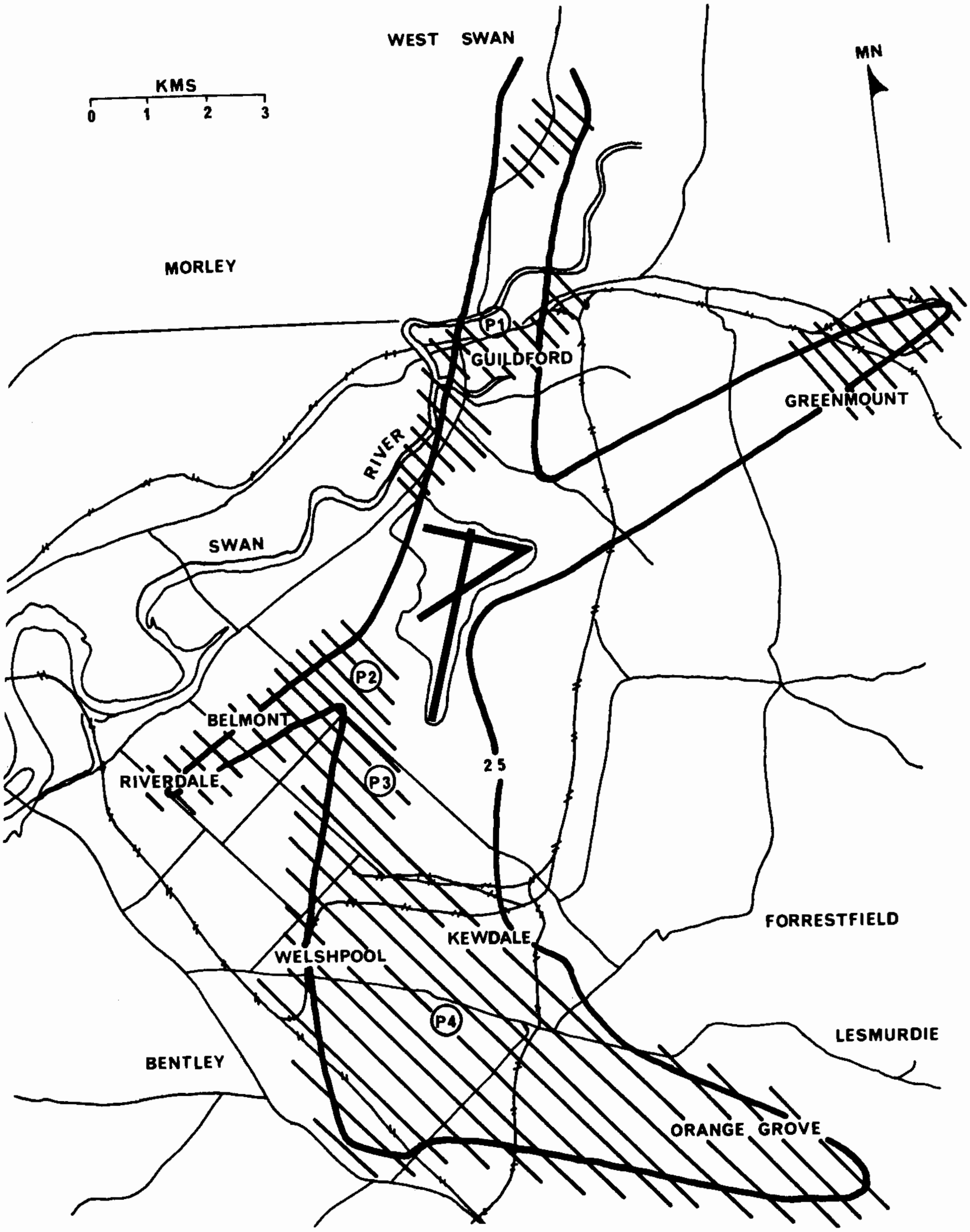

FIGURE 3.4 Perth airport and surrounding areas. The solid line shows the nominal 25 NEF contour used for stratification. The sampled area is shaded. Noise measurement sites and code numbers are circled.

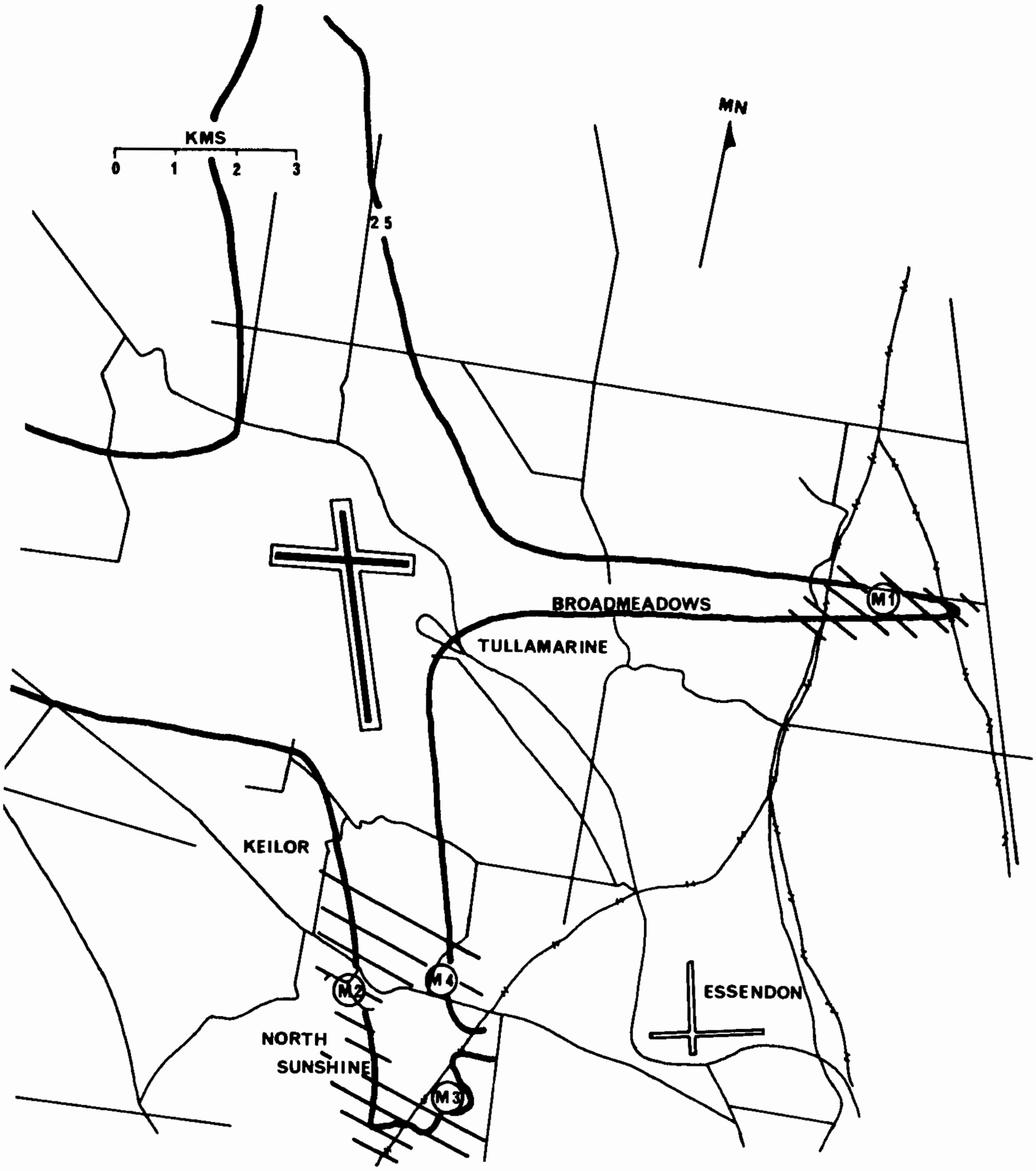

FIGURE 3.5 Melbourne airport and surrounding areas. The solid line shows the nominal 25 NEF contour used for stratification. The sampled area is shaded. Noise measurement sites and code numbers are circled.

3.1.2 Sample selection

Nominal NEF contours* were superimposed on aerial photographs and orthophotomaps (scale = 1:10,000) of all areas to be surveyed. In heavily built-up areas, 1:2,000 scale orthophotomaps were used where available. Each exposure zone was divided into "sample blocks" containing not less than 75 residences (the average was approximately 110), and the number of dwellings in each block was counted. In this process, Australian Bureau of Statistics census data giving the number of dwellings in each census district, and the proportions of flats and home units, proved valuable. Sample blocks outside but adjacent to the 25 NEF contour were also included; these are described as lying in the 20-25 NEF zone.

At Melbourne, some possible sample areas were excluded, as they fell inside the 20 NEF contour for Essendon, a nearby general aviation airport.

The required number of sample blocks in each exposure zone was randomly selected, with probability proportional to the number of dwellings counted in the block. The addresses of all dwellings in each selected block were then listed by field observation. At the same time, the presence of any structure which could shield the dwelling from aircraft noise, or reflect sound onto it, was noted.

Twenty-five dwellings were then randomly selected in each block, under the conditions that they be as near to each other as possible, but that there be at least two other dwellings between any two sampled dwellings. This was done by dividing the block into "strings" - lists of dwellings, in the order in which they occur, in a street block or part thereof. Strings were ordered according to geographical proximity. One string was then randomly selected, with probability proportional to size, and a dwelling selected in that string. From here, every third dwelling in the string was taken to be in the sample. On reaching the end of this string, a random dwelling was selected in the next string, and every third dwelling from here was taken to be in the sample, returning to the beginning of the string on reaching the end. This process was continued until 25 dwellings had been selected. Interviews were sought at the first 16 dwellings in a block and the remaining dwellings were used as replacements in the case of non-response (see Section 3.3). At Perth and Richmond, some isolated farm-houses in rural areas were excluded from the sample for operational reasons. Unless a string in these areas contained at least 5 dwellings it was classified as non-residential and excluded.

In some exposure zones, particularly those with NEF > 35, there were not enough dwellings to make up the required numbers. Where the number of dwellings selected by the above procedure fell below 23 per block, every second dwelling, rather than every third, was selected. Even so, some blocks contained fewer than the required number of dwellings.

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* The most recent NEF contours available from the Department of Transport Australia and the Department of Defence (for Richmond) were used.

3.1.3 Control sample

The areas between aircraft flight-paths which have very low nominal aircraft noise exposure were chosen as "control" areas. These areas were defined by rotating the NEF contour overlay to bisect the angle between runways. The control areas can therefore be considered comparable to the sample areas in terms of distance from the airport, etc. The required number of blocks in these areas, as shown in Table 3.1, were chosen by selecting census districts with probability proportional to the number of dwellings which they contain. The chosen census districts were then regarded as blocks, and dwellings were listed and selected for the sample as described above.

At Richmond, only one group of dwellings was available for use as a control area. Dwellings in this group were listed and arbitrarily divided into two blocks. The dwellings to be included in the sample were then selected as above.

3.2 The Questionnaire

3.2.1 Development of Questionnaire

The interview schedule was developed over a period of 12 months. Firstly, a review was made of the questionnaires used in previous major aircraft noise studies (e.g., Borsky, 1961; McKennell, 1963; Tracor, Inc., 1971). From this review a preliminary schedule was drafted. This was assessed by a number of independent experts*. A questionnaire was then developed for a pilot survey of 160 randomly selected residents around Sydney airport. The pilot schedule consisted of 65 questions. It included many of the questions commonly used in noise studies as well as a number of novel items.

On the basis of the results of the pilot survey and of feedback provided by interviewers, the schedule was revised. The final version consisted of 45 questions and took an average of 30 minutes to administer. The schedule is similar in its overall structure to those used by previous researchers. It begins with questions about the neighbourhood and progresses to noise in general, then aircraft noise in particular. A wide range of aircraft noise reactions is covered, including annoyance, activity disturbance, fear of crashing and health effects. There are also questions designed to assess general attitudes towards aircraft noise. The final questions deal with demographic information.

Because of continual media publicity most respondents were likely to be aware of aircraft noise as a controversial environmental issue. The problem of response bias arises because some people who are not really affected themselves, may tend to exaggerate their responses if they have strong feelings about issues related to the environment, aircraft noise and/or airport development. To minimize the effects of such bias a neutral/prompted question strategy is used. The schedule allows respondents to spontaneously mention and to rate aircraft noise before they are told what

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* These included Dr. J.J. Ray, Prof. R. Rylander, Dr. S. Sörensen and officers of the Australian Bureau of Statistics. Their assistance is gratefully acknowledged.

the survey is specifically about. Thus, the early questions are either open-ended (e.g., Q.4, Q.8) or are neutral with respect to aircraft noise (e.g. Q.5, Q.9, Q.10). It is not until Q.17 that the questions focus on aircraft noise.

3.2.2 Summary of questions

A copy of the interview schedule is reproduced in Appendix A together with basic data from the social survey (see Section 3.6). The interviewers' briefing notes on each question are also given in Appendix A. The questions are summarized as follows:

Q.1 Length of residence.
Q.2 Overall rating of neighbourhood.
Q.3 Features liked in neighbourhood.
Q.4 Features disliked in neighbourhood.
Q.5 Ratings of specific neighbourhood features.
Q.6 Feature most worth improving.
Q.7 General self-rating of health.
Q.8 Health effects of conditions in neighbourhood.
Q.9 Health effects of specific conditions including aircraft noise.
Q.10 Ratings of annoyance from everyday situations including noise.
Q.11 Times usually at home.
Q.12 Prior knowledge of the survey.
Q.13 Noises heard in neighbourhood.
Q.14 Specific noises including aircraft noise.
Q.15 Annoyance ratings for noises heard.
Q.16 Noise most worth eliminating.
Q.17 Rating of how much AFFECTED by aircraft noise.
Q.18 Activities disturbed by aircraft noise.
Q.19 Activity most worth having free from disturbance.
Q.20 Rating of overall annoyance from activity disturbance.
Q.21 House vibration caused by aircraft noise.
Q.22 Startle caused by aircraft noise.
Q.23 Rating of fear caused by aircraft noise.
Q.24 Perception of sound made by aircraft.
Q.25 Health symptoms caused by aircraft noise.
Q.26 "Noisiest plane" versus "steady build-up".
Q.27 Period most worth having free from aircraft noise.
Q.28 Perception of airport-generated noise.

Q.29 Complaint action taken.
Q.30 Complaint actions person feels like taking.
Q.31 Prior knowledge about aircraft noise in neighbourhood.
Q.32 Adaptation to aircraft noise.
Q.33 Perception of change in amount of aircraft noise.
Q.34 Thoughts of moving from neighbourhood.
Q.35 Rating of fear of aircraft crashing.
Q.36 General annoyance rating categories.
Q.37 Attitudes and opinions about aircraft noise.
Q.38 Rating of DISSATISFACTION because of aircraft noise.
Q.39 Other comments about aircraft noise or neighbourhood.
Q.40 Age category.
Q.41 Occupation.
Q.42 Sex.
Q.43 Education level.
Q.44 Home ownership.
Q.45 Type of dwelling.

If a zero rating was given in Q.17 (how much "affected") then questions 18 to 36, inclusive, were skipped. This was done on the grounds that it would be absurd to ask details of how aircraft noise affects someone who claims to be 'not at all affected'. Although the response "Don't know" was allowed for in most questions, interviewers were trained to encourage respondents to 'have a go'. Interviewers were told not to readily accept the immediate "I don't know" some people are prone to give whenever they are required to think about an answer.

3.2.3 Rating scales and opinion thermometer

Many of the questions in the interview schedule require the respondent to give a rating. In some cases a simple rating scale was used (e.g. "very good, fairly good, average, fairly bad, very bad" used in Q.2, Q.5 and Q.7). The respondent was shown a card with these categories listed and was asked to select the most suitable descriptor.

However, such simple scales are not adequate for the main ratings used to measure annoyance and other aspects of subjective reaction to aircraft noise. To ensure reliable responses an "Opinion Thermometer" was used (see Figure 3.6). This consists of a card picturing a thermometer marked '0-10' with five verbal descriptions ('none'to 'very much'). In Q.10, respondents were instructed how to use it and encouraged to indicate the strength of their reaction by selecting a number. Earlier studies showed that an Opinion Thermometer in this form is most suitable for obtaining the many ratings required for an accurate assessment of subjective reaction. The detailed psychological scaling procedures used to estimate an individual's overall reaction are discussed in Chapter 5.

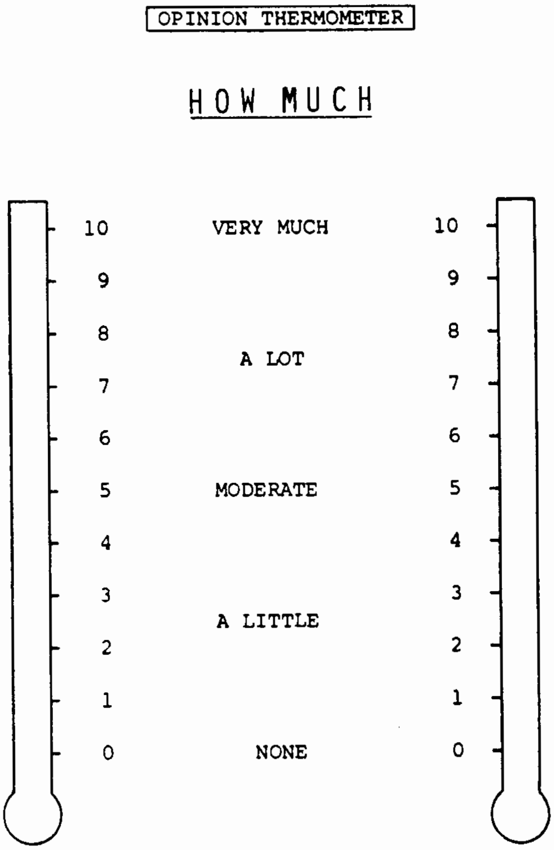

FIGURE 3.6 The "Opinion Thermometer" used for rating subjective reaction.

3.3 Field Procedures

A total of 57 interviewers were engaged on the social survey around the five airports: Sydney (21), Richmond (4), Adelaide (11), Perth (12) Melbourne (9). Most of the interviewers were experienced field agents engaged by the Australian Bureau of Statistics. All except two were women. Interviewers underwent a three-day training course which included extensive supervised practice with the schedule. After the course interviewers spent one day conducting interviews and then returned for a revision session.

Interviewers were given lists of the 25 addresses selected in each sample block (see Section 3.1). The first 16 addresses on each list (14 in Richmond) were designated 'primary' and interviews were sought at each of them. In the event of failure to obtain an interview at a particular address, a substitution was made of the first available address from the remaining 'reserves'. Although this procedure may lead to a lower response rate, it does ensure that a minimum number of interviews are obtained in each possible exposure zone.

When contact was made at an address the interviewer first inquired who were the members of the household aged 18 or over. These were assigned a number corresponding to the order in which the names were given. The interviewer then consulted a random number table to find which of the household members was to be the respondent. Respondent Selection Tables of random numbers were computer-generated for each sample block (see Figure 3.7). A person was deemed to be beyond the scope of the survey if he/she was:

i) Not aged 18 years or over at date of contact.

ii) Not able to understand English.

iii) A foreign diplomat or foreign service person.

iv) Not a usual resident at the address.

v) Too infirm to be interviewed.

vi) Not going to be home at all during the survey period.

If the selected respondent proved to be beyond scope then another person was chosen using the Respondent Selection Table. Note, however, that if the selected respondent refused to be interviewed, no new selection was made and the address was coded 'refusal'.

3.4 Response Rate

The social survey was carried out over a six month period in 1980. The survey dates for the five airports were:

Sydney	20 Feb	-	2 April
Richmond	20 Feb	-	26 March
Perth	8 May	-	5 June
Adelaide	5 June	-	3 July
Melbourne	24 July	-	7 August

A total of 3,575 successful interviews were obtained, 1515 in Sydney, 311 in Richmond, 682 in Perth, 710 in Adelaide and 357 in Melbourne. Full details of the response data are given in Table 3.2. While the overall response rate was 81.6%, there was considerable variation across airports. The lowest response rate was obtained in Sydney (76.4%) - this was partly due to the comparitively high proportion of households where no-one spoke English (6.5%). The response rates around the other airports ranged from 83.6% in Richmond to a high 89.8% in Adelaide.

The refusal rate was 7.1% overall, but this varied markedly with airport. The difference in refusal rates between Sydney and Adelaide (9.0% versus 3.3%) may reflect the fact that the interviewers were less experienced in the former case. It may also be due to differences between the populations in the two cities. The disproportionately high number of vacant dwellings in Adelaide resulted from the fact that the sample area happened to include a beach resort with unoccupied holiday flats.

INTERVIEWER WORKLOAD NO.

ADDRESS CODE	NUMBER OF ELIGIBLE HOUSEHOLD MEMBERS						
	1	2	3	4	5	6	7+
01	1	1	2	3	1	4	6
02	1	1	3	1	2	6	6
03	1	2	1	4	4	5	3
04	1	1	2	4	2	3	1
05	1	2	2	2	1	3	3
06	1	2	2	2	5	2	1
07	1	1	3	2	2	5	1
08	1	2	3	4	5	2	5
09	1	1	2	2	1	3	2
10	1	2	3	4	3	2	6
11	1	1	3	4	1	6	7
12	1	1	1	2	4	6	3
13	1	1	1	4	5	1	2
14	1	1	2	2	5	5	7
15	1	2	3	2	5	4	1
16	1	1	3	1	3	1	1
17	1	1	1	3	1	3	7
18	1	1	1	3	3	3	3
19	1	1	3	2	3	2	4
20	1	1	1	1	3	5	7
21	1	2	2	2	3	5	1
22	1	2	3	1	4	1	5
23	1	1	1	2	3	1	1
24	1	2	1	4	1	5	6
25	1	2	1	1	5	4	5

FIGURE 3.7 Respondent Selection Table.

	OVERALL		SYDNEY		RICHMOND		ADELAIDE		PERTH		MELBOURNE	
	N	%	N	%	N	%	N	%	N	%	N	%
SAMPLE SET	4,531		2,031		381		848		847		424	
SAMPLE LOSS												
Listing Error	22		7		4		4		5		2	
Vacant Dwelling	130		41		5		53		27		4	
EFFECTIVE SAMPLE	4,379	100	1,983	100	372	100	791	100	815	100	418	100
NON-RESPONSE												
Refusal	309	7.1	179	9.0	33	8.9	26	3.3	48	5.9	23	5.5
Non-contact	205	4.7	113	5.7	21	5.6	15	1.9	48	5.9	8	1.9
All residents away	49	1.1	21	1.1	3	0.8	11	1.4	10	1.2	4	1.0
Beyond Scope* (Language)	194	4.4	129	6.5	1	0.3	25	3.2	17	2.1	22	5.3
Beyond Scope* (Other)	47	1.1	26	1.3	3	0.8	4	0.5	10	1.2	4	1.0
TOTAL	804	18.4	468	23.6	61	16.4	81	10.2	133	16.3	61	14.6
COMPLETED INTERVIEWS (Response Rate)	3,575	81.6	1,515	76.4	311	83.6	710	89.8	682	83.7	357	85.4

TABLE 3.2 Summary of response data.

(* These refer to cases where all household members were beyond scope.)

A validation survey was conducted immediately after the main survey around each airport. This entailed a field-supervisor calling back at a random sample of 10% of the original addresses to confirm that an interview was conducted in the prescribed manner and to check the accuracy of the factual information obtained. No inexplicable discrepancies were detected.

3.5 Composition of Sample

Table 3.3 lists the numbers of respondents in each exposure zone around each airport. The unfilled cells represent zones which contained no dwellings. The cell targets were as follows: Sydney (112), Richmond (42), Adelaide (64), Perth (48), Melbourne (80). In the higher zones on each flight path there were not enough dwellings for these targets to be achieved.

The sample also included 'controls', that is residents in areas not under the established flight paths around each airport. A total of 282 such people were interviewed, the numbers for each airport being: Sydney (112), Richmond (28), Adelaide (64), Perth (46), Melbourne (32). After completion of the survey it was discovered that the control area in Richmond was exposed to frequent flyovers from aircraft performing training circuits. It was decided not to exclude the Richmond 'controls' from the results. Consequently, a slight inflationary effect of the small Richmond group on the overall data from the control sample would be expected. Data from the control sample is tabulated wherever appropriate throughout the report.

AIRPORT	FLIGHT PATH	NOMINAL NEF ZONE				
		20-25	25-30	30-35	35-40	40+
Sydney	N	107	112	109	110	19
	E	111	112	102	36	18
	S	112	-	-	-	-
	W	112	112	114	113	4
Richmond	E	56	37	21	-	-
	W	42	42	43	42	-
Adelaide	N	65	64	65	65	6
	E	64	35	-	-	-
	S	64	64	65	25	-
	W	64	-	-	-	-
Perth	N	46	48	40	48	19
	E	48	48	-	-	-
	S	48	48	48	38	-
	W	48	48	48	13	-
Melbourne	E	80	80	-	-	-
	S	80	81	4	-	-

TABLE 3.3 Numbers of respondents in each exposure zone around the five airports.

The demographic composition of the survey sample is detailed in Appendix A where responses for each questionnaire item are summarized. It is noteworthy that the sample comprised 2004 female and 1571 male respondents, a ratio of 1.28:1. Given that adult males and females are roughly equally distributed in the community, it would appear that the sample contains more female respondents than expected in a random sample. A likely reason for this apparent discrepancy is the present procedure of sampling on the basis of dwellings, and then randomly selecting one respondent at each dwelling. There was not an even distribution of males and females across different-sized households. In particular, single-person households were more likely to comprise a female. The ratio of females to males in single-person households was found to be 1.69:1.

3.6 Questionnaire Results

The responses to each item in the interview schedule are given in Appendix A. The basic data are tabulated for each airport as well as overall. The most informative descriptive statistic was used to summarize the data in each question (viz., percentage, mean, median, mode).

In interpreting any differences in the basic data for the various airports one must bear in mind that the survey samples differed in their distribution across exposure zones (see Table 3.3). The samples were chosen so as to give a representative spread across exposure zones, but differences in population distribution around the airports led to differences in the sample composition. In Melbourne, for example, the survey sample has much less noise exposure than in Sydney, a difference which is reflected in responses to a number of questions. In other words, the results for the different airports cannot be directly compared without taking account of differences in noise exposure.

CHAPTER 4

NOISE ASSESSMENT

4.1 Units of Measurement

Throughout the world, many different units are currently used to measure the amount of "exposure" to aircraft noise at a given point. The official unit in Australia is the Noise Exposure Forecast, or NEF*. This has also been used by the United States Federal Aviation Agency. Similar units, such as the Noise and Number Index (NNI) and the Day/Night Noise Level (L_{dn}) are used by other authorities in various countries.

A different set of units, known as "peak level" indices, has also been proposed (Rylander et al, 1972), and it has been claimed that these units show better correlation with measures of subjective reaction than units such as NEF (sometimes referred to as "equal-energy" units). For this study, it was decided to calculate the values of both equal-energy and peak-level indices at each dwelling at which an interview was conducted.

Calculation of NEF requires knowledge of the noise levels of all aircraft heard, as a function of distance from the aircraft, as well as of the number of aircraft heard, and their flight track and rate of ascent or descent. Noise levels are measured in terms of the Effective Perceived Noise Level (EPNL), the units of EPNL being EPNdB. EPNL values for each aircraft heard in a day are added, on an energy basis, with a correction of approximately 12.2 EPNdB to be added to the EPNL of aircraft flying between 10 pm and 7 am, and an arbitrary constant of -88. This is expressed by the formula

$$NEF = 10\log\{\sum_{i,j} (N_{i,j} + 16.67\ N'_{i,j})10^{EPNL_{i,j}/10}\} -88 \qquad (4.1)$$

where $EPNL_{i,j}$ is the energy-mean value of EPNL for aircraft of type i performing operation j, $N_{i,j}$ is the number of such aircraft operating per day during the times 7 am - 10 pm, and $N'_{i,j}$ is the number operating between 10 pm and 7 am.

The index L_{dn} was also calculated. This is defined in a very similar way to NEF, the differences being:

a) Sound Exposure Level (SEL) is used instead of EPNL to represent the noise of individual aircraft.

b) Levels of aircraft flying at night are corrected by 10 dB instead of 12.2 dB. This has the effect of changing the constant 16.67 in equation (4.1) to 10.

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* A distinction is sometimes made between a Noise Exposure Index (NEI) which measures existing noise exposure and a Noise Exposure Forecast (NEF) which measures projected future exposure. However, the exposure index is referred to in the scientific literature simply as NEF. To avoid confusion, the term NEF is used throughout this report. Note that all calculations of noise exposure in terms of NEF are estimates of current exposure.

c) The constant -88 in equation (4.1) is replaced by -49.4.

Peak-level noise indices have, in general, not been closely defined. They are intended to give a measure of the sound level of the noisiest events heard in a day. One such measure which has been proposed is the average sound level of the loudest aircraft type which is heard more than three times a day. The quantity to be measured is the maximum sound level of overflights, in dB(A) (Rylander et al, 1980). For the purpose of this study, the "average" level was taken as the energy-mean. This unit is referred to as LTYPE. Three other similar peak-level indices, referred to as LX3, LX5 and LX10, were also calculated. These are respectively, the sound level in dB(A) exceeded by an average of three, five and ten aircraft per day. Another similar unit which has been proposed recently (Rylander, 1981) is the (arithmetic) mean level of the loudest five aircraft movements per day. The formula used for this calculation is given in Appendix C. The unit is referred to as MEAN5..

There are, of course, cases when values of these indices cannot be calculated. For instance, neither LTYPE, LX3, LX5, LX10 nor MEAN5 can be calculated in cases where there are fewer than three aircraft movements per day. The present study included some areas where this was the case (see Figure 4.1). The unit MEAN5 was also calculated in a form under which points experiencing fewer than 5 overflights per day were assigned the arithmetic mean max dB(A) of all overflights. This unit is referred to as MEAN5'.

Some claims have been made that aircraft noise measurement units should be independent of the overall frequency of overflights (Rylander et al, 1980). None of the above units has this property. An index which does have this property was calculated, namely the level in dB(A) exceeded by 10% of all overflights. This unit is referred to as LX10%; its value does not depend on the number of overflights per day.

In addition to these units, several other variables were calculated. It was necessary to know the contribution to various equal-energy indices from overflights between 10 pm and 7 am, in order to investigate the effect of changing the night weighting constants in the indices. Also, an "evening" weighting has been included in some indices, and to investigate this possibility it is necessary to calculate the contribution due to overflights between 7 pm and 10 pm. These variables were calculated for the indices NEF2, NEF3 and L_{dn}. (See Table 4.1 and Section 4.2 for definitions of NEF2 and NEF3.) They are referred to as NEF2N, NEF2E, etc.

Some analyses require the value of a certain weighted mean noise level, defined by

$$\text{WMEAN} = \frac{\Sigma\, L_i\, 10^{L_i/10}}{\Sigma\, 10^{L_i/10}} \qquad (4.2)$$

where L_i are noise levels of aircraft, taken as EPNL in this case. This unit is used in analyses described in Chapter 8, and its calculation is given in Appendix C.

The number of aircraft overflights per day with maximum noise levels greater than 70 dB(A) was also calculated.

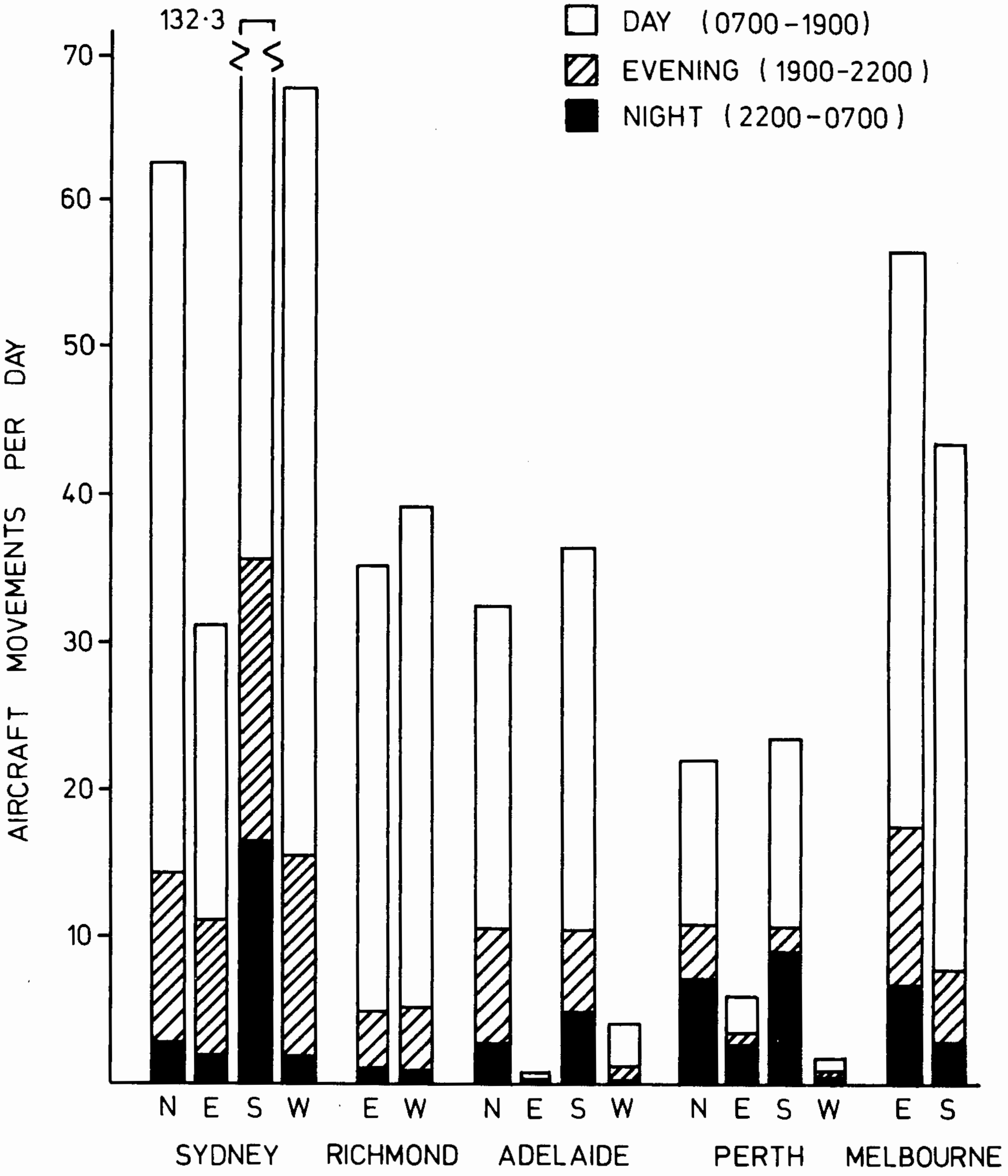

FIGURE 4.1 a) Average numbers of aircraft movements during day, evening and night hours for all flight-paths included in the survey. (Aircraft smaller than a Fokker F27 are not included).

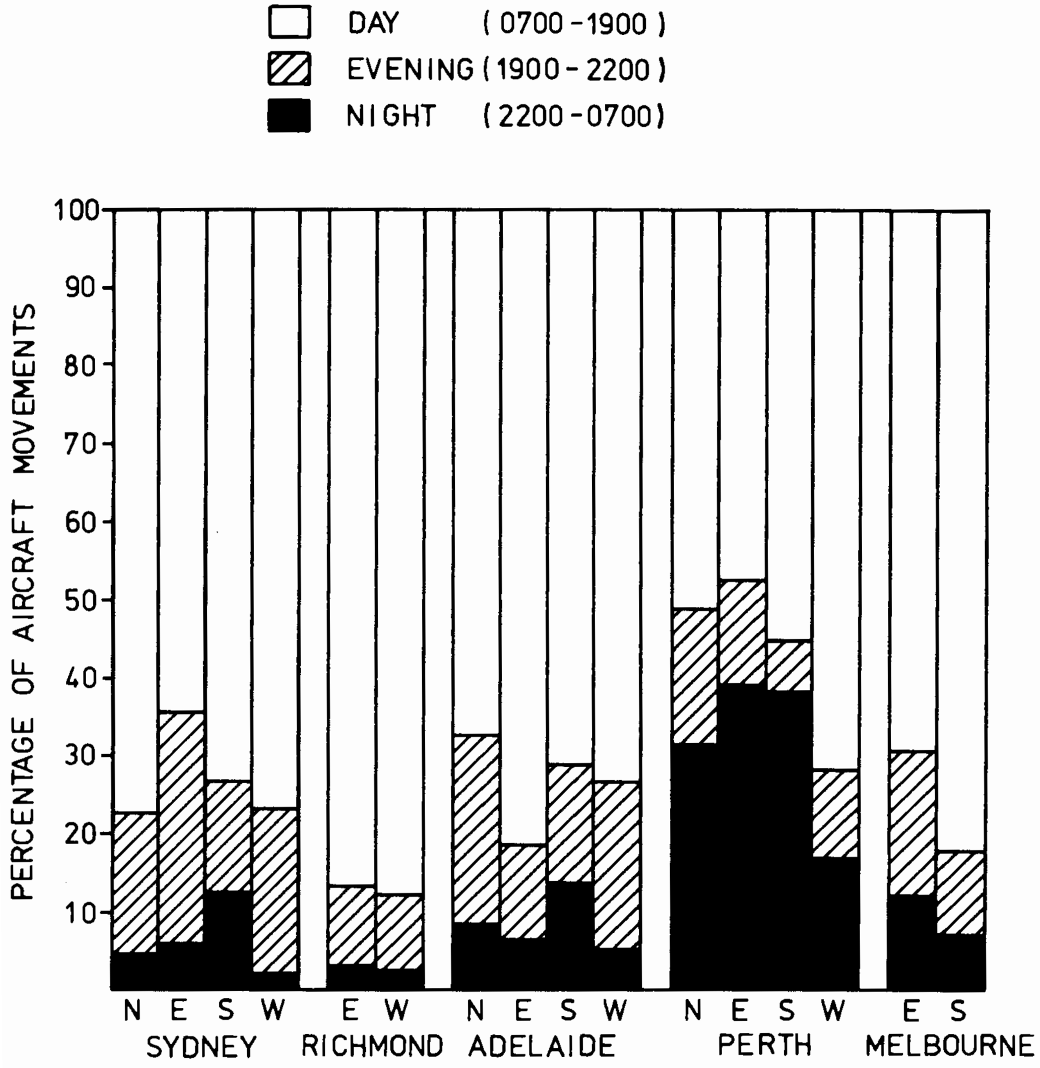

FIGURE 4.1 b) Distribution of aircraft movements during day, evening and night hours for all flight-paths included in survey.

Table 4.1 gives a summary of all units calculated, together with their definitions.

UNIT	DEFINITION
NEF1	Noise Exposure Forecast, calculated using nominal curves for EPNL values of individual aircraft types, and for height-vs-distance profiles for aircraft on departure.
NEF2	As for NEF1, but using EPNL values and departure profiles which have been corrected on the basis of measurements at each airport.
NEF3	As for NEF2, but including noise from aircraft using reverse-thrust, and those taking off on other runways.
NEF4	As for NEF3, but including the effects of shielding or reflection by structures near each residence.
L_{dn}	Day/Night Noise Level, calculated using corrected SEL values and departure profiles, and including noise from other runways.
LTYPE	Energy-mean level of the loudest aircraft type whose average frequency of operation is greater than three per day. Arrivals and departures are considered to constitute different aircraft types. Only overflights are considered - not noise from the airport itself.
LX3	Sound level, in dB(A), exceeded by an average of three aircraft per day. Only overflights considered.
LX5	Sound level, in dB(A), exceeded by an average of five aircraft per day. Only overflights considered.
LX10	Sound level, in dB(A), exceeded by an average of ten aircraft per day. Only overflights considered.
LX10%	Sound level, in dB(A), exceeded by 10% of aircraft. Only overflights considered.
MEAN5	Arithmetic mean dB(A) level of all aircraft whose level exceeds LX5. Only overflights considered.
MEAN5'	As for MEAN5 but points with less than 5 overflights per day assigned the overall arithmetic mean dB(A) level.
NEF2N	Contribution to NEF2 from operations occurring between 10 pm and 7 am, without the night weighting.

4.1

UNIT	DEFINITION
NEF2E	Contribution to NEF2 from operationsoccurring between 7 pm and 10 pm.
NEF3N, NEF3E, $L_{dn}N$, $L_{dn}E$	Defined as for NEF2N and NEF2E
N70	Mean number of aircraft per day whose sound level exceeds 70 dB(A). Only overflights considered.
WMEAN	Weighted mean noise level, in EPNL, from overflights. Weighting formula is given by equation (4.2).

Table 4.1 (cont'd) Definitions of noise exposure units used in the social survey analysis.

4.2 "Nominal" NEF

Figures 3.1-3.5 show all airports studied, together with the location of noise measurement sites. The strategy adopted in this study for assessing noise exposure was to find co-ordinates for each dwelling at which an interview was conducted and to use these co-ordinates, together with information on aircraft noise levels, modes of operation and numbers of aircraft using the relevant runway, to calculate values of all noise measures used. Co-ordinates were found from 1:10,000 scale maps or photographs, on which individual buildings could be identified. They were specified in terms of distance from runway threshold, distance to the side of runway centre-line, and height above the runway. In cases where flight tracks for departing aircraft were curved, the first two co-ordinates were re-defined to represent the distance travelled by the aircraft and the perpendicular distance to its flight track. On some runways, more than one flight track was specified.

NEF was calculated in four forms, as described in Table 4.1. Of these, the simplest is known as NEF1. Here, noise levels of the various aircraft were taken from information obtained from Transport Australia. These "nominal" levels were, in general, derived from the results of aircraft noise certification trials. Standard height-versus-distance profiles for aircraft on departure were also used. (On approach, a standard glide-slope of 3^{o} was always assumed.)

Exact data giving the number of aircraft using each runway during "day", "evening" and "night" hours by aircraft type were easily available only at Sydney, where these data are stored on punched paper tape. For other airports, it was necessary to count control-tower flight strips to obtain this information. Wherever possible, data were obtained for a period of six months immediately prior to the survey at that airport. However, at Perth and Adelaide, data on the proportion of movements occurring in the evening period were based on counts over three months, although the other data is based on six-month counts. At Richmond, it was found that the number of circuits performed by an aircraft in training was not recorded on the flight strip. Since these circuits represent most of the overflights heard, they could not be ignored. A policy of recording the number of circuits performed was instituted, but this means that data from Richmond is for the period December 1980 - February 1981. (The survey was conducted in February - March 1980.) Because movements are usually low in December, the numbersof movements were corrected to give the average over a six month period, with December counted only once.

The numbers of aircraft movements per day, as found from the data described above, are given in Figure 4.1 and in more detail in Appendix B. "Nominal" NEF was found by calculating aircraft heights, and the distance to the aircraft, for each aircraft type and each mode of operation. Using nominal values for aircraft noise levels, this leads to values of EPNL, and, using equation (4.1), to NEF.

4.3 Measurement Procedures

In order to check the accuracy of the noise levels and takeoff profiles used in calculating NEFl, measurements were made at a number of sites around each airport, and the measured noise levels compared with those predicted using the "nominal" data. These sites are shown in Figures 3.1-3.5. At Sydney and Richmond, tape-recordings were made of over 40 aircraft at each site. This allowed values of EPNL, as well as maximum dB(A), to be calculated. In Sydney, the maximum dB(A) levels of all aircraft have been monitored at five sites for several years by the Sydney Airport Noise Monitoring Centre. This allows very accurate energy-mean noise levels to be calculated at these points. Data from two other noise monitoring sites were rejected, as noise levels at these sites are influenced by surrounding buildings and other features.

At airports other than Sydney and Richmond, an unattended noise measurement system was set up at four sites, consisting of a sound level meter, set on A weighting and Slow response with the DC output connected to a continuously-running chart recorder. Measurements were taken for approximately two weeks at each site, the equipment being calibrated regularly during this time. Noise events recorded were later compared with aircraft movements, as recorded on flight strips, to find whether an aircraft was operating at the appropriate time, and if so, its type. In this way, energy-mean maximum dB(A) levels for each aircraft type were found at each site.

At site S7 in Sydney and at all sites in Richmond, recordings were made by two microphones, placed 1.2 m and 0.5 m from the ground. All other recordings were made at 1.2 m from the ground, except those from the Sydney Airport Noise Monitoring Centre, which were made at approximately 7 m. Two recordings were made at some sites because it has been suggested that recorded noise levels, particularly of propeller-driven aircraft, can depend critically on the distance of the microphone from the ground (Heller et al, 1980). At site S7, the microphone at 0.5 m gave consistently lower values of EPNL and max dB(A). However, the differences in energy-mean levels for a given aircraft type were of the order of 1 dB or less, which is similar to the standard error of estimate for these values. At Richmond, differences were small with the exception of EPNL values on departure, measured near the runway centre-line (sites R1 and R3). These showed differences of 1.8 EPNdB at site R1 and 1.1 EPNdB at site R3 (for C130 aircraft), with the lower microphone giving the higher reading. The difference appears to be due to a more prominent pure-tone at the lower microphone, giving a greater tone correction in EPNL. Although a difference of 1.8 EPNdB is not negligible, it appears that such differences are not common. It should also be noted that the indices of noise exposure at Richmond are dominated by jet aircraft rather than C130's due to the high noise levels of B707's and C141's, and at other airports, exposure from propeller-driven aircraft is very small. Because of this, no account was taken in the analysis of differences between levels recorded at different microphone heights, levels recorded at 1.2 m being used wherever possible.

4.4 Corrected Noise Emission Levels and Take-Off Profiles

The procedure used in analysing the data described above was firstly to attempt to identify reasons for any differences between "nominal" and measured max dB(A) levels. This gave rise to "corrections" to the nominal levels. Differences between EPNL and max dB(A) at sites where tape-recordings were used were then inspected and compared with their nominal values, so that corrected values of EPNL could be calculated.

Intuitively, the factor most likely to cause deviations from nominal noise levels is the "ground effect", which should tend to reduce noise levels for aircraft near the horizon. Figure 4.2 shows differences between measured and nominal max dB(A) levels for Boeing 727 -200 aircraft on approach, plotted against $\sin\theta$ where θ is the angle between the aircraft and the horizontal, as seen from the measurement position. It is clear that for low values of $\sin\theta$, measured levels are indeed lower than expected, and that even directly beneath the aircraft they are, in general, 1-2dB below their expected value. The residual scatter could not be significantly reduced by invoking any known positional or topographical variables, but appears to be site-dependent, since levels tended to be consistently high or low for all aircraft types at a given site. Although the relationship in Figure 4.2 may appear to be non-linear, with a change of slope at about $\sin\theta=0.5$, the data here were not considered adequate to support such a hypothesis, particularly since no such non-linearity is present in results for other aircraft. Thus, a linear regression was used to describe the data, giving the result shown in Table 4.2. Figure 4.2 also shows values of a standard correction for ground effect and shielding by the aircraft fuselage, which is given by Serendipity Inc. (1970).

Results obtained similarly for other aircraft are also shown in Table 4.2, and the data are shown graphically in Figure 4.3. It is notable that for McDonnell-Douglas DC9 aircraft only, differences between measured and nominal dB(A) levels were significantly negatively correlated with distance from runway threshold, as well as positively with $\sin\theta$. It is presumed that this is due to the smaller DC9 aircraft occasionally turning onto their final approach path closer to the runway than the measurement position, and thus registering low sound levels. This was observed to occur at some sites where monitoring was attended. Another notable feature of the results is that max dB(A) levels of DC10 and F27 aircraft are consistently higher than their nominal values, unlike other aircraft types investigated.

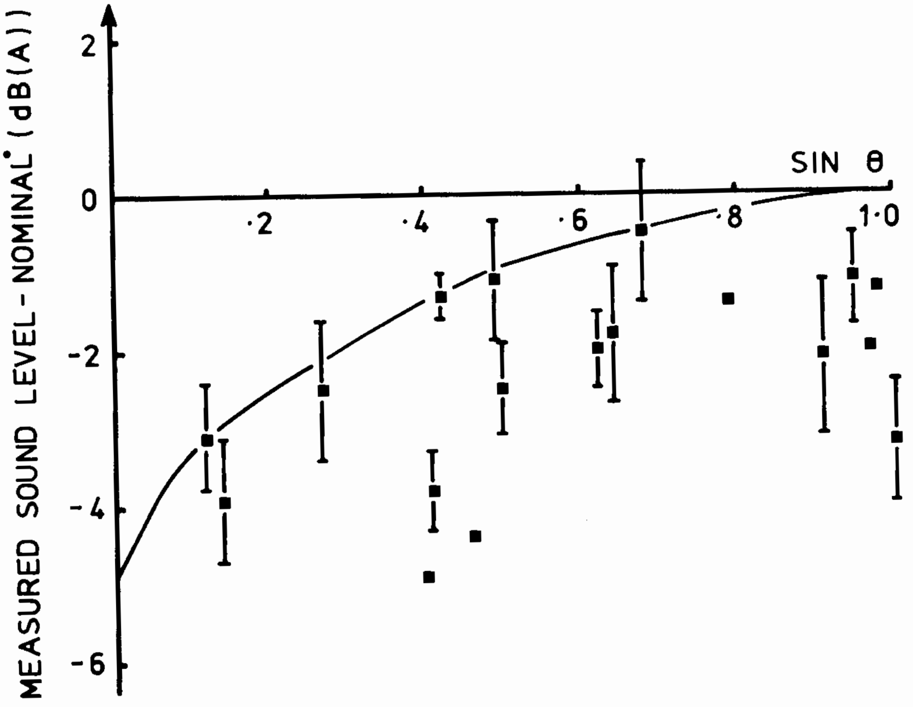

FIGURE 4.2 Differences between measured and nominal values of energy-mean max dB(A) for Boeing 727-200 aircraft on approach. Error bars represent one standard error of estimate. The curve represents a standard correction for the ground effect and shielding by the aircraft fuselage.

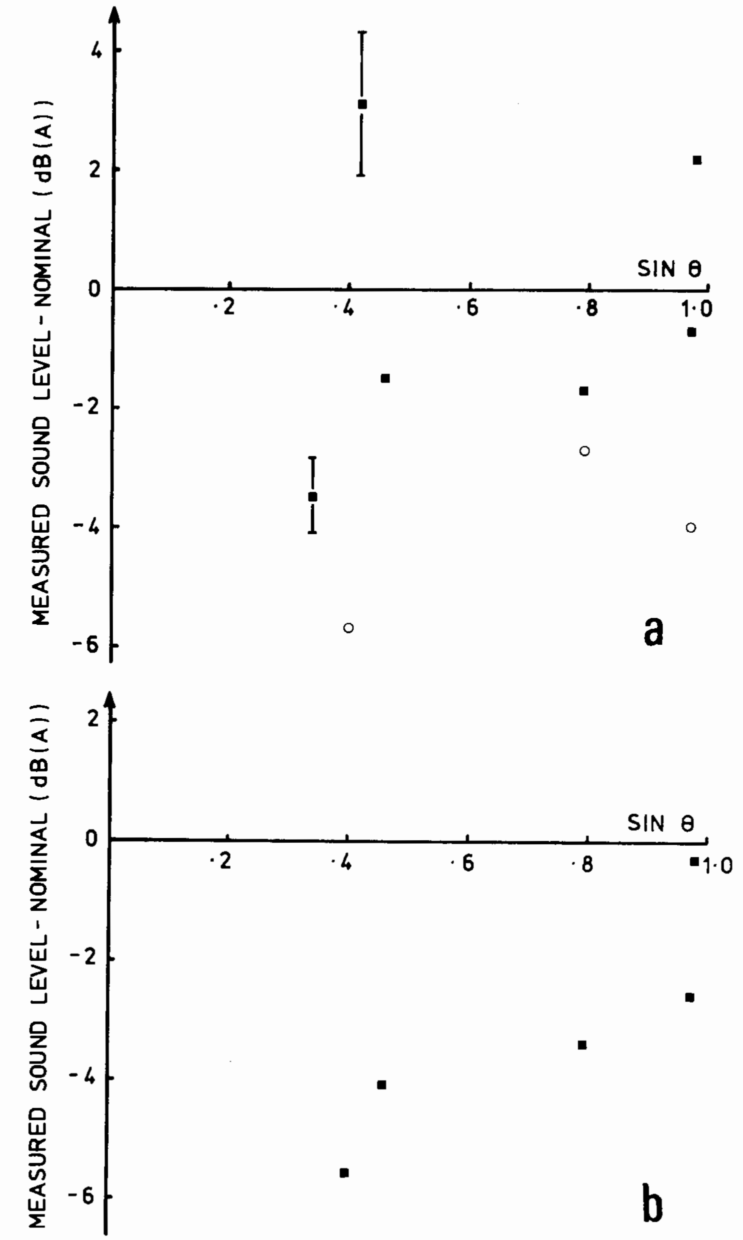

FIGURE 4.3 Differences between measured and nominal values of energy-mean max dB(A) for the following aircraft on approach:

(a) ■ - Boeing 707; O-McDonnell-Douglas DC8
(b) Boeing 727-100

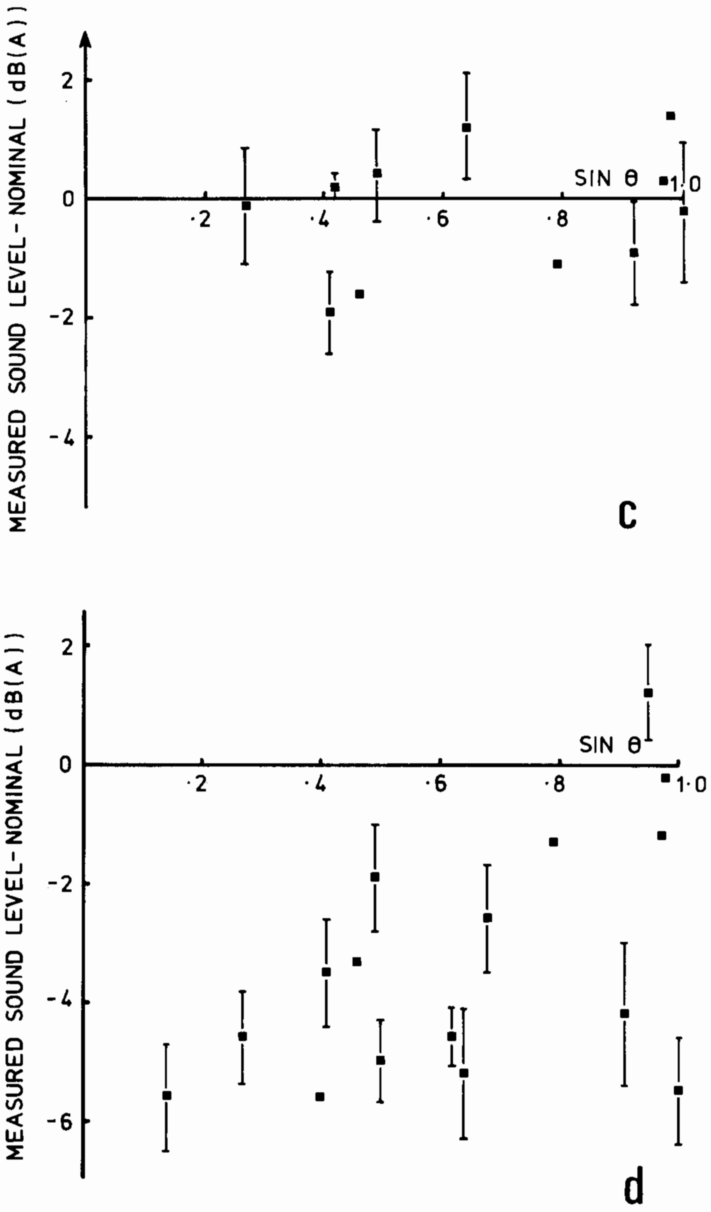

FIGURE 4.3 (Cont'd) Differences between measured and nominal values of energy-mean max dB(A) for the following aircraft on approach:

(c) Boeing 747 (d) McDonnell-Douglas DC9

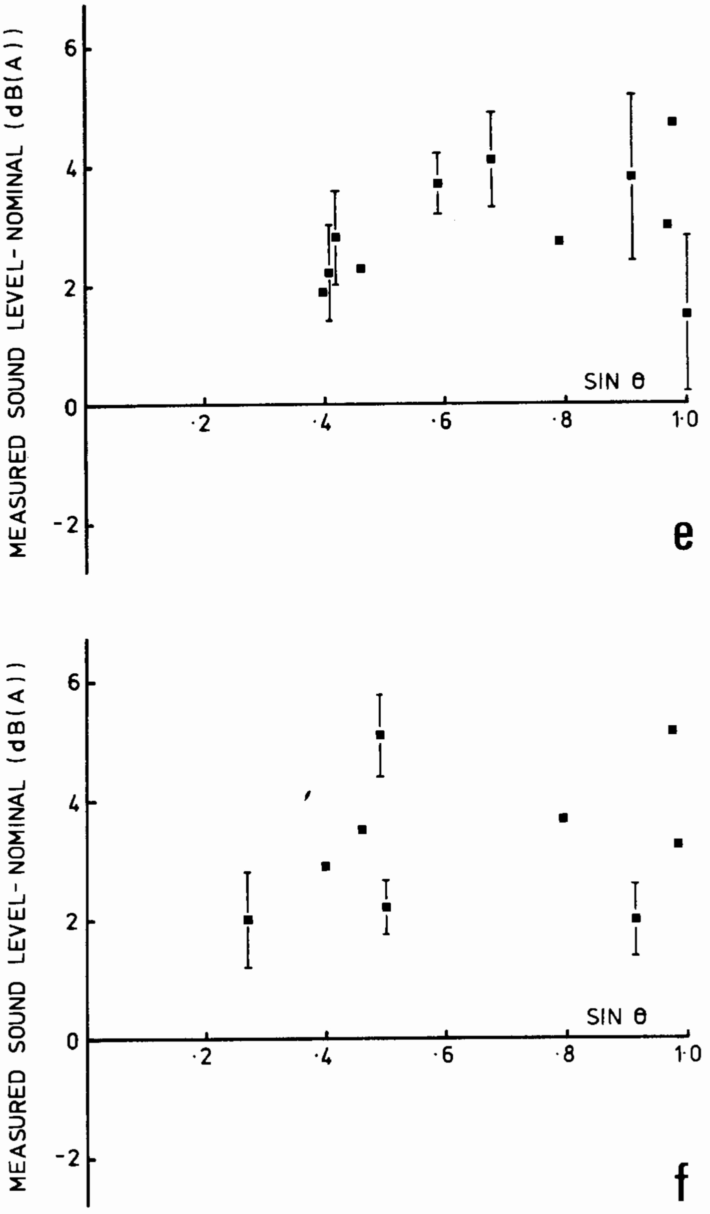

FIGURE 4.3 (Cont'd) Differences between measured and nominal values of energy-mean max dB(A) for the following aircraft on approach:

(e) McDonnell-Douglas DC10 (f) Fokker F27

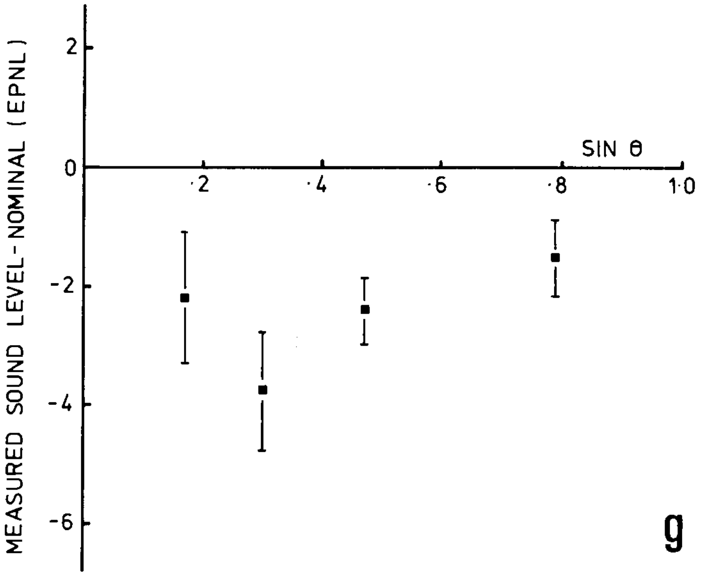

FIGURE 4.3 (cont'd) Differences between measured and nominal values of EPNL for the Lockheed C130.

Aircraft Type	Correction to Max dB(A) on Approach (dB)	Standard Error of Estimate (dB)
B707	-1	3
B727-100	$-3.8+1.5 \sin\theta$	2
B727-200	$-3.3+1.5 \sin\theta$	1.2
B747	$-1.7+1.9 \sin\theta$	1.6
DC8	-2	4
DC9	$-5+5.7 \sin\theta-0.55D$	1.6
DC10	$2.2+1.1 \sin\theta$	1.5
F27	3.3	1.5
F28	regarded as DC9 (see text)	
C130	$-3+2.0 \sin\theta$	2
CC08	regarded as F27 (see text)	
C141*	0	4
Other military jets	regarded as 707	

TABLE 4.2 Corrections applied to nominal max dB(A) levels of each aircraft type. θ = angle between aircraft and horizon. D = distance from runway threshold, km.

* Nominal levels used for C141, as no measurement data were available. Standard error of estimate set at a conservative figure.

In analysing noise levels of aircraft on departure, another variable must be considered, namely, the height-vs-distance profile of the aircraft. Initially only sites with $\sin\theta > .9$ (based on the nominal profile) were studied, to control the ground effect. Measured max dB(A) levels were converted, using nominal noise emission levels, to assumed values of the aircraft's height. A typical resulting graph, for 727-200 aircraft, is shown in Figure 4.4.

It is clear that in most cases the aircraft are following a profile considerably steeper than the nominal*. One possible explanation for this is that almost all measurement sites shown in Figure 4.4 are on runways which are not preferred for departure. Thus, these runways would only be used when a strong headwind is present, whereas the nominal profile assumes no wind. Also, aircraft using non-preferred runways tend to carry lighter loads. The site shown by an open circle represents a clear exception.

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* Another possibility is that aircraft thrust settings could have been lower than the nominal value. Discussions with airport personnel suggest that this is unlikely. For the purpose of predicting noise levels, the precise reason for the low measured levels is in any case generally irrelevant.

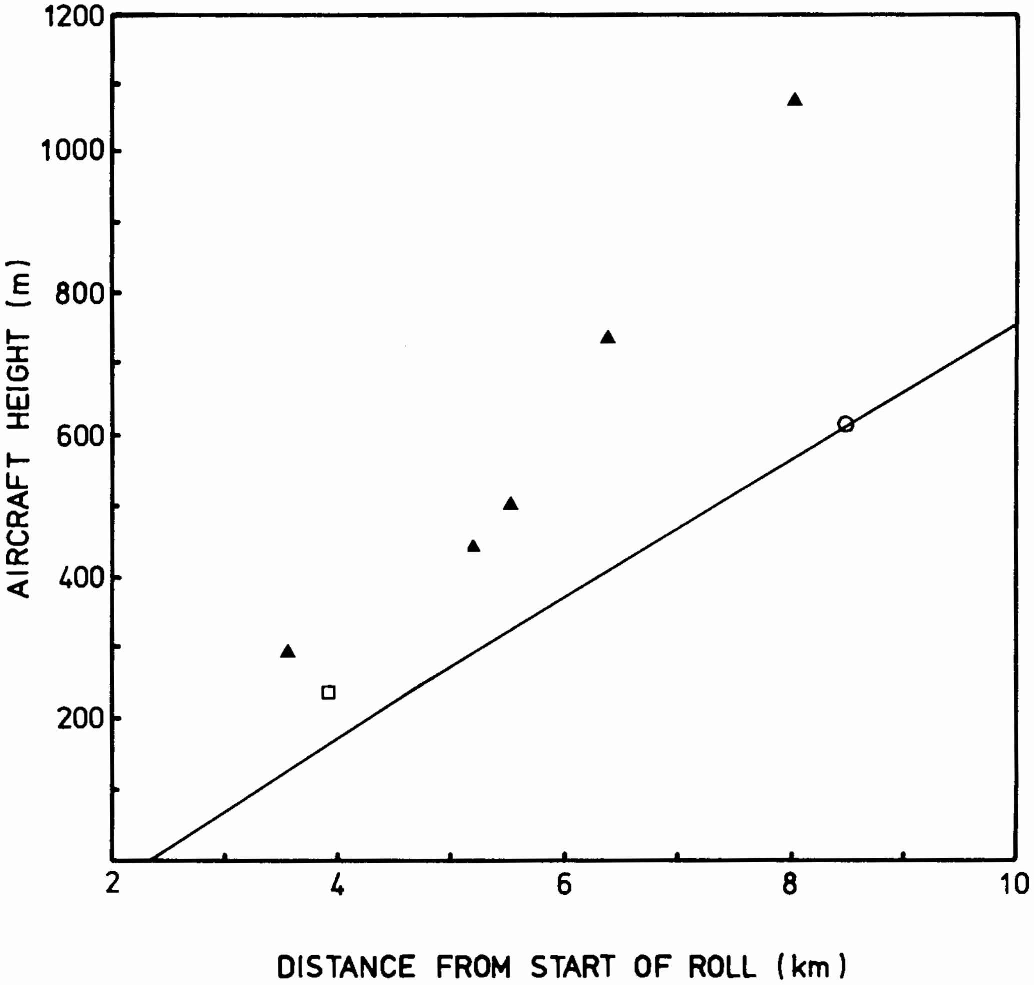


FIGURE 4.4 Aircraft height, calculated from energy-mean max dB(A) levels of Boeing 727-200 aircraft on departure. All sites are near the runway centre-line. □ - site on preferred departure runway. ○ - site in Perth. The line represents the nominal profile on departure.

The site is in Perth, on a non-preferred departure runway. It was found that on all runways in Perth, aircraft appeared to follow the nominal profile. This could be related to the extra loads of fuel which must be carried from Perth.

If the nominal profile is used for preferred departure runways, and for all runways in Perth, and a calculated profile is used on other runways, differences between "expected" and measured dB(A) levels are shown in Figure 4.5. The ground effect is again evident, but apart from this the residual variance could not be significantly reduced by the use of other variables.

For other aircraft, the same procedure was followed. Similar results were obtained, with some exceptions (see Figure 4.6). Boeing 747 aircraft departing on runway 34 in Sydney appear, from limited data, to follow a profile closer to the nominal than to that calculated from other runways. This could result from aircraft using this runway when the preferred runway (runway 16) is not usable, and their load is too heavy to permit takeoff on the other, shorter, runway. In the absence of any data, DC10 aircraft were assumed to be in a similar position, and the nominal profile was also used for them on this runway. DC9 aircraft appeared to follow a profile steeper than the nominal even on preferred departure runways. This profile also appeared to steepen dramatically after about 5.5 km from start of roll. The latter effect is probably spurious, resulting from aircraft turning from their assumed flight-tracks, as for DC9's on approach. However, the observed noise levels can be explained adequately by assuming a very steep (and probably unrealistic) profile after this point. Assumed profiles for all aircraft on departure, based on this analysis, are given in Table 4.3.

Aircraft Type	Height-versus-Distance Profile on Departure.		Standard Error of Estimate for Max dB(A) Levels (dB)
	Preferred Departure Runway (and Perth)	Non-Preferred Departure Runway	
B707	6600/4.8/-	6600/4.8/-	4
B727-100	6000/7.24/6300/7.0	6000/12.5/-	4
B727-200	7700/5.93/7700/5.5	7700/10.2/-	2.5
B747*	7100/5.2/-	7100/8.5/-	3
DC8	6600/5.9/-	6600/5.9/-	4
DC9	3900/7.9/14100/17.7	3900/7.9/14100/17.7	1.5
DC10*	7100/5.2/-	7100/8.5/-	3
F27	3000/8.6/3300/5.49	3000/8.6/3300/5.49	4
F28	regarded as DC9 (see text)		
C130	4800/5.0/-	4800/5.0/-	2.5
CC08	regarded as F27 (see text)		
C141**	6600/4.8/-	6600/4.8/-	4

TABLE 4.3 Height-versus-distance profiles for each aircraft type. Profiles are represented by: distance to lift-off (feet)/ angle of climb (degrees)/distance to change of slope - if any (feet)/new angle of climb (degrees).

* Runway 34 in Sydney regarded as preferred (see text).

** B707 profile used for C141, in the absence of other data.

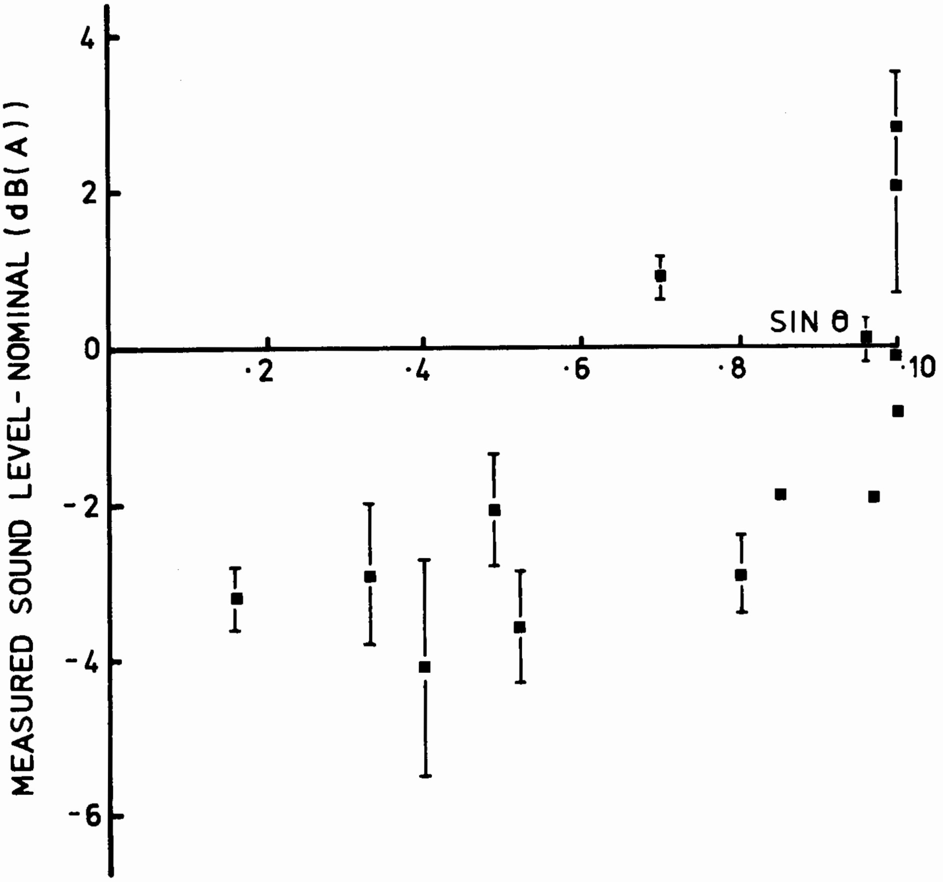


FIGURE 4.5 Differences between measured energy-mean max dB(A) levels on departure and levels calculated using the corrected height-versus-distance profile found from Figure 4.4. Error bars represent one standard error of estimate.

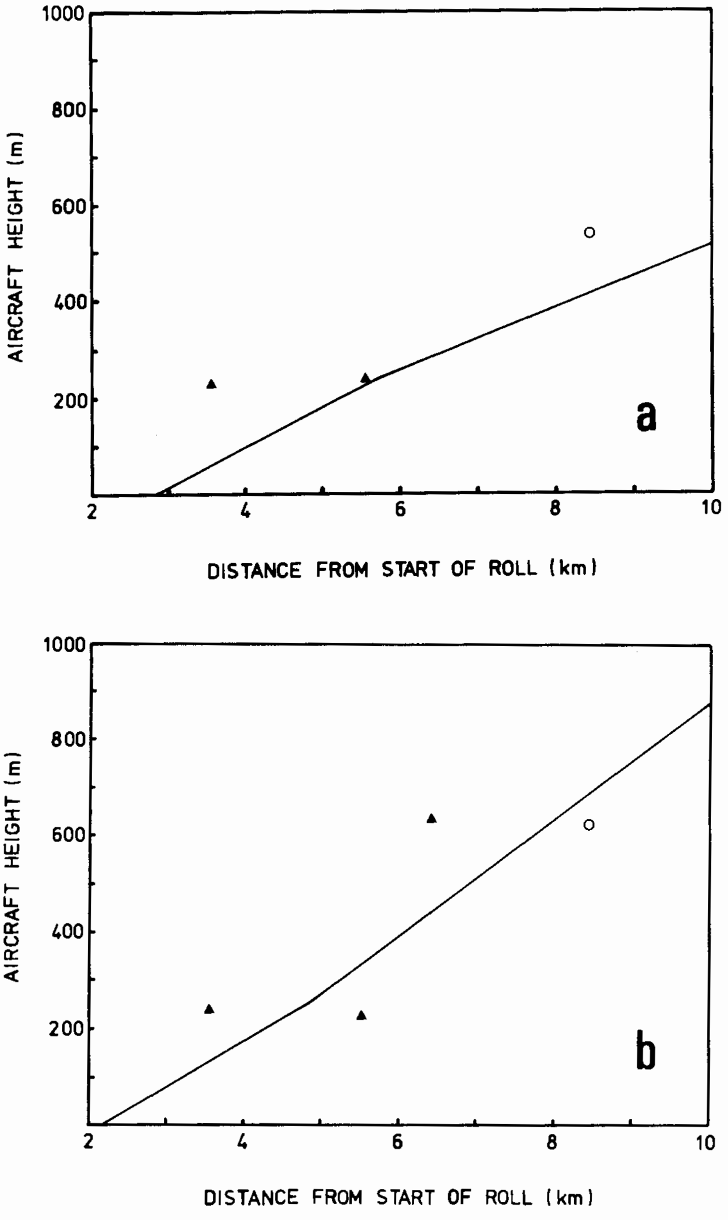


FIGURE 4.6 Aircraft heights calculated from energy-mean max dB(A) levels of the following aircraft on departure. (All sites are near the runway centre-line. ▢ Site on preferred-departure runway. ○ Site in Perth).

a) Boeing 707 b) Boeing 747

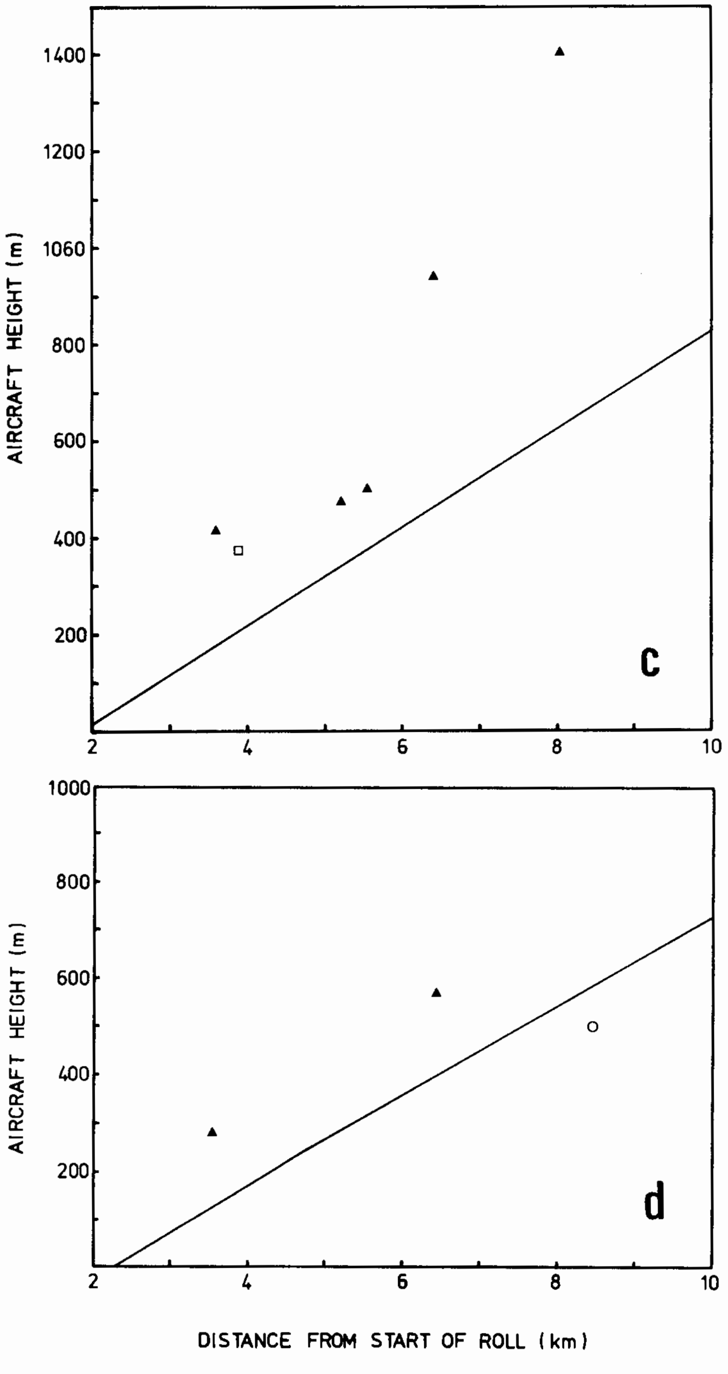


FIGURE 4.6 (Cont'd) c) McDonnell-Douglas DC9
d) McDonnell-Douglas DC10

Two further points are noteworthy. Max dB(A) levels of Fokker F28 aircraft, although measured reliably at only three sites, were consistently several dB above their "expected" levels on both approach and departure. The measured levels were better described by expected levels of a DC9 than of an F28. Accordingly, F28's were regarded as DC9's in calculating "corrected" values of NEF. Similarly, measured noise levels of CC08 aircraft were much lower than their nominal levels, and agreed better with levels of F27's.

Measured differences between EPNL and max dB(A) values were, in general, somewhat greater than their nominal values. No association was found between corrections to this difference and Θ or distance from runway threshold. Mean differences between nominal and measured values of (EPNL-max dB(A)) are shown in Table 4.4. Corrections to nominal SEL values were taken to be the same as those for EPNL values.

The corrections above were used to find more accurate values of EPNL for each aircraft type, at each residence. Standard errors of estimate were found from standard deviations of data such as that in Figure 4.2 about their regression lines. EPNL values were then combined as in equation (4.1) to give the unit NEF2.

Aircraft Type	Difference Between measured value of (EPNL - max dB(A)) and its Nominal Value (dB)
B707	+2.0
B727-100	+2.4
B727-200	+3.4
B747	+2.4
DC8	+2.0
DC9	+3.7
DC10	+3.7
F27	-0.8
F28	regarded as DC9 (see text)
C130	0
CC08	regarded as F27 (see text)
C141*	0

TABLE 4.4 Mean differences between the measured value of (EPNL - max dB(A)) and its nominal value, for each aircraft type.

* Nominal value used for C141, as no measurement data available.

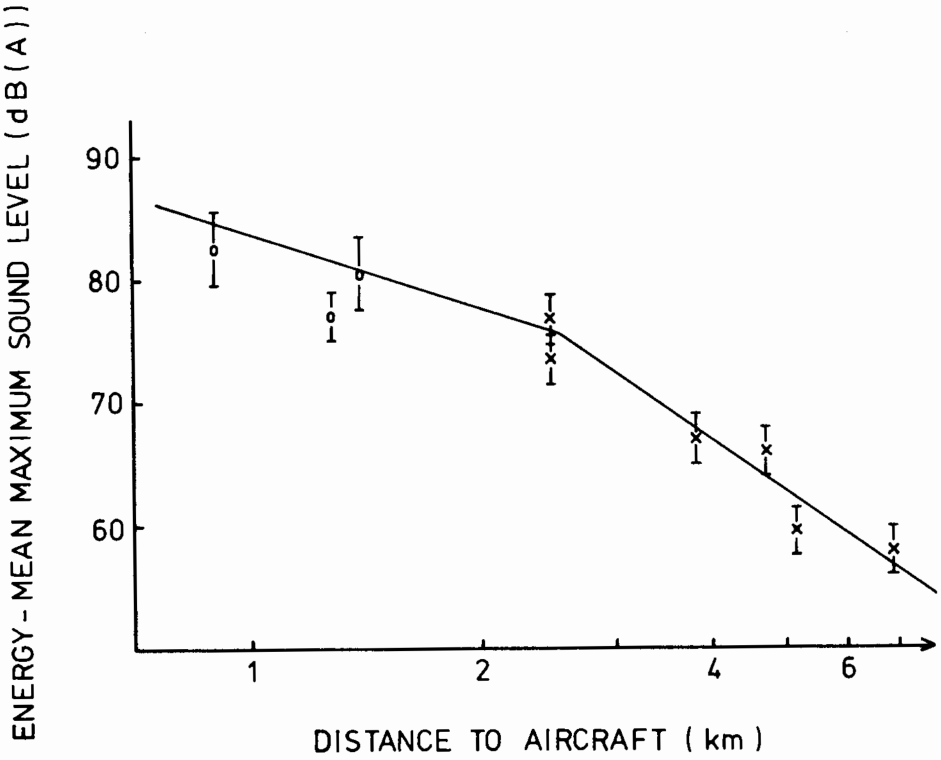


FIGURE 4.7 Energy-mean max dB(A) levels resulting from aircraft still on the ground, and either taking off or applying reverse-thrust.
x - data from Chessell et al (1976)
O - data from the present study
Error bars represent one standard error of estimate. Data for B727 aircraft are shown. Results for other aircraft are very similar.

4.5 Noise from Other Runways

In some areas studied, it was clear that noise generated by aircraft at the airport itself, either in taking off on another runway or in using reverse thrust on landing, was at least as important in energy terms as noise from aircraft actually flying over the point. It was thus necessary to calculate the level of this noise in a form which was compatible with NEF, and could be added to it.

A study of max dB(A) levels from takeoff and reverse thrust has been performed by C.I. Chessell at Sydney Airport (Chessell et al, 1976). He found that noise levels were similar in the two cases, if the distance to the aircraft is the same. Energy-mean values of max dB(A) for reverse thrusts are plotted against (approximate) distance to the aircraft in Figure 4.7. Also shown are two levels from takeoffs and one from reverse thrusts found in the present study. These were the only sites at which max DB(A) levels from aircraft still on the ground could be reliably calculated. Results from both Chessell's work and the present study indicate that these levels are relatively independent of aircraft type (to within about 2dB) for commercial jet aircraft.

The data in Figure 4.7 were fitted by two straight lines - with slope 13 dB per doubling of distance for large distances (Chessell's data) and 6 dB per doubling of distance (i.e. attenuation from spherical spreading only) at closer distances, the joining point being at a distance of 2.5 km. These curves give a good fit to the data, and a change of slope of this order, due to shielding and meteorological effects, is not unreasonable.

Conversion of max dB(A) to EPNL is not straightforward in this case. It was assumed that typical values of EPNL-max dB(A) for flyovers would also apply here, except for the value of the duration correction in EPNL. The duration of noise generated at the airport will not vary with distance from the aircraft, as it does with aircraft flyovers. Chessell gives durations (i.e. times for which the dB(A) level is within 10 dB of maximum) for flyovers and for reverse thrusts. These are shown in Figure 4.8. It is clear that the duration of reverse thrusts is equivalent to that of a flyover at approximately 350 m.

For a 727 or DC9 at this distance, EPNL-max dB(A)~10.5 dB. However, noise from reverse thrust or takeoff will have much quicker rise and fall times than a flyover. With instantaneous rise and fall, this results in a difference in integrated energy of about 3.8 dB. In view of this, it was considered that a value EPNL-max dB(A)~14 dB was reasonable for noise from aircraft on the ground.

Using this conversion, and the previously-described equation for prediction of max dB(A), EPNL levels for takeoffs and landings on all runways at the airport were calculated. These were added on an energy basis, using the usual NEF corrections for number of aircraft in the day and night hours, and added to the previously-determined value of NEF2. The resulting unit is referred to as NEF3.

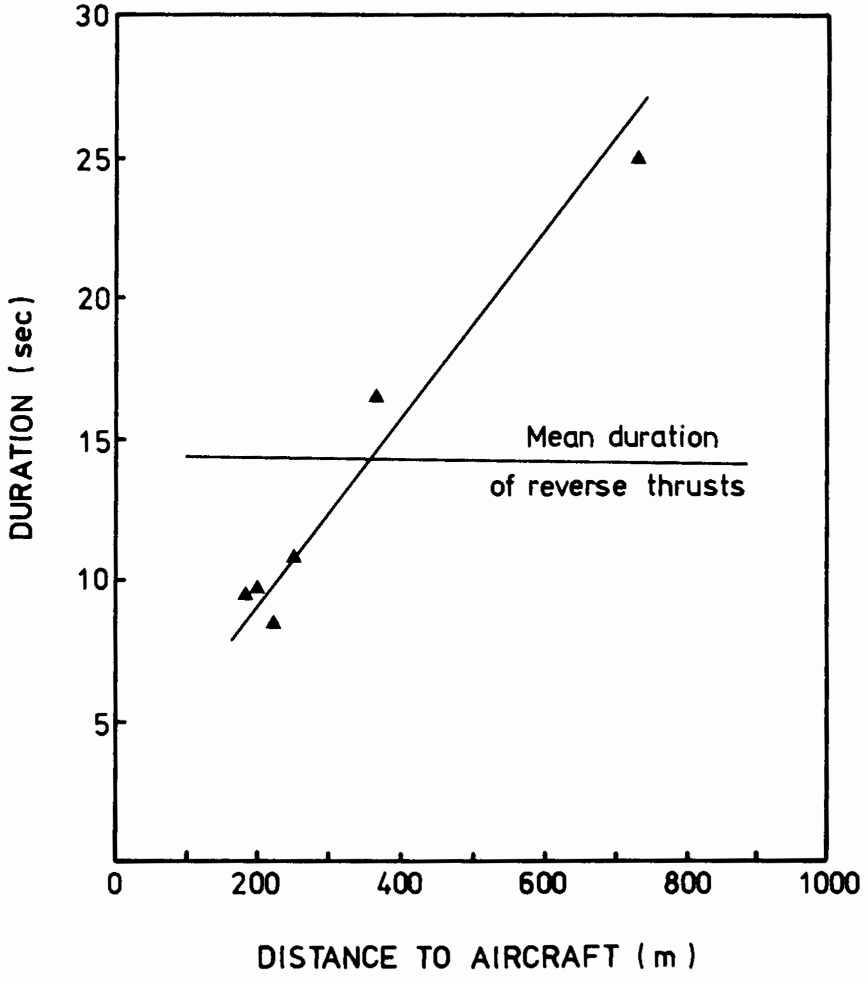


FIGURE 4.8 Mean duration of overflights and of reverse thrusts, using data from Chessell et al (1976).

4.6 Shielding by Buildings and Other Obstructions

During the process of listing residencesto be included in the survey, the presence of any large obstructions was noted. The size of the obstruction (usually the number of storeys of a building), its distance from the residence (less than 50 m, 50 - 100 m, or greater than 100 m) and whether or not it was between the residence and the flight-path were recorded.

For residences which were shielded by obstructions, the shielding, in dB, was calculated from the standard barrier-attenuation formula (Beranek, 1971) with attenuation taken as zero where line-of-sight propagation exists. For aircraft on takeoff, the correction was calculated separately for each aircraft type, since their heights at the residence may vary considerably. Where an obstruction was on the opposite side of a residence from the flight-path and within 50 m of it, noise levels at the residence were increased to account for reflection effects. The increase was 3 dB for a two-storey obstruction and 4.5 dB if it was higher.

These corrections were added to the unit NEF3, giving a unit referred to as NEF4.

4.7 "Peak Level" Indices

These units were based on max dB(A) levels calculated using the corrected emission levels and takeoff profiles described in Section 4.4. In order to determine the level exceeded by a given number of aircraft, it is necessary to know the probability distribution of noise levels from each aircraft type. By analysis of long-term data from the Sydney Airport Noise Monitoring Centre, it was found that this distribution was closely approximated by a normal distribution with a standard deviation of 2.8 dB, almost independent of aircraft type and distance from the airport. The accuracy of this assumption is demonstrated in Figure 4.9, which shows the overall distribution of noise levels at one monitoring site, and the distribution calculated using the above assumption.

The index LTYPE, defined in Table 4.1, was easily calculated from energy-mean dB(A) values. The indices LX3, LX5, LX10, LX10% and N70 were found by calculating the number of aircraft of each type with max dB(A) levels greater than some trial level, and adjusting the trial level until the desired number of aircraft exceeded it. The index MEAN5 and the unit WMEAN were calculated as described in Appendix C.

4.8 Standard Errors of Estimate

Estimation of errors in equal-energy units was made on the basis of the residual scatter about the regression lines of energy-mean max dB(A) vs sinθ, with an allowance for the scatter of (EPNL - max db(A)). These errors were combined for each aircraft type, in proportion to the number of operations, and calculated for each residence. R.M.S. errors for each flight-path are given in Table 4.5. The overall R.M.S. value of (NEF2 - NEF1) is 1.4 dB. Thus, since the overall R.M.S. error in NEF2 is 2.3 dB, the corrections incorporated in NEF2 probably reduced the error in NEF1 by about 25%.

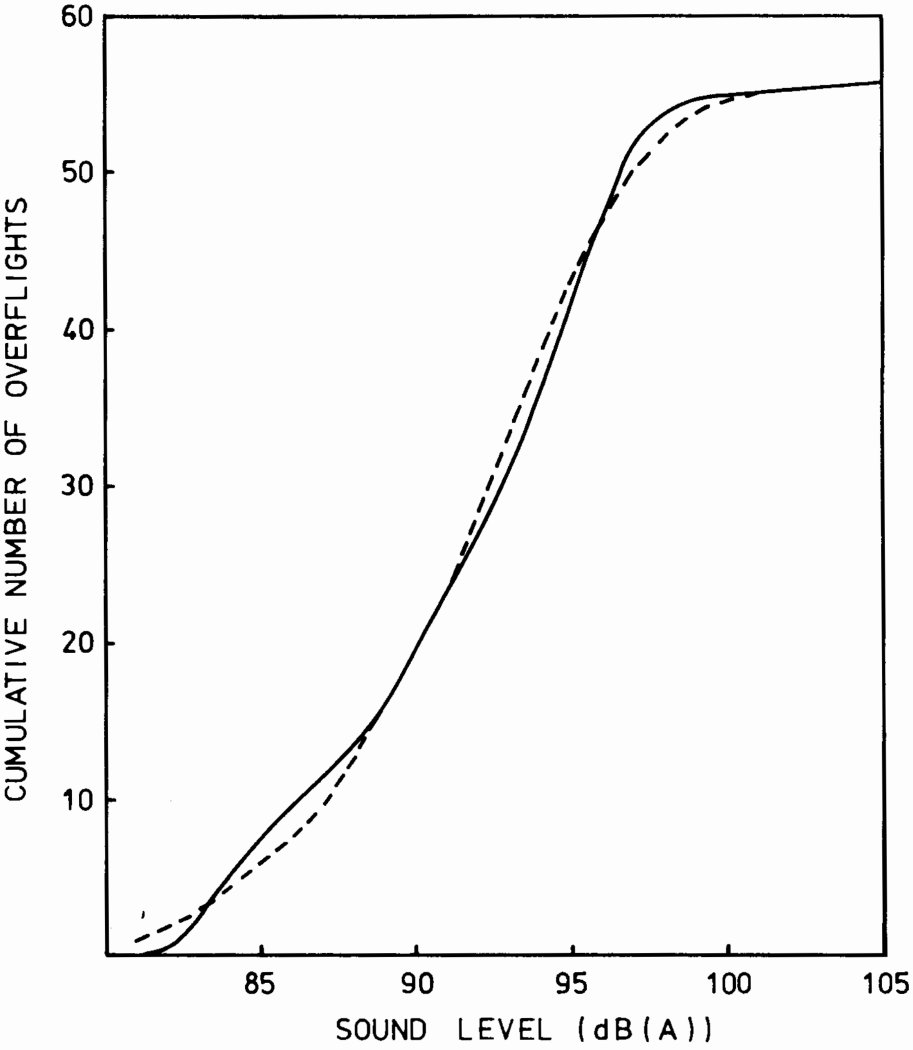


FIGURE 4.9 Distribution of noise levels from overflights at one Noise Monitoring Centre terminal in Sydney.

—— Measured distribution
--- Distribution calculated using normal distribution, standard deviation 2.8 dB, for all aircraft types.

4.8

Airport	Flight Path	R.M.S. Standard Error in NEF2 (dB)
SYDNEY	N	2.4
	E	2.2
	S	2.4
	W	2.0
RICHMOND	E	3.1
	W	3.0
ADELAIDE	N	2.0
	E	2.3
	S	2.1
	W	2.1
PERTH	N	2.4
	E	2.4
	S	2.3
	W	2.9
MELBOURNE	E	1.8
	S	1.9
ALL		2.3

TABLE 4.5 R.M.S. values of the standard error in NEF2, calculated for each flight-path surveyed.

Errors of estimate for peak-level indices are more difficult to estimate, since they depend not only on errors of estimation of mean max dB(A), but also on departures from the assumed probability distribution of levels. This probably results in standard errors 1 to 1.5 dB greater than those of equal-energy indices.

The sources of errors in the prediction of energy-mean EPNL appear to be localized over distances of, at most, several hundred meters, since there is no obvious correlation between errors for measurement sites separated by distances of this order. Thus, while errors may be correlated for all residences in a survey block, errors for different blocks can probably be considered to be randomly distributed.

If, as has been recently suggested (Schomer and De Vor,1981), part of the between-sites scatter could be due to meteorological conditions which persist over times of the order of weeks, true standard errors of estimate would be smaller than those stated above. This is because part of the scatter would then effectively represent measurement error which is randomised between sites, rather than real inter-site differences.

CHAPTER 5

MEASURING SUBJECTIVE REACTION TO AIRCRAFT NOISE

5.1 The Nature of Subjective Reaction

A preliminary study was conducted in order to determine how best to assess reaction to aircraft noise (Hede, Bullen & Rose, 1979). In this study 100 residents were interviewed about how they feel when they are affected by aircraft noise. Out of 24 words used to describe feelings most people selected the words 'annoyed' (38%) and 'irritated' (31%), clearly indicating that annoyance is the predominant reaction to aircraft noise. However, the study also showed that other reactions besides annoyance are experienced. In particular, it is clear that aircraft noise causes a reaction of fear. Respondents were asked to select words to describe their feelings when specific activity disturbances were experienced. They preferred annoyance-related words for disturbances to conversation, TV viewing, listening, sleeping/resting and reading/studying. However, for startle and house vibration they selected fear-related words significantly more often than annoyance words. Further, the study indicated that the word 'affected' tapped a more general reaction than the word 'annoyed'. The partial correlation between noise exposure and 'affectedness' at constant annoyance was 0.25. If annoyance were the only component of subjective reaction a zero correlation would have been obtained. The authors contend that general reaction rather than simply annoyance should be seen as the dependent variable in social studies of the effects of aircraft noise.

5.2 Measuring Reaction to Aircraft Noise

5.2.1 Single rating scales

In order to measure human reaction in a social survey one must ask people to report on and give ratings of their feelings. A common practice in noise surveys is to assess reaction by means of a single rating scale consisting of between 3 and 7 verbal categories such as 'highly annoyed, moderately annoyed, slightly annoyed or not at all annoyed' (e.g., McKennell, 1970; Rylander et al., 1972; Langdon, 1976). A major problem with a single rating is that there can be no check on the consistency of the response, that is, no estimate of reliability. This is a serious deficiency since there are a number of uncontrollable factors in social surveys which can influence any particular response. For example, the precise manner in which the interviewer asks the question, momentary distractions, variations in the exact connotations the words have for the respondent, the presence of non-verbal cues or unconscious promptings given by the interviewer (e.g., a slight emphasis, pause or inflection in reading the rating categories; a pen inadvertantly poised above a particular category). In short, it should be remembered that even in a laboratory experiment there are innumerable factors which are uncontrollable and which contribute to the error variance. In the informal setting of an interview there is much more chance of bias and error arising from a myriad of sources. One cannot expect that a once-only rating will provide the accuracy needed for a proper assessment of aircraft noise reaction. If the physicist with his highly advanced sound-measuring equipment is required to take many readings to reduce error variance, then surely the social scientist with his comparitively crude measurement tool, the rating scale, is being rather presumptuous in obtaining only one estimate of annoyance. By basing the annoyance measure on a number of different ratings one can minimize the chances that extraneous uncontrolled factors will bias the results.

5.2.2 Disturbance annoyance scales

In the classic studies of aircraft noise (Borsky, 1961; McKennell, 1963), subjective reaction was assessed by means of a scale constructed from responses to questions about activity disturbances caused by the noise. This approach has been followed in many subsequent studies (Mather, 1970; Tracor, 1971; R. Travers Morgan, 1974; Borsky, 1978). While disturbance scales are usually very reliable in that they yield consistent scores, they are open to serious doubt as valid measures of annoyance (cf. Hede et al., 1979). Such scales assume that the more disturbances you experience the more annoyed you will be overall. While this may indeed be true, it does not follow that a person who experiences only a few of the disturbances cannot be highly annoyed. As Edwards (1975) states in criticising the scale used by McKennell:

> "...a person cannot score a point on the scale for the question concerned unless he experiences the particular disturbance. He can be fiercely annoyed by other aspects of aircraft noise, but his Guttman Annoyance Score may still be low." (p.46)

There is considerable variation across studies in the number of disturbances included in the scale, and also in whether or not the scale includes a self-rating of annoyance. These two factors exert a major influence on the scale score an individual will obtain. It has been shown (Hede, 1980) that a person who, for example, suffers disturbances only to TV listening and to sleeping, but who is extremely annoyed overall by aircraft noise, would score as follows on a number of scales:

McKennell	3/6	=	5.0
Tracor	10/45	=	2.2
Borsky	18/54	=	3.3

Such differences occur not only in selected individual cases but would also be evident in group data on community reaction to aircraft noise. Although information about activity disturbances is obviously relevant in an assessment of the effects of aircraft noise, a disturbance scale is not an acceptable measure of reaction.

5.3 Psychological Scaling of Subjective Reaction

Psychological scaling procedures enable responses in a number of questionnaire items to be combined to form an overall score on a particular attribute. This study employed Likert scaling which is a simple additive procedure. The reliability or consistency of a Likert scale can be calculated by means of the alpha statistic:

$$\alpha = \frac{n\, r_{ij}}{1 + (n - 1) r_{ij}}$$

where, n = number of items in the scale

r_{ij} = average of the inter-item correlations

Alpha values range from 0 to 1 and, while it is desirable to have values of about 0.90, the minimum acceptable value is about 0.75. A number of scales were constructed in this study in order to get the broadest possible coverage of subjective reaction to aircraft noise.

5.3.1 ANNOYANCE scale

Respondents were required to give four different ratings of annoyance during the interview. Three of these involved using the opinion thermometer to give a numerical rating between 0 and 10 of 'how much' annoyance was felt. The first was a neutral rating included among ratings of other everyday annoyances (Q.10xi), the second was a rating among a list of neighbourhood noises (Q.15iii), and the third was a rating of annoyance caused by activity disturbance (Q.20). The fourth annoyance rating entailed selecting a verbal category to describe annoyance, and was included as a check on the reaction scale and for comparison with the results of other investigators (see Section 5.4). The three opinion thermometer ratings were combined to form the ANNOYANCE scale with scores ranging from 0 to 30. A summary of the scale is given in Table 5.1. The reliability was high(α = 0.92).

5.3.2 DISTURBANCE scale

This scale was constructed on the basis of reports of activity disturbances given in Q.18. A point was scored for each disturbance reported and scale scores ranged from 0 to 8 (see Table 5.2). The reliability of this scale was acceptable (α = 0.85).

Item		Item-Total Correlation	Alpha if Item Deleted
Q.10	Neutral rating of annoyance	.82	.91
Q.15	Annoyance rating in list of noises	.88	.86
Q.20	Rating of annoyance from disturbances	.83	.90

TABLE 5.1 Summary of ANNOYANCE scale (α = 0.92)

	Item	Item-Total Correlation	Alpha if Item Deleted
i)	Conversation	.70	.82
ii)	TV Flicker	.56	.84
iii)	Listening to TV, radio or music	.69	.82
iv)	Sleeping	.55	.84
v)	Relaxing	.68	.83
vi)	Reading/Studying	.62	.83
vii)	Entertaining	.66	.83
viii)	Other	.25	.87

TABLE 5.2 Summary of DISTURBANCE scale (α = 0.85)

5.3.3 COMPLAINT DISPOSITION scale

It had been found in previous surveys that additional information about subjective reaction can be obtained by including items on feelings about complaint action. In Q.30 respondents were asked: "Please say whether or not you would like to do any of these things in relation to aircraft noise. Firstly, do you think you would like to sign a petition?..." It is important to note that this question does not ask whether the person has taken or intends to take the various complaint actions. Rather, it is designed to assess how strongly people feel about noise by asking whether they feel like taking action. Scores ranged from 0 to 8 on the basis of one point for each action (see Table 5.3). This scale was also quite reliable (α = 0.88).

	Item	Item-Total Correlation	Alpha if Item Deleted
i)	Sign a petition	.65	.86
ii)	Complain to local officials	.75	.85
iii)	Complain to your member of Parliament	.76	.85
iv)	Write a letter to the editor	.60	.87
v)	Attend a meeting of neighbours	.68	.86
vi)	Attend a protest rally	.64	.86
vii)	Become a member of a protest group	.58	.87
viii)	Take some kind of legal action	.50	.88

TABLE 5.3 Summary of COMPLAINT DISPOSITION scale (α = 0.88)

5.3.4 G scale

The key questions designed to measure reaction were Q.17 and Q.38 which required respondents to give opinion thermometer ratings of "How much you personally are affected by aircraft noise overall" and "How dissatisfied are you with the amount of aircraft noise in this neighbourhood?". These questions were specifically chosen to assess overall general reaction. The ratings were added to give a score on G scale ranging from 0 to 20. The high inter-item correlation (r = 0.82) indicates that this scale is acceptably reliable.

5.3.5 Other measures of reaction

As well as the above scales there were two single ratings designed to measure specific reactions that some people experience as a result of aircraft noise. The first was a rating of "how much you feel frightened or worried by aircraft noise" (Q.23). This is a measure of the fear reaction caused by the noise itself, and must be distinguished from the fear many have that a plane might crash in their neighbourhood. The latter is considered an intervening variable that serves to modify subjective reaction to aircraft noise (see Section 5.5). The other single measure of reaction was a rating of "how much your health has been affected by aircraft noise" (Q.25B).

5.4 General Reaction (GR)

5.4.1 Computation of GR

Scores on G scale are regarded as providing a direct measure of the dependent variable in this study, namely, the overall reaction experienced by an individual because of exposure to aircraft noise. Scores on the other scales and the two single ratings can also be assumed to provide useful data on reaction. In order to derive the best possible index of general reaction it is desirable to include these other measures in addition to the G scale scores. However, these other measures vary in their importance as indicators of general reaction. It is necessary to assign weightings to them according to their importance, and this can be gauged by means of a multiple regression on G.

Results of the multiple regression analysis are given in Table 5.4. It can be seen that all variables except HEALTH rating loaded significantly into the regression equation. This means that there is no point in adding the health rating because the part of general reaction it measures is already adequately accounted for by the other variables in the equation.

The index of GENERAL REACTION (GR) is derived by taking the average of: i) the G scale score, and ii) the score on G derived using the regression equation.

Reaction Variable	Partial Correlation Between Variable and G Holding Higher Variables Constant	Significance Level for Inclusion of Variable	R^2 After Inclusion of Variable
ANNOYANCE scale	.914	<.001	.836
COMPLAINT DISPOSITION scale	.326	<.001	.854
DISTURBANCE scale	.231	<.001	.861
FEAR rating	.203	<.001	.867
HEALTH rating	.022	Not Significant	.867

TABLE 5.4 Results of multiple regression of various reaction variables on G.

Thus, $GR = (G + x_1A + x_2D + x_3CD + x_4F + C) / k$

where G = Score on G scale (0-20)

A = Score on ANNOYANCE scale (0-30)

D = Score on DISTURBANCE scale (0-8)

CD = Score on COMPLAINT DISPOSITION scale (0-8)

F = Rating of FEAR

C = Constant

k = Constant for re-scaling 0-10

x_i = Weighting factor

Substituting the weightings obtained in the regression on G:

$$GR = (G + .44A + .38D + .31CD + .20F + .43) / 4.125$$

To summarize, GR is derived from two general ratings of reaction, three annoyance ratings and one rating of fear reaction, as well as the responses to questions on activity disturbance and disposition towards complaint action. GR is a single score with a 0-10 range which provides an accurate and reliable measure of an individual's overall subjective reaction to aircraft noise. The frequency distribution of GR scores for different noise exposure groups is illustrated in Figure 5.1

5.4.2 Interpretation of GR scores

Psychological scales are designed to 'spread people out' on the attribute being assessed. The actual scores are arbitrary and can be interpreted only by relating them to other independent indicators. Most

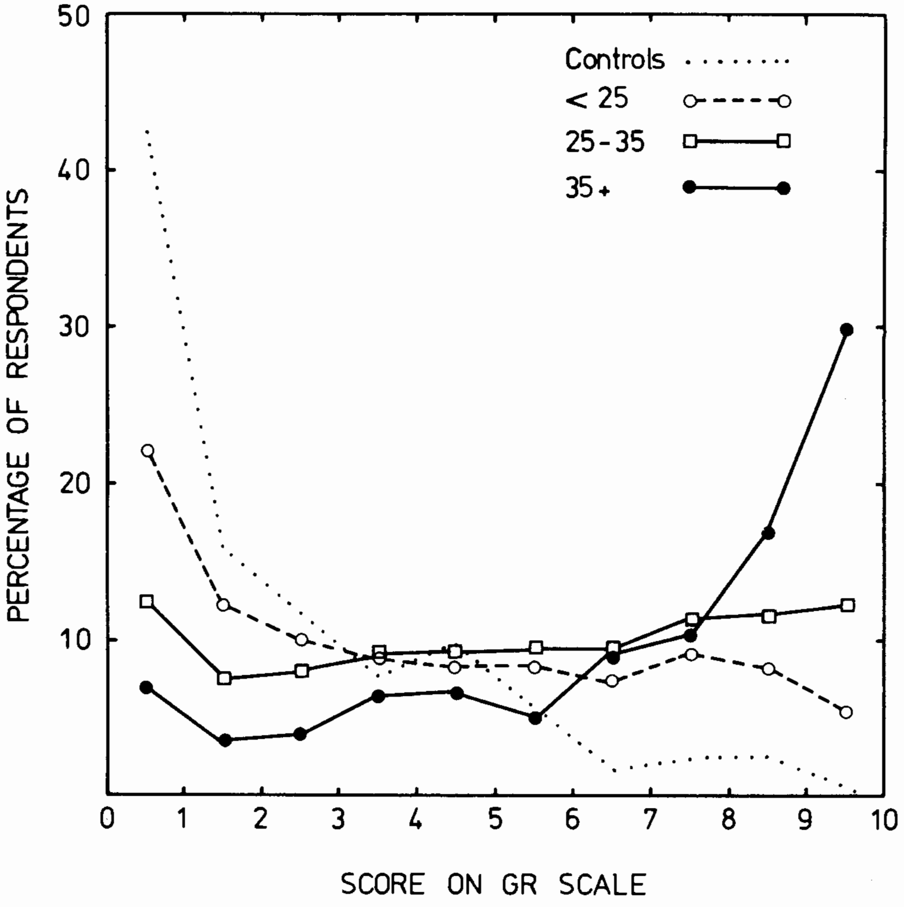


FIGURE 5.1 Frequency distribution of scores on the GR scale broken down by noise exposure measured in terms of NEF3.

previous investigators have failed to provide any such 'pegs' on their scales of noise reaction. It is not possible, therefore, to gauge which point indicates 'high' reaction on the various scales used.

An attempt was made by Schultz (1978) to synthesize data from many different social surveys on a number of noise sources. Because different scales were used in the various surveys Schultz adopted a procedure for arbitrarily classifying respondents as "highly annoyed". On rating scales with verbal categories respondents were classed as highly annoyed if they selected that category, and on non-verbal scales the top 27-29% of the steps were taken as defining highly annoyed. Quite apart from the obvious question about the reliability of a single rating (see Section 5.2.1), there arises the question of the accuracy of the description "highly annoyed". Unless data are provided on how the scale scores are related to other responses, one cannot determine what the description really means, whether the classification is justified, and how the scale compares with those used by other researchers.

In accordance with the present approach of assessing <u>general</u> reaction and not simply annoyance reaction, a definition was sought for the description "<u>seriously affected</u>" rather than "highly annoyed". This was done using the procedure introduced by McKennell (1963) of determining the points on the GR scale at which 50% of respondents reported a variety of opinions and behaviours related to aircraft noise reaction (see Figure 5.2). Although activity disturbances are not independent of GR they are included in the figure for comparison. The <u>meaning</u> of scores on the GR scale can be judged from Figures 5.3, 5.4 and 5.5 which detail the relationship between GR scores and the percentage giving the various responses on the 'peg' questions.

It is proposed that a score of GR ⩾ 8 be taken as indicating that a respondent is "<u>seriously affected</u>". Such a cut-off seems justified in that it represents an 'average' response of 8-out-of-10 on the ratings of affectedness and dissatisfaction as well as the three annoyance ratings and the fear rating. Also, each of the activity disturbances listed in Q.18 was reported by a majority of respondents with GR scores of 8 or more (see Figure 5.5). More than 95% of these respondents rated their neighbourhood as 'bad' or 'very bad' for aircraft noise, and the majority of them spontaneously mentioned aircraft noise as the feature most worth improving in Q.6 (see Figure 5.3). Furthermore, most of these respondents chose the categories "considerably" or "highly" to describe their general feelings of annoyance (see Figure 5.5). There can be no doubt that respondents with GR ⩾ 8 can reasonably be described as "seriously affected" by aircraft noise.

It is also proposed that a cut-off of GR ⩾ 4 be used to define the classification "<u>moderately affected</u>". Again, an examination of the data in Figures 5.2 to 5.5 shows that such a criterion is reasonable. There are three activity disturbances which were reported by the majority of respondents who obtained this score. Also, most of these repondents rated their neighbourhood as 'bad' for aircraft noise, and reported that the noise caused their house to vibrate or shake. Marginally less than 50% of them selected aircraft noise as the nieghbourhood feature most worth improving.

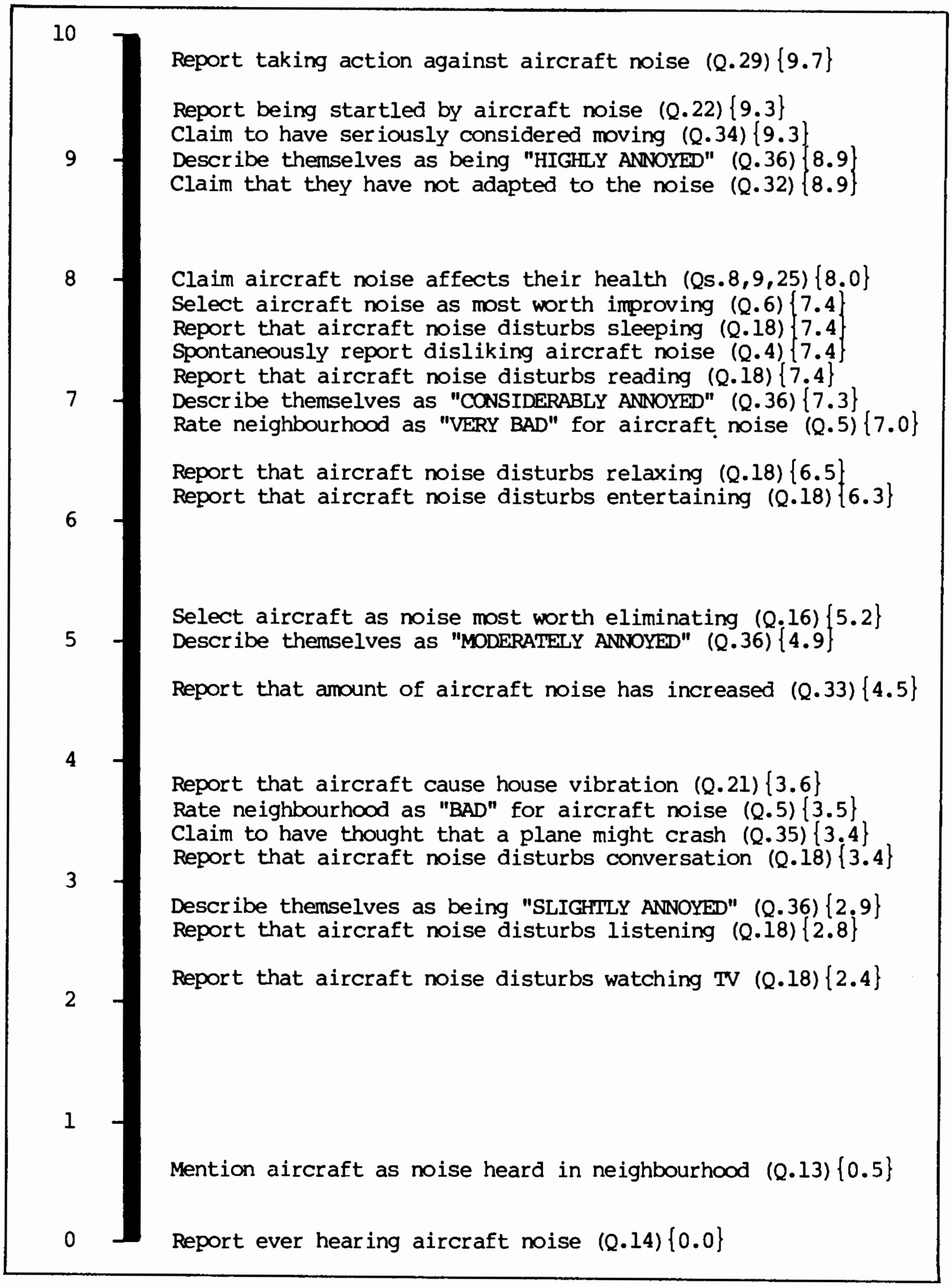


FIGURE 5.2 Points on the GR scale at which 50% of respondents ...

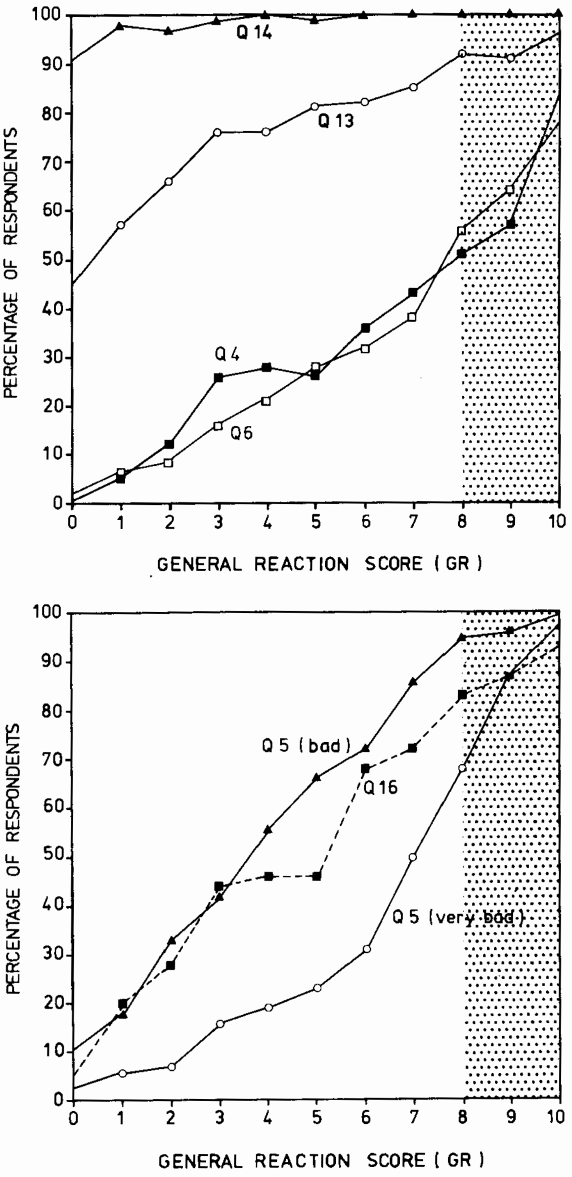
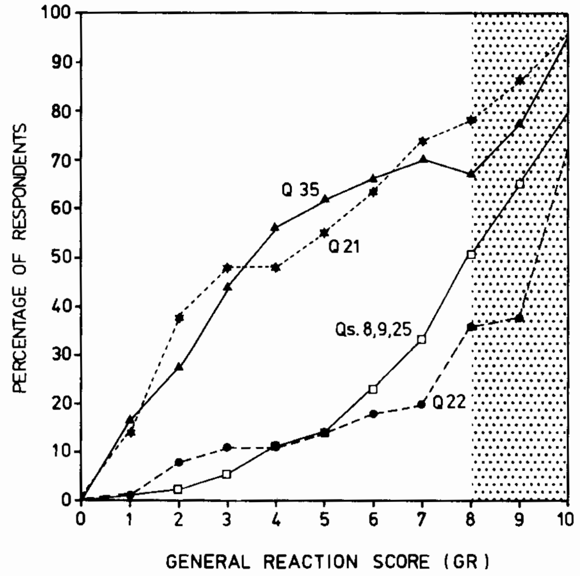


FIGURE 5.3 Percentage of respondents at each GR level who: spontaneously mentioned aircraft noise as a feature disliked (Q.4); mentioned aircraft noise as a noise heard (Q.13, Q.14); rated their neighbourhood as 'bad' or 'very bad' for aircraft noise (Q.5); selected aircraft noise as the feature most worth improving (Q.6) and as the noise most worth eliminating (Q.16). (Shaded area = seriously affected).



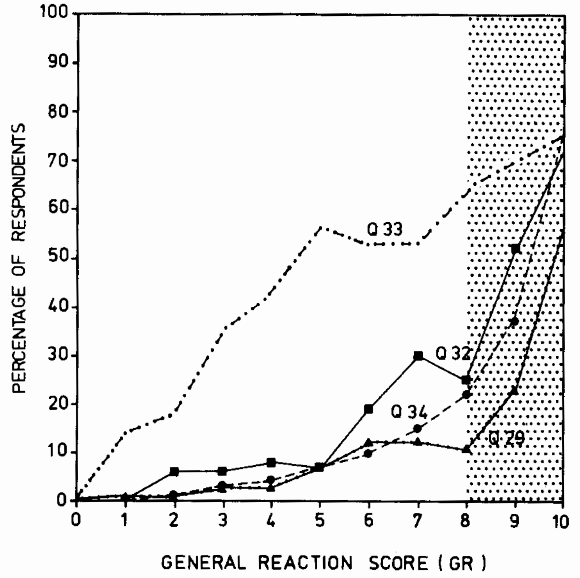


FIGURE 5.4 Percentage of respondents at each GR level who: reported being startled by aircraft noise (Q.22); reported that the noise causes house vibration (Q.21); claimed in at least one question that their health is affected by aircraft noise (Q.8, Q.9, Q.25); reported having thought about a plane crash (Q.35); claimed to have taken action against aircraft noise (Q.29); said they had not become used to the noise (Q.32); felt the noise had increased (Q.33); claimed to have thought of moving (Q.34). (Shaded area = seriously affected).

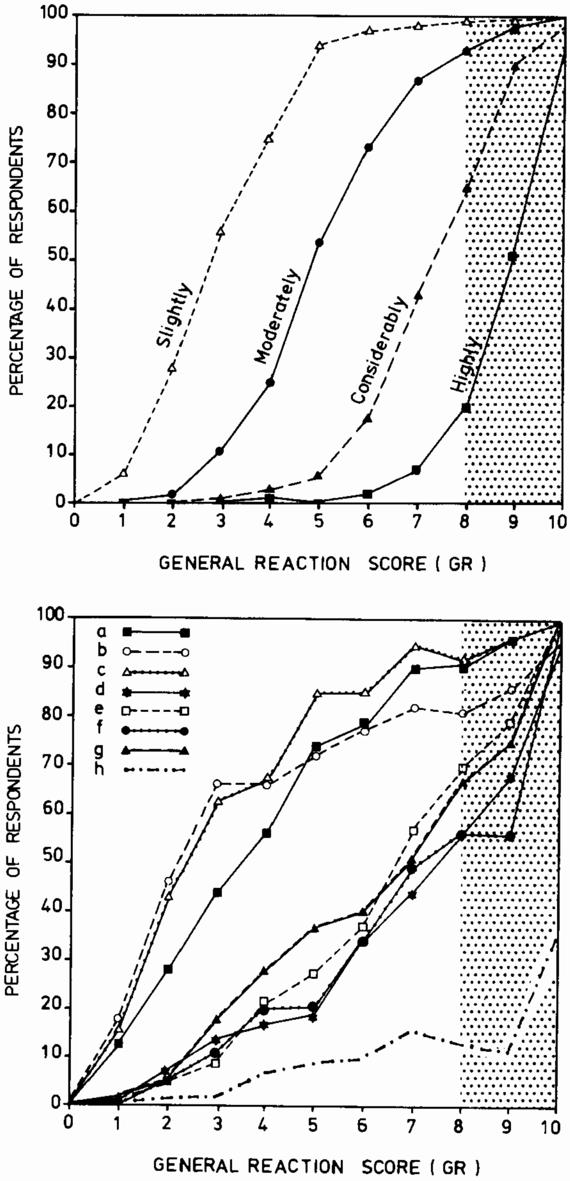


FIGURE 5.5 Percentage of respondents at each GR level who described themselves as slightly, moderately, considerably or highly annoyed (Q.36) and who reported the following activity disturbances in Q.18: a) conversation; b) TV flicker; c) listening to TV, radio, music; d) sleeping; e) relaxing; f) reading or studying; g) entertaining; h) other activities. (Shaded area = seriously affected).

5.5 Modifying Variables

It is not simply the noise level or the number of overflights that determines how much a person will be affected by aircraft noise. A consistent finding in noise surveys has been that psychological factors play an important role in determining subjective reaction. For example, in a study of traffic noise Langdon (1976) found that individual differences in sensitivity to noise accounted for about five times as much of the variation in reaction as the amount of noise itself. Also, it has often been reported that attitudes towards the noise source and the noise-makers affect how people react. In a study of noise from the Concorde aircraft McKennell (1978) reported that subjective reaction depended more on the person's "level of patriotic feeling about the aircraft" than on the level of noise exposure. The present questionnaire included a number of items designed to assess psychological factors which could modify a person's reaction to aircraft noise. Responses were scaled using Likert scaling procedures.

5.5.1 NOISE SENSITIVITY scale

Question 10 required respondents to give opinion thermometer ratings of the annoyance they feel in sixteen everyday situations a number of which involved noise. An indication of a person's sensitivity to noise in general, is given by the extent to which that person is annoyed by many different noises. Of the seven noise situations one was included in the GR scale (viz., "you hear a jet passing overhead"), and the other six were combined to form the NOISE SENSITIVITY scale (see Table 5.5). The reliability of this scale was just barely acceptable($\alpha = 0.78$) but could not be improved by omitting any item. Scores ranged from 0-60 but were re-scaled 0-10 for later analysis. In cases where one of the scale items happened to be missing (e.g. because the respondent claimed not to have experienced the situation), the mean of the other five items was assigned as its score. If data was missing for more than one item, then no scale score was computed for that respondent.

5.5.2 ANNOYANCE TENDENCY scale

It is likely that quick-tempered individuals who tend to get easily annoyed with everyday frustrations will be more annoyed by aircraft noise, and that individuals of calm temperament will be less annoyed. The extent to which the respondent is susceptible to annoyance was measured by means of a scale constructed from the ratings given for the remaining nine items in Q.10 (see Table 5.6). This scale of ANNOYANCE TENDENCY proved reasonably reliable ($\alpha = 0.81$). Up to three missing items were allowed before a respondent was taken to be missing on the scale. Missing items were assigned a score equal to the mean of the other items.

5.5.3 NEGATT scale

The most important 'modifier' of human noise reaction is attitude, for it determines what the noise 'means' for the individual. For example, if a person believes that the airlines don't care about the disruption they cause or that government officials are not doing enough to combat noise,

	Item	Item-Total Correlation	Alpha if Item Deleted
ii)	You are woken up by a dog barking.	.49	.76
iii)	An unanswered telephone keeps on ringing.	.49	.76
vi)	You are trying to concentrate in noisy surroundings.	.55	.75
ix)	Someone uses a motor mower while you are resting	.62	.73
xiii)	Your conversation is interrupted by traffic noise	.50	.76
xv)	A neighbour's radio or TV is playing loudly.	.55	.75

TABLE 5.5 Summary of NOISE SENSITIVITY scale ($\alpha = 0.78$)

	Item	Item-Total Correlation	Alpha if Item Deleted
i)	You are held up in traffic.	.45	.79
iv)	You are unable to find a space in a car park.	.57	.78
v)	Someone is reading over your shoulder.	.44	.80
vii)	A person never stops complaining.	.58	.78
viii)	Someone pushes in ahead of you in a queue.	.57	.78
x)	You smell vehicle exhaust fumes.	.48	.79
xii)	You have to stand up on public transport.	.46	.79
xiv)	You see litter in a public park.	.45	.79
xvi)	You find a public telephone out-of-order	.52	.79

TABLE 5.6 Summary of ANNOYANCE TENDENCY scale ($\alpha = 0.81$)

then he is more likely to be affected than a person with the same noise exposure who believes that airport officials are doing their best to reduce noise. Q.37 consisted of ten statements about the airport, the airlines, the government etc. Half of them expressed positive views and half negative views to control for any tendency towards positive or negative responses. Respondents were required to indicate their opinion on a scale "strongly agree, agree, undecided, disagree, strongly disagree".

	Item	Item-Total Correlation	Alpha if Item Deleted
i)	The airport should be moved to an area where there are no houses.	.58	.78
ii)	Aircraft noise is really <u>not</u> much of a problem.	.59	.78
iii)	Pilots do their best to keep the noise down when flying over residential areas.	.43	.80
iv)	Most people who complain about aircraft noise are just troublemakers.	.45	.79
v)	The government has no real concern for people affected by aircraft noise.	.46	.79
vi)	Airport officials are continually trying to find ways of reducing aircraft noise disturbance to residents.	.49	.79
vii)	It is no use complaining about aircraft noise because no one will ever do anything about it.	.31	.81
viii)	Whatever the inconvenience to airlines there should be more restrictions on aircraft flights over residential areas.	.55	.78
ix)	Airlines do not care about the disruption caused by aircraft noise.	.59	.78
x)	Aircraft manufacturers spend a lot of money trying to reduce the noise of aircraft engines.	.40	.80

TABLE 5.7 Summary of NEGATT scale ($\alpha = 0.81$)

For scaling purposes, responses to the positive statements were reversed so that the scale scores measured the negative attitudes of the respondent. Each item was scored 0-4 from strongly disagree to strongly agree. The response "I don't know" was regarded as expressing neither positive nor negative opinions and was scored the same as "undecided". Responses to the ten items were combined to form NEGATT scale with scores from 0-40 re-scaled to 0-10. A summary of the scale is given in Table 5.7 ($\alpha = 0.81$).

An attempt was made to construct a scale of NEIGHBOURHOOD DISSATISFACTION from the ratings in Q.5 of various neighbourhood features. However, the reliability was unacceptably low ($\alpha = 0.63$). For subsequent analysis it was decided to use the overall rating given in Q.2 as an indication of neighbourhood dissatisfaction.

A major determinant of subjective reaction to aircraft noise is the fear many people have that an aircraft might crash in the neighbourhood (Borsky, 1961; McKennell, 1963; Tracor, 1971). This important modifier was assessed by the variable CRASH which consisted of the opinion thermometer rating in Q.35 of "how much you feel afraid or worried about a possible plane crash in this neighbourhood".

The effect of the above factors in modifying reaction is discussed in Section 6.6.

CHAPTER 6

DOSE/RESPONSE ANALYSIS

6.1 The Form of Dose/Response Analysis

Analysis of survey results to give an overall curve relating aircraft noise exposure to reaction to the noise is complicated by a number of factors:

a) There are a large number of possible descriptors of noise exposure (see Chapter 4). Differences in the performance of these descriptors are discussed in Chapter 8. In this chapter, although dose/response functions are shown for a number of noise descriptors, attention will be concentrated on two units. These are NEF3 - the best available approximation to the official noise exposure unit used in Australia - and $NEF_{3,6}$ - a unit which was found to have a significantly higher correlation with reaction than NEF3 (see Chapter 8). $NEF_{3,6}$ differs from NEF3 in that only noise from overflights is considered, the night weighting used is 3 dB instead of 12.2 dB, and there is an evening weighting of 6 dB.

b) There are at least two possible descriptors of reaction to aircraft noise. These are the respondent's score on the GR scale of overall reaction to the noise (see Section 5.4) and a 0/1 variable representing whether or not the respondent is "seriously affected" by the noise (i.e. has GR $\geq$ 8). This 0/1 variable is referred to as SA. Another variable, representing whether or not the respondent is "moderately affected" by the noise (i.e. has GR $\geq$ 4) is known as MA.

c) There are at least two possible ways of finding a dose/response function. Data from all respondents may be combined in a regression equation to give the curve which best fits the response - this is known as the use of individual data. Alternatively, responses of individuals in a defined geographical area can be averaged, and a regression performed on these average values, assuming exposure to be roughly constant throughout the area. If SA is used as the response variable, the average value in an area is simply the proportion of people who are seriously affected by the noise. This approach is known as the use of grouped or clustered data. The advantages of using individual data are:-

   i) Variations between individuals are preserved, so that the effects of personal characteristics on response can be more easily studied. These variations may be "averaged out" in clustered data.

   ii) If, as in this study, small-scale variations in noise exposure have been calculated, these extra data can be used, to give finer discrimination between noise exposure units. That is, the power of statistical tests which differentiate between exposure units is increased (see Chapter 8).

The advantages of using clustered data are:

i) The data are automatically corrected for the number of respondents in a cluster. That is, if a dose/response curve is required which represents responses over a sample of affected areas, rather than over the sample of respondents in the survey, clustered data will give a better approximation than individual data, unless weighting factors are applied to individual responses. This is important for the present survey, as the number of respondents in various noise zones differed substantially between airports (see Section 3.4).

ii) Scatter about the dose/response curve for clustered data gives an idea of the variation in average response between different affected areas. (The effect of sampling error within a cluster, however, must be considered. This can sometimes be quite large.)

6.2 Dose/Response Functions for Individual Data

Figure 6.1 shows regression lines for GR, and for the percentage of respondents who are seriously and moderately affected, in terms of the noise indices NEF3 and $NEF_{3,6}$, using individual data. Linear regressions were used for GR. Quadratic regressions were used for SA and MA, since this resulted in a significantly better fit to the data. The use of higher-order equations did not result in a statistically significant improvement in the fit. It must be remembered that these regression lines reflect results from Sydney more strongly than other airports, since there were more respondents in Sydney (see Table 3.4).

Correlations between these measures of reaction and exposure are shown in Table 6.1 (Differences between exposure units are discussed in detail in Chapter 8.) The square of the correlation co-efficient gives the proportion of the variance in the reaction variable which is explained by the exposure variable. Thus it can be seen that no more than 13% of the variance in the reaction variables is explained by the exposure variables. Correlations similar to these have been found in numerous previous studies of aircraft noise.

Exposure Measure / Reaction Measure	NEF3	$NEF_{3,6}$
GR	.310	.361
SA	.289	.331
MA	.238	.286

TABLE 6.1 Co-efficients of correlation between measures of exposure to aircraft noise and measures of reaction to it, using individual data. Linear predictive equations are used for GR and quadratic equations for SA and MA.

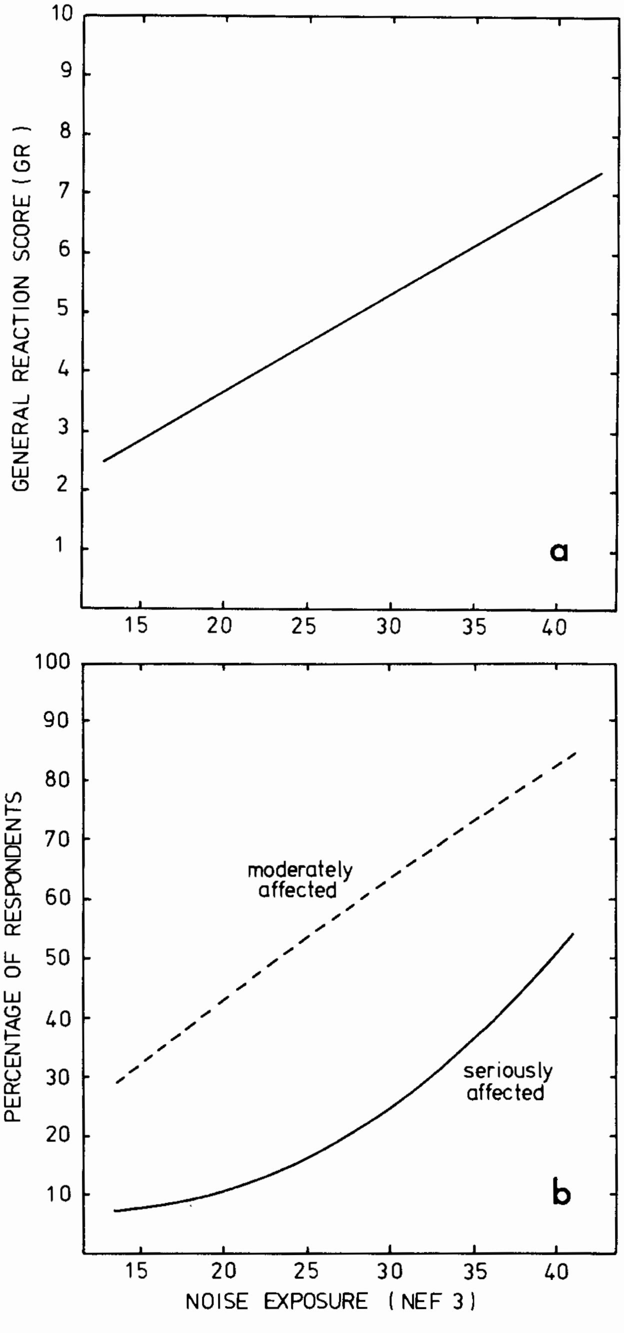


FIGURE 6.1 Dose/response functions for individual data:

a) GR score b) Percentage affected as a function of exposure in NEF3.

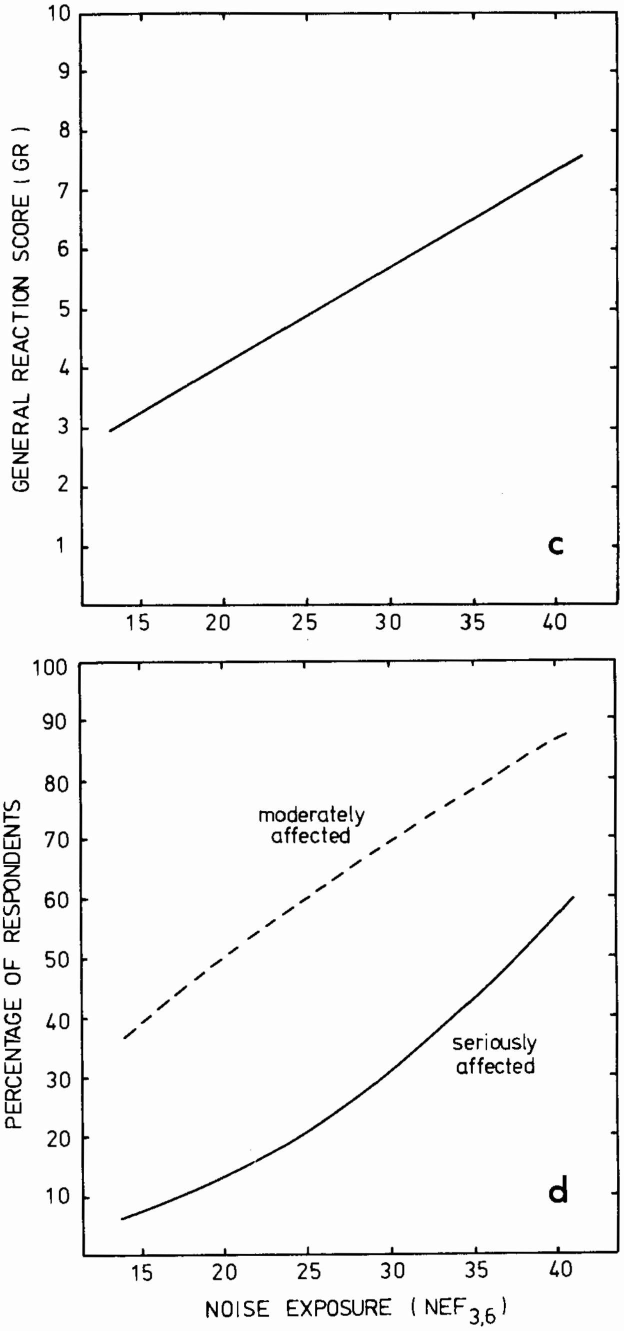


FIGURE 6.1 (Cont'd) Dose/response functions for individual data:

c) GR score d) Percentage affected as a function of exposure in $NEF_{3,6}$.

6.3 Dose/Response Functions for Clustered Data

Clusters of respondents can be formed by averaging all responses from a given exposure zone. Exposure zones are defined by the survey sampling procedures (see Section 3.1.2). Across a zone, noise exposure measured by most decibel-like units varied by about ± 2.5 dB from its mean value. Clusters containing fewer than 40 respondents were excluded. A total of 42 clusters could be formed in this way.

Regressions were performed between mean values of exposure and mean values of response in each cluster, using the exposure variables NEF3 and $NEF_{3,6}$, and the response variables GR, SA and MA. As in the case of individual data, linear regressions were used for GR and quadratic regressions for SA and MA. The resulting curves are shown in Figure 6.2. It is clear that these are quite similar to the curves of Figure 6.1, indicating that the biasing effect of using different sample sizes in different areas is small. Correlation co-efficients between exposure and reaction variables for clustered data (see Table 6.2) were naturally considerably higher than those for individual data. Clustered dose/response data for all major noise exposure units calculated in this study are shown in Figure 6.3. For these graphs the measure of reaction is SA (i.e., percentage seriously affected). The units of exposure are explained and defined in Chapter 4. These data are presented in tabular form in Appendix D. Correlation co-efficients are given in Table 6.3 and discussed in Section 8.6.

Possibly the most interesting of these dose/response relationships is that between the percentage of respondents seriously affected by the noise and L_{dn}. Schultz (1978) has published a synthesis of results from 11 social surveys, analysed with L_{dn} as the exposure variable and the percentage of respondents "highly annoyed" as the reaction variable. Figure 6.3(f) shows that Schultz's results are not in close agreement with those from the present survey, as analysed here.

The reason for this discrepancy appears to lie in differences between the present definition of "seriously affected" and Schultz's definition of "highly annoyed". Question 36 of the interview schedule asked respondents to rate their "general feelings about the aircraft noise in this neighbourhood" in terms of the categories "highly annoyed, considerably annoyed, moderately annoyed, slightly annoyed or not at all annoyed". Under Schultz's definition, a respondent would be classified as highly annoyed if and only if he chose that category in response to Q.36.

Exposure Measure / Reaction Measure	NEF3	$NEF_{3,6}$
GR	.699	.823
SA	.733	.839
MA	.656	.788

TABLE 6.2 Co-efficients of correlation between measures of exposure to aircraft noise and measures of reaction to it, using clustered data. Linear predictive equations are used for GR and quadratic equations for SA and MA.

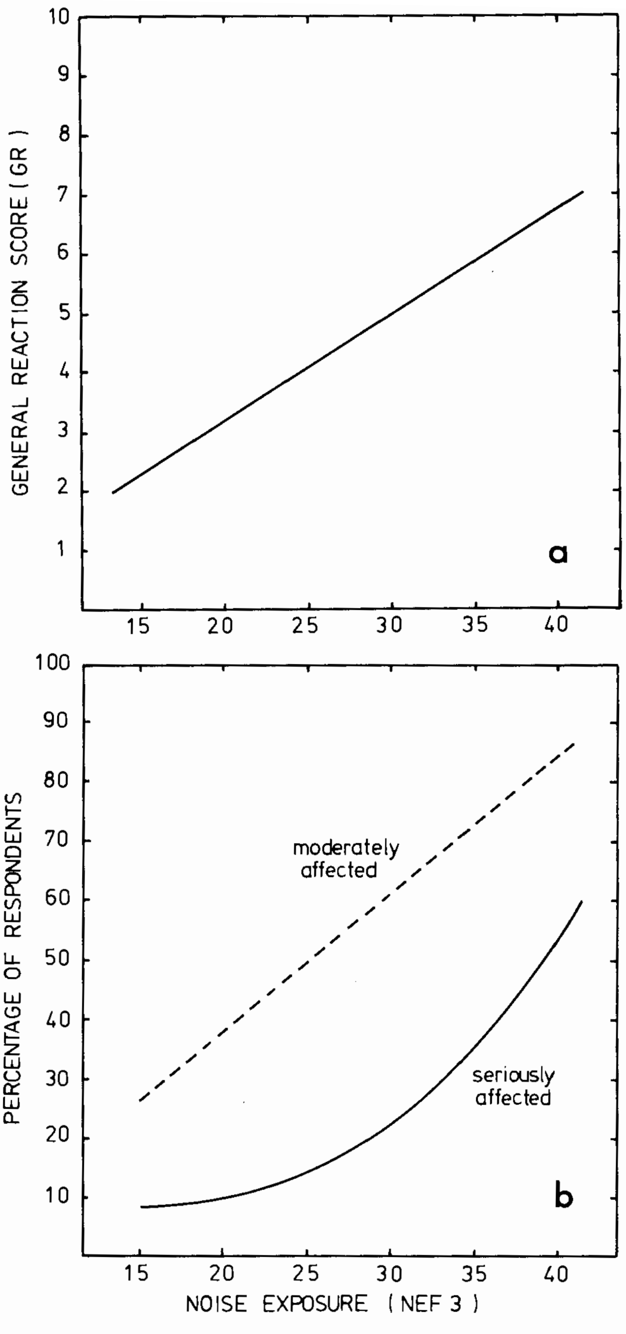


FIGURE 6.2 Dose/response functions for clustered data:

a) GR score b) Percentage affected as a function of exposure in NEF3.

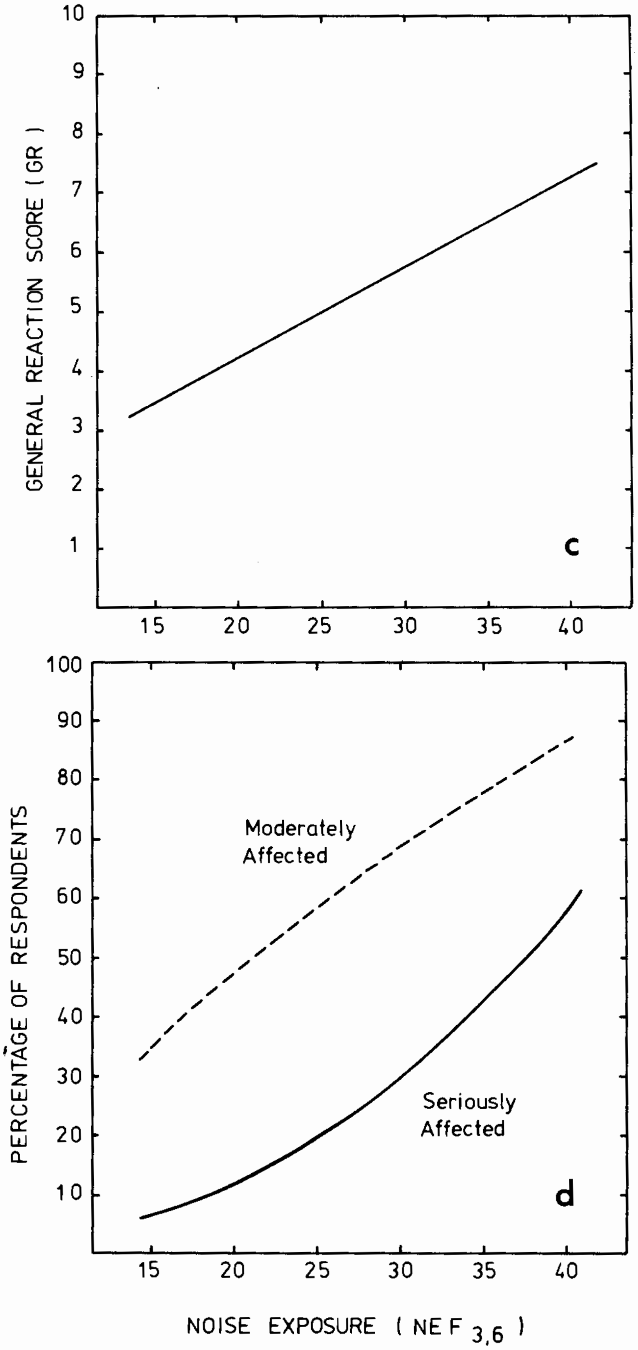


FIGURE 6.2 (Cont'd) Dose/response functions for clustered data:

c) GR score d) Percentage affected as a function of exposure in $NEF_{3,6}$.

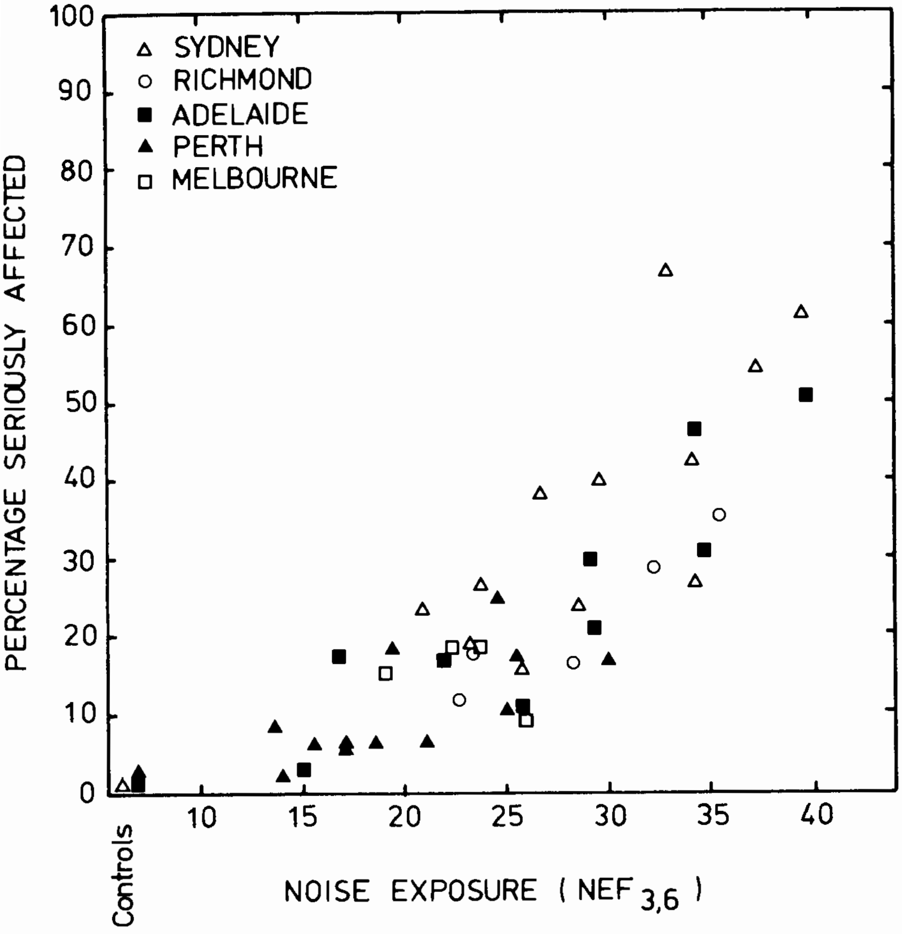


FIGURE 6.3 Dose/response relationships for clustered data. Percentage seriously affected as a function of exposure in $NEF_{3,6}$.

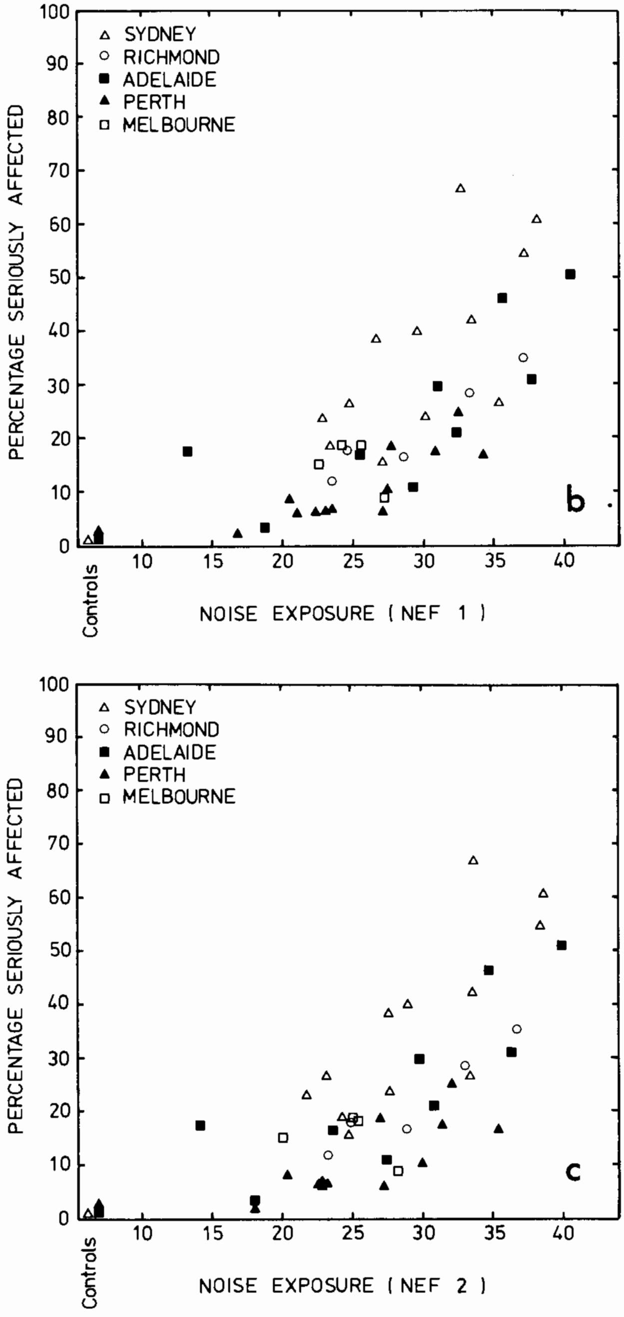


FIGURE 6.3 (Cont'd) Dose/response relationships for clustered data. Percentage seriously affected as a function of exposure in NEF1 (b) and NEF2 (c).

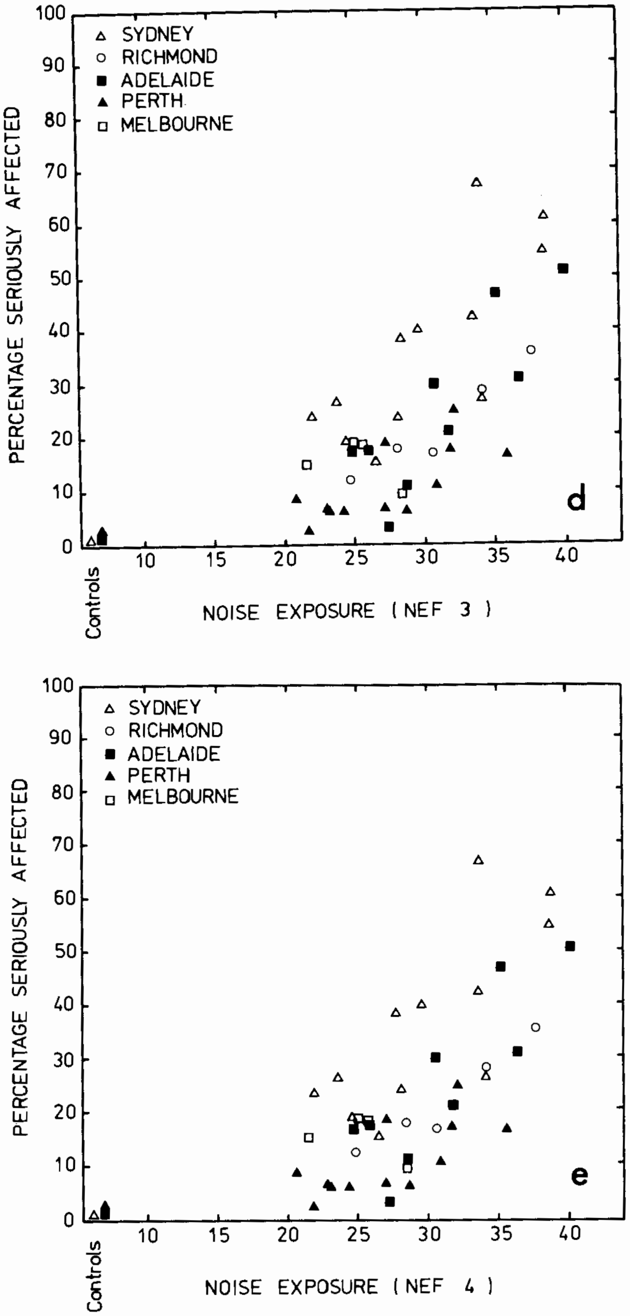


FIGURE 6.3 (Cont'd) Dose/response relationships for clustered data. Percentage seriously affected as a function of exposure in NEF3(d) and NEF4(e).

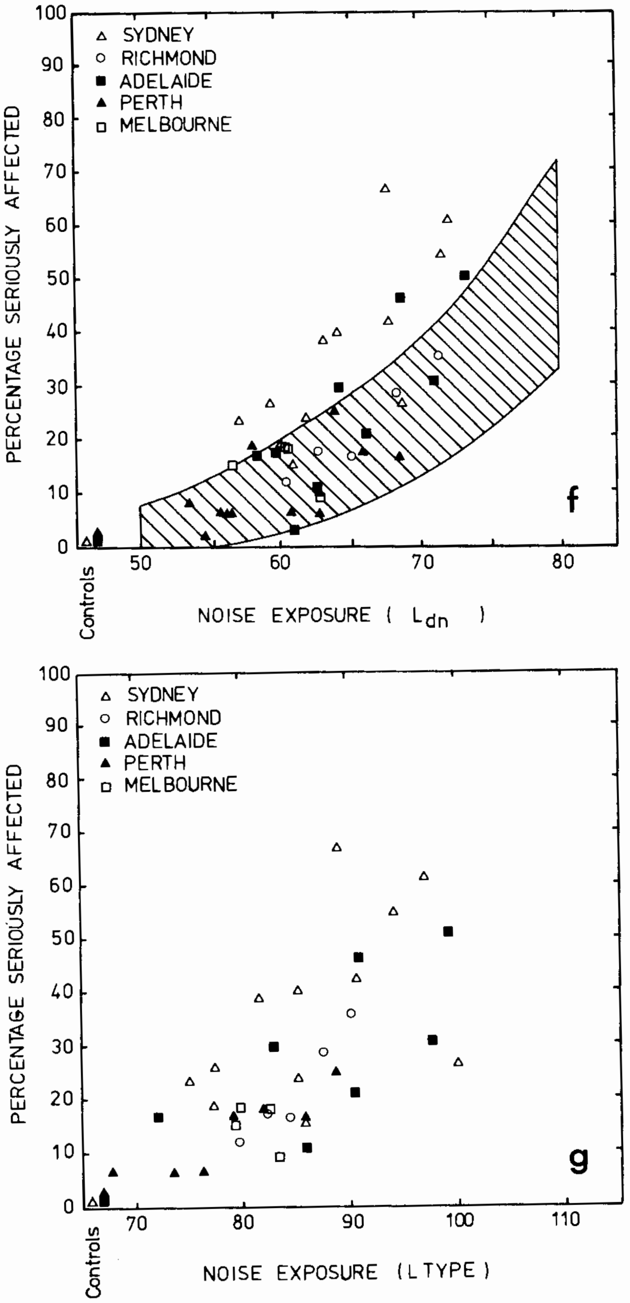
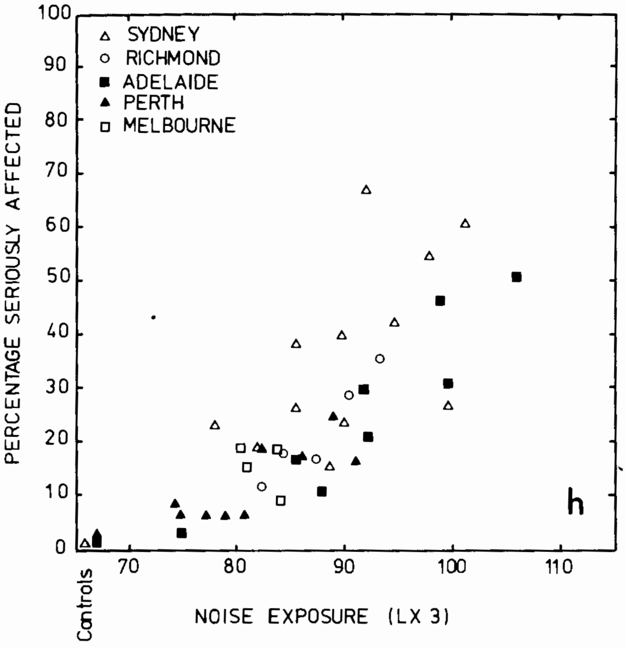


FIGURE 6.3 (Cont'd) Dose/response relationships for clustered data. Percentage seriously affected as a function of exposure in L_{dn} (f) and LTYPE (g). Note: The shading in f) represents the "percentage highly annoyed" data from Schultz (1978) and covers 90% of his data points.



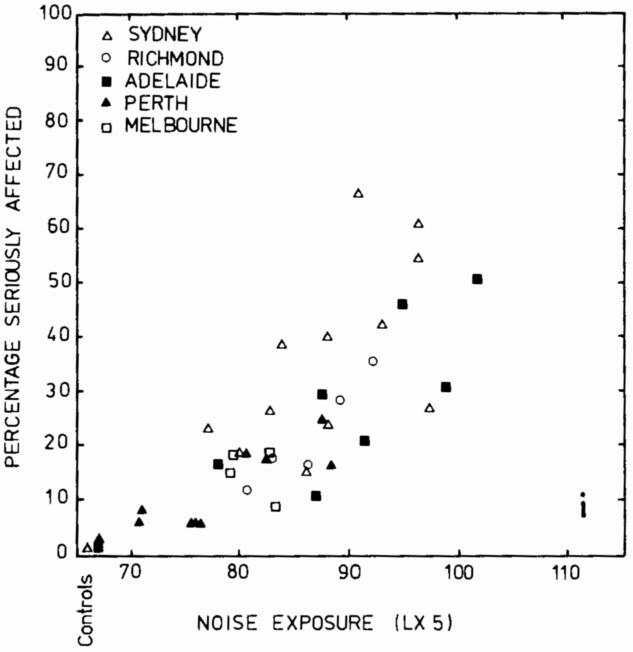
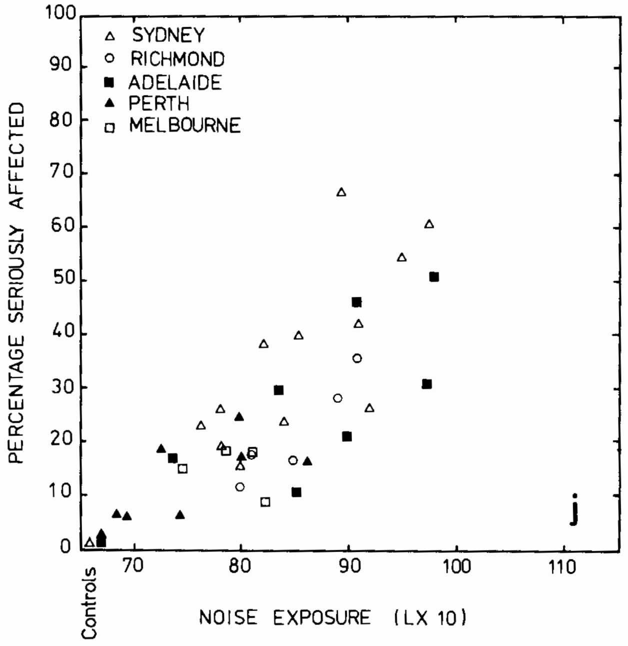


FIGURE 6.3 (Cont'd) Dose/response relationships for clustered data. Percentage seriously affected as a function of exposure in LX3 (h) and LX5 (i).



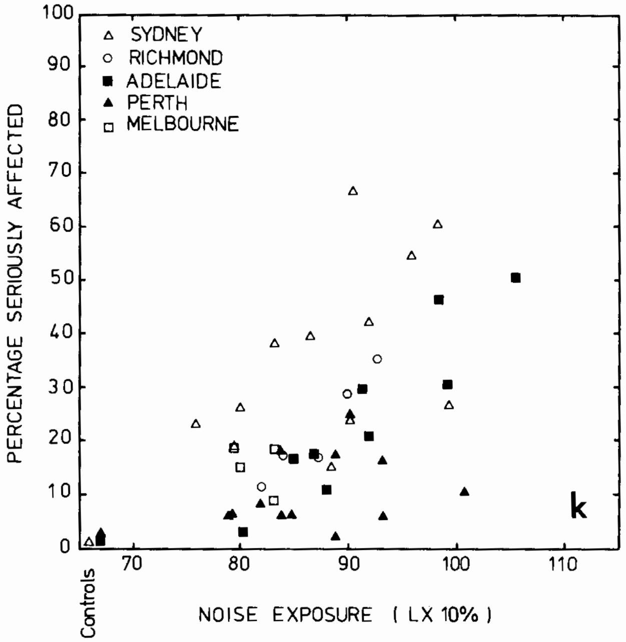


FIGURE 6.3 (Cont'd) Dose/response relationships for clustered data. Percentage seriously affected as a function of exposure in LX10 (j) and LX10% (k).

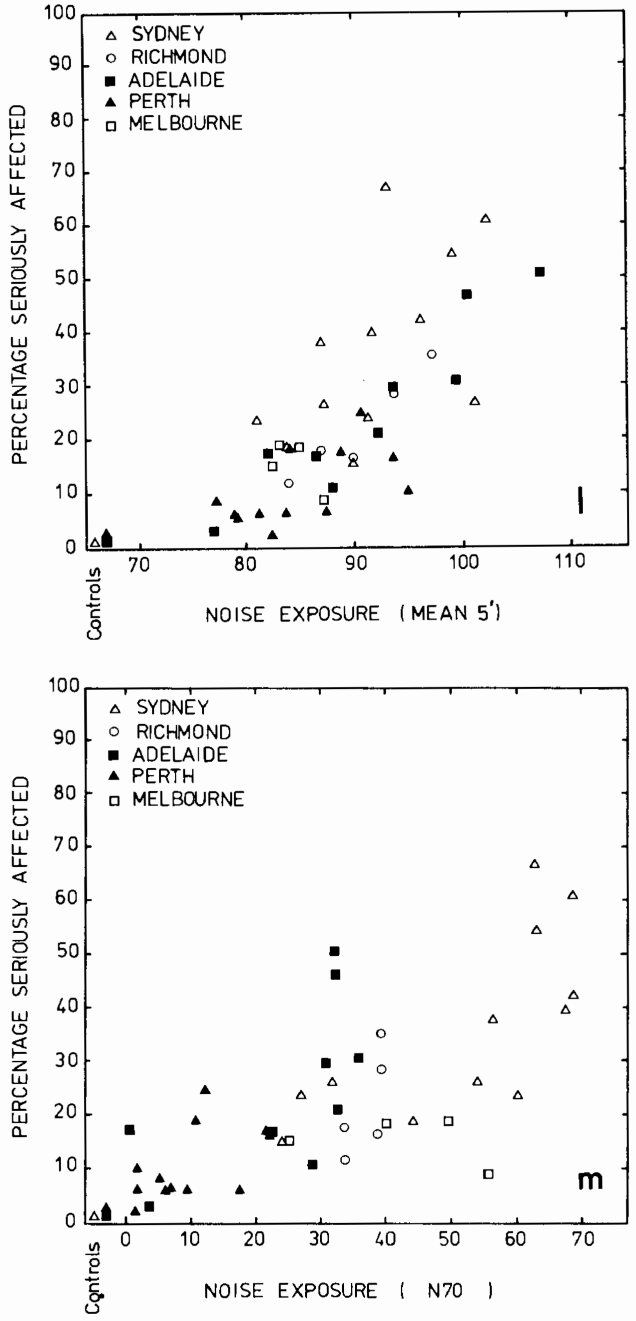


FIGURE 6.3 (Cont'd) Dose/response relationships for clustered data. Percentage seriously affected as a function of exposure in MEAN5' (l) and N70 (m).

Exposure Measure	Correlation with Percentage Seriously Affected
$NEF_{3,6}$	.821
NEF1	.713
NEF2	.722
NEF3	.705
NEF4	.705
L_{dn}	.716
LTYPE	.671
LX3	.766
LX5	.755
LX10	.731
LX10%	.515
MEAN5'	.736
N70	.714

TABLE 6.3: Co-efficients of (linear) correlation between the percentage of respondents seriously affected by aircraft noise and various measures of noise exposure (clustered data).

Figure 6.4 shows the percentage of respondents who are highly annoyed, under this definition, as a function of L_{dn}. These data show good agreement with those of Schultz.

It is clear that, on average, "highly annoyed" represents a stronger reaction than "seriously affected". This can be seen in Figure 5.1, which shows that the point on the GR scale at which 50% of respondents are "highly annoyed" is 8.9, compared with 8.0 which was taken as the definition of "seriously affected". The authors believe that "seriously affected" is the more appropriate measure of response for the following reasons:

i) The words "affected" and "dissatisfied" (as used in Questions 17 and 38 of the interview schedule respectively), which form the basis of the GR scale, appear to tap a more general reaction than the word "annoyed" (see Section 5.4). In particular, "affected" includes reactions of fear caused by the noise, perception of health effects caused by the noise, etc. It is therefore not surprising that some respondents who rate quite highly on the GR scale would not describe themselves as "highly annoyed". Schultz considers that "highly annoyed" corresponds to the top 27-29% of an annoyance scale, whereas it corresponds to only the top 11% of the GR scale. It seems clear that the

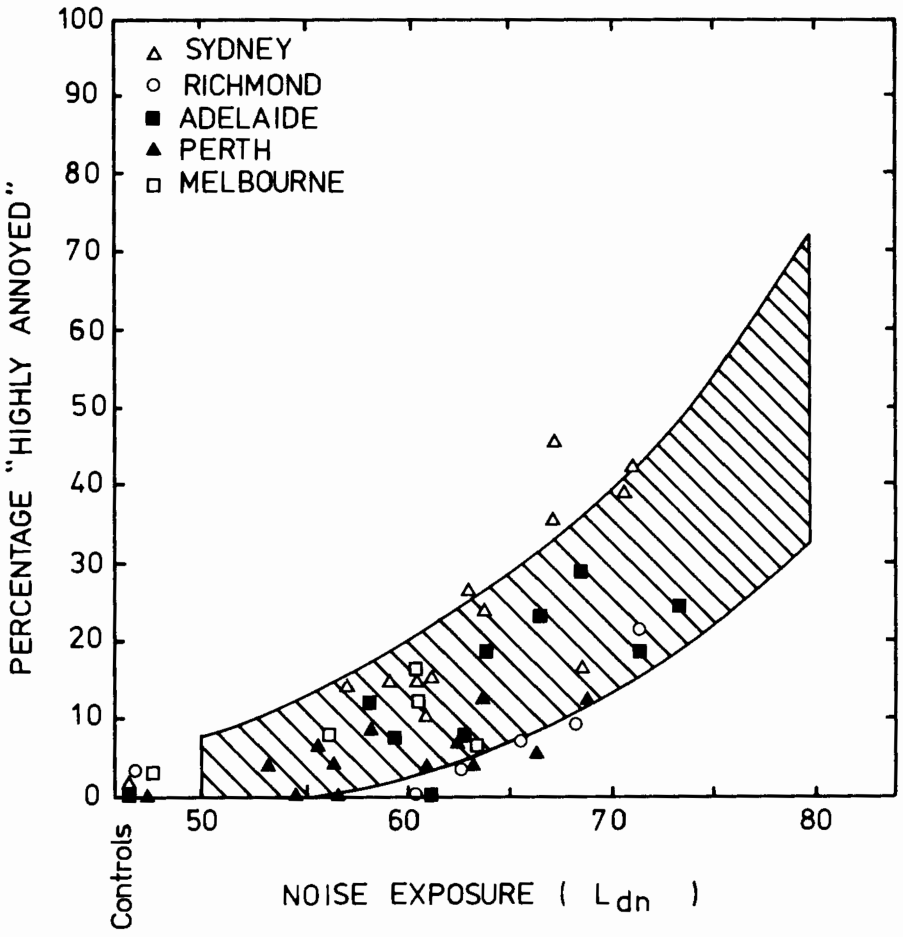


FIGURE 6.4 Dose/response relationship for clustered data, using percentage "highly annoyed" as the response variable. The shaded area covers 90% of the data points given by Schultz (1978).

more general reaction is a more appropriate measure, both for descriptive and for legislative purposes.

ii) Responses to various questions throughout the schedule, as shown in Figure 5.1, indicate that a score of 8.9 on the GR scale represents a very high level of reaction. The level appears to be higher than that implied by the phrase "seriously affected", and higher than that at which most people would feel "something should be done about the noise". In particular, at GR = 7.4, 50% of respondents claim that the noise disturbs sleep, at GR = 8.0, 50% report in at least one question that the noise influences their health, and at GR = 9.3, 50% claim to have seriously considered moving because of the noise, which certainly represents a very high level of reaction. Thus, "highly annoyed" (at GR = 8.9) would seem to exclude some people whose degree of reaction would normally be termed "high".

iii) It is difficult to see how "highly annoyed", under Schultz's definition, could be measured using a scale in place of a single question, unless exactly the same question were asked at different points in the interview schedule. It is argued in Section 5.2 that a scale provides a more accurate and reliable measurement tool than a single question.

6.4 Effect of Sampling Error on Clustered Dose/Response Data

Each point shown in Figure 6.3 represents a proportion of respondents in a sample population. Clusters with fewer than 40 respondents were not included, but 40 is still a relatively small number, so that each point in these figures will be subject to some sampling error in determining the proportion of the population which is seriously affected. The sampling error for each point may be roughly estimated by $(P(1-P)/N)^{\frac{1}{2}}$ where P is the sample percentage seriously affected and N is the number of respondents in the cluster (Hays, 1963). This expression gives the standard error of estimate for the true percentage.

Using this expression, the overall R.M.S. sampling error amounts to 5 percentage points, or 9% of the overall variance in percentage seriously affected. This should be remembered when interpreting the graphical data, since it means that sampling errors of up to ten percentage points in percentage seriously affected are quite possible. It should also be noted when stating that $NEF_{3,6}$, for instance, accounts for 70% of the variance in percentage seriously affected, that a further 9% of this variance is accounted for by sampling error.

6.5 Other Aspects of Reaction to Aircraft Noise

6.5.1 Activity disturbance

The most common effect of aircraft noise on residents is the disturbance it causes to everyday activities. Figure 6.5 plots the percentage of respondents reporting various disturbances as a function of noise exposure zone. (Data for each of the five airports are given in

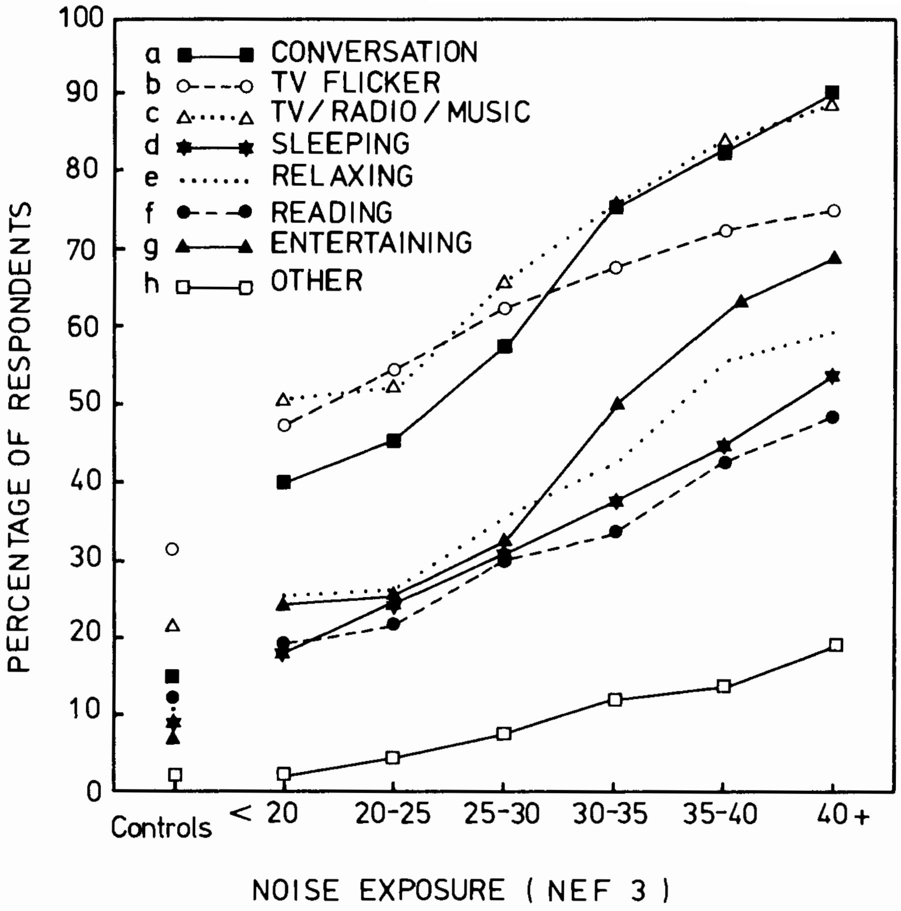


FIGURE 6.5 Percentage of respondents reporting disturbances to various activities, as a function of noise exposure.

Table D.17 of Appendix D.) The results are very similar to those reported in previous studies (e.g., McKennell, 1963; R. Travers Morgan, 1974). The mostly commonly experienced disturbances are those to conversation and to listening activities (TV, radio and music). Even at levels of noise exposure less than 25 NEF the majority of respondents report at least one of these disturbances. TV picture flicker is also a very commonly reported problem. The slope on the curve for TV flicker appears less steep than for the other disturbances, possibly due to the fact that it is not actually the noise that causes this disturbance but the TV signal reflected from the plane. Even in control areas TV flicker was reported by more than 30% of respondents.

From Figure 6.5 it may appear that sleep disturbance is among the less common problems caused by aircraft noise. However, examination of the data from another question on activity disturbance shows that sleep disturbance is by no means a minor problem. Question 19 asked which activity respondents would most like to have free from aircraft noise disturbance - the responses are summarized in Table 6.4 Overall, TV flicker was preferred as the disturbance most worth eliminating; it was selected by 25.8% of respondents. However, for those who are seriously affected by aircraft noise, sleep disturbance seems quite definitely to be the major problem - 26.7% of them chose sleeping. Two other disturbances were also frequently selected, namely conversation and listening to TV, radio or music. The other activity disturbances were chosen by comparatively few respondents.

The figures for the various airports (see Appendix Table D.18) also indicate that disturbances divide into two groups with conversation, TV flicker, listening and sleeping being by far the more serious. However, there is some variation among airports as to which disturbance was preferred as the one most worth eliminating. For Sydney, Richmond and Melbourne it was TV flicker, whereas for Adelaide the most preferred was listening to TV, radio or music. Sleep disturbance was the one most often chosen by Perth residents, probably because of the relatively high proportion of night-time aircraft operations at this airport. It is noteworthy, however, that in the data on percentages reporting disturbances by exposure zone (see Appendix Table D.17) sleep disturbance was not greater for Perth than for the other airports.

Activity Disturbance	Percentage of all Respondents	Percentage of Seriously Affected Respondents
Conversation	19.7	19.7
TV flicker	25.8	16.2
TV/Radio/Music	19.6	18.9
Sleeping	19.1	26.7
Relaxing	6.4	9.5
Read/Study	3.3	2.8
Entertaining	4.1	4.5
Other	1.9	1.6

TABLE 6.4 Percentage of respondents selecting each disturbance as most worth eliminating.

6.5.2 Aircraft noise in relation to other neighbourhood factors

Question 5 of the interview schedule required respondents to rate their neighbourhood for a variety of features including aircraft noise. Figure 6.6 plots the percentage who gave the ratings "bad" or "very bad" for each feature as a function of exposure zone. (Detailed data for each airport are given in Appendix Table D.19). The only feature which is strongly related to exposure is "amount of aircraft noise". Dissatisfaction with amount of pollution also seems to increase with exposure possibly because respondents regard aircraft noise as pollution or because of air pollution from aircraft engines. There appears to be no tendency for people to find fault with all features in an area because it is exposed to high levels of aircraft noise. Respondents in noise affected areas did not rate their neighbourhood any worse than control respondents for features other than aircraft noise and pollution. Indeed, it would appear that dissatisfaction with public transport facilities decreases as noise exposure increases, no doubt reflecting the fact that areas closer to airports tend to be better serviced by public transport.

6.5.3 Aircraft noise in relation to other noises

How is aircraft noise perceived in relation to other noises in the neighbourhood? In Q.15 respondents rated their annoyance from each of a list of noises. Figure 6.7 shows the relationship between noise exposure and the percentage of respondents annoyed, that is, giving a rating of at least 4 on the 0-10 opinion thermometer. (Appendix Table D.20 provides the data for individual airports). The only curve that increases with noise exposure is that for aircraft noise. Community annoyance with other noises remains fairly constant across aircraft noise exposure zones. In areas with low exposure to aircraft noise (less than 20 NEF), more people were annoyed by traffic noise than by aircraft noise.

6.5.4 Other effects of aircraft noise

A variety of aspects of aircraft noise reaction are illustrated in Figure 6.8, which plots the percentages reporting various effects in each exposure zone. (These effects were used as 'pegs' for interpreting scores on the GR scale - see Section 5.4.2). From Figure 6.8 (a) it appears that the questionnaire responses best able to differentiate reaction across exposure zones were the spontaneous mentioning of aircraft noise as a feature disliked (Q.4) and the selecting of aircraft noise as the feature most worth improving (Q.6).

The only effect which does not increase significantly with increasing exposure is the general rating of health in Q.7 (see Figure 6.8 (b)). Respondents in high noise zones were no more likely to rate their health as "bad" or "very bad" than people with less noise exposure (F = 0.52). There were three other questions relating to health and a detailed discussion of them is given in Section 7.7. In Q.8, respondents were asked whether anything about living in their neighbourhood might have influenced their health, and if so, what it was. In Q.9 and Q.25 they were asked whether and in what way aircraft noise had influenced their health. Table 6.5 summarizes the relationship between noise exposure and the numbers of respondents who reported health effects in answer to at least one of the

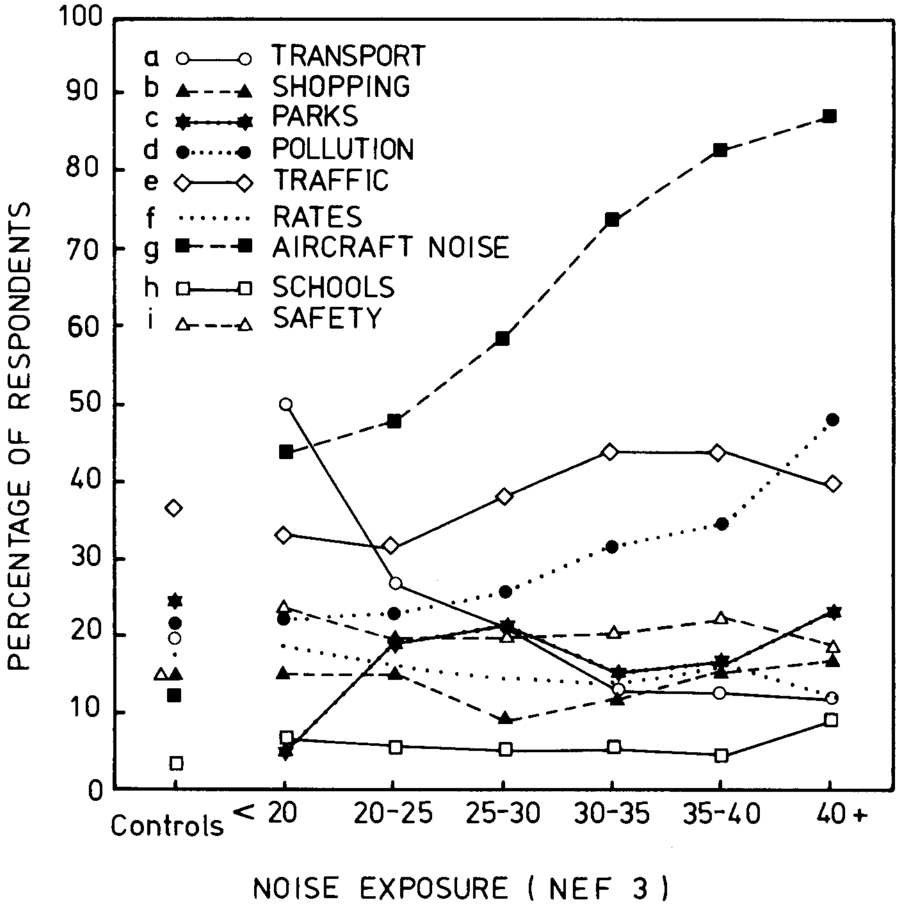


FIGURE 6.6 Percentage of respondants rating various neighbourhood features as "bad" or "very bad", as a function of noise exposure.

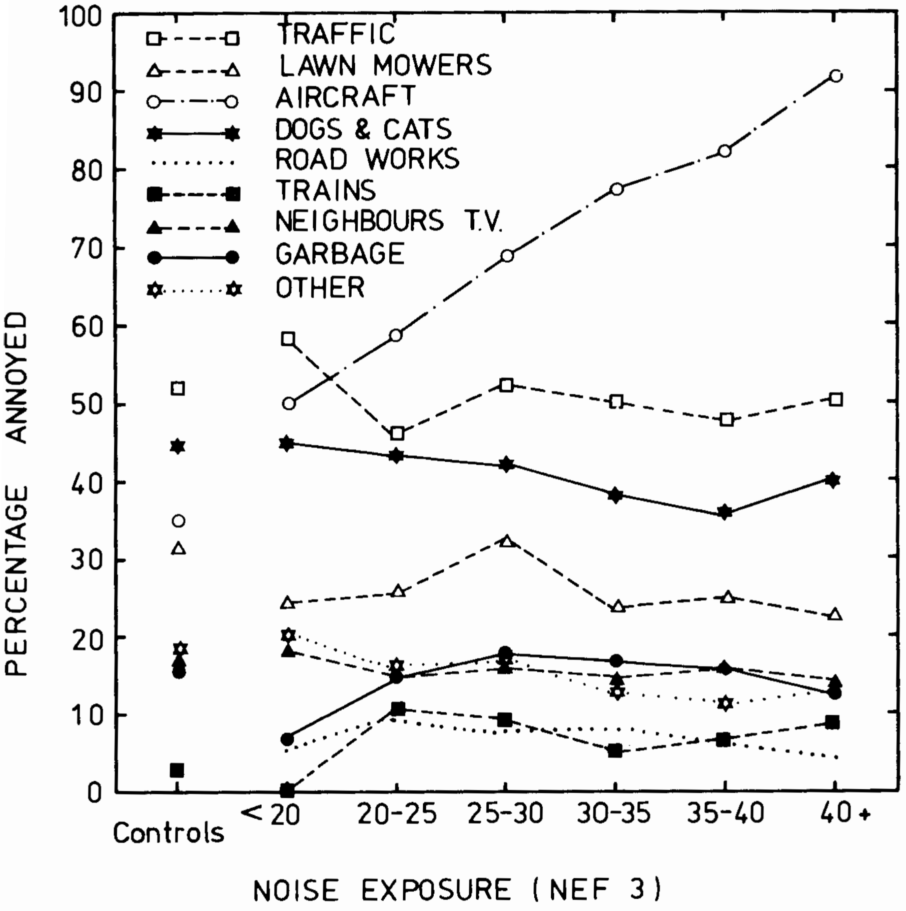


FIGURE 6.7 Percentage of respondents rating their annoyance at various noises as at least 4 on the opinion thermometer, as a function of noise exposure.

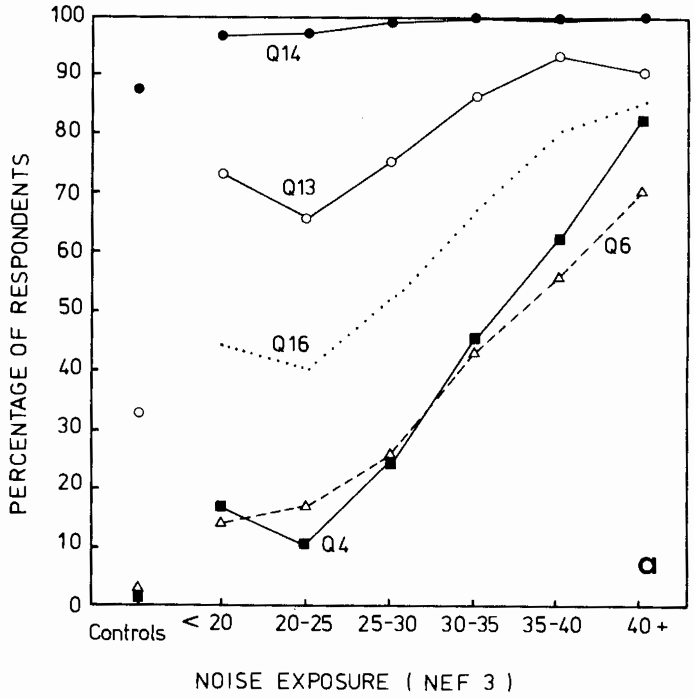


FIGURE 6.8 Percentage of respondents reporting various effects, as a function of noise exposure. The effects are: Q.14 - respondent reports ever hearing aircraft noise (A.N.); Q.13 - mentions A.N. as heard in neighbourhood; Q.16 - selects A.N. as noise most worth eliminating; Q.6 - selects A.N. as neighbourhood feature most worth improving; Q.4 - spontaneously mentions A.N. as feature disliked; Q.35 - reports thinking a plane might crash; Q.22 reports being startled by A.N.; Q.25 - claims health is influenced by A.N.; Q.7 - reports general health is "bad" or "very bad"; Q.21 - reports that A.N. causes house vibration; Q.32 - claims not to have adapted to A.N.; Q.34 - claims to have seriously considered moving because of A.N.; Q.29 - reports taking complaint action against A.N.

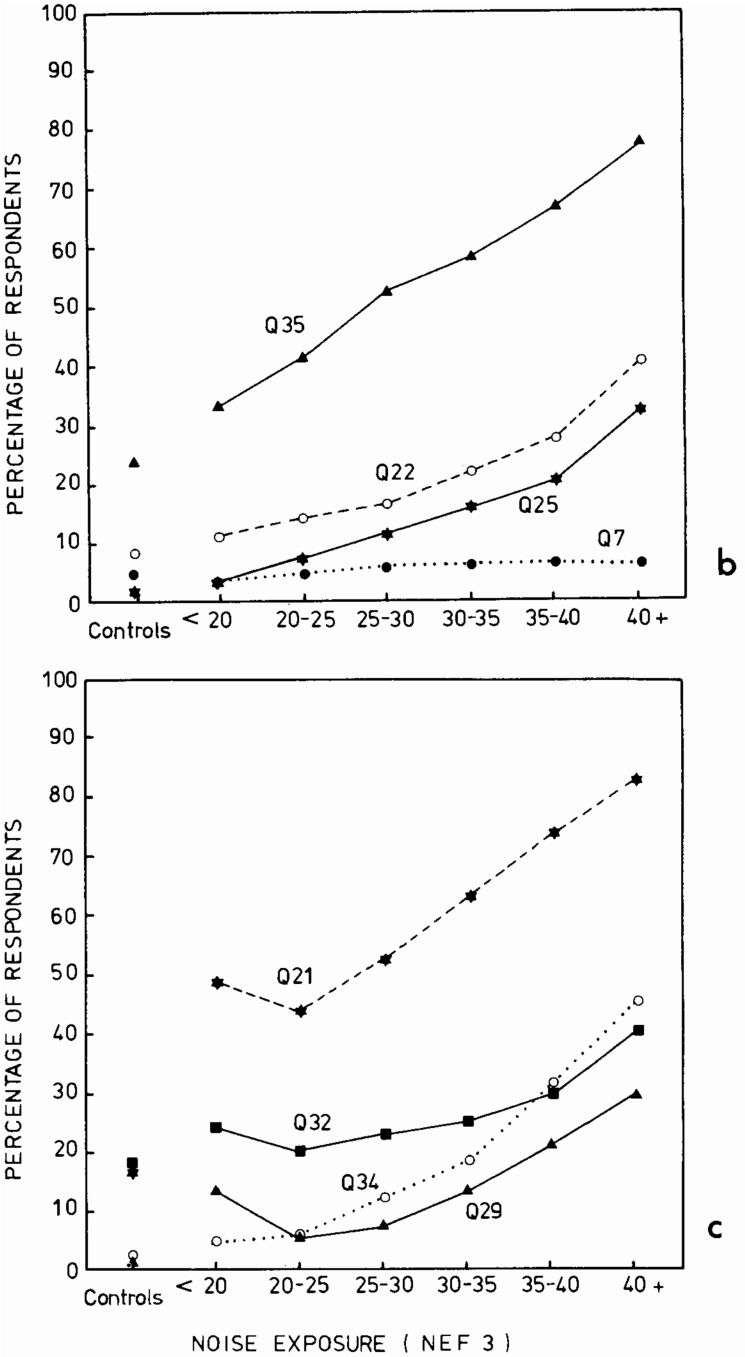


FIGURE 6.8 Continued.

NEF 3 zone	Number of Respondents	Percentage Reporting Effect at Least Once	Percentage Reporting Effect at Least Twice	Percentage Reporting Effect thee Three Times	Mean Rating of 'Health Affected'
<20	81	16.1	4.9	2.5	0.34
20-25	614	16.5	5.7	1.6	0.45
25-30	1095	23.7	11.2	3.0	0.75
30-35	708	31.1	15.0	5.1	0.99
35-40	531	40.5	21.5	7.7	1.24
40+	220	52.7	31.8	12.3	2.07
Correlation with NEF3		0.23	0.20	0.13	0.17

TABLE 6.5 Effect of noise exposure on reporting of health effects in Q.8, Q.9 and Q.25, and on rating of how much health is affected (Q.25 B). All correlations are significant (p<.001)

questions,at least two of the questions, or to all three of them. Figures for each airport are given in Appendix Table D.21. All relationships are significant at the .05 level. The Pearson correlation co-efficients between noise exposure and belief that the noise causes health effects are 0.13 for three reports, 0.20 for at least two reports, and 0.23 for at least one report. Correlations with GR are 0.26 for three reports, 0.44 for at least two reports, and 0.56 for at least one report. These correlations seem sufficiently strong for beliefs about noise-induced health effects to be regarded as part of the overall reaction to aircraft noise. Note that the present measure of reaction GR does adequately encompass beliefs about health effects. This is indicated by the fact that a rating of how much aircraft noise affects one's health (Q.25 B) did not load significantly into the regression equation used to derive GR (see Section 5.4.1). Table 6.5 also gives the means for this rating of how much one's health is affected. It has a correlation with GR of 0.44 and is also significantly correlated with noise exposure (r = 0.17).

6.6 Effect of Modifying Variables

6.6.1 Relationship between modifying variables and reaction

Much previous research has centred on attempts to find variables which explain the residual scatter about dose/response regression lines for individual data (see particularly TRACOR, Inc., 1971). The variables studied usually represent personal characteristics or attitudes which are hypothesised to modify response to the noise. Of course, it is not hypothesised that these variables result in response to aircraft noise even when no noise is present, although it may be observed that this assumption is made in the course of the multiple regression analyses used by TRACOR and others. Rather, the degree of reaction to a given exposure is assumed to be controlled or modified by these variables, somewhat in the manner of a variable-gain amplifier.

A number of such variables can be studied in the present analysis, namely:

i) Negative attitudes toward the airport, the airlines and the aircraft industry. This is expressed by the scale NEGATT, which is derived from responses to Q.37 of the interview schedule (see Section 5.5).

ii) Fear of aircraft crashing in the area. This is expressed by the opinion thermometer rating in Q.35, and is referred to as CRASH. CRASH should be distinguished from fear generated by the noise, which is assessed by Q.23 and which is included as one of the components of GR (see Section 5.4). In principle, CRASH is a reaction to the presence of aircraft, and not their noise level.

iii) Sensitivity to noise in general. This is expressed by the scale NOISE SENSITIVITY, which is derived from some of the items in Q.10 of the interview schedule (see Section 5.5).

iv) Tendency to become annoyed or to express annoyance at common sources of frustration, apart from noise. This is expressed by the scale ANNOYANCE TENDENCY, which is derived from other items in Q.10 of the interview schedule (see Section 5.5).

v) Overall dissatisfaction with the neighbourhood. This is expressed by the rating in Q.2 of the interview schedule, and is referred to as NEIGHBOURHOOD DISSATISFACTION. An attempt was made to measure this variable more accurately by forming a scale from responses to Q.5 (ratings of specific neighbourhood features). However, responses did not form a unified scale (see Section 5.5).

Correlations between these modifying variables and GR are given in Table 6.6. Although all variables are significantly correlated with GR, they are also intercorrelated among themselves, so that if some are known, others may not add significantly to the ability to predict GR. A multiple regression was used to test this, and the results are shown in Table 6.7.

Modifying Variable	Correlation with GR	Correlation with Noise Exposure (NEF3)
NEGATT	.676	.216
CRASH	.618	.190
NOISE SENSITIVITY	.348	-.033
NEIGHBOURHOOD DISSATISFACTION	.170	.110
ANNOYANCE TENDENCY	.278	-.041

TABLE 6.6 Co-efficients of correlation between modifying variables and reaction to aircraft noise, and between modifying variables and noise exposure.

Modifying Variable	Partial Correlation between GR and variable, Holding All Higher Variables Constant	Significance Level for Inclusion of Variable	R^2 After Inclusion of Variable
NEGATT	.677	<.001	.458
CRASH	.443	<.001	.565
NOISE SENSITIVITY	.246	<.001	.591
NEIGHBOURHOOD DISSATISFACTION	.078	<.001	.593
ANNOYANCE TENDENCY	.022	not Significant	.594

TABLE 6.7 Results of a multiple regression, explaining GR in terms of modifying variables. Variables were entered into the equation in the order of their partial correlation with GR, which is their order of appearance in the table.

It is clear that if NEGATT, CRASH and NOISE SENSITIVITY are known, the effects of ANNOYANCE TENDENCY and NEIGHBOURHOOD DISSATISFACTION are negligible. The first three variables together explain 59% of the variance in GR, compared with 13% for the best index of noise exposure.

Regression lines for the individual dose/response relationships between GR and NEF3 for respondents with high, medium and low values of these three modifying variables are given in Figure 6.9. The strong influence of the modifiers is evident from these graphs. In Figure 6.9 (a), for example, it can be seen that respondents with highly negative attitudes tended to have high GR scores even at low exposure levels. By contrast, those with positive attitudes (low NEGATT) were relatively unaffected even at high levels of noise exposure.

6.6.2 Relationship between modifying variables and noise exposure

It has been concluded from data such as that in the previous section that psychological modifying variables such as negative attitudes, fear of crashes and noise sensitivity are much more important in determining individual reaction to aircraft noise than is the level of the noise itself. This may well be the case. However, the correlations between these variables and noise exposure - shown in Table 6.6 - suggest that some other factors may also be operating. If a variable is to be considered as a personal characteristic which modifies reaction to noise, it would normally be expected to show little correlation with noise exposure. Any correlation would be expected to be negative, resulting from "self-selection" - that is, people with high values of the modifying variable choose not to live in areas of high exposure, or move away quickly. This is the case for NOISE SENSITIVITY ($r = -.03$). However, NEGATT and CRASH show relatively high positive correlations with noise exposure ($r = .22$ for NEGATT and $r = .19$ for CRASH) which approach the strength of the correlation between exposure and GR. The relationships between these three variables and noise exposure are shown graphically in Figure 6.10, and mean values of the

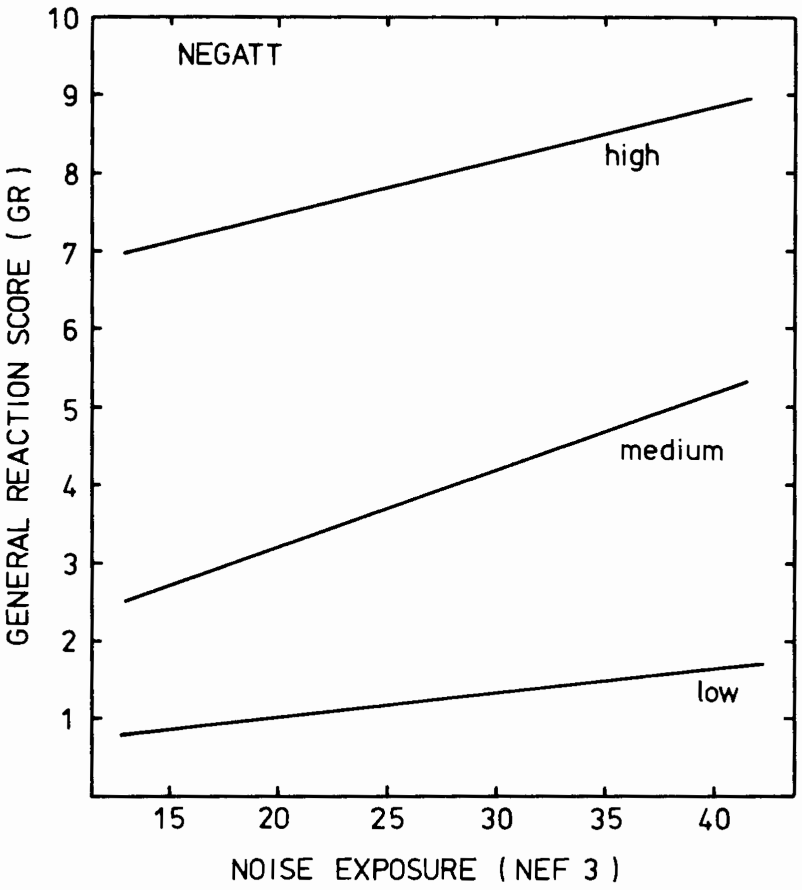


FIGURE 6.9 a) Dose/response relationship between GR and NEF3 for high (⩾7), medium (3-7) and low (<3) values of NEGATT.

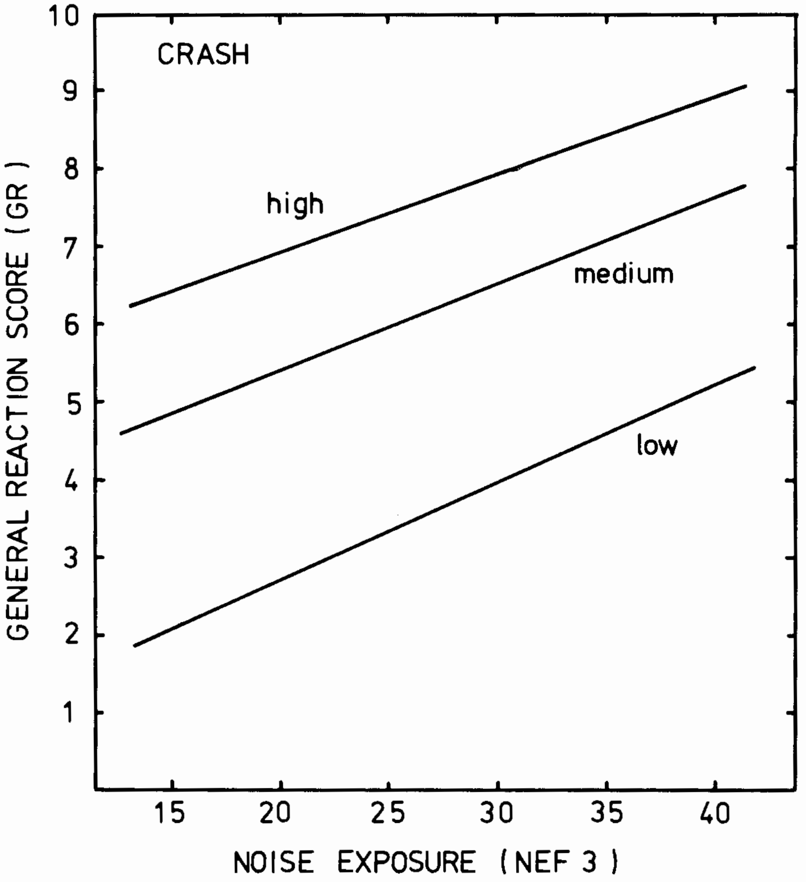


FIGURE 6.9 b) Dose/response relationship between GR and NEF3 for high (≥8), medium (4-8) and low (<4) values of CRASH.

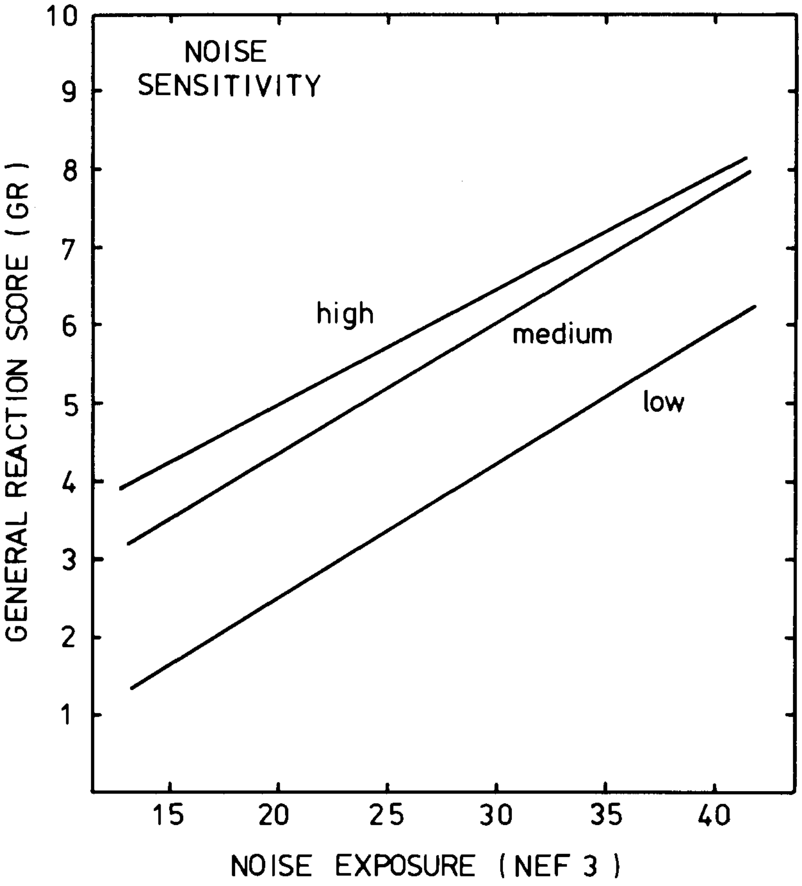


FIGURE 6.9 c) Dose/response relationship between GR and NEF3 for high (≥8), medium (4-8) and low (<4) values of NOISE SENSITIVITY.

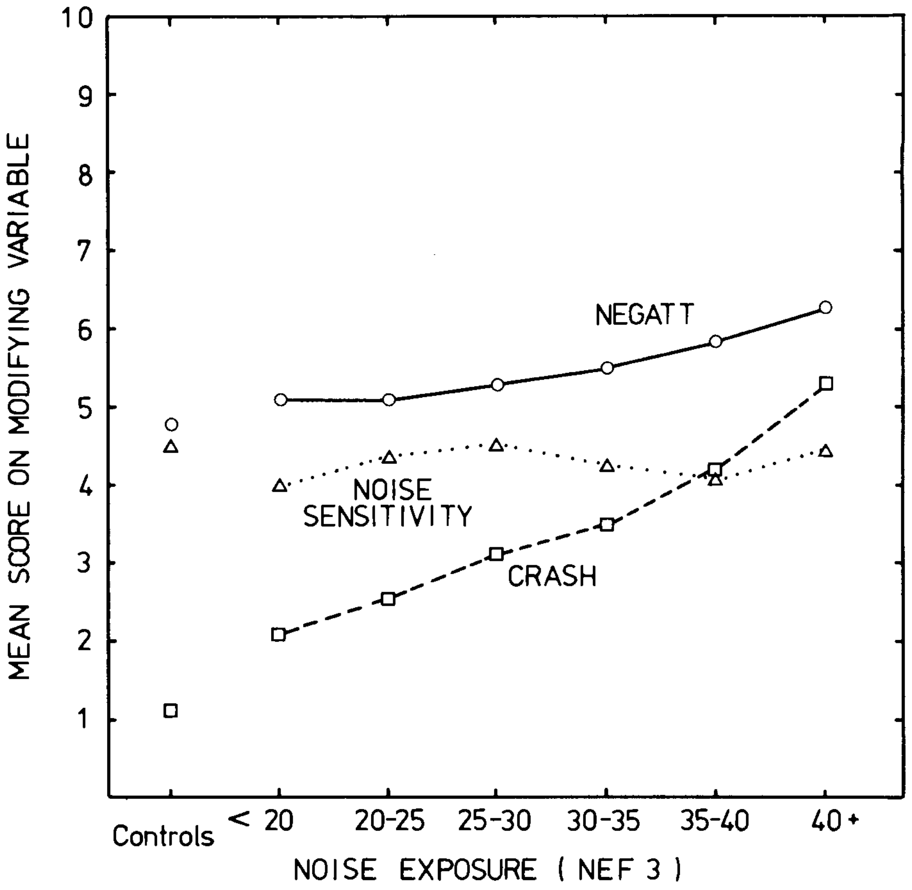


FIGURE 6.10 Mean value of modifying variable as a function of noise exposure
○—○ - NEGATT
□--□ - CRASH
△. . .△ - NOISE SENSITIVITY

variables in each cluster are given in Appendix Tables D.23-D.25.

Taking the case of NEGATT first, two possible explanations for this correlation with exposure can be put forward:

i) NEGATT could be influenced by exposure. It is conceivable that exposure to aircraft noise could affect one's attitudes towards the airport, towards the government's efforts to control noise pullution, etc., so that these attitudes would become more negative. To the extent that this is so, NEGATT would not be a variable <u>modifying</u> reaction, but would itself be a <u>part</u> of an individual's reaction to aircraft noise. In this case, the high correlation between NEGATT and GR would reflect not the influence of psychological factors on reaction, but the inter-correlation of the various aspects of overall reaction to aircraft noise.

ii) NEGATT could be influenced by reaction. This possibility arises because some questions which comprise the NEGATT scale may have been interpreted as being "loaded". An example is the statement in Q.37 ii) : "Aircraft noise is really <u>not</u> much of a problem." It is, of course, possible to agree that overall, aircraft noise is a small problem while claiming to be seriously affected by it personally. However, such a response may seem unacceptable to some respondents, who could feel that they were undermining their own position. This item is perhaps the most extreme example of this effect, but it may also have been a problem in Q.37 i), iv) and possibly viii). To the extent that this occurred, the high correlation between NEGATT and GR would be spurious.

In the case of CRASH, the situation is even more problematical. CRASH could conceivably have been affected by exposure as described for NEGATT above. It seems unlikely that it was affected by reaction in the way described for NEGATT. However, there is a third possible explanation for the correlation between CRASH and exposure. It would seem reasonable that a person who is naturally afraid of aircraft crashing would have that fear enhanced if their residence were close to the aircraft when they fly over. This would not be due to the noise - totally silent aircraft could in principle evoke just as much fear. However, in practice, the level of aircraft noise is of course very highly correlated with distance from the aircraft, giving an explanation for the correlation between CRASH and exposure. To the extent that this mechanism operates, CRASH would still be a genuine modifying variable, its correlation with exposure being due to mutual correlation with a third variable - distance from the aircraft.

It is extremely difficult - in some cases, impossible - to disentangle the causal relationships among exposure, reaction and these psychological variables. However, the case for CRASH as an independent personal variable which modifies reaction appears to be stronger than that for NEGATT, and there seems little reason to doubt that NOISE SENSITIVITY is a genuine modifying variable. The relationship between NOISE SENSITIVITY and GR, while not as strong as that for NEGATT or CRASH, is as strong as that for noise exposure. It can therefore be stated with some confidence that personal characteristics, including sensitivity to noise in general, and probably fear of aircraft crashing and negative attitudes toward the airport or air base, have a very important modifying effect on reaction to aircraft noise, although the exact strength of this effect is not easily determinable.

The problems of interpretation described above are not unique to the present study, but have existed in almost all attempts to define modifying variables and their relationships with reaction to noise. The problems are discussed in detail by Alexandre (1976) and in a previous report (Hede et al, 1979).

CHAPTER 7

OTHER RESULTS

7.1 Possible Sources of Bias

7.1.1 Effect of number of in-scope household members

The sample-selection procedures for this survey were designed to ensure that a (clustered) random sample of households was obtained in each noise zone, and that the respondent was randomly selected from the in-scope members of the household (see Section 3.1). This means that the sample is a random sample of household representatives,but not of individuals. For example, an individual in a single-person household has twice as much chance of appearing in the sample as an individual in a two-person household, etc. This fact implies that in analyses in which the number of affected individuals is important, such as those performed in Chapter 9, the use of weighting factors to account for this non-representativeness may be required.

However, these weighting factors are required only if response to aircraft noise is linked to the number of in-scope household members - otherwise, the unrepresentativeness of the sample is unimportant. (See Section 3.3 for definitions of which household members are within the scope of the survey.) The two important measures of response used in this report are the respondent's score on the GR scale of overall reaction to aircraft noise (see Section 5.4) and whether or not the respondent is seriously affected by the noise (i.e. has GR $\geqslant$ 8). The latter measure is the one used for analysis of noise indices (Chapter 8), and is considered the most important measure of the seriousness of the aircraft noise problem in an area (Chapter 9). The GR scale provides a more sensitive instrument for investigating the effects of various personal characteristics on reaction. The effect of the number of in-scope household members on these measures of response is shown in Table 7.1

Number of In-scope Household Members	Number of Respondents	Percentage Seriously Affected	Mean GR
1	697	22.1	4.58
2	2007	26.6	5.21
3	528	23.3	5.05
4	202	25.7	5.10
5	61	27.9	5.91
≥6	25	28.0	4.86

Relationship with percentage seriously affected not significant at 0.05 level ($\chi^2 = 6.92$)
Relationship with GR is significant ($F = 3.68$, $p < .001$)
0.8% of variance in GR is explained by number of in-scope household members ($\xi = .091$)

TABLE 7.1 Effect of number of in-scope household members on percentage seriously affected by aircraft noise, and on GR.

It is clear that there is no significant effect on the proportion of respondents who are seriously affected by the noise. Thus analyses described in Chapter 8 and 9 are carried out without regard to the effect of the number of in-scope household members. On the other hand, the effect on GR is significant at the .05 level, although only 0.8% of the variation in GR is accounted for by this variable. Thus if, for instance, analyses were required in terms of the mean value of GR for all individuals with a given noise exposure, some weighting factors should be included, although their effect would be small. For example, in the population of sampled households, the difference between the mean value of GR with and without correcting for the number of in-scope household members is .06 points on the GR scale. (The range of the scale is 0-10.)

It seems likely that the effect on GR is due to differences in the demographic make-up of households with different numbers of in-scope members. In particular, there are significant differences in the age of residents in households with different numbers of in-scope members (χ^2=567.7, p<.001, γ=-.32), with single-person households tending to have older residents. The mean value of GR tends to be lower for older people (see Section 7.2), in line with the trend seen in Table 7.1.

7.1.2 Effect of aircraft crash at Sydney Airport

On 21st February, 1980 - the day after the Sydney survey began - a tragic accident occurred at Sydney Airport, in which 13 people were killed when a Beechcraft King Air aircraft crashed into the side of a runway. It is, of course, very difficult to gauge the short-term effect, if any, of such an event on the stated reactions of residents to aircraft noise. However, some attempt was made to take this into account by instructing interviewers to note on the schedule if the respondent mentioned the crash at any time during an interview. Interviewers, of course, did not mention the crash. Reported mentions were coded with the other data from the schedule.

Only respondents in Sydney were included in the analysis, since at other airports only five people mentioned the Sydney crash. Of 1480 Sydney respondents for whom the data was coded, 107 mentioned the crash. Table 7.2 shows that these people had significantly higher values of GR than others with the same noise exposure, as measured by the index NEF3 (see Chapter 4 for a description of NEF3)*. Two percent of the overall variation in GR at Sydney was "explained" by mentions of the crash. It is, however, impossible to determine whether the crash increased these people's reaction, or whether a higher level of reaction led them to mention the crash.

As could be expected, respondents mentioning the crash had significantly higher fear of aircraft crashing, as measured by the variable CRASH (see Section 6.6.1 - F = 62.9, p<.001, 4.0% of variance explained). Again it is impossible to determine whether the crash increased these people's fear or vice-versa.

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* The effect of noise exposure was controlled by using two-way analysis of variance, with NEF3 divided into six categories and treated as nominal level data. This technique is used throughout this chapter. In no case is the interaction between the variable of interest and NEF3 significant at the .05 level.

Respondent Mentions Sydney Airport Crash	Number of Respondents	Mean GR	Mean GR Correcting for Noise Exposure (NEF3)
YES	107	8.05	7.75
NO	1373	6.01	6.03

Main effect of mentioning crash on GR is significant ($F=30.9, p<.001$)
2.0% of variance in GR is explained by mentioning the crash, after correcting for noise exposure ($\beta = .14$)

TABLE 7.2 Effect of mentioning Sydney Airport crash on GR.

7.1.3 Effect of previous knowledge of survey

Question 12 of the interview schedule asked whether respondents had heard of the survey before and, if so, what they had heard. This question was included to check whether the supposedly neutral questions in the first part of the interview schedule were actually neutral, in the sense that respondents were not aware at that stage that the interview was largely concerned with aircraft noise.

In fact, only 88 respondents answered that they had heard of the survey, and of these, only 10 stated that it was concerned with aircraft noise. The mean value of the "neutral" aircraft noise annoyance question (Q.10 xi) for these respondents was 5.00, compared with 5.44 for all others. Thus, there is no reason to suspect that these respondents artificially inflated their ratings. (It was considered unnecessary, and of questionable validity, to perform a statistical test for a sample as small as this.)

7.2 Effect of Demographic Variables on GR

7.2.1 Age, sex, education, occupation and home ownership

The effects of age, sex and three variables which may provide a rough indication of socio-economic status are shown in Tables 7.3 - 7.7. The effects of these variables are also shown after correcting for the effect of noise exposure (measured by the index NEF3). This guards against the possibility that some variables may show a relationship with GR due to a relationship between the variable and noise exposure.

It is clear that the only one of these variables which has an appreciable effect on GR is age - older people tending to show lower reaction. Age accounts for 1.2% of the variation in GR, compared with 9.6% for NEF3. (This can be improved to 12.4% by using other exposure indices - see Chapter 8.) It must be noted, however, that the measures of socio-economic status used here are far from precise. In particular, interviewers commented that many people seemed to misinterpret the question on home ownership (Q.44 of the schedule), answering "own" when they were in fact "buying" their home - that is, paying it off.

Age (yrs)	Number of Respondents	Mean GR	Mean GR, Correcting for Noise Exposure (NEF3)
18-29	879	5.51	5.52
30-39	679	5.46	5.53
40-49	527	5.44	5.47
50-59	442	5.05	5.06
60-69	405	5.38	5.29
>70	318	4.49	4.37

Main effect of age on GR is significant ($F = 8.92$, $p<.001$). 1.2% of variance in GR is explained by age, after correcting for noise exposure ($\beta = .11$)

TABLE 7.3 Effect of age on GR.

Sex	Number of Respondents	Mean GR	Mean GR, Correcting for Noise Exposure (NEF3)
MALE	1428	5.57	5.50
FEMALE	1827	5.10	5.16

Main effect of sex on GR is significant ($F = 10.44$, $p = .002$) 0.3% of variance in GR is explained by sex, after correcting for noise exposure ($\beta = .05$)

TABLE 7.4 Effect of sex on GR.

Education	Number of Respondents	Mean GR	Mean GR, Correcting for Noise Exposure (NEF3)
1-3 yrs primary	28	5.70	5.79
4-6 yrs primary	421	5.46	5.29
1-4 yrs secondary	1768	5.21	5.26
5-6 yrs secondary	604	5.37	5.34
1-2 yrs tertiary	164	5.14	5.04
3+ yrs tertiary	262	5.67	5.74

Main effect of education on GR not significant at .05 level ($F = 1.60$)

TABLE 7.5 Effect of education on GR.

Occupation	Number of Respondents	Mean GR	Mean GR, Correcting for Noise Exposure (NEF3)
Professional/ Managerial	651	5.40	5.41
White Collar	524	5.28	5.27
Blue Collar	1119	5.52	5.46
Home Duties	961	5.02	5.09

Main effect of occupation on GR is significant (F = 2.90, p = .03) 0.3% of variance in GR is explained by occupation, after correcting for noise exposure (β = .05).

TABLE 7.6 Effect of occupation on GR.

Home Ownership	Number of Respondents	Mean GR	Mean GR Correcting for Noise Exposure (NEF3)
Own	1404	5.40	5.28
Buying	1018	5.24	5.44
Renting	801	5.24	5.19

Main effect of home ownership in GR not significant at .05 level (F = 1.55).

TABLE 7.7 Effect of home ownership on GR.

Age (yrs)	Number of Respondents	Mean NEGATT	Mean NEGATT Correcting for Noise Exposure (NEF3)
18-29	883	5.54	5.54
30-39	687	5.53	5.55
40-49	535	5.44	5.45
50-59	450	5.29	5.30
60-69	412	5.35	5.33
>70	321	5.28	5.24

Main effect of age on NEGATT is significant (F = 3.92, p = .002). 0.6% of variation in negative attitude is explained by age, after correcting for noise exposure (β = .08).

TABLE 7.8 Effect of age on negative attitude.

Age (yrs)	Number of Respondents	Mean CRASH	Mean CRASH Correcting for Noise Exposure (NEF3)
18-29	883	3.54	3.55
30-39	687	3.69	3.72
40-49	535	3.91	3.94
50-59	450	3.12	3.13
60-69	412	2.97	2.91
>70	321	2.38	2.30

Main effect of age on CRASH is significant (F = 10.56, $p<.001$)
1.4% of variance in fear of crashing is explained by age, after correcting for noise exposure ($\beta = .12$)

TABLE 7.9 Effect of age on fear of crashing.

The effect of age was also evident in the modifying variables negative attitude and fear of crashing (NEGATT and CRASH - see Section 6.6.1). Both these variables appear to be lower for older respondents - see Tables 7.8 and 7.9. It is therefore possible that the effect of age on GR is due to its effect on these modifying variables. In other words, older people may tend to be less affected by aircraft noise because they have more positive attitudes towards aviation, and are less afraid that an aircraft might crash in the neighbourhood.

7.2.2 Length of residence

It is also possible that the effect of age on GR is due to an effect of length of residence - that is, recent inmovers tend to be young, and those who remain for some time will be those who are less affected by the noise, so that older residents will tend to be less affected than younger ones. Table 7.10 shows a slight effect of length of residence on GR in the expected direction, but the effect is too weak to provide a sufficient explanation for the effect of age.

Length of Residence	Number of Respondents	Mean GR	Mean GR, Correcting for Noise Exposure (NEF3)
<1 yr	532	5.65	5.48
1 -2 yrs	344	5.35	5.43
2 -5 yrs	543	5.26	5.37
5-10 yrs	549	5.47	5.53
>10 yrs	1210	5.12	5.10
All of life	77	4.96	4.93

Main effect of length of residence on GR is significant (F = 2.48,p = .03)
0.4% of variance in GR is explained by length of residence, after correcting for noise exposure ($\beta = .06$)

TABLE 7.10 Effect of length of residence on GR.

The effect of noise exposure on length of residence can be found by using six categories of noise exposure, treated as ordinal-level data. The effect is significant ($\chi^2 = 53.5$, $p < .001$), but again rather weak ($\gamma = -.02$).

7.2.3 Type of dwelling

"Type of dwelling" (Q.45 of the interview schedule) was intended as a very rough measure of the acoustic isolation of the residence: "house" implied all four walls were detached, "semi-detached" implied one wall was shared with another residence, and "villa-home" implied that two walls were shared. However, as Table 7.11 shows, although the effect of type of dwelling on GR is significant, it is not in line with predictions based on the above classification. It is clear that other factors related to type of dwelling have an effect on GR.

7.2.4 Proportion of time spent at home

In Question 11 of the interview schedule the respondent was asked the number of days per week that he was usually at home in the morning, afternoon and evening periods. It was hoped that this would give some idea of how often the respondent heard the aircraft noise to which his residence was exposed. It could be expected that respondents who are home more often would have a higher level of reaction. However, Table 7.12 shows that there was no significant relationship between the proportion of time spent at home and reaction to aircraft noise.

Interviewers reported that some respondents appeared to misunderstand Q.11. For example, some respondents were said to have answered that they were home every morning, meaning that they were home for breakfast. A less precise, but possibly more reliable, guide to the effect of the proportion of time spent at home would be to consider the group of respondents who gave their occupation as "home duties". This group is compared with others in Table 7.13. It is clear that there is a small but significant effect in the opposite direction to that which would have been expected. This effect can probably be explained in terms of the slightly lower reaction of females (see Table 7.4). This study thus provides no evidence for the assumption that residents who spend more time at home will be more affected by aircraft noise.

Type of Dwelling	Number of Respondents	Mean GR	Mean GR Correcting for Noise Exposure (NEF3)
House	2536	5.16	5.21
Semi-detached	262	6.22	5.89
Villa-home	103	5.81	5.57
Top-floor unit	132	5.39	5.37
Other Unit	204	5.72	5.66
Other	8	4.21	4.53

Main effect of type of dwelling on GR is significant ($F = 3.32, p = .006$) 0.5% of variance in GR is explained by type of dwelling, after correcting for noise exposure ($\beta = .07$).

TABLE 7.11 Effect of type of dwelling on GR

Mean Number of Time Periods per Day spent at home	Number of Respondents	Mean GR	Mean GR Correcting for Noise Exposure (NEF3)
0	33	5.04	4.81
1	904	5.21	5.24
2	1532	5.38	5.37
3	782	5.34	5.33

Main effect of number of periods on GR not significant at .05 level (F = 0.60)

TABLE 7.12 Effect on GR of mean number of time periods (morning, afternoon, evening) spent at home per day.

Occupation	Number of Respondents	Mean GR	Mean GR, Correcting for Noise Exposure (NEF3)
Home Duties	961	5.02	5.10
Other	2294	5.44	5.41

Main effect of occupation on GR is significant (F = 7.15, p = .008) 0.3% of variance in GR is explained by occupation, after correcting for noise exposure (β = .05)

TABLE 7.13 Effect on GR of occupation (classified only as 'home duties' vs. 'other').

7.3 Neutral Versus Prompted Responses

7.3.1 Annoyance ratings

The questionnaire employed a neutral/prompted design in order to guard against possible response bias effects (see Section 3.2.1). Of the three ratings of aircraft noise annoyance, one was given early in the interview in the context of everyday annoyances (Q.10xi) another rating was made in the context of various neighbourhood noises (Q.15iii), and the third was made after the respondent had been told the survey was particularly interested in aircraft noise (Q.20). The mean ratings given in these three cases were 5.4, 5.9 and 5.5 respectively. Clearly, there is no indication that respondents tend to exaggerate their ratings when they know the purpose of the survey. It might be alleged that only those seriously affected by aircraft noise would be likely to show response bias. However, the means for those with GR ≥ 8 were 9.4, 9.8 and 9.6 for the three ratings, respectively. Again, there is no tendency for respondents to increase their ratings once they perceive the purpose of the survey.

7.3.2 Reported health effects of aircraft noise

The neutral/prompted question strategy was also used to assess health symptoms which respondents attribute to aircraft noise. It has been alleged (Barker & Tarnopolsky, 1978) that the noise-wording of a question can inflate responses by up to a factor of two. But in assessing and controlling for such bias, account must be taken of several other factors which can cause inconsistencies in response, namely, errors of attribution and memory (Hede, 1979).

The interview schedule included three separate questions on health symptoms. The first was open - "Is there anything about living in this neighbourhood that you think might have influenced your health in any way?" (Q.8). It is likely, however, that some affected people would simply forget to mention aircraft noise in answer to this question. Another question asked whether any of a list of environmental conditions might have influenced the respondent's health (Q.9). Memory factors, it is argued, should be less of a problem in this question because of its specific reference to aircraft noise. Nevertheless, this question is neutral with respect to noise because aircraft noise is only one of a list of conditions specified. The third question on health effects was asked directly and may be susceptible to bias because it was noise-worded: "Do you think the aircraft noise in this neighbourhood might have influenced your health in any way?" (Q.25). It is possible that the wording of this question invites a positive response especially from people who are annoyed by aircraft noise.

All three questions also asked "In what way has (aircraft noise) influenced your health?". Answers to this question were classified in terms of whether or not a "real" physical or psychological health effect was given. The criteria used were comparatively strict, in order to distinguish health effects from annoyance. For example, "sleeplessness" and "irritability" were classified as health effects, but "disturbs sleep" and "irritation" were not. It will be obvious that some classifications were very difficult, and the majority of the analysis was performed on the basis of the respondent's simple yes/no response.

7.3.3 Patterns of response to health questions

There are 12 different combinations of answers to the three questions on health effects. Table 7.14 lists the numbers who answered in each response pattern. There were 2,341 people who consistently reported no health effects at all (pattern 'a'), and 243 who were consistent in not attributing health effects to aircraft noise (pattern 'b'). Only 150 respondents gave answers in pattern 'l' indicating completely reliable reporting of their belief that they suffered health effects due to aircraft noise. However, there were another 269 people who reported health effects in both Q.9 and Q.25 but failed to report an effect due to aircraft noise in Q.8 (patterns 'j' and 'k'). It is probable that these people simply forgot to mention either the symptom or its cause in the open question. When their memory was cued by the words 'aircraft noise' in the neutral list (Q.9) these respondents were apparently able to recall their symptom. Bias may be evident in response patterns 'g' and 'h' where respondents did not report an aircraft noise symptom in either of the neutral questions, but did report a symptom in the noise-prompted question. There were a total of 118 respondents who displayed such "bias".

Q.25 (Noise-Worded)	Q.9 (Neutral List)	Q.8(Open)		
		No Effect Reported	Effect Reported, Aircraft Noise Not Mentioned	Effect Reported, Attributed to Aircraft Noise
No Effect	No Effect	a) 2341	b) 243	c) 13
	Effect Reported	d) 295	e) 61	f) 27
Effect Reported	No Effect	g) 95	h) 23	i) 9
	Effect Reported	j) 184	k) 85	l) 150

TABLE 7.14 Number of respondents giving each of the twelve patterns of response to the three questions on health effects of aircraft noise.

The remaining response patterns, however, indicate various types of inconsistency. In particular, patterns 'd', 'e' and 'f' occurred when a person gave a negative response in Q.25 after having reported health effects earlier in the interview. It is clear from Table 7.14 that responses in these patterns occurred about three times more frequently than the "biased" patterns referred to above. This result is intriguing, and no satisfactory explanation has been found. One possibility is that when presented with a list such as that in Q.9, some respondents felt obliged to answer "yes" to at least one question. It would be assumed that fewer of these respondents would be likely to give a "real" health effect in answer to the question "In what way has this affected your health?". However, if only respondents who gave a "real" effect are considered, 226 respondents gave "inconsistent" responses in patterns d) and e), compared with 151 who gave "biased" responses in patterns g) and h). Another possibility is that the result is an artifact produced by the procedure of assuming a negative response to Q.25 when a respondent gave a zero rating in Q.17 and was, therefore, not asked the aircraft noise questions. However, of the respondents giving inconsistent responses, only 8 were not actually asked the noise-worded question.

7.3.4 Symptom reporting and noise exposure

A comparison of responses in Q.9 and Q.25 provides a more simplified picture of symptom reporting. One might assume that response bias is evident for those who report a symptom in the noise-worded question (Q.25) after not reporting a symptom in the neutral question (Q.9).

Inconsistent reporting occurs in the opposite case where a symptom is reported for the neutral but not for the noise-worded question. Table 7.15 provides a breakdown by noise exposure zone of the various response patterns. As would be expected, reliable reports of symptoms in both questions increased with increasing noise exposure and reports of no symptoms in either question decreased. It is interesting that the percentages showing biased and inconsistent response patterns showed similar increases with exposure. It is possible that these two patterns may occur for similar reasons.

7.3.5 Symptom reporting and reaction

One might expect that respondents who are seriously affected by aircraft noise would be more prone to bias in symptom reporting. Details of the response patterns given by seriously affected people (GR ≥ 8) are compared with those for less affected people in Table 7.16. No symptoms were reported in either question by 34.1% and symptoms were reported in both questions by 37.4% of seriously affected respondents. As expected, some of these people gave the biased pattern of a symptom report only in the noise-worded question (7.8%). However, a much larger proportion reported a symptom only in the neutral question (20.8%). This suggests that both types of inconsistent pattern are due to respondent error, and that symptom reporting only in noise-worded questions cannot be assumed to indicate response bias. It is improbable that the noise-wording prompts more people to underestimate than are prompted to exaggerate their reaction to aircraft noise. The inconsistencies found among responses to Q.8, Q.9 and Q.25 provide clear confirmation of the need for social surveys to include repeated measures of the major aspects of subjective reaction to aircraft noise.

	No Effect in Q.9		Effect in Q.9	
	No Effect in Q.25	Effect in Q.25	No Effect in Q.25	Effect in Q.25
Exposure (NEF3)	No Effect	Bias	Inconsistent	Reliable
Controls	94.3	1.8	2.9	1.1
<20	84.0	1.2	11.1	3.7
20-25	83.9	3.3	7.2	5.7
25-30	76.5	2.6	10.5	10.5
30-35	69.4	4.4	12.6	13.7
35-40	59.6	3.4	16.9	20.2
40+	47.5	10.9	14.0	27.6

TABLE 7.15 Percentages of respondents in each exposure zone giving the four types of answer about health effects of aircraft noise.

	No Effect In Q.9		Effect in Q.9	
	No Effect in Q.25	Effect in Q.25	No Effect in Q.25	Effect in Q.25
Seriously Affected	No Effect	Bias	Inconsistent	Reliable
Yes	34.1	7.8	20.8	37.4
No	86.6	2.3	7.7	3.5

TABLE 7.16 Percentages of respondents seriously affected giving various response patterns for questions on health effects.

7.4 Characteristics of Complainants

In answer to Q.29 of the interview schedule, 412 people stated that they or their family had "... tried to do something to have the aircraft noise reduced in this neighbourhood". Of these, 213 had signed a petition, while the rest had complained in a more active manner. (The most common alternative to signing a petition was complaining to local officials.) To investigate this group, two "dummy" variables were created - CA1, which takes the value 1 if the respondent took any complaint action and 0 otherwise, and CA2 which takes the value 1 only for "active" complaint - i.e. all forms of complaint except signing a petition. Relationships between noise exposure (as measured by the index NEF3) and these measures of complaint may be gauged either by the Pearson correlation co-efficient r, or the non-parametric statistic γ (using six categories of exposure). Values of these parameters are given in Table 7.17.

	Strength of relationship with NEF3	
Variable	r	γ
All complaint (CA1)	.19	.40
"Active" complaint (CA2)	.09	.26
Respondent "Seriously Affected" by noise (SA)	.28	.43

TABLE 7.17 Measures of the strength of relationships between noise exposure (NEF3) and the variables shown, in terms of the Pearson correlation co-efficient r, and the non-parametric statistic γ.

It is clear that "active" complaint, as represented by CA2, is much less strongly correlated with noise exposure than is overall reaction to the noise. The usefulness of active complaint as a measure of reaction to aircraft noise therefore seems very questionable. The variable CA1 is more closely correlated with exposure, possibly indicating that more passive forms of complaint action are a better indication of reaction. It could, of course, also indicate that petitioners tend to concentrate their efforts in areas of a higher noise exposure.

It is unfortunately not possible to investigate the relationship between complaint action and GR, or other personal characteristics, since the wording "... you or your family ..." in Q.29 means that the complainant may not be the respondent, although they will usually have the same noise exposure. However, the question on home ownership is still relevant, and Table 7.18 shows a strong relationship between complaint action (particularly CA2) and home ownership. This suggests that other demographic variables may also be important, a result which has been found in other studies (McKennell, 1963).

7.5 Effect of Previous Knowledge of Aircraft Noise Problem

Question 31 of the interview schedule asks whether the respondent knew about the aircraft noise in the neighbourhood before he moved there, and if so, whether the noise is different from what he expected. In analysing responses to this question, only recent inmovers were considered (length of residence less than 1 year), since it was felt that other respondents may not be able to accurately recall their previous expectations. Table 7.18 shows that this variable has a comparatively strong effect on GR, explaining 19% of its variance, compared with 6% of the variance explained by noise exposure (i.e. NEF3) for this group of respondents. Three possible explanations can be put forward for this effect:

a) Expectations about the extent of a noise problem in an area have a very significant modifying influence on reaction to the noise.

Home Ownership	Number of Respondents	Percentage Complaining (CA1)	Percentage "Actively" Complaining (CA2)
Own	1540	16.1	8.3
Buying	1100	11.7	5.5
Renting	898	3.9	1.3

Effect of home ownership on complaint is significant (χ^2 = 82.2, p<.001 for CA1, χ^2 = 51.9, p<.001 for CA2)
γ = -.39 for CA1, γ = -.45 for CA2.

TABLE 7.18 Effect of home ownership on complaint actiòn.

Previous Knowledge of Noise	Number of Respondents	Mean GR	Mean GR Correcting for Noise Exposure (NEF3)
No Knowledge	181	7.05	7.18
Found it More than Expected	189	7.29	7.07
Found it the Same or Less than Expected	126	4.85	4.87

Main effect of previous knowledge of noise on GR is significant
(F = 59.5, $p<.001$)
19% of variance in GR is explained by previous knowledge of the noise, after correcting for noise exposure (β = .44)

TABLE 7.19 Effect of previous knowledge of aircraft noise on GR. Only respondents living at the address for less than 1 year are included in the analysis.

b) When people are aware of the extent of a noise problem, only those who are not sensitive to noise choose to move into the area.

c) Respondents who had previously given high ratings of their reaction to the noise felt obliged to "explain" their reaction by stating that the noise problem was unexpected.

These explanations are, of course, not mutually exclusive. However, the possibility that c) is the most important explanation means that these results should be interpreted with caution.

7.6 Perception of the Characteristics of Aircraft Noise

Question 24 of the interview schedule asked whether respondents were bothered by any of a number of characteristics of aircraft noise. These are: "the loudness of the noise; the low roaring sound of the engines; the high-pitched whine of the engines; the time the plane takes to pass over; changes in the sound of the engines". Figure 7.1 shows the relationships between responses to this question and noise exposure, for all respondents. Percentages of respondents who are bothered by each aspect, both overall and for seriously affected respondents only, are shown in Table 7.20. It is clear that the loudness of the noise is the feature most disliked in both cases. No other feature stands out as being more bothersome than the rest.

Characteristic of Noise	Percentage of All Respondents Bothered	Percentage of Seriously Affected Respondents Bothered
Loudness	65.2	98.7
Low Roaring	48.6	83.9
High-Pitched Whine	42.3	78.5
Time to Pass Over	44.6	80.5
Changes in Sound	26.4	55.6
Other	14.8	27.1

TABLE 7.20 Percentage of respondents bothered by characteristics of aircraft noise.

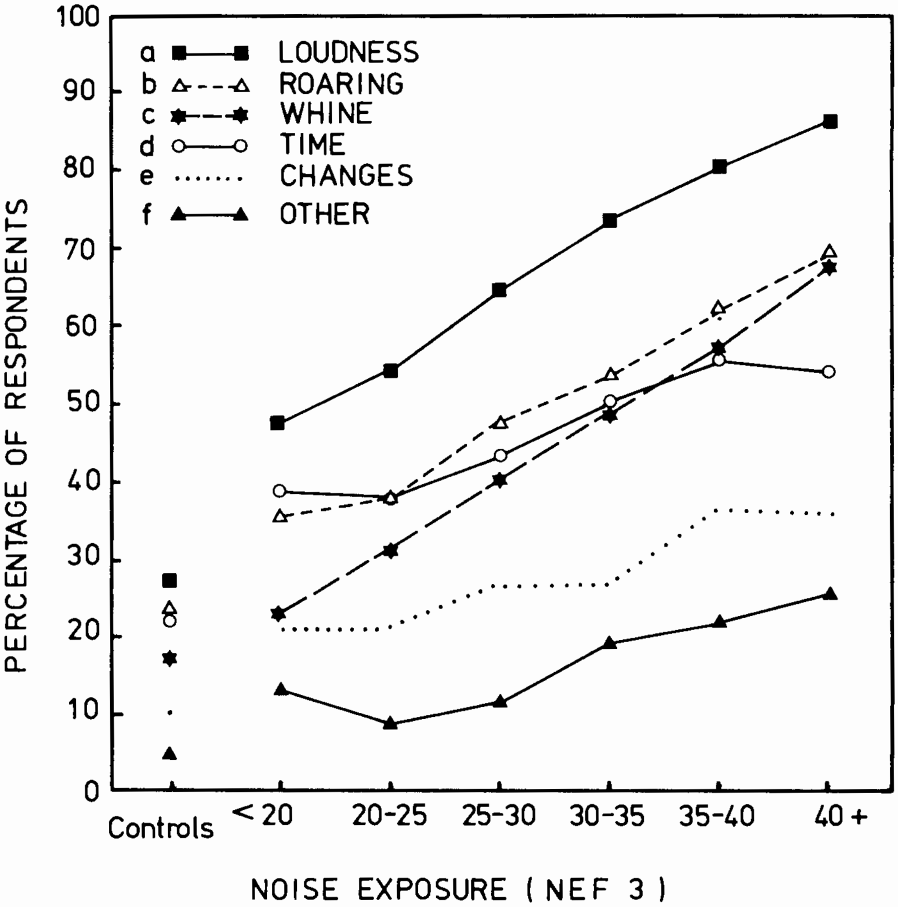

FIGURE 7.1 Percentage of respondents bothered by characteristics of aircraft noise, as a function of noise exposure.

CHAPTER 8

AIRCRAFT NOISE EXPOSURE INDICES

8.1 Differences Between Exposure Indices

Aircraft noise exposure indices are usually based on a measure which approximates subjective response to the noise of individual aircraft, combined with methods for taking account of the number and variety of aircraft operations. NEF is one such system, and a number of others are in use, or have been proposed, in various countries.

The three basic features of an index of aircraft noise exposure are:

i) the units used to measure noise from an individual aircraft,

ii) the method of combining these units, and

iii) the weightings, if any, given to aircraft flying at particularly sensitive times of the day.

These features of an index must be examined and tested separately in order to find an optimal index of exposure.

One index can be regarded as "better" than another if it is more closely related to measures of human reaction to the noise. That is, an index should predict, as closely as possible, the extent of reaction to the noise. The strength of the relationship between values of an index and measures of reaction can be gauged by the (product-moment) correlation between the two measures. Despite the fact that this gives an objective test which can decide between two indices, the practical difficulties in applying the test are often considerable, and at present no index has been unambiguously shown to be the most suitable.

8.1.1 Noise from an individual aircraft

Human reaction to a single aircraft noise event has been extensively studied in laboratory experiments. One of the earliest was a study by Kryter and Pearsons (1963) which led to a unit of measurement known as Perceived Noise Level (PNL). This has been subsequently modified to take account of the duration of the noise event and the possible presence of pure tones, to give the Effective Perceived Noise Level (EPNL).

An alternative, and much simpler, unit is the maximum noise level of the overflight in dB(A), as measured by a sound level meter set on "slow" response. This has become more popular recently because of its simplicity and ease of comprehension. Another unit which is widely used is the Sound Exposure Level (SEL), which is defined by

$$\mathrm{SEL} = 10 \log\{\frac{1}{t_o} \int_{-\infty}^{\infty} 10^{L(t)/10} dt\} \qquad (8.1)$$

where L(t) is the sound level in dB(A) at time t, and t_o = 1 sec. The major advantage of SEL is that it is compatible with units used for measuring steady-state noise. Other more exotic units include the time during which the sound level, in dB(A), exceeds a specified value (Winer, 1979), and the time during which the Speech Interference Level exceeds a specified value (Tracor, 1971).

Many studies have shown that these units are highly correlated among themselves, implying that there would be little difference between them in their ability to predict community reaction (Bishop, 1975; Tracor, 1971). In the present study, correlations between EPNL and max dB(A) levels for recorded overflights are shown in Table 8.1. Because of these high correlations, and because different methods of combining the units can confuse differences between the units themselves, it appears that laboratory studies, rather than social surveys, are the appropriate method of testing differences between measures of noise from an individual overflight.

Various studies appear to indicate that units such as EPNL, with corrections for duration and tonal content of the noise, perform better than others(Rice, 1977 (a); Scharf and Hellman, 1978). On this basis, and because it is traditionally used in the index NEF, EPNL was normally used in the present analysis as the basic unit for noise exposure indices similar in form to NEF. SEL was used when necessary for comparison with other studies. For "peak level" indices, however, the unit max dB(A) has traditionally been used, and this usage was retained for the purpose of comparison.

8.1.2 Energy-summation indices

Methods of calculating the total noise exposure from a number of different events vary widely. The first and still the most common method adds individual noise levels on an energy basis. That is, if L_i represent levels from individual events and N is the number of events per day, the index is given by

$$I = 10 \log\{\frac{N}{K} \sum_{i=1}^{K} 10^{L_i/10}\} \qquad (8.2)$$

Engine Type	Approach	Departure	All
Low By-Pass Ratio Turbo-fan	.905/14.0/116	.945/9.7/26	.950/13.2/142
High By-Pass Ratio Turbo-fan	.890/15.1/41	.957/12.7/11	.951/14.6/52
Turbo-prop	.926/12.7/110	.929/11.3/61	.939/12.2/171
All	.886/13.6/267	.963/11.0/98	.928/12.9/365

TABLE 8.1 Relationship between EPNL and max dB(A) for tape-recorded overflights measured in the present study. Figures given are correlation co-efficient/mean (EPNL-maxdB(A))/number of overflights. This data is for illustration only, as the sample of overflights is small, and not intended to be representative of any particular location.

for some sufficiently large number K. This formula was used for the first exposure unit to be accurately defined - the Community Noise Rating (CNR), developed by Kryter (1970).

With refinements to the unit of measurement for individual events, CNR evolved into NEF. A more recently-defined unit using the same energy-summation formula is the Day-Night Noise Level (L_{dn}), which differs from NEF in using SEL in place of EPNL, and in having slightly different night weightings. Many other units follow the same formula.

8.1.3 Peak-level indices

Another group of indices, referred to here as peak-level indices, have the property that they depend only on the level of the loudest aircraft heard. The first such index to be defined in the literature was that which is called LTYPE in this study (see Section 4.1). This was defined in the early 1970's by Rylander, Sörensen and Kajland (1972), who claimed that the index was more highly correlated with reaction to the noise than energy-summation indices*. This particular index is open to the objection that its value depends on the type of aircraft which fly, as well as on their noise levels. The indices LX3, LX5, LX10 and MEAN5 were included in this study in order to test peak-level indices which do not have this property.

8.1.4 'Pseudo equal-energy' and frequency-independent indices

A group of indices which are referred to here as 'pseudo equal-energy' indices are defined by the formula

$$I = 10C \log\{\frac{N}{K} \sum_{i=1}^{K} 10^{L_i/10C}\} \qquad (8.3)$$

for a sufficiently large value of K, where C is a constant to be determined. If C = 1, equation (8.3) is identical to equation (8.2), and the index is a true equal-energy index. Putting C = 1.33 gives the German Stör index Q, apart from time of day weightings. As C increases, the weighting given to events with high noise levels decreases. Also, equation (8.3) can be written as

$$I = 10C \log\{\frac{1}{K} \sum_{i=1}^{K} 10^{L_i/10C}\} + 10C \log N \qquad (8.4)$$

The first term depends only on the distribution of noise levels, and not on the number of exposures. Thus, if the distribution of levels is kept the same, doubling the number of exposures increases I by 10 C log(2), so that as C increases, the effect of changing the number of exposures is increased.

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* This higher correlation was postulated to occur only in areas where more than 50 overflights per day had levels greater than 70 dB(A).

Although it was not feasible in this study to test a large number of indices with differing values of C, it was possible to test whether C should be different from 1. For values of C close to 1 equation (8.3) can be shown to be equivalent to

$$I \sim 10C \log\left\{\frac{N}{K} \sum_{i=1}^{K} 10^{L_i/10}\right\} + (1-C) \frac{\sum_{i=1}^{K} L_i 10^{L_i/10}}{\sum_{i=1}^{K} 10^{L_i/10}} \qquad (8.5)$$

(see Appendix C). The first term represents C times the usual energy-summation index. The second term represents (1-C) times a weighted average of noise levels from individual aircraft, which has been called WMEAN in this study (see Section 4.1). Thus, if WMEAN adds significantly to the ability of an energy-summation index to predict reaction to the noise, it can be said that C is significantly different from 1.

Another type of index which has been discussed is one which is independent of the number of aircraft operations experienced, and depends only on the probability distribution of levels. Again, a large number of such indices are possible. Three units of this form were available for testing in this study, namely the energy-mean level, the level exceeded by 10% of aircraft (LX10%), and WMEAN.

8.2 Testing the Significance of the Difference between Two Correlation Co-efficients

In most studies of the effects of noise on communities, it is necessary at some stage to choose a unit of noise exposure from several possibilities, on the basis of the product-moment correlations between exposure units and a measure of reaction. Since the correlation co-efficients are generally close for all units, it becomes important to test the significance of small differences between them.

Consider a measure of reaction, R, and two exposure measures E and F, such that their correlations with R are $r_{E,R}$ and $r_{F,R}$ respectively. Since E and F will usually be highly correlated, $r_{E,R}$ and $r_{F,R}$ will not be independent. In particular, the sampling distribution of $r_{F,R}$ given the value of $r_{E,R}$ will be very different from its form if $r_{E,R}$ is unknown. Thus it is not appropriate to perform a simple F-test on the ratio of variances $(1-r^2_{E,R})/(1-r^2_{F,R})$, since this assumes that the variances are independent. This appears to be the test employed by Ollerhead (1978).

A method exists (Hotelling, 1940) for testing the significance of the difference $r_{E,R} - r_{F,R}$ in terms of the statistic

$$t = \frac{(r_{E,R} - r_{F,R})((N-3)(1+r_{E,F}))^{\frac{1}{2}}}{(2(1-r_{E,R}{}^2 - r_{F,R}{}^2 - r_{E,F}{}^2 + 2r_{E,R}\, r_{F,R}\, r_{E,F}))^{\frac{1}{2}}} \qquad (8.6)$$

However, in most cases, the question of interest is not strictly whether the population correlation with one index is greater than that with the other, but rather whether one index can unambiguously be said to be the correct measure of exposure, with any correlation between the other index and reaction being due solely to the intercorrelation of the indices. It is possible that reaction could be determined by a combination of two factors, each measured by a different index. In this case, whether $r_{E,R}$ or $r_{F,R}$ was larger would depend on the sampling distributions of E and F in the population sampled. A significant difference between the two correlation co-efficients would mean that one index had more explanatory power in populations where the distributions of E and F were similar to that in the sample, but would not necessarily give the most useful index for describing large changes in this distribution.

To overcome this problem, the significance test used in the present study is based on partial correlations. Co-efficients of partial correlation are formed between R and one index, holding the other index constant. For example, $r_{E,R.F}$ represents the partial correlation between E and R, holding F constant. A standard t-test is used to test their significance. A one-tailed test is used, with $\alpha = .05$, since the possibility that the co-efficient could in reality be negative - that is, that reaction could fall with increasing values of an index - is discounted. The interpretation of these partial correlations is as follows:

I) $r_{E,R.F}$ significant, $r_{F,R.E}$ non-significant: Knowledge of the value of E leads to a better prediction of R than knowledge of F alone, but the reverse is not true. E is unambiguously a better index than F.

II) Neither $r_{E,R.F}$ nor $r_{F,R.E}$ significant: E and F are so highly inter-correlated and/or so weakly correlated with R that it is not possible to decide, with 95% confidence, which index is better.

III) Both $r_{E,R.F}$ and $r_{F,R.E}$ significant: Neither index is optimal in its description of R, and some combination of the two, or perhaps an index with intermediate properties, appears to be best.

These cases will be referred to as relationships of type I, II and III in the following section. Where a difference is simply said to be "significant", a relationship of type I is implied.

8.3 Differences between Indices in the Present Study

8.3.1 General comparison of indices

For the purpose of comparing noise indices, it was decided that the most important property of a person's reaction which should be predicted by an index is whether or not he is seriously affected by the noise. This was chosen in preference to scores on the GR scale of general reaction (see Section 5.4), since it was felt that it was more important for an index to predict the number of people showing more extreme reaction than to predict the score of the "average" person. Therefore a variable known as SA ('seriously affected') was defined so that SA = 1 if GR $\geq$ 8 and SA = 0 otherwise (see Section 5.4.2). SA was the "reaction" variable used in all comparisons of different noise indices. Since SA takes only two possible values, whereas GR may take a large number of values, correlations with SA are inevitably lower than those with GR.

Because peak-level indices have no night weighting, and in order not to confuse comparisons of indices with comparisons of night weighting factors, a form of NEF was calculated which has no night weighting. In anticipation of notation used in the next section, this index is referred to as NEF$_{0,0}$. Both NEF2 and NEF3 (see Chapter 4) were calculated in this form, giving NEF2$_{0,0}$ and NEF3$_{0,0}$.

Correlations between SA and the various indices calculated for this study are shown in Table 8.2. It appears that equal-energy indices are better predictors of SA than the peak-level indices tested, which are in turn better than the frequency-independent indices. For example, the correlation between SA and NEF2$_{0,0}$ is .3252, compared with .2954 for the "best" of the peak-level indices (LX3) and .2229 for the "best" of the frequency-independent indices (LX10%).

The significance of these differences was tested using the method described in Section 8.2. Differences between NEF2$_{0,0}$ and the other indices were tested, and the relevant partial correlation co-efficients are given in Table 8.3. It is clear that all differences are of type I, with the exception of that between NEF2$_{0,0}$ and N70. This indicates that, with this exception, NEF2$_{0,0}$ is clearly superior as a predictor of SA to the other indices tested. (The moderate negative partial correlations between SA and the frequency-independent indices at constant NEF2$_{0,0}$ will be discussed in Section 8.3.4 .)

Index	Index Type	Correlation with SA
NEF2$_{0,0}$	Equal-energy	.3252
NEF3$_{0,0}$	"	.3131
$L_{dn}2_{0,0}$	"	.3069
LTYPE	Peak-Level	.2621
LX3	"	.2954
LX5	"	.2887
LX10	"	.2819
MEAN5	"	.2850
MEAN5'	"	.2937
N70	"	.2601
LX10%	Frequency-independent	.2229
$\overline{\text{EPNL}}$	"	.2216
WMEAN	"	.1769

TABLE 8.2 Correlations between SA and various noise exposure indices. Definitions of all indices are given in Table 4.1, with the exception of $\overline{\text{EPNL}}$ and $L_{dn}2_{0,0}$ $\overline{\text{EPNL}}$ is the overall energy-mean value of EPNL for all aircraft included in the analysis (i.e. excluding aircraft smaller than a Fokker F27). $L_{dn}2_{0,0}$ is defined analagously to NEF2$_{0,0}$.

Index	Correlation Between SA and NEF2$_{0,0}$ Holding Index Constant	Correlation Between SA and Index Holding NEF2$_{0,0}$ Constant
$L_{dn}2_{0,0}$	.1128*	.0010
NEF3$_{0,0}$	.0932*	.0111
LTYPE	.1770*	-.0294
LX3	.1295*	-.0174
LX5	.1206*	-.0247
LX10	.1174*	-.0438
MEAN5	.1307*	-.0293
MEAN5'	.1496*	-.0324
N70	.2239*	.0985*
LX10%	.2473*	-.0479
$\overline{\text{EPNL}}$	.2472*	-.0402
WMEAN	.2812*	-.0490

TABLE 8.3 Partial correlations for the indices in Table 8.2;

* - co-efficient significant at .05 level (one-tailed test).

The fact that $L_{dn}2_{0,0}$ shows a significantly lower correlation with SA than NEF2$_{0,0}$ appears to indicate the superiority of EPNL over SEL for measuring noise from an individual overflight. Although this may well be the case, this result should be treated with some caution, since it must be remembered (see Chapter 4) that values of SEL were not measured in this study. Corrections applied to nominal SEL values were taken to be the same as those applied to nominal EPNL's. Thus, SEL values are subject to unspecified errors, which may be large enough to affect correlations with reaction.

8.3.2 The four forms of NEF

The fact that NEF2$_{0,0}$ correlates more highly with SA than NEF3$_{0,0}$ appears to indicate that noise from the airport itself, resulting from reverse thrusts and takeoffs on other runways, has little effect on overall reaction to aircraft noise. (See Chapter 4 for definitions of NEF1 to NEF4.) Possible explanations for this result include:

a) The method used for predicting the level of airport-generated noise could have been grossly in error. This appears unlikely, for, to explain the observed difference in correlation, the value of NEF3 - NEF2 must have been over-estimated by a factor typically much larger than 2.

b) Airport-generated noise has a different spectrum from flyover noise, which may result in less reaction. This could result if EPNL - dB(A) differences for airport-generated noise have been over-estimated, or if EPNL itself is not adequate to describe reaction to this noise.

c) Noise from the airport may not be seen as having the same connotations as noise from aircraft passing overhead, and in particular, may not invoke a fear that the aircraft will crash. This would mean that airport-generated noise had less overall effect on residents than flyover noise.

d) Airport-generated noise may not be generally referred to as "aircraft noise", and its effect may not have been included when respondents rated, for instance, how much they are "affected by aircraft noise overall".

Any of possibilities b), c) and d) would provide grounds for assessing airport-generated noise and flyover noise by separate measures, as is done for aircraft and traffic noise, at least until more accurate measures of noise and/or reaction are available. Accordingly, $NEF2_{0,0}$ rather than $NEF3_{0,0}$ will be used as the basic equal-energy unit in the rest of this chapter.

This conclusion is supported by analysis of results from Question 28 of the interview schedule, which asked "Do you hear the noise of planes when they are at the airport itself, as distinct from flying overhead?". The percentage of affirmative answers to this question is plotted in Figure 8.1, as a function of the contribution to $NEF3_{0,0}$ resulting from airport-generated noise (i.e. the value of $NEF3_{0,0}$ if no overflights were present). Also shown is the percentage of affirmative answers to Q.14(iii) ("Please tell me whether or not you ever hear the following noises in this neighbourhood...aircraft?"), as a function of $NEF2_{0,0}$. It is clear that the proportion of people who report hearing the two types of aircraft noise is dramatically different, for the same level of exposure (in terms of energy-summated EPNL).

NEF1 and NEF4 were not available in a form without night weighting. However, NEF1 showed a significantly lower correlation with SA than NEF2 (.288 vs .294), as could be expected. The correlation between NEF4 and SA was slightly, but significantly, lower than that of NEF3 (.282 vs .284). However, in this case, the accuracy of corrections for shielding is open to considerable doubt, so that this result may simply reflect errors in these corrections. The mean difference between NEF3 and NEF4 is only .01 dB, indicating that few dwellings experienced significant shielding.

8.3.3 Peak-level and frequency-independent indices

It is clear from Table 8.3 that N70 - the number of aircraft per day whose level exceeds 70 dB(A) - is the only peak-level index which is significantly correlated with SA independently of $NEF2_{0,0}$. (N70 can be described as a peak-level index since it satisfies the definition that only aircraft which exceed a given level are considered in the index).

Question 26 of the interview schedule represents an attempt to directly ask respondents to differentiate between the peak-level and equal-energy principles. It asked: "What do you think affects how you feel about aircraft noise? Is it the noisiest plane you hear in a day, or is it the steady build-up of all the planes you hear in a day, or would you say these two aspects affect you equally?". (It was expected that with such a relatively complicated question, many respondents would choose

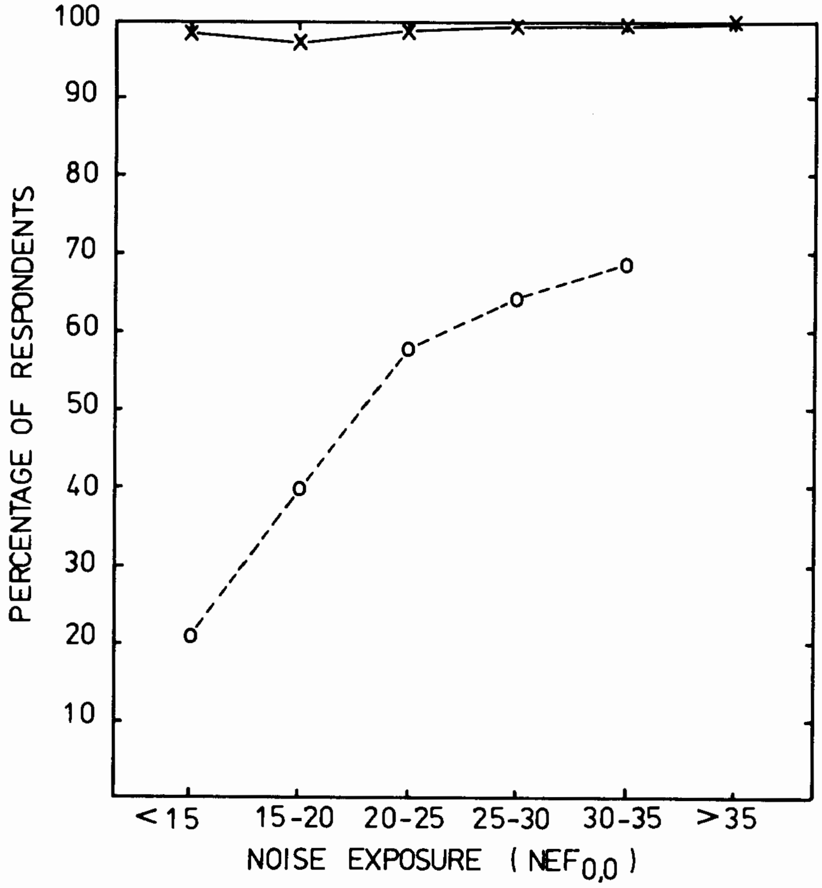

FIGURE 8.1 Proportion of respondents claiming to hear noise from aircraft.

X—X: Proportion claiming to hear aircraft, plotted against total exposure from overflights.

o--o : Proportion claiming to hear noise from planes at the airport, plotted against total exposure from reverse-thrusts and takeoffs on other runways.

Response to Q.26	Percentage of All Respondents	Percentage of Seriously Affected Respondents
"Noisiest plane"	32	20
"Steady build-up"	16	25
"Equally"	34	54
Not affected by noise or don't know	18	1

TABLE 8.4 Responses to Question 26 of the interview schedule, for all respondents and for those seriously affected by aircraft noise.

"equally" as the easy answer.) Responses are given in Table 8.4. It is clear that while overall, more respondents chose "noisiest" than "build-up", this was reversed for respondents who were seriously affected by the noise. This provides further support for the use of equal-energy indices, rather than peak-level indices, for assessing the number of people seriously affected by the noise.

It has been claimed (Rylander et al, 1972; Rylander, 1981) that the indices LTYPE and MEAN5 are more appropriate than equal-energy indices only when the number of aircraft per day with levels greater than 70 dB(A) (i.e., N.70) is greater than 50. In order to test this, an analysis was performed including only the 950 respondents for whom N70>50. This showed that the correlation between NEF2$_{0,0}$ and SA for these respondents (viz., .290) was still significantly higher than that for LTYPE (.267) and MEAN5 (.271).

It appears that N70, or perhaps some similar index, could provide useful information in addition to that provided by NEF2$_{0,0}$. It is therefore possible that this index could be routinely given in addition to NEF as an extra measure of noise exposure. If such an extra measure is wanted, an index such as N70 certainly appears, from this data, to be the most suitable. However, it should be noted that the explanatory power of N70 alone is considerably lower than that of NEF2$_{0,0}$. It explains 6.8% of the variance in SA, compared with 10.6% for NEF2$_{0,0}$. Using both NEF2 and N70, the proportion rises to 11.4% (co-efficient of multiple correlation = .338). Whether this increase in explanatory power justifies the use of two noise indices is a decision which must be left to the relevant regulatory authorities.

Frequency-independent indices clearly have considerably less explanatory power than NEF2$_{0,0}$, and their usefulness as alternative noise indices seems very questionable. The "best" frequency-independent index, LX10%, explains only 5.0% of the variation in SA, compared with 10.6% for NEF2$_{0,0}$. Their relatively large negative partial correlations with SA at constant NEF2$_{0,0}$ indicate not that they are useful noise indices, but that the constant C in equation (8.3) should be somewhat different from 10.

8.3.4 'Pseudo equal-energy' indices

The indices given by equation (8.3) were investigated by adding WMEAN to a predictive equation for SA which already contained $NEF2_{0,0}$. It was found that WMEAN did add significantly to the predictive power of $NEF2_{C,0}$, indicating that the optimum value for C in equation (8.3) is not 1. The regression equation obtained was

$$SA = \frac{1}{100} (2.22\ NEF2_{0,0} - 0.39\ WMEAN) + 0.11 \qquad (8.7)$$

This indicates that the value of C should be about 1.2 . Confidence limits on the co-efficients in the regression equation imply that the 95% confidence interval for C is about 1.06 to 1.42. In more familiar terms, the co-efficient of log N in equation (8.4) can be said with 95% confidence to be between 10.6 and 14.2.

In practice, an index using C = 1.2 would behave in a very similar way to $NEF2_{0,0}$. The proportion of the variance of SA which is explained would be increased from 10.6% to 10.8%. In this sample, the mean difference between the two indices was about 1.9 dB, with a standard deviation of 1.3 dB. Since it is unlikely that operating conditions at Australian airports will change in such a way as to greatly increase this difference, the usefulness of changing the constant 10 in the energy-summation formula seems doubtful. It is worth noting that the effects of WMEAN and N70 are relatively independent - that is, the effect of each variable is still significant when the other is held constant ($NEF2_{0,0}$ also being held constant). The effect of N70 is considerably stronger than that of WMEAN.

8.4 Time-Of-Day Weighting Factors in Exposure Indices

A separate problem from that of combining noise levels from individual events is the question of whether events occurring at different times of the day should be given different weightings, and if so, how large the weightings should be. Although most existing noise indices incorporate such weightings, it has been noted that little experimental evidence has been produced to justify their use (Fidell and Schultz, 1980; Galloway, 1980). It has recently been suggested that weightings in most indices are too high. Ollerhead (1978) argues that night weightings should be replaced by a 5 or 6 dB weighting over the "extended evening" period.

8.4.1 Results of the present study

An attempt was made in this study to systematically investigate many possible combinations of time-of-day weightings to find the most appropriate form. On the basis of the analysis in section 8.3, the basic index used was energy-summated EPNL from overflights, to which various night and evening weightings were applied. The resulting indices are referred to as $NEF_{x,y}$, where x represents the night weighting in dB and y the evening weighting. "Night" and "evening" are taken as 2200 - 0700 and 1900 - 2200 hours, respectively. Such indices may be calculated using the variables NEF2, NEF2N and NEF2E (see Chapter 4). For example, NEF with 6 dB night weighting and 6 dB evening weighting would be given by

$$NEF_{6,6} = 10 \log\{10^{NEF2/10} - 12.69x10^{NEF2N/10} + 2.98x10^{NEF2E/10}\} \quad (8.8)$$

To find the best night and evening weighting factors, correlations between $NEF_{x,y}$ and SA were found for values of x and y between $-\infty$ and 12. These are shown in Figure 8.2. (A weighting of $-\infty$ means that overflights at this time are ignored altogether in the index.)

The index with the highest correlation with SA is $NEF_{0,6}$. Correlations which are not significantly different at the .05 level from that of $NEF_{0,6}$ are shaded in Figure 8.2 They are the co-efficients for $NEF_{-\infty,-\infty}$, $NEF_{-\infty,0}$, $NEF_{-\infty,3}$, $NEF_{-\infty,6}$, $NEF_{0,0}$, $NEF_{0,3}$, $NEF_{0,9}$, $NEF_{3,6}$, $NEF_{3,9}$, $NEF_{3,12}$ and $NEF_{6,12}$. No differences between co-efficients were of type III (see Section 8.2). It is clear that the standard form of NEF, which corresponds to $NEF_{12,0}$, has a night weighting which is much too large. Indeed, combinations of night and evening weightings used in most existing indices can be seen to be less than optimal.

It is possible that this result was artifactual, due to a relationship between modifying variables (particularly negative attitude and fear of crashing) and night-time noise exposure. This possibility was suggested by the fact that values of these modifying variables appeared to be particularly low in Perth, and it happened that Perth has the largest proportion of night-time noise exposure of any airport. The most important modifying variables appear to be NEGATT and CRASH (see Section 6.6), since these have the highest correlation with SA and with noise exposure.

To investigate this possibility, multiple regressions were performed between SA and the variables NEGATT, CRASH AND $NEF_{x,y}$. Co-efficients of multiple correlation for the values of x and y used previously are shown in Figure 8.3 The index with the highest correlation is now $NEF_{0,-\infty}$, and co-efficients which do not differ significantly from this are shaded in Figure 8.3. It is clear that the overall results are little changed by controlling for NEGATT and CRASH in the analysis. Confidence limits are wider, since NEGATT and CRASH do not appear to be pure modifying variables (see Section 6.6.2), so that controlling for these variables removes some variation in SA which is actually due to exposure. However night weightings used in existing noise exposure indices are still seen to be too high.

8.4.2 Other evidence relevant to time-of-day weightings

Responses to an independent question in the interview schedule provide support for the use of non-zero night and evening weightings in assessing noise exposure. Question 27 asked: "Suppose you could have aircraft stopped from flying over in one of these 3-hour periods. Which one would you most like to have free from aircraft noise?". Respondents were shown a card giving eight 3-hour periods beginning at 6 am.

There may be some ambiguity in the wording of this question. Respondents could have answered with the period during which they are most "sensitive" to noise, irrespective of their current exposure.

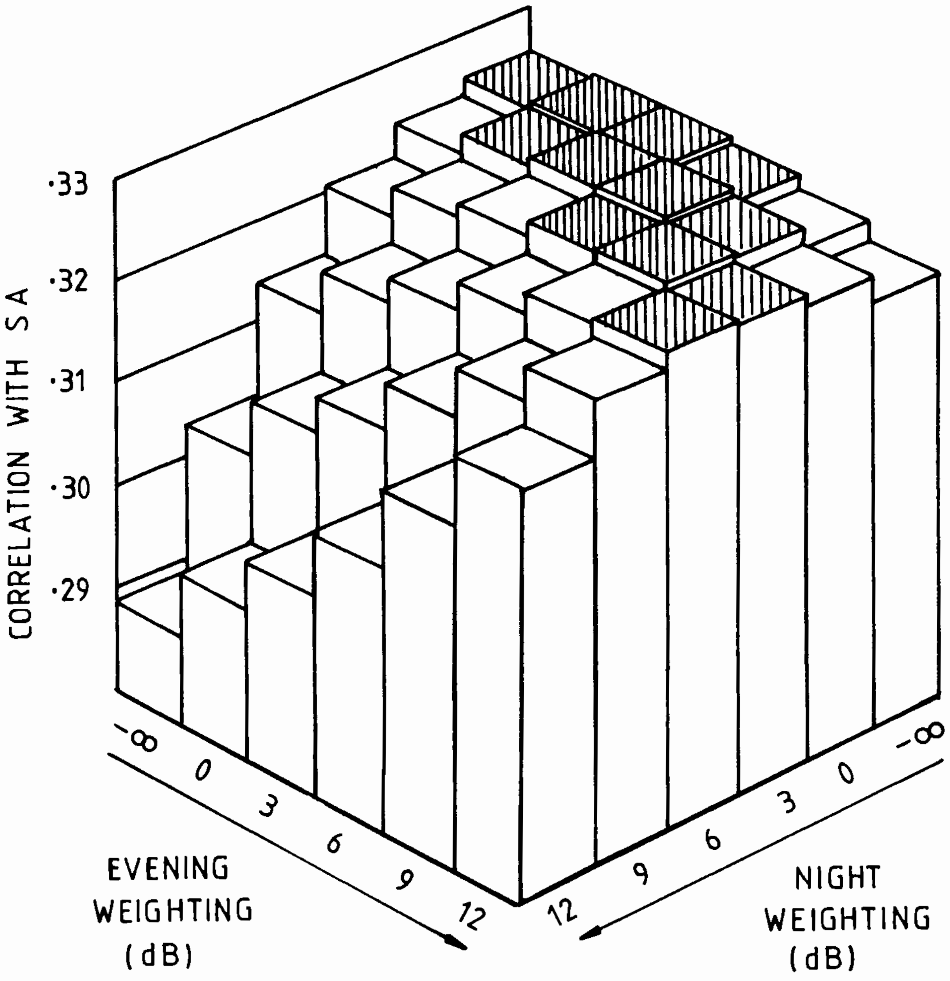

FIGURE 8.2 Correlation co-efficients between SA and $NEF_{x,y}$ for various values of the night weighting x and evening weighting y. The index with the highest correlation has 0 dB night weighting and 6 dB evening weighting. Shading indicates indices whose correlation with SA does not differ significantly from this.

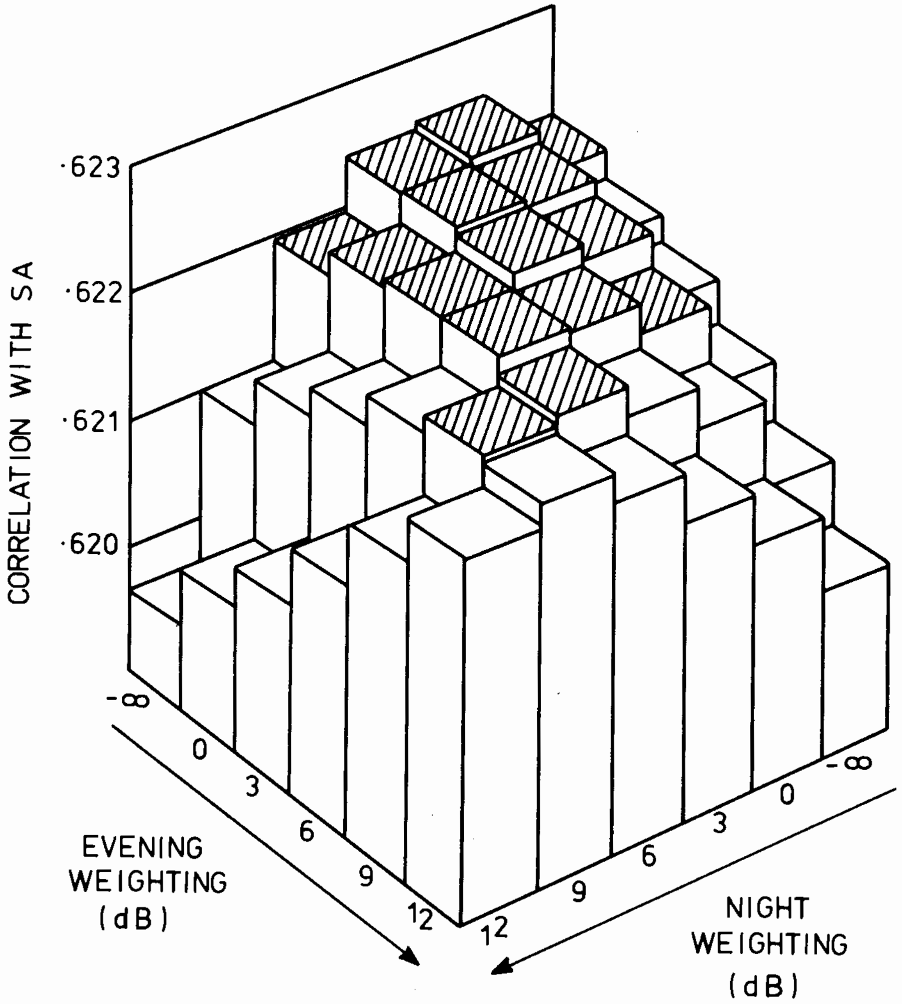

FIGURE 8.3 Co-efficients of multiple correlation between SA and the variables NEGATT, CRASH and $NEF_{x,y}$ for various values of the night weighting x and evening weighting y. The index with the highest correlation has 0dB night weighting and -∞ dB evening weighting. Shading indicates indices whose correlation with SA does not differ significantly from this.

Alternatively, they could have given the period during which they feel the noise is "worst" at present. If zero night and evening weightings were applicable, then, using the first interpretation of the question, respondents' answers should have been distributed roughly equally in all 3-hour periods. Using the second interpretation, the responses should have tended to fall in periods with greater exposure.

In fact, both overall responses and responses from people who were seriously affected by the noise showed a strong tendency to fall in evening and night periods (see Table 8.5). Thus, under the first interpretation of the question, evening and night weightings should both be greater than zero. Also, mean daytime noise exposure (i.e., energy-summated EPNL) was 7.8 dB greater than that in the evening, and 10.6 dB greater than that at night. It is therefore clear that under the second interpretation of the question, both weightings should again be greater than zero.

8.5 Use of Clustered Data

It has been argued (Schultz, 1978) that analysis of survey results should be based on aggregate responses of groups of people exposed to similar noise conditions, rather than on individual data. The authors believe that the techniques used here meet all objections which have been raised against the use of individual data, and that the use of group, or clustered, data serves only to reduce the power significance tests, since the number of points over which a correlation co-efficient is calculated is drastically reduced. However, the data from the present study can be analysed in clusters, using the noise zones which were used for stratification of the sample (Section 3.1). These covered 5 NEF units, and since they were determined separately for each flight-path, yield zones approximately 5 dB wide for all exposure units. Standard deviations of decibel-like units within a cluster were typically about 2.5 dB, ranging from 0.7 dB to 4.7 dB. The latter value occurred for MEAN5 in the 20-25 NEF cluster in the south of Adelaide, and was exceptional - only two other standard deviations were over 4.0 dB.

Response to Q.27	Percentage of All Respondents	Percentage of Seriously Affected Respondents
Day (0600-1800)	14	19
Evening (1800-2100)	31	44
Night (2100-0600)	33	35
Not affected by noise, no period wanted free, or don't know	22	2

TABLE 8.5 Responses to Question 27 of the interview schedule, for all respondents and for those seriously affected by aircraft noise.

The proportion of the population which is seriously affected by the noise (that is, the mean value of SA) is shown plotted against the mean value of various noise indices in Figure 6.3. Correlations between the percentage seriously affected and mean values of the indices are given in Table 8.6. Significance tests on differences between these correlations confirm previous results (see Table 8.7). In particular, the correlation between SA and $NEF2_{0,0}$ is significantly higher than all others, and N70 is the only variable which has a significant positive correlation with SA after the effect of $NEF2_{0,0}$ is accounted for.

8.6 Summary of Conclusions Concerning Aircraft Noise Exposure Indices

On the basis of the analysis described above, it appears that an index based on energy-summation is not only easier to calculate over a wide area than most alternatives, but is also more closely correlated with human reaction to the noise. While slight improvements can be made to its predictive power, it is questionable whether these are large enough to justify more complex calculation procedures and greater difficulty in interpretation of the index. Thus, accepting EPNL as the unit of measurement for a single overflight, an index similar to NEF seems appropriate. However, the night weighting constant in NEF has been shown to be too large, although both night and evening weightings should be greater than zero.

Of the indices having non-zero night and evening weightings, $NEF_{3,6}$ has the highest correlation with reaction (as measured by the variable SA). $NEF3_{6}$ explains 10.6% of the variation in SA, compared with 8.6% for $NEF_{12,0}$ (i.e., standard NEF). Accordingly, $NEF_{3,6}$ has been used as the best index of exposure at various points throughout this report, including the plotting of exposure contours in the following chapter. However, in choosing weightings for a practical noise index, the consequences of choosing a night weighting which is in fact too small must be considered.

Index	Correlation Between % Seriously Affected and Mean Value of Index
$NEF2_{0,0}$	.8172
$NEF2_{12,0}$	.7219
$NEF3_{12,0}$	.7045
LTYPE	.6714
LX3	.7661
LX5	.7549
LX10	.7314
MEAN5	.7511
MEAN5'	.7359
N70	.7143
LX10%	.5149

TABLE 8.6 Correlations between the percentage of respondents in a cluster who are seriously affected by aircraft noise and the mean value of various noise indices.

Index	Correlation Between % Seriously Affected and $NEF2_{0,0}$ Holding Index Constant	Correlation Between % Seriously Affected and Index Holding $NEF2_{0,0}$ Constant
$NEF2_{12,0}$	,5725*	-.1758
$NEF3_{12,0}$	.5939*	-.1364
LTYPE	.6183*	-.1314
LX3	.4520*	-.0436
LX5	.4469*	-.0855
LX10	.5144*	-.2601
MEAN5	.4667*	-.1306
MEAN5'	.5394*	-.1468
N70	.6619*	.4142*
LX10%	.7509*	-.1873

TABLE 8.7 Partial correlations for the indices in Table 8.6.

*- co-efficient significant at .05 level, one-tailed test.

This could encourage a rapid expansion of the number of aircraft movements at night, and thus create much more disturbance than would be caused by an overestimation of the correct weighting. Because of this, and also to avoid the complexity of applying two different weighting factors, it may be more reasonable in a practical index to apply a 6 dB weighting to both evening and night operations, at least until further data are available. It may be noted that although the raw correlation between $NEF_{6,6}$ and SA is lower than that for $NEF_{3,6}$ (Figure 8.2), when the effect of modifying variables is accounted for it is actually higher (Figure 8.3).

CHAPTER 9

THE AIRCRAFT NOISE PROBLEM IN AUSTRALIA

9.1 Noise Exposure Estimation

This study has shown that community reaction to aircraft noise in Australia is best explained by the noise exposure index $NEF_{3,6}$ (see Section 8.4). Figure 9.1 reproduces the dose/response functions for $NEF_{3,6}$ and for standard NEF (i.e., NEF3) with separate regression lines for each airport. The data points are 'clustered' by sampling zone (see Section 6.3). The overall linear correlation with percentage seriously affected was higher for $NEF_{3,6}$ ($r = 0.82$) than for NEF3 ($r = 0.71$). A comparison of the two sets of graphs in Figure 9.1 shows how the dose/response functions change when exposure is estimated in terms of the revised rather than standard NEF. In particular, the regression lines for Sydney and Perth which seem too high and too low, respectively, when plotted against NEF3, appear less aberrant when $NEF_{3,6}$ is used as the exposure index.

The regression line for Melbourne appears to show a counter-intuitive negative relationship between noise exposure and community reaction. However, this regression is based on only four points over a short range, and is dominated by the unusually low response in one zone. It should not be taken as indicating a genuine peculiarity about the residents of Melbourne, but simply illustrates the dangers of basing conclusions on limited data. It is interesting to observe that a similar, apparently negative, function can be seen in the first four data points for Sydney.

The revised index $NEF_{3,6}$ differs from the standard NEF3 in two respects:

1) $NEF_{3,6}$ replaces the 12.2 dB night weighting in NEF3 with weightings of 3 dB for night and 6 dB for evening operations.

2) $NEF_{3,6}$ measures noise only from aircraft overflights, and does not include airport-generated noise, that is, noise from reverse-thrust braking or from take-offs on other runways (see Section 8.3.2).

The practical effect of using the revised index is seen in Table 9.1 which lists the difference between the mean values of NEF3 and $NEF_{3,6}$ for the various exposure zones at each airport. Large differences occur for Perth mainly because of the comparatively high proportion of night operations at this airport (see Section 4.2). The net effect of replacing the 12.2 dB night penalty with the 3-6 dB night-evening penalty is to reduce the estimate of exposure in Perth by between 5.7 and 10.0 dB. It is this reduction that serves to bring the Perth dose/response function more into line with the norm (see Figure 9.1). In other words, it is not that Perth residents are less affected by aircraft noise, but that standard NEF overestimates their exposure by applying a night penalty that is too high.

The differences between the standard and revised estimates of noise exposure are comparatively small in most other areas. However, large differences do occur in Adelaide in the low exposure zones on the eastern

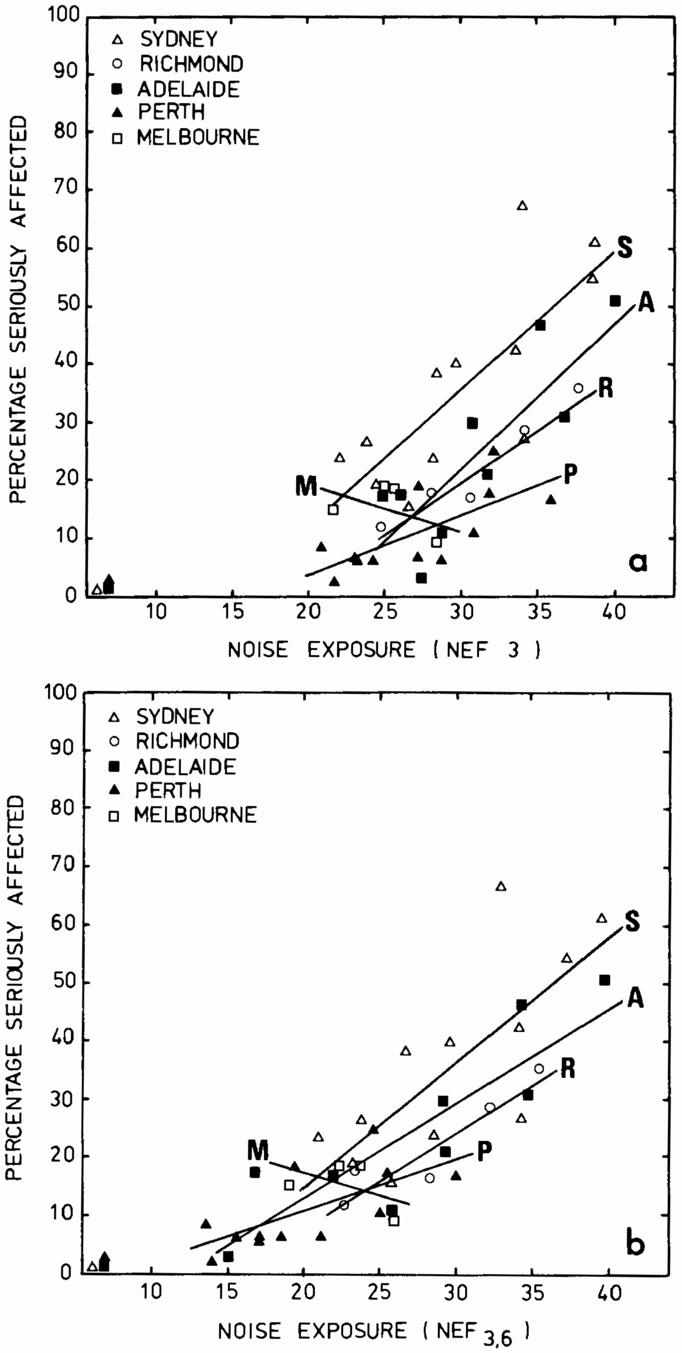

FIGURE 9.1 Dose/response functions for standard NEF (a) and revised NEF (b) with separate regression lines for each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	1.4	1.5	1.0	1.2
	E	1.1	-0.2	0.0	-
	S	1.0	-	-	-
	W	0.1	-0.1	-0.4	-0.4
Richmond	E	4.6	-	-	-
	W	2.2	2.3	2.0	2.3
Adelaide	N	2.7	1.9	1.0	0.7
	E	9.0	-	-	-
	S	2.8	2.7	1.9	-
	W	12.2	-	-	-
Perth	N	10.0	7.6	6.4	5.7
	E	6.7	6.1	-	-
	S	7.4	7.5	7.4	-
	W	7.8	5.8	6.0	-
Melbourne	E	2.5	2.4	-	-
	S	2.4	2.2	-	-

TABLE 9.1 Differences between mean values of standard and revised NEF ($NEF3-NEF_{3,6}$) for each exposure zone around the five airports.

and western flight paths where $NEF_{3,6}$ is much lower than NEF3. The two zones in question are close to the airport under rarely-used flight paths, and much of the noise estimated in NEF3 is from airport-generated noise. Also, the sampling area under the eastern flight path at Richmond was quite close to the airport. The large difference between standard and revised NEF in this area is mainly due to the exclusion of airport-generated noise from $NEF_{3,6}$.

Noise exposure contours were derived for each airport in terms of both standard and revised NEF. This was done by calculating exposure at grid points on each flight path using a basic grid size of 500m by 10m and, where necessary to pin-point turns etc., a finer grid size of 100m by 10m. By selecting the grid points at which a particular NEF value occurred (viz., 20.0, 25.0 etc), it was possible to plot contours with considerable accuracy on large-scale orthophoto maps. These were later transferred to smaller maps for reproduction in Figures 9.2 to 9.6.*

The differences between the standard and revised estimates of the 25 NEF contour for the various airports can be seen in these Figures. The most obvious is that the standard NEF contour bulges out in areas close to the airport whereas the revised contour does not. This is due to the inclusion of airport-generated noise in the standard measure. The other major difference between the two sets of contours can be seen in Perth

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* The 'NEF' contours on these figures are estimates of actual exposure. In Australia they are conventionally termed 'NEI' contours (see p.36).

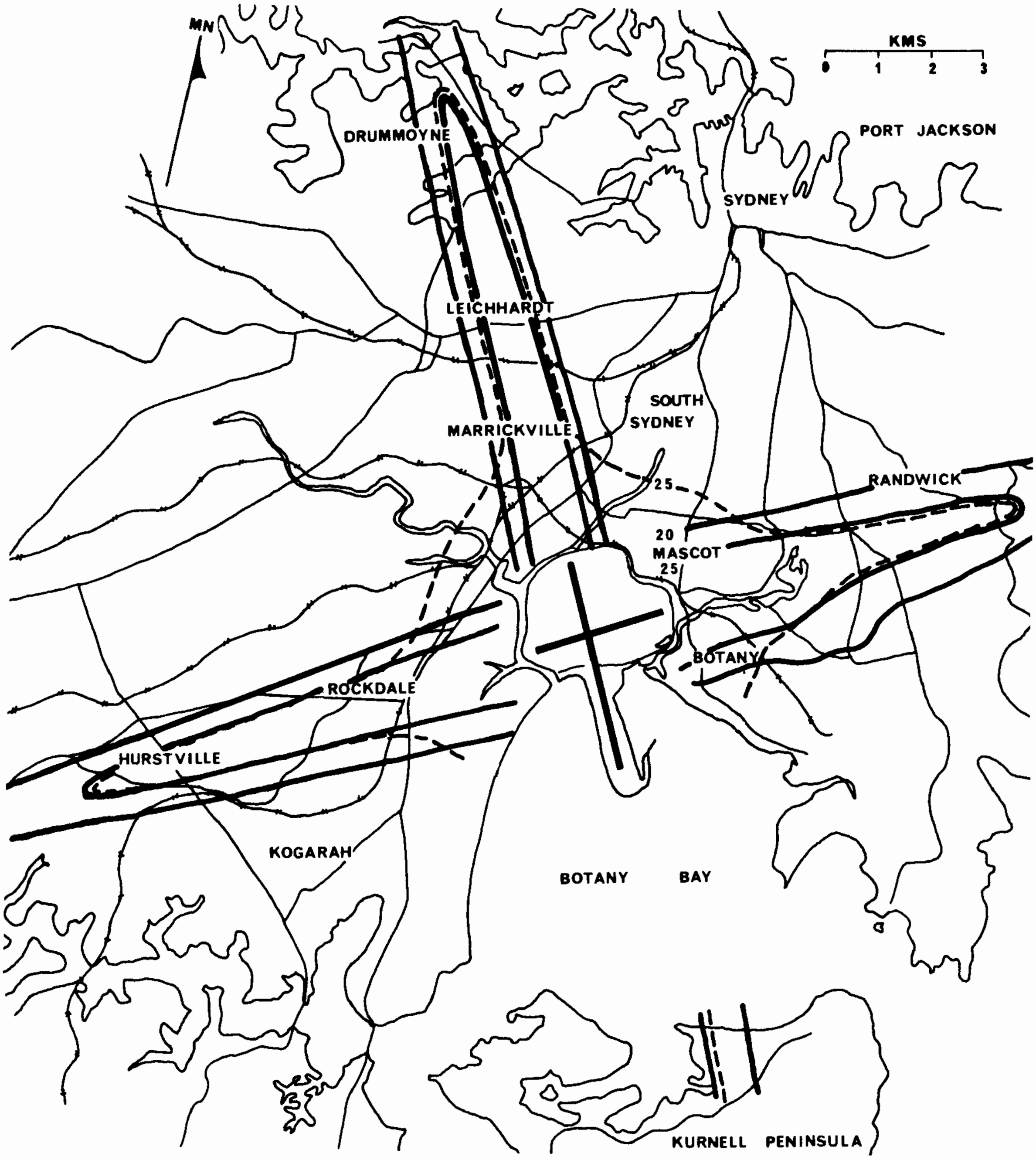


FIGURE 9.2 Noise exposure contours around SYDNEY airport.
——— Revised NEF (20 & 25), ---- standard NEF (25).

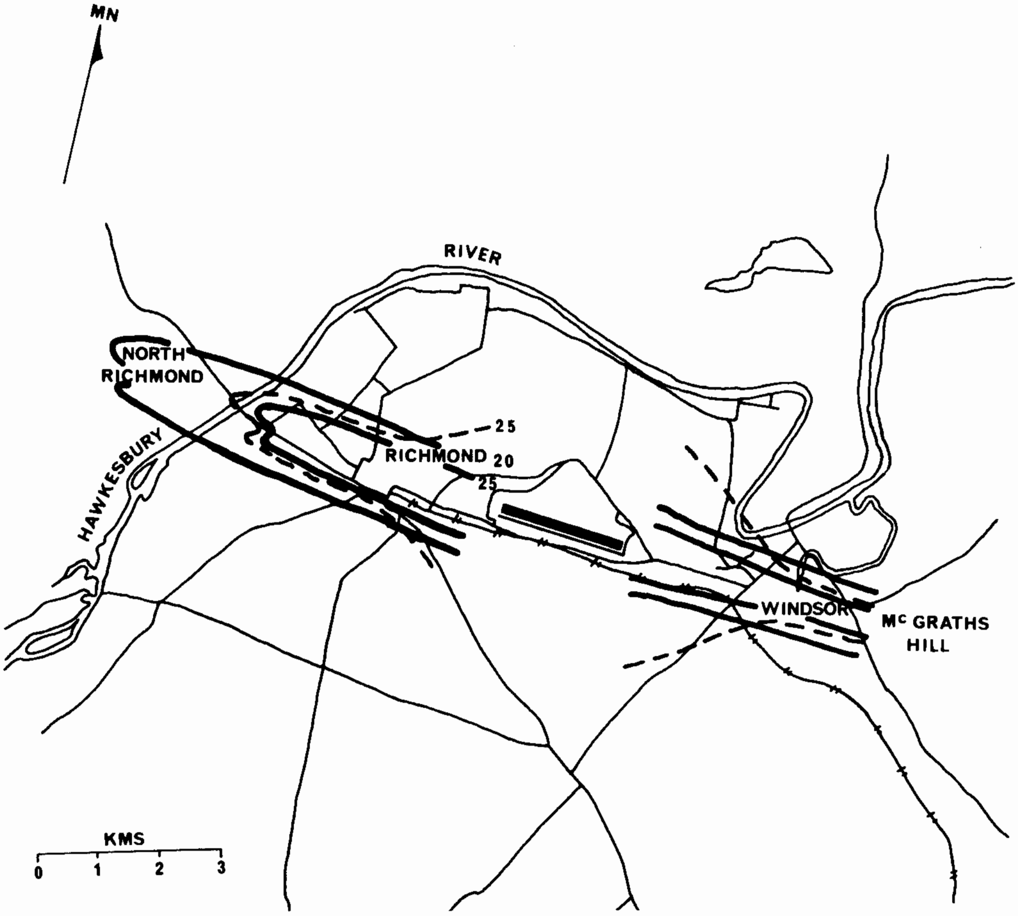


FIGURE 9.3 Noise exposure contours around RICHMOND air base.
—— Revised NEF (20 & 25), - - - standard NEF (25).

<u>FIGURE 9.4</u> Noise exposure contours around ADELAIDE airport.
—— Revised NEF (20 & 25), - - - standard NEF (25).

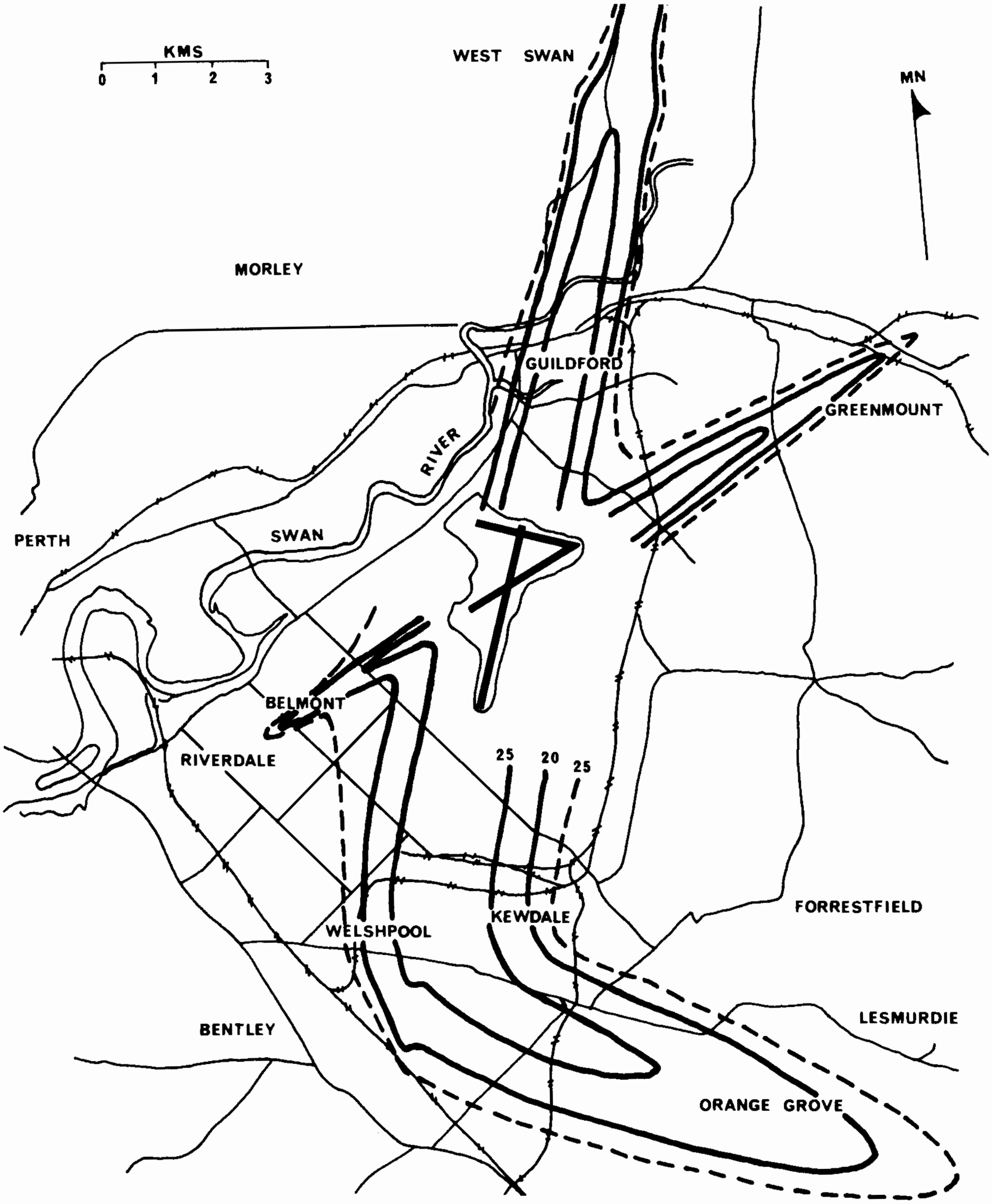


FIGURE 9.5 Noise exposure contours around PERTH airport.
—— Revised NEF (20 & 25), - - - standard NEF (25).

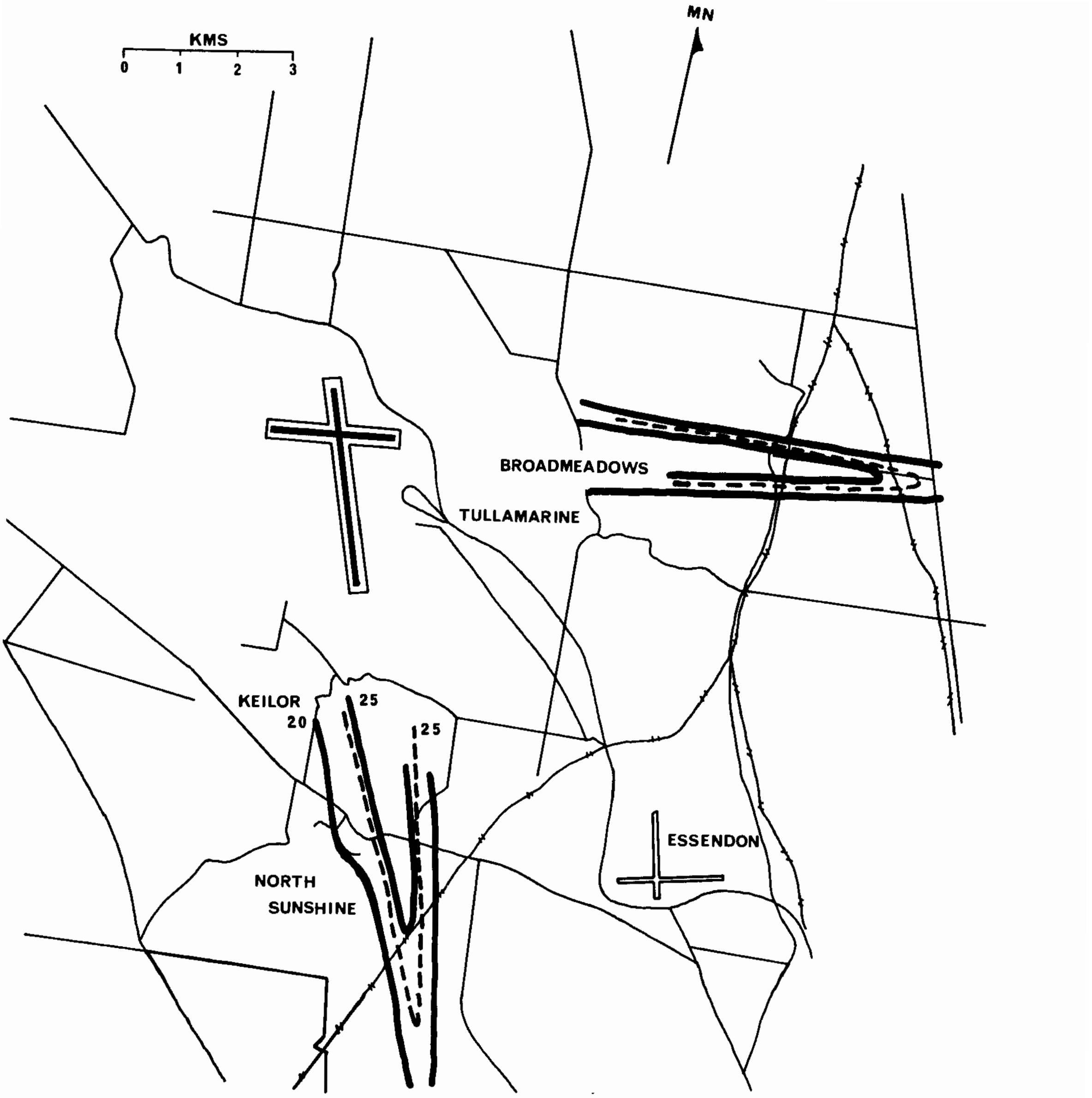


FIGURE 9.6 Noise exposure contours around MELBOURNE airport.
—— Revised NEF (20 & 25), - - - standard NEF (25).
(Contours calculated only for residential areas).

(Figure 9.5) where the 25 contour for standard NEF falls outside the 20 contour for revised NEF.

9.2 Population Affected by Aircraft Noise

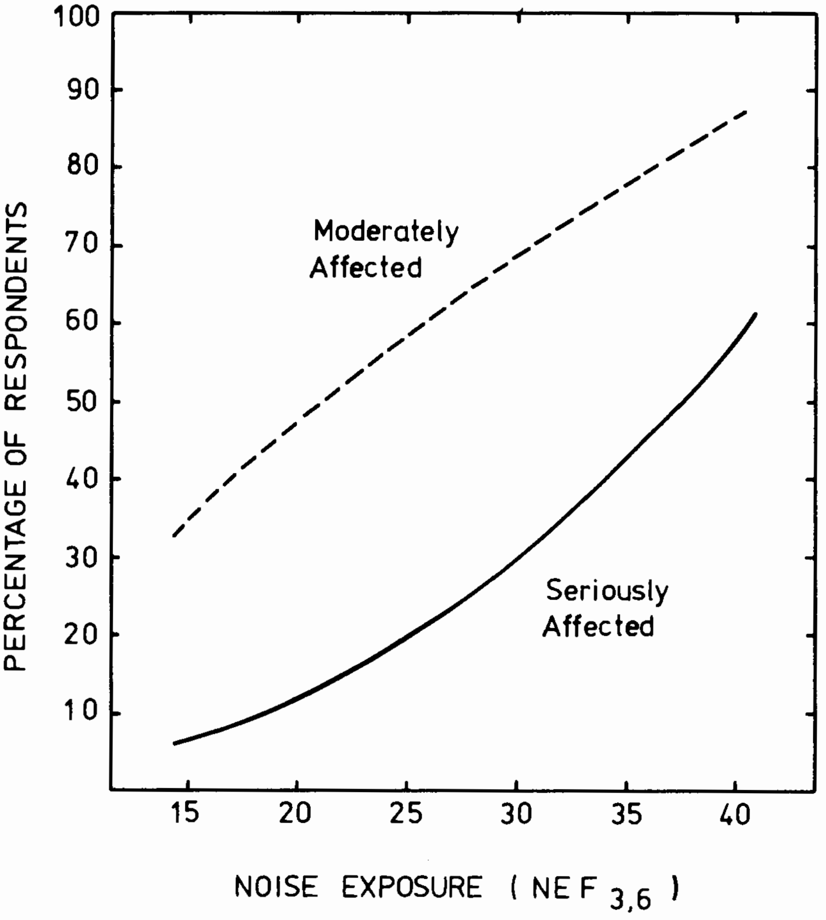
From the dose/response data it is possible to calculate the number of people affected by aircraft noise around the various airports. Firstly, contours were plotted for the values of $NEF_{3,6}$ in 5 dB steps from 20 to 40 using the procedure outlined above. Counts were then made of the number of dwellings in each contour zone. The counts were made either from aerial photographs (scale = 1:10,000) or where appropriate, from Census data. Counts for the zone 15-20 NEF were estimated by extrapolation. The mean number of residents per dwelling was obtained for each flight path area from the social survey data (see 'Contact Record' in Appendix A). Finally, the numbers of individuals seriously or moderately affected were calculated using the percentage data obtained in the survey analysis. Full details of the estimates are given in Appendix E and a summary is provided in Table 9.2. Note that the estimate of the population moderately affected includes those who are seriously affected.

9.3 Implications for Land-Use

It cannot be disputed that many people in Australia are living in areas exposed to excessive amounts of aircraft noise. However, the issue of what constitutes "excessive" noise is a complex one involving subjective judgment in addition to scientific assessment. Moreover, the issue of what should be done about excessive aircraft noise is essentially a socio-political one and is beyond the scope of the scientist. The scientist can provide the dose/response relationship from which one can determine the extent to which a community will be adversely affected by various amounts of noise. From the results of this study the best estimate of this relationship is that reproduced in Figure 9.7 which plots community reaction as a function of exposure measured by the index $NEF_{3,6}$.

Airport	Seriously Affected	Moderately Affected
Sydney	78,800	231,300
Richmond	1,200	4,400
Adelaide	16,600	65,200
Perth	4,600	16,600
Melbourne	5,800	19,900

TABLE 9.2 Estimated numbers of residents seriously affected (GR $\geq$ 8) or moderately affected (GR $\geq$ 4) by aircraft noise around the five airports.



<u>FIGURE 9.7</u> Dose/response function. Community reaction as a function of aircraft noise exposure measured by the revised index $NEF_{3,6}$. (Clustered data).

It is clear from Figure 9.7 that there is no 'cut-off' in the sense of a point at which community reaction to aircraft noise increases sharply. Thus, in choosing a level at which aircraft noise can be described as "excessive", one is not choosing a cut-off. From the graph it can be seen that in areas with an exposure level of 20 NEF, almost half the residential population will be at least moderately affected, and 12% of residents will be seriously affected by aircraft noise. Considering what it means to be moderately or seriously affected (as defined by responses on the GR scale - see Section 5.4), it does not seem unreasonable to describe a $NEF_{3.6}$ value of 20 as an "excessive" amount of aircraft noise - more than is acceptable or desirable in a residential area. Therefore, it is considered appropriate that the 20 NEF contour be plotted on maps showing aircraft noise exposure around airports.

If it were possible to alter aircraft operations or to re-zone around airports so that there were no residential areas inside the 20 NEF contour, then the aircraft noise problem in Australia would be dramatically reduced. Even then, however, the problem would not be completely eliminated because many people are adversely affected by noise exposure levels less than 20 NEF (see Appendix E).

To describe 20 NEF as an excessive amount of aircraft noise is to offer a reasonable interpretation of the scientifically determined dose/response relationship. Whether or not areas with this exposure are incompatible with residential zoning is another matter. As scientists, the authors are charged with describing community reaction to aircraft noise. The task of <u>prescribing</u> regulations and standards relating to land-use around airports properly belongs to legislative and planning authorities. They must translate the findings of the present investigation into practical guidelines. This translation will necessarily involve reaching a compromise between what is desirable in terms of the quality of life in a residential area, and what is practicable given the demand for housing and the many other facets of urban community management.

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APPENDICES

APPENDIX A

THE INTERVIEW SCHEDULE

This section contains a copy of the interview schedule, along with the basic data for each question. Figures are given for the overall sample as well as for each airport (S = Sydney, R = Richmond, A = Adelaide, P = Perth, M = Melbourne). Percentages, means, medians, modes or raw numbers are recorded depending on which statistic is the most informative.

Unless otherwise stated percentages are based on the total numbers of respondents. Medians are based on the code numbers given in the question. For example, in Q.5 a median score of 2.0 would correspond to 'fairly good'. The reference for modes is stated wherever it is appropriate (e.g., the modes given for Q.6 refer to the features in Q.5). Where questions were asked according to a previous response (e.g., Q.8) actual numbers are reported to avoid ambiguity about the percentage base. Note in questions 3 and 4 the code letters were as follows: Q = Quiet, S = Safety, OR = Other response, AN=Aircraft noise, ON = Other noise).

In questions 18 to 36 the reported data include recoded 'Skips' unless otherwise indicated. (These questions were skipped if the respondent gave a zero rating in Q.17 for overall 'affect'). Skips were recoded as follows: negative responses were assumed in questions 18, 21, 22, 24, 25, 29, 30 & 35; zero ratings were assumed in questions 20, 23, 25 & 35; nil responses were assumed in questions 19, 27 & 36. For the remaining skipped questions no assumptions were made about 'Skip' respondents and they are omitted from the frequency data (cf. questions 26, 28, 31, 32, 33 & 34).

The interviewer training notes on each question are given at the end of this section.

CONFIDENTIAL

AUSTRALIAN GOVERNMENT

COMMUNITY SURVEY

ANSS - (1980)

Workload Number ☐☐☐☐	**Address Code** ☐☐
Respondent's Address: ----------------------------------- ----------------------------------- **Date:** / /80 **Time:** **Start:**___________ **Finish:**__________ **Interviewer's Name:** ________________________________	**Office** No. ☐☐☐☐ (2) ☐☐ (6)

1\. THE FIRST QUESTION IS:
HOW MANY YEARS HAVE YOU BEEN LIVING AT THIS ADDRESS?

Less than 1 year	☐	1
1 - 2 years	☐	2
2 - 5 years	☐	3
5 - 10 years	☐	4
More than 10 years	☐	5
All of life	☐	6
Don't know	☐	0

2\. HOW WOULD YOU RATE THIS NEIGHBOURHOOD OVERALL AS A PLACE TO LIVE?
IS IT VERY GOOD, FAIRLY GOOD, AVERAGE, FAIRLY BAD OR VERY BAD?

(Show Card A)

Very good	☐	1
Fairly good	☐	2
Average	☐	3
Fairly bad	☐	4
Very bad	☐	5
Don't know	☐	0

3\. WHAT ARE SOME OF THE THINGS YOU LIKE ABOUT LIVING IN THIS NEIGHBOURHOOD?... IS THERE ANYTHING ELSE YOU WOULD CONSIDER AN ADVANTAGE OF LIVING AROUND HERE?

– – – – – – – – – – – – – – – – – – – –

– – – – – – – – – – – – – – – – – – – –

– – – – – – – – – – – – – – – – – – – –

	Office	
Q	☐	1
S	☐	2
OR	☐	3
DK	☐	0

4\. WHAT ARE SOME OF THE THINGS YOU DISLIKE ABOUT LIVING IN THIS NEIGHBOURHOOD?...
IS THERE ANYTHING ELSE YOU WOULD CONSIDER A DISADVANTAGE OF LIVING AROUND HERE?

– – – – – – – – – – – – – – – – – – – –

– – – – – – – – – – – – – – – – – – – –

– – – – – – – – – – – – – – – – – – – –

	Office	
AN	☐	1
ON	☐	2
S	☐	3
OR	☐	4
DK	☐	0

	All	S	R	A	P	M
Percent	16.4	16.7	26.7	15.8	15.2	10.1
	10.4	11.6	12.5	9.3	7.6	10.9
	16.5	16.7	20.6	10.8	18.8	19.0
	17.0	16.4	12.2	15.8	17.4	25.2
	37.3	36.2	26.4	45.2	38.6	33.9
	2.3	2.4	1.6	3.0	2.3	0.8
	0.0	0.0	0.0	0.1	0.0	0.0
Percent	36.9	34.7	43.1	44.8	35.9	27.2
	31.6	30.6	30.2	31.3	32.6	35.3
	26.6	28.6	21.5	20.6	27.4	33.3
	3.2	3.5	3.5	1.7	3.7	3.4
	1.6	2.4	1.6	1.7	0.4	0.6
	0.1	0.2	0.0	0.0	0.0	0.3
Percent	23.3	18.8	28.3	25.8	26.2	27.5
	0.0	0.0	0.0	0.0	0.0	0.0
	76.5	80.9	71.7	74.2	73.5	72.0
	0.3	0.3	0.0	0.0	0.3	0.6
Percent	34.0	44.4	32.8	39.6	17.9	10.6
	7.6	7.6	9.6	6.3	8.7	6.7
	0.1	0.2	0.0	0.0	0.0	0.0
	57.9	47.4	57.6	53.9	73.0	81.5
	0.5	0.5	0.0	0.1	0.4	1.1

5. NOW I WOULD LIKE TO ASK YOU ABOUT SOME SPECIFIC NEIGHBOURHOOD FEATURES. USING THIS SCALE AGAIN (Show Card A) PLEASE GIVE A RATING FOR EACH ACCORDING TO WHAT YOU PERSONALLY THINK THIS NEIGHBOURHOOD IS LIKE.

FIRSTLY, WOULD YOU RATE THIS NEIGHBOURHOOD AS VERY GOOD, FAIRLY GOOD, AVERAGE, FAIRLY BAD OR VERY BAD FOR PUBLIC TRANSPORT? ... WHAT ABOUT ...?

	Very good	Fairly good	Average	Fairly bad	Very bad	DK
i) PUBLIC TRANSPORT	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 0
ii) SHOPPING CENTRES	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 0
iii) PARKS & PLAYGROUNDS	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 0
iv) AMOUNT OF POLLUTION	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 0
v) AMOUNT OF TRAFFIC	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 0
vi) COUNCIL & WATER RATES	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 0
vii) AMOUNT OF AIRCRAFT NOISE	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 0
viii) SCHOOLS & COLLEGES	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 0
ix) GENERAL SAFETY OF AREA	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 0

6. THESE FEATURES ARE LISTED ON THIS CARD (Show Card B). PLEASE READ THROUGH THEM AND TELL ME WHICH ONE YOU WOULD MOST LIKE TO HAVE IMPROVED IN THIS NEIGHBOURHOOD.

(Record: 1 - 9 Item number; 0 = DK) ☐

7. HOW WOULD YOU RATE YOUR HEALTH? IN GENERAL, WOULD YOU SAY YOUR HEALTH IS: VERY GOOD, FAIRLY GOOD, AVERAGE, FAIRLY BAD OR VERY BAD?

(Show Card A)

Very good	☐ 1
Fairly good	☐ 2
Average	☐ 3
Fairly bad	☐ 4
Very bad	☐ 5
DK	☐ 0

	All	S	R	A	P	M
Median	2.1	1.9	3.3	2.0	1.8	3.7
	2.0	2.0	2.2	1.9	1.5	2.5
	2.3	2.2	2.0	2.3	2.5	3.1
	2.9	3.4	2.1	2.7	2.3	2.6
	3.2	3.4	3.0	3.0	3.0	3.1
	2.9	2.9	3.0	2.5	3.0	3.1
	4.0	4.5	4.0	3.8	3.5	3.6
	2.1	2.1	2.0	2.1	1.9	2.3
	2.6	2.7	2.5	2.4	2.4	2.6
Mode	vii)	vii)	i)	vii)	v=vii)	i)
(See Q.5)						
Percent	43.0	42.8	40.5	39.6	46.2	46.5
	31.2	31.0	28.3	33.9	28.9	33.1
	20.2	20.3	24.1	20.8	19.5	16.2
	3.9	4.1	4.8	3.7	4.0	2.5
	1.7	1.8	2.3	2.0	1.3	1.4
	0.1	0.1	0.0	0.0	0.1	0.3

8. SOME PEOPLE FIND THAT THEIR <u>HEALTH</u> IS INFLUENCED BY CONDITIONS IN THEIR NEIGHBOURHOOD. FOR EXAMPLE, THEY MAY GET HEADACHES, HAVE ALLERGY PROBLEMS, FEEL TIRED AND IRRITABLE, AND SO ON.

IS THERE ANYTHING ABOUT LIVING IN THIS NEIGHBOURHOOD THAT YOU THINK MIGHT HAVE INFLUENCED YOUR HEALTH IN ANY WAY?

Yes ☐ 1
No ☐ 2
DK ☐ 0

If yes:

A. WHAT IS IT? ...
IS THERE ANYTHING ELSE ABOUT LIVING IN THIS NEIGHBOURHOOD THAT HAS INFLUENCED YOUR HEALTH?

Office

\- -

\- ☐

B. IN WHAT WAY HAS THIS INFLUENCED YOUR HEALTH?

Office

\- -

\- ☐

	All	S	R	A	P	M
Number	624	324	65	107	74	54
	2937	1183	244	602	606	302
	14	8	2	1	2	1
Number "Aircraft Noise"	202	125	16	37	11	13

9. I HAVE A LIST OF ENVIRONMENTAL CONDITIONS FOUND IN SOME NEIGHBOURHOODS. PLEASE SAY WHETHER YOU THINK THESE CONDITIONS IN THIS AREA MIGHT HAVE INFLUENCED YOUR HEALTH IN ANY WAY. THE FIRST ONE IS...

(<u>If yes - Probe</u>: IN WHAT WAY HAS THIS INFLUENCED YOUR HEALTH?)

	Yes	No	DK
i) POLLUTION FROM FACTORIES	☐ 1	☐ 2	☐ 0
<u>If yes</u>:			
IN WHAT WAY...? ________________		☐	
ii) TRAFFIC EXHAUST FUMES	☐ 1	☐ 2	☐ 0
<u>If yes</u>:			
IN WHAT WAY...? ________________		☐	
iii) AIRCRAFT NOISE	☐ 1	☐ 2	☐ 0
<u>If yes</u>:			
IN WHAT WAY...? ________________		☐	
iv) INDUSTRIAL WASTE	☐ 1	☐ 2	☐ 0
<u>If yes</u>:			
IN WHAT WAY...? ________________		☐	
v) TRAFFIC NOISE	☐ 1	☐ 2	☐ 0
<u>If yes</u>:			
IN WHAT WAY...? ________________		☐	
vi) OTHER CONDITIONS (Specify ____________)	☐ 1	☐ 2	☐ 0
<u>If yes</u>:			
IN WHAT WAY...? ________________		☐	

	All	S	R	A	P	M
Number						
"Yes"	227	170	6	20	14	17
Real effect	117	83	3	12	11	8
"Yes"	467	276	25	71	49	46
Real effect	211	120	6	36	25	24
"Yes"	817	444	75	150	94	54
Real effect	555	297	48	109	63	38
"Yes"	99	63	9	9	9	9
Real effect	31	19	3	4	3	2
"Yes"	432	251	42	50	62	27
Real effect	284	174	27	29	43	11
"Yes"	147	58	23	19	36	11
Real effect	69	20	11	9	20	9

10. THE NEXT QUESTION DEALS WITH EVERYDAY THINGS THAT MANY PEOPLE FIND ANNOYING, THINGS THAT GET ON THEIR NERVES. FOR EACH OF THE SITUATIONS I READ OUT WOULD YOU PLEASE USE THIS OPINION THERMOMETER TO GIVE A RATING BETWEEN 0 AND 10 OF HOW MUCH ANNOYANCE YOU FEEL (Show OT).

FOR EXAMPLE, IF YOU FIND THE SITUATION VERY MUCH ANNOYING GIVE IT A HIGH RATING (SAY 9 OR 10), IF YOU FEEL MODERATE ANNOYANCE GIVE IT A RATING AROUND 5, AND IF YOU FEEL LITTLE OR NO ANNOYANCE GIVE IT A LOW RATING AROUND 0. PLEASE BASE YOUR RATING ON YOUR OWN PERSONAL EXPERIENCE AND DISREGARD HOW OTHERS MIGHT FEEL.

FIRSTLY, HOW MUCH ANNOYANCE DO YOU FEEL WHEN...?

(Record: 00-10 = Rating; 11 = Don't Know; 12 = Never Experienced)

i) YOU ARE HELD UP IN TRAFFIC ☐☐

ii) YOU ARE WOKEN UP BY A DOG BARKING ☐☐

iii) AN UNANSWERED TELEPHONE KEEPS ON RINGING ☐☐

iv) YOU ARE UNABLE TO FIND A SPACE IN A CAR PARK ☐☐

v) SOMEONE IS READING OVER YOUR SHOULDER ☐☐

vi) YOU ARE TRYING TO CONCENTRATE IN NOISY SURROUNDINGS ☐☐

vii) A PERSON NEVER STOPS COMPLAINING ☐☐

viii) SOMEONE PUSHES IN AHEAD OF YOU IN A QUEUE ☐☐

ix) SOMEONE USES A MOTOR MOWER WHILE YOU ARE RESTING ☐☐

x) YOU SMELL VEHICLE EXHAUST FUMES ☐☐

xi) YOU HEAR A JET PASSING OVERHEAD ☐☐

xii) YOU HAVE TO STAND UP ON PUBLIC TRANSPORT ☐☐

xiii) YOUR CONVERSATION IS INTERRUPTED BY TRAFFIC NOISE ☐☐

xiv) YOU SEE LITTER IN A PUBLIC PARK ☐☐

xv) A NEIGHBOUR'S RADIO OR TV IS PLAYING LOUDLY ☐☐

xvi) YOU FIND A PUBLIC TELEPHONE OUT-OF-ORDER ☐☐

	All	S	R	A	P	M
Mean	5.1	5.2	5.2	4.7	4.7	5.6
	4.3	4.0	4.5	4.2	4.5	5.0
	3.7	3.5	3.6	3.9	3.8	4.3
	5.1	5.2	4.8	5.1	4.8	5.5
	3.8	3.6	4.0	3.9	4.2	3.6
	5.3	5.2	5.4	5.5	5.4	5.5
	6.6	6.5	6.7	6.5	6.9	6.5
	6.6	6.6	6.5	6.5	6.7	6.8
	3.9	3.8	4.1	4.0	3.7	4.1
	4.6	4.8	4.6	4.6	4.2	4.8
	5.4	6.3	5.3	5.6	4.0	4.4
	3.9	4.2	4.5	3.6	3.2	4.1
	4.4	4.6	4.5	4.5	4.0	4.4
	7.3	7.1	7.6	7.3	7.3	7.5
	4.3	4.0	4.6	4.8	4.0	4.6
	7.6	7.8	7.9	7.2	7.1	8.1

11. COULD YOU PLEASE TELL ME HOW MANY DAYS PER WEEK YOU ARE USUALLY AT HOME IN THE MORNING. COUNT ALL DAYS INCLUDING WEEKENDS. ...

AND HOW MANY AFTERNOONS ARE YOU USUALLY AT HOME? ...

AND FINALLY, HOW MANY EVENINGS ARE YOU USUALLY AT HOME?

(Record: 0-7 = Days at home; 9 = DK)

Morning ☐

Afternoon ☐

Evening ☐

---

12. BY THE WAY, HAD YOU HEARD ABOUT THIS SURVEY BEFORE?

Yes	☐	1
No	☐	2
DK	☐	0

If yes: WHAT HAD YOU HEARD?

Office

_ ☐

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

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13. THIS SURVEY IS GENERALLY INTERESTED IN ALL NEIGHBOURHOOD CONDITIONS, BUT IN PARTICULAR WE ARE INTERESTED IN THE VARIOUS KINDS OF NOISE PEOPLE HEAR IN DIFFERENT AREAS OF AUSTRALIA.

WHAT ARE THE KINDS OF NOISE YOU HEAR IN THIS NEIGHBOURHOOD? ...

ARE THERE ANY OTHER KINDS OF NOISE YOU HEAR IN THIS AREA?

Office

_ _

_ ☐

	All	S	R	A	P	M
Median	3.9	3.5	4.3	4.2	4.3	3.8
	4.0	4.1	4.4	3.5	4.4	3.6
	6.2	6.4	6.2	5.9	6.2	6.4
Number	88	27	9	28	21	3
	3474	1482	299	679	660	354
	13	6	3	3	1	0
"Aircraft Noise"	10	1	2	5	1	1
Percent "Aircraft Noise"	75.9	75.9	86.5	78.6	70.7	71.4

14. I HAVE A LIST OF NOISES HERE. WOULD YOU PLEASE TELL ME WHETHER OR NOT YOU EVER <u>HEAR</u> THE FOLLOWING NOISES IN THIS NEIGHBOURHOOD?

	Yes	No	DK	
i) TRAFFIC	☐ 1	☐ 2	☐ 0	(76)
ii) LAWN MOWERS	☐ 1	☐ 2	☐ 0	
iii) AIRCRAFT	☐ 1	☐ 2	☐ 0	
iv) DOGS & CATS	☐ 1	☐ 2	☐ 0	
v) ROAD WORKS	☐ 1	☐ 2	☐ 0	
vi) TRAINS	☐ 1	☐ 2	☐ 0	(8)
vii) NEIGHBOURS' TV OR RADIO	☐ 1	☐ 2	☐ 0	
viii) GARBAGE COLLECTION	☐ 1	☐ 2	☐ 0	
ix) OTHER NOISES (Specify)	☐ 1	☐ 2	☐ 0	

\- - - - - - - - - - - -

	All	S	R	A	P	M
% "Yes"	87.8	87.5	91.6	87.0	90.2	82.9
	78.9	72.3	88.1	81.3	83.4	85.2
	98.1	97.7	99.0	98.9	97.9	98.0
	77.5	72.0	79.4	78.6	83.0	86.6
	22.6	19.9	21.5	26.1	26.2	20.7
	28.0	22.7	45.7	5.9	41.5	53.5
	31.9	34.1	42.1	28.5	28.4	27.5
	48.8	45.6	70.1	53.7	42.8	45.9
	20.9	19.1	28.3	19.7	21.7	22.7

14. I HAVE A LIST OF NOISES HERE. WOULD YOU PLEASE TELL ME WHETHER OR NOT YOU EVER HEAR THE FOLLOWING NOISES IN THIS NEIGHBOURHOOD?

	Q.15 Annoyance
i) TRAFFIC	☐☐
ii) LAWN MOWERS	☐☐
iii) AIRCRAFT	☐☐
iv) DOGS & CATS	☐☐
v) ROAD WORKS	☐☐
vi) TRAINS	☐☐
vii) NEIGHBOURS' TV OR RADIO	☐☐
viii) GARBAGE COLLECTION	☐☐
ix) OTHER NOISES (Specify)	☐☐

_ _ _ _ _ _ _ _ _ _ _ _

15. I WILL READ THROUGH THE LIST AGAIN. THIS TIME PLEASE USE THE OPINION THERMOMETER TO RATE HOW MUCH ANNOYANCE YOU FEEL ABOUT THESE NOISES IN THIS NEIGHBOURHOOD. BASE YOUR RATING ON YOUR OWN PERSONAL EXPERIENCE.

FIRSTLY, HOW MUCH ANNOYANCE DO YOU FEEL ABOUT NOISE FROM...?

(Read only the items that received a 'yes' response in Q.14 and record as previously)

16. SUPPOSE YOU COULD GET RID OF ONE OF THESE NOISES FROM THE NEIGHBOURHOOD, WHICH ONE WOULD YOU MOST LIKE TO GET RID OF?

(Show Card C)

(Record: 1-9 = Item number; 0 = DK) ☐

17. THIS SURVEY IS PARTICULARLY INTERESTED IN HOW PEOPLE ARE AFFECTED BY AIRCRAFT NOISE.

WOULD YOU PLEASE USE THE OPINION THERMOMETER TO ESTIMATE HOW MUCH YOU PERSONALLY ARE AFFECTED BY AIRCRAFT NOISE OVERALL.

(Record: 00-10 = Rating; 11 = DK) ☐☐

Mean	3.9	4.3	4.2	3.6	3.5	3.5
	2.3	2.3	2.7	2.4	1.9	2.5
	5.9	6.7	6.0	6.0	4.5	5.0
	3.3	3.1	3.4	3.2	3.4	4.1
	0.7	0.7	0.6	0.7	0.6	0.7
	0.7	0.6	1.1	0.1	0.8	1.8
	1.3	1.4	1.8	1.1	1.0	1.0
	1.4	1.5	3.0	1.2	0.6	1.2
	1.1	1.1	1.6	0.9	1.1	1.3
Mode (See Q.14)	iii)	iii)	iii)	iii)	iii)	iii)
Mean	5.4	6.2	5.6	5.3	3.9	4.5

NOTE: Interviewers to complete

If a zero rating was given in the previous question skip to question 37. Otherwise continue with next question.

Skip ☐ 0

Continue ☐ 1

18. FOR EACH OF THE FOLLOWING ACTIVITIES PLEASE TELL ME WHETHER OR NOT YOU FIND THAT THEY ARE DISTURBED BY AIRCRAFT NOISE.

FIRSTLY, DO YOU FIND THAT AIRCRAFT NOISE IN THIS NEIGHBOURHOOD DISTURBS CONVERSATION?...

WHAT ABOUT...?

	Yes	No	DK
i) CONVERSATION	☐ 1	☐ 2	☐ 0
ii) WATCHING TELEVISION (i.e., TV FLICKER)	☐ 1	☐ 2	☐ 0
iii) LISTENING TO TV, RADIO OR MUSIC	☐ 1	☐ 2	☐ 0
iv) SLEEPING	☐ 1	☐ 2	☐ 0
v) RELAXING	☐ 1	☐ 2	☐ 0
vi) READING OR STUDYING	☐ 1	☐ 2	☐ 0
vii) ENTERTAINING	☐ 1	☐ 2	☐ 0
viii) OTHER (Specify) ____________________	☐ 1	☐ 2	☐ 0

19. SUPPOSE YOU COULD ELIMINATE THE DISTURBANCE AIRCRAFT NOISE CAUSES TO ONE OF THESE ACTIVITIES, WHICH ONE WOULD YOU MOST LIKE TO HAVE FREE FROM DISTURBANCE?

(Show Card D)

(Record: 1-8 = Item number; 0 = DK) ☐

20. HOW MUCH ANNOYANCE DO YOU FEEL OVERALL BECAUSE OF ACTIVITY DISTURBANCES CAUSED BY AIRCRAFT NOISE?

PLEASE USE THE OPINION THERMOMETER TO GIVE A RATING OF YOUR ANNOYANCE.

(Record: 00-10 = Rating; 11 = Don't Know) ☐☐

	All	S	R	A	P	M
Percent	19.8	16.5	14.1	18.2	29.5	23.8
	80.2	83.5	85.9	81.8	70.5	76.2
% "Yes"	60.9	68.9	66.6	61.3	46.8	49.3
	61.3	67.0	68.2	57.9	46.5	66.4
	65.4	70.6	69.1	67.5	53.8	57.7
	32.5	34.7	32.2	33.7	28.9	28.3
	37.7	44.9	41.2	36.5	24.8	31.1
	30.6	36.6	33.4	30.1	20.2	23.5
	39.4	47.5	40.5	39.6	28.2	25.5
	9.0	10.5	10.9	10.4	6.6	2.5
Mode (See Q.18)	ii)	ii)	ii)	iii)	iv)	ii)
Mean	5.5	6.2	5.6	5.4	4.0	4.7

21. DO YOU FIND THAT AIRCRAFT MAKE THIS HOUSE (UNIT) VIBRATE OR SHAKE?

Yes	☐	1
No	☐	2
DK	☐	0

22. DO YOU FIND THAT AIRCRAFT NOISE STARTLES YOU OR MAKES YOU JUMP?

Yes	☐	1
No	☐	2
DK	☐	0

23. USING THE OPINION THERMOMETER AGAIN WOULD YOU PLEASE ESTIMATE HOW MUCH YOU FEEL FRIGHTENED OR WORRIED BY AIRCRAFT NOISE.

(Record: 00-10 = Rating; 11 = DK) ☐☐

24. A. I WOULD LIKE TO FIND OUT WHAT IT IS THAT BOTHERS PEOPLE ABOUT THE NOISE THAT AIRCRAFT MAKE. PLEASE SAY WHETHER OR NOT YOU ARE BOTHERED BY ANY OF THE FOLLOWING THINGS.

FIRSTLY ARE YOU BOTHERED BY...?

	Yes	No	DK
i) THE LOUDNESS OF THE NOISE	☐ 1	☐ 2	☐ 0
ii) THE LOW ROARING SOUND OF THE ENGINES	☐ 1	☐ 2	☐ 0
iii) THE HIGH-PITCHED WHINE OF THE ENGINES	☐ 1	☐ 2	☐ 0
iv) THE TIME THE PLANE TAKES TO PASS OVER	☐ 1	☐ 2	☐ 0
v) CHANGES IN THE SOUND OF THE ENGINES	☐ 1	☐ 2	☐ 0

B. IS THERE ANYTHING ELSE ABOUT THE SOUND OF THE AIRCRAFT THAT BOTHERS YOU?

Office

\- ☐

	All	S	R	A	P	M
Percent	55.0	52.7	62.7	59.3	52.9	53.2
	44.8	47.1	37.3	40.6	46.9	46.5
	0.2	0.2	0.0	0.1	0.1	0.3
Percent	19.5	21.6	21.5	19.4	15.7	16.5
	80.4	78.2	78.5	80.6	84.3	83.5
	0.1	0.3	0.0	0.0	0.0	0.0
Mean	2.9	3.4	2.9	2.9	1.9	3.1
% "Yes"	65.2	72.2	65.0	68.0	50.6	58.0
	48.6	53.6	50.8	51.1	34.5	47.9
	42.3	48.5	46.9	39.7	32.8	34.7
	44.6	52.5	43.7	45.1	30.1	38.4
	26.4	31.6	22.5	24.9	18.2	26.3

25. SOME PEOPLE FIND THAT THEIR HEALTH IS INFLUENCED BY AIRCRAFT NOISE. FOR EXAMPLE, THEY MAY GET HEADACHES, FEEL TIRED AND IRRITABLE, AND SO ON.

DO YOU THINK THE AIRCRAFT NOISE IN THIS NEIGHBOURHOOD MIGHT HAVE INFLUENCED YOUR HEALTH IN ANY WAY?

Yes ☐ 1
No ☐ 2
DK ☐ 0

If yes: A. IN WHAT WAY HAS AIRCRAFT NOISE INFLUENCED YOUR HEALTH?

Office
☐

____

____

B. PLEASE USE THE OPINION THERMOMETER TO ESTIMATE HOW MUCH YOUR HEALTH HAS BEEN AFFECTED BY AIRCRAFT NOISE.

(Record: 00-10 = Rating; 11 = DK) ☐☐

26. WHAT DO YOU THINK AFFECTS HOW YOU FEEL ABOUT AIRCRAFT NOISE? IS IT THE NOISIEST PLANE YOU HEAR, OR IS IT THE STEADY BUILD-UP OF ALL THE PLANES YOU HEAR IN A DAY, OR WOULD YOU SAY THESE TWO ASPECTS AFFECT YOU EQUALLY.

Noisiest ☐ 1
Build-up ☐ 2
Equal ☐ 3
DK ☐ 0

27. SUPPOSE YOU WERE ABLE TO HAVE AIRCRAFT STOPPED FROM FLYING OVER IN ONE OF THESE 3-HOUR PERIODS (Show Card E), WHICH ONE WOULD YOU MOST LIKE TO HAVE FREE FROM AIRCRAFT NOISE?

(Record: 1-8 = Period; 0 = DK) ☐

28. DO YOU HEAR THE NOISE OF PLANES WHEN THEY ARE AT THE AIRPORT ITSELF, AS DISTINCT FROM FLYING OVERHEAD?

Yes ☐ 1
No ☐ 2
DK ☐ 0

	11	S	R	A	P	M
Number	552	321	45	102	51	33
	3000	1180	265	604	629	322
	23	14	1	4	2	2
Number (Real Effect)	477	274	38	91	45	29
Mean	0.8	1.2	0.6	0.9	0.3	0.4
Percent (Non-Skip)	36.5	27.4	42.3	40.4	47.2	46.0
	18.2	22.5	21.3	14.5	10.8	16.2
	38.6	44.3	27.0	40.4	31.4	32.0
	6.7	5.7	9.4	4.6	10.6	5.9
Mode	6-9pm	6-9pm	6-9pm	6-9pm	12-3am	6-9pm
Number (Non-Skip)	1255	471	148	353	226	57
	1601	786	119	228	253	215
	10	8	0	0	2	0

29. HAVE YOU OR YOUR FAMILY EVER TRIED TO DO ANYTHING TO HAVE THE AIRCRAFT NOISE REDUCED IN THIS NEIGHBOURHOOD?

Yes ☐ 1
No ☐ 2
DK ☐ 0

If yes: WHAT DID YOU DO?

_ _

_ _

Office ☐

If no: IS THERE ANY PARTICULAR REASON YOU HAVEN'T TRIED TO DO ANYTHING?

_ _

_ _

Office ☐

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30. I HAVE A LIST OF SOME OF THE THINGS PEOPLE DO TO HAVE CONDITIONS IMPROVED IN THEIR NEIGHBOURHOODS. PLEASE SAY WHETHER OR NOT YOU WOULD LIKE TO DO ANY OF THESE THINGS IN RELATION TO AIRCRAFT NOISE. FIRSTLY, DO YOU FEEL YOU WOULD LIKE TO SIGN A PETITION? ... WHAT ABOUT ...?

	Yes	No	DK
i) SIGN A PETITION	☐ 1	☐ 2	☐ 0
ii) COMPLAIN TO LOCAL OFFICIALS	☐ 1	☐ 2	☐ 0
iii) COMPLAIN TO YOUR MEMBER OF PARLIAMENT	☐ 1	☐ 2	☐ 0
iv) WRITE A LETTER TO THE EDITOR	☐ 1	☐ 2	☐ 0
v) ATTEND A MEETING OF NEIGHBOURS	☐ 1	☐ 2	☐ 0
vi) ATTEND A PROTEST RALLY	☐ 1	☐ 2	☐ 0
vii) BECOME A MEMBER OF A PROTEST GROUP	☐ 1	☐ 2	☐ 0
viii) TAKE SOME KIND OF LEGAL ACTION	☐ 1	☐ 2	☐ 0

NOTE: Omit next question (Q.31) if response to Q.1 was "all of life".

	All	S	R	A	P	M
Percent	11.5	17.4	5.8	12.8	2.8	5.9
	88.4	82.5	93.9	87.2	97.1	94.1
	0.2	0.1	0.3	0.0	0.1	0.0
Mode (See Q.30)	i)	i)	ii)	i)	ii)	ii)
% "Yes"	50.2	60.1	37.6	53.1	33.3	45.7
	31.9	39.8	24.4	33.4	18.5	27.2
	30.4	37.0	24.1	33.0	19.2	24.6
	16.3	21.0	13.2	15.4	9.8	13.2
	35.6	41.5	25.4	38.6	25.4	33.3
	17.2	22.8	12.9	19.4	7.8	10.6
	10.9	14.1	7.1	12.7	5.6	7.3
	9.0	12.6	5.5	8.5	4.4	6.4

31. DID YOU KNOW ABOUT THE AIRCRAFT NOISE IN THIS NEIGHBOURHOOD BEFORE YOU MOVED HERE?

Yes	☐	1
No	☐	2
DK	☐	0

If yes:
IS THE AIRCRAFT NOISE IN THIS AREA DIFFERENT FROM WHAT YOU EXPECTED? IS IT MUCH MORE, A BIT MORE, ABOUT THE SAME, A BIT LESS OR MUCH LESS THAN YOU EXPECTED BEFORE YOU MOVED HERE?

(Show Card F)

Much more	☐	1
A bit more	☐	2
About the same	☐	3
A bit less	☐	4
Much less	☐	5
DK	☐	0

If "more", or if "no" to first part:
DO YOU THINK YOU WOULD HAVE STILL MOVED HERE HAD YOU KNOWN HOW MUCH AIRCRAFT NOISE THERE WOULD BE?

Yes	☐	1
No	☐	2
DK	☐	0

32. DO YOU THINK YOU HAVE BECOME USED TO AIRCRAFT NOISE IN THE TIME YOU HAVE BEEN LIVING IN THIS NEIGHBOURHOOD?

Yes	☐	1
No	☐	2
DK	☐	0

33. HAS THE AMOUNT OF AIRCRAFT NOISE IN THIS NEIGHBOURHOOD CHANGED OVER THE PAST FIVE YEARS (If less than 5 years say: SINCE YOU MOVED HERE)? IS IT MUCH MORE, A BIT MORE, ABOUT THE SAME, A BIT LESS OR MUCH LESS THAN IT WAS BEFORE?

Much more	☐	1
A bit more	☐	2
About the same	☐	3
A bit less	☐	4
Much less	☐	5
DK	☐	0

	All	S	R	A	P	M
Number	1448	578	209	319	230	112
(Non Skip)	1315	636	54	240	229	156
	103	51	4	22	22	4
	387	206	42	80	38	21
	289	116	45	69	41	18
	652	210	114	143	125	60
	94	38	14	18	15	9
	43	9	4	14	11	5
	8	4	2	0	2	0
	1065	493	97	175	200	100
	690	386	32	131	89	52
	167	30	3	76	19	39
Percent	74.1	67.4	78.3	73.3	84.6	84.2
(Non Skip)	25.0	31.1	21.0	26.5	14.3	15.4
	0.9	1.4	0.8	0.2	1.0	0.4
Percent	28.1	34.3	24.0	23.9	22.5	22.4
(Non Skip)	26.8	25.5	28.8	26.2	29.9	26.1
	40.8	35.7	44.2	47.8	41.6	45.2
	2.7	2.8	2.6	1.5	2.9	4.8
	0.7	0.6	0.0	0.5	1.5	0.7
	0.9	1.2	0.4	0.0	1.7	0.7

34. HAVE YOU EVER SERIOUSLY CONSIDERED MOVING FROM THIS NEIGHBOURHOOD BECAUSE OF THE AIRCRAFT NOISE?

Yes ☐ 1
No ☐ 2
DK ☐ 0

If yes:
WHAT SORT OF REASONS DID YOU HAVE FOR DECIDING NOT TO LEAVE?

☐

- - - - - - - - - - - - - - - - - - - -

If no:
DO YOU THINK YOU WOULD SERIOUSLY CONSIDER MOVING IF THE AMOUNT OF AIRCRAFT NOISE INCREASED IN THE FUTURE?

Yes ☐ 1
No ☐ 2
DK ☐ 0

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35. HAVE YOU EVER THOUGHT THAT THERE IS A DANGER THAT A PLANE MIGHT CRASH IN THIS NEIGHBOURHOOD?

Yes ☐ 1
No ☐ 2
DK ☐ 0

If yes:
USING THE OPINION THERMOMETER WOULD YOU PLEASE ESTIMATE HOW MUCH YOU FEEL AFRAID OR WORRIED ABOUT A POSSIBLE PLANE CRASH IN THIS NEIGHBOURHOOD.

(Record: 00-10 = Rating; 11 = DK) ☐☐

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36. HOW WOULD YOU DESCRIBE YOUR GENERAL FEELINGS ABOUT THE AIRCRAFT NOISE IN THIS NEIGHBOURHOOD? WOULD YOU SAY YOU ARE:

HIGHLY ANNOYED ☐ 1
CONSIDERABLY ANNOYED ☐ 2
MODERATELY ANNOYED ☐ 3
SLIGHTLY ANNOYED ☐ 4
(Show Card G) NOT AT ALL ANNOYED ☐ 5
(DK) ☐ 0

	All	S	R	A	P	M
Number	588	351	52	99	52	34
(Non Skip)	2276	913	214	482	429	238
	2	1	1	0	0	0
	Modal reason in all cases: FINANCIAL					
Number	1067	460	105	220	166	116
	1133	430	108	245	239	111
	92	42	4	16	23	7
Percent	52.5	56.9	63.0	51.0	39.6	52.4
	47.2	42.7	36.7	48.9	60.4	47.3
	0.2	0.4	0.3	0.1	0.0	0.3
Mean	3.2	3.8	3.4	2.8	2.1	3.5
Percent	16.1	24.2	9.3	14.8	5.6	10.4
	15.4	17.6	17.0	17.0	10.1	11.8
	19.1	19.1	20.6	19.7	16.6	21.6
	16.6	13.5	19.6	17.5	19.6	19.9
	32.7	25.6	33.4	31.0	47.9	36.4
	0.1	0.2	0.0	0.0	0.1	0.0

NOTE: In case of 'SKIP' resume interview with next question (Q.37).

37. I WOULD LIKE TO ASK ABOUT YOUR GENERAL ATTITUDES AND OPINIONS ON AIRCRAFT NOISE. I WILL READ OUT A NUMBER OF STATEMENTS, AND FOR EACH OF THEM WOULD YOU PLEASE USE THIS CARD (Show Card H) TO INDICATE WHETHER YOU: STRONGLY AGREE, AGREE, ARE UNDECIDED, DISAGREE OR STRONGLY DISAGREE.

THE FIRST STATEMENT IS:

	SA	A	U	D	SD	DK
i) THE AIRPORT SHOULD BE MOVED TO AN AREA WHERE THERE ARE NO HOUSES.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0
ii) AIRCRAFT NOISE IS REALLY NOT MUCH OF A PROBLEM.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0
iii) PILOTS DO THEIR BEST TO KEEP THE NOISE DOWN WHEN FLYING OVER RESIDENTIAL AREAS.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0
iv) MOST PEOPLE WHO COMPLAIN ABOUT AIRCRAFT NOISE ARE JUST TROUBLEMAKERS.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0
v) THE GOVERNMENT HAS NO REAL CONCERN FOR PEOPLE AFFECTED BY AIRCRAFT NOISE.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0
vi) AIRPORT OFFICIALS ARE CONTINUALLY TRYING TO FIND WAYS OF REDUCING AIRCRAFT NOISE DISTURBANCE TO RESIDENTS.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0
vii) IT IS NO USE COMPLAINING ABOUT AIRCRAFT NOISE BECAUSE NO ONE WILL EVER DO ANYTHING ABOUT IT.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0
viii) WHATEVER THE INCONVENIENCE TO AIRLINES THERE SHOULD BE MORE RESTRICTIONS ON AIRCRAFT FLIGHTS OVER RESIDENTIAL AREAS.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0
ix) AIRLINES DO NOT CARE ABOUT THE DISRUPTION CAUSED BY AIRCRAFT NOISE.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0
x) AIRCRAFT MANUFACTURERS SPEND A LOT OF MONEY TRYING TO REDUCE THE NOISE OF AIRCRAFT ENGINES.	☐ 5	☐ 4	☐ 3	☐ 2	☐ 1	☐ 0

	All	S	R	A	P	M
Median	3.9	4.0	3.4	4.0	3.7	3.6
	2.4	2.1	2.6	2.4	3.5	3.3
	3.2	3.1	3.2	3.2	3.3	3.1
	2.1	2.0	2.2	2.1	2.2	2.2
	3.1	3.4	3.0	3.1	2.8	3.2
	3.3	3.3	3.3	3.3	3.5	3.2
	2.8	3.1	3.2	2.5	2.4	3.1
	3.8	3.9	3.6	3.8	3.6	3.7
	3.1	3.5	2.5	3.1	2.7	2.9
	3.4	3.4	3.5	3.5	3.6	3.4

38. HOW DISSATISFIED ARE YOU WITH THE AMOUNT OF AIRCRAFT NOISE IN THIS NEIGHBOURHOOD?

PLEASE USE THE OPINION THERMOMETER TO ESTIMATE HOW MUCH DISSATISFACTION YOU FEEL OVERALL.

(Record: 00-10 = Rating; 11 = DK) ☐☐

39. ARE THERE ANY OTHER COMMENTS YOU WOULD LIKE TO MAKE ABOUT AIRCRAFT NOISE OR ABOUT ANY OTHER ASPECT OF LIVING IN THIS NEIGHBOURHOOD?

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40. FINALLY, I NEED TO GET SOME BACKGROUND INFORMATION FOR STATISTICAL PURPOSES.

WOULD YOU PLEASE INDICATE YOUR AGE GROUP FROM THE CATEGORIES ON THIS CARD.

(Show Card I)

18-29 yrs ☐ 1
30-39 yrs ☐ 2
40-49 yrs ☐ 3
50-59 yrs ☐ 4
60-69 yrs ☐ 5
Over 70 yrs ☐ 6
Refuse ☐ 7

41. WHAT IS YOUR OCCUPATION?

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Office
☐

42. Interviewers to complete

Sex of Respondent
Male ☐ 1
Female ☐ 2

	All	S	R	A	P	M
Mean	5.1	6.0	4.8	5.1	3.7	4.3
Percent	27.3	25.4	33.4	24.8	28.3	33.3
	20.7	21.3	18.3	16.5	18.3	33.1
	16.1	16.6	15.1	14.9	15.4	18.2
	13.8	13.5	14.5	14.1	17.0	8.1
	12.4	12.6	10.0	17.5	11.9	4.8
	9.5	10.4	8.4	12.3	8.9	2.2
	0.1	0.1	0.3	0.0	0.1	0.3
See over for details of occupation						
Percent	43.9	44.8	47.9	45.1	41.6	39.2
	56.1	55.2	52.1	54.9	58.4	60.8

43. FROM THIS CARD (<u>Show Card J</u>) PLEASE TELL ME WHAT IS THE HIGHEST LEVEL OF <u>EDUCATION</u> YOU HAVE COMPLETED?

1 - 3 yrs Primary	☐	1
4 - 6 yrs Primary	☐	2
1 - 4 yrs Secondary	☐	3
5 - 6 yrs Secondary	☐	4
1 - 2 yrs Tertiary	☐	5
3 + yrs Tertiary	☐	6
Refuse	☐	7
DK	☐	0

<u>If Tertiary</u>:

COULD YOU PLEASE TELL ME THE NAME OF THE TERTIARY INSTITUTION YOU ATTENDED?

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

<u>Office</u>

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44. DO YOU OR YOUR FAMILY OWN THIS HOUSE (UNIT), ARE YOU BUYING IT OR DO YOU RENT IT?

Own	☐	1
Buying	☐	2
Renting	☐	3
DK or other	☐	0

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45. <u>Interviewers to complete</u>

Type of dwelling

House	☐	1
Semi-detached	☐	2
Villa-home	☐	3
Topfloor Unit	☐	4
Other Unit	☐	5
Other dwelling	☐	6

	All	S	R	A	P	M
Percent	0.8	1.0	1.0	1.00	0.1	1.1
	12.8	14.3	9.6	16.2	8.5	10.4
	54.5	51.4	57.6	52.3	63.8	52.1
	18.3	18.2	16.4	17.7	16.0	26.6
	5.1	5.2	6.8	5.1	5.0	3.6
	8.1	9.6	7.7	7.6	6.6	5.9
	0.1	0.1	0.0	0.0	0.0	0.0
	0.2	0.2	1.0	0.1	0.0	0.0
Percent	43.1	45.9	38.3	50.1	38.4	30.5
	30.8	25.5	21.2	27.2	37.2	56.9
	25.1	27.9	39.9	21.8	22.6	12.0
	1.0	0.7	0.6	0.8	1.8	0.6
Percent	77.5	63.2	83.3	78.6	95.6	96.1
	8.0	14.0	4.2	4.8	3.1	1.7
	3.4	4.8	0.6	5.6	0.7	0.6
	3.9	6.2	3.2	4.8	0.1	0.0
	6.7	11.3	6.4	5.9	0.1	1.7
	0.2	0.4	0.0	0.0	0.3	0.0

WORKLOAD NO. ☐☐☐☐

CONTACT RECORD

SCHEDULE NO. ☐

ADDRESS: Code ☐☐								
	HOUSEHOLD					RESPONDENT		
Call No.	1st Call	2nd Call	3rd Call	4th Call	5th Call	1st Call	2nd Call	3rd Call
Date								
Time								
Contact (√/x)								
Successful? Yes ☐ No ☐	If no: Non Contact ☐ Refusal ☐ Beyond Scope ☐ Explain:							

GOOD MORNING/AFTERNOON/EVENING, I'M ... (HERE'S MY IDENTIFICATION).

THIS ADDRESS HAS BEEN SELECTED IN AN OFFICIAL SURVEY THE AUSTRALIAN GOVERNMENT IS CONDUCTING ON NEIGHBOURHOOD LIVING CONDITIONS.

THE INFORMATION IS QUITE CONFIDENTIAL, AND WILL BE USED FOR PLANNING FUTURE COMMUNITY IMPROVEMENTS.

I NEED TO INTERVIEW ONLY ONE PERSON FROM THIS HOUSEHOLD, BUT THE PERSON TO BE INTERVIEWED HAS TO BE SELECTED RANDOMLY.

YOU CAN HELP BY FIRSTLY TELLING ME HOW MANY PEOPLE LIVE IN THIS HOUSEHOLD. ☐
NOW I NEED TO KNOW HOW MANY OF THEM ARE AGED 18 OR OVER. COULD YOU PLEASE TELL ME WHO THEY ARE? ☐

Person Number	Relationship to informant	Sex (Circle)	Age
1		M F	
2		M F	
3		M F	
4		M F	
5		M F	
6		M F	
7		M F	

INTERVIEWER NOTES ON THE QUESTIONS

Introduction This section outlines the purpose of each question and provides information on how the questions are to be administered in the interview. Specific notes are given on procedures for recording responses.

Question 1 This question is a straightforward 'ice-breaker'. It asks simply how long the respondent (R) has lived at the address. Even if R takes a little time working out precisely how many years do not suggest a "rough estimate" as this may be a cue to guessing throughout the interview. Rather, let the respondent give an estimate and tick the appropriate category. Probe if you are uncertain which category applies. For example, if R says "about 2 years" probe whether this means "1-2 years or 2-5 years". If the estimate seems to equal R's age and R does not volunteer "all my life", probe whether "all of life" is appropriate. (Note that Q.31 is omitted if the response here is "all of life".)

Question 2 This is a neutral question on satisfaction with the neighbourhood. It is important not only because it elicits an opinion unbiased by any specific reference to noise, but also because it introduces the respondent to the procedure for making a simple rating. Interviewers are to show the flash card but are still to read out the response categories listed in the schedule. Make sure R chooses one of the categories from the card. If, for example, R says "good" probe with "Would you say 'very good' or 'fairly good'?" An alternative probe would be the more general form "Would you please select one of the categories from the card".

Question 3 This and the next three questions are needed to get a perspective on how aircraft noise is perceived in relation to other neighbourhood conditions. Firstly, question 3 asks which features are liked about the area. Interviewers are to record everything that is said. When the respondent has finished his/her answer, the second part of the question is asked to ensure a complete answer. If R lists things disliked these are to be recorded in the space for the next question but that question is still to be asked.

Question 4 This is a crucial question which allows R to spontaneously mention aircraft noise as a feature disliked about the neighbourhood. Interviewers will have to be very careful not to react. Probe for a complete answer with the second part of the question, but be sure not to imply that something has been omitted if R does not mention aircraft noise. If R simply says "Noise" probe with "Could you be more specific?" but avoid appearing particularly interested in noise.

Question 5 This question asks R to rate a number of neighbourhood features. Obtain a rating for each feature in turn without making any reference to whether the features were given as responses to the two previous questions. Be consistent in the way you ask about each feature, making sure that you don't give any non-verbal cues, especially for the item about aircraft noise. If R wants to chat about the various features, record the comments but do not encourage the digression. At the appropriate moment interrupt with "What about...?" and go onto the next item.

Question 6 The respondent is asked to select which one feature is most worth having improved. Encourage R to make a choice from the features on the flash card. If R insists on nominating more than one then record them in the order they are given.

Question 7 This is the first of three questions designed to obtain an unbiased assessment of possible health effects. Question 7 simply asks for an overall rating of the respondent's health. Interviewers are to avoid getting drawn into lengthy explanations about why this question is being asked. If necessary, simply explain that the reason for asking about health will become clear in the next question, but ensure that R gives a rating here before asking Q.8.

Question 8 The preamble to this question is important, for it serves to focus respondents on neighbourhood conditions which may affect their health. This is a neutral form of a later question specifically on aircraft noise (Q.25), and is needed for assessing possible response bias. If R answers "yes", ask part A with the probe given, and then ask part B. Interviewers must guard against giving non-verbal cues that might lead R to suspect that aircraft noise is of particular significance.

Question 9 This is another neutral question on possible health effects - aircraft noise is listed as one of several environmental conditions. Respondents are asked whether they think the various conditions might have influenced their health. Whenever a "yes" response is given, probe with "In what way...?". All the items are to be asked in a consistently neutral manner, and no emphasis or hesitation must occur with the item on aircraft noise.

Question 10 This question is designed to assess respondents' sensitivity to noise annoyance and to general annoyance. A number of noise items are interspersed among other items - all must be asked in the same way with no emphasis on the noise items. The opinion thermometer is introduced here. As the preamble is read interviewers are to point to the relevant parts of the opinion thermometer - respondents will quickly understand its use. The opinion thermometer will be used frequently in later questions, and it is important that respondents become proficient in using it in this question. Note that the numbers '0-9' are recorded as '00-09' and that the code '12' is used if R reports never having been in the situation.

Question 11 In this question R is asked to state how many days per week he/she is at home in the morning/afternoon/evening. Obtain an estimate for each period in turn. Note that the 'DK' category is '9'. The information from this question will be used to determine whether the amount of time spent in the exposure area influences how much effect the noise has on an individual.

Question 12 In case word has spread around the neighbourhood this question is needed to check on prior knowledge of the survey, which is a potential source of response bias. Interviewers are to ask the first part offhandedly and if a positive response is given, to follow-up immediately with the second part without seeming to be reading from the schedule. In other words, do not tick the 'yes' box until after you have asked "What had you heard?".

Question 13 This question aims to introduce the topic of noise without implying that the respondent has been previously misled. In this open question R is invited to specify the noises heard in the neighbourhood and is given the opportunity to nominate aircraft noise. Interviewers must make sure they are neutral in their reactions to the responses given, and when probing they must not imply that something has been omitted.

Question 14 The respondent is asked to say whether or not various noises are ever heard. Some respondents can be expected to say "No" and then add something to the effect that they hear the noise but that it's not a problem. In such cases interviewers are to probe with "Do you ever hear noise from...around here?". If in doubt tick 'yes' - this question is essentially a lead-in for the next question.

Question 15 This question asks for an annoyance rating for the various neighbourhood noises. Ask about those noises for which the 'yes' box was ticked in the previous question. Avoid giving any emphasis to any of the items. For item 14 ix) read out the first of any 'other' noises specified in the previous question. Respondents should have no difficulty using the opinion thermometer to give their ratings.

Question 16 This question is designed to determine which noise R finds most bothersome. It is an important question which is neutral with respect to aircraft noise but allows people the chance to nominate it as the most serious noise problem. Again, of course, interviewers have to guard against any possibility of bias through prompting. Encourage R to select one of the noises and record the item number from the flash card (note the number when you take the card back). Simply record the number without any comment or reaction.

Question 17 This is the first of the questions directly on aircraft noise and is asked of all respondents. They are required to give a rating of how much they are affected overall - this covers a more general reaction than annoyance. Those respondents who report being 'not at all affected' (i.e., give a zero rating) are not asked the next nineteen questions.

NOTE Interviewers are to complete the item at the top of page 8. If a zero rating was given in Q.17 tick 'skip' and go to Q.37. If a non-zero rating was given tick 'continue' and proceed with the next question (Q.18).

Question 18 This question asks respondents to state whether or not various activity disturbances are experienced as a result of aircraft noise. For 'other' (item viii) interviewers are to ask "Are there any other activities you find are disturbed by aircraft noise?".

Question 19 This question is designed to find out which activity disturbance is most important to the respondent. Interviewers are to encourage R to select one activity from the flash card. If R insists on nominating more than one item, note them down, but enter in the coding box the first one mentioned.

Question 20 The rating in this question concerns the annoyance felt overall because of activity disturbances. Although previous aircraft noise surveys have typically asked for ratings of annoyance from each activity disturbance, it is argued that the present general rating provides a more valid index of subjective reaction. In the analysis this rating will be combined with other ratings to form an annoyance scale.

Question 21 The question simply asks whether or not aircraft cause the house (or unit) to shake, a phenomenon that many people find disturbing.

Question 22 This is a straightforward question on the respondent's reaction to aircraft noise, namely, whether or not a startle response is experienced. This reaction seems to relate more to feelings of fear rather than annoyance.

Question 23 In this question respondents are required to give an opinion thermometer rating on how much they are frightened by aircraft noise. This rating will be used to assess the reaction of fear as distinct from annoyance.

Question 24 This is essentially a question about perception. Respondents are asked whether or not they are bothered by various characteristics of the sound of aircraft noise.

Question 25 This is the 'noise-prompted' form of an earlier neutral question (Q.8), although interviewers are not to draw attention to this fact. Respondents indicate whether or not they think aircraft noise has affected their health. If a positive response is given, respondents are asked firstly, in what way their health has been affected (Part A) and secondly, to rate how much it has been affected (Part B). Interviewers must avoid being drawn into discussion on the issue of health effects of noise.

Question 26 This is not an easy question, but it has been found to cause no difficulty if interviewers read it carefully and fairly slowly. Respondents are asked if how they feel about aircraft noise is affected by the noisiest planes, the build-up of all planes or equally by both aspects. The data from this question will be useful for understanding more about the way in which noise affects people.

Question 27 This is an important question concerning the time of day respondents find aircraft noise most bothersome. It asks which of eight 3-hour periods R would most like to have free from the noise of aircraft. Again, R should be encouraged to select one period. If R insists on more than one, interviewers are to note them down in the order R gives them, but to enter the first one in the coding box.

Question 28 This question simply asks whether the respondent hears aircraft noise from the airport itself. This includes noise from ground-running, reverse-thrust braking and take-off thrust.

Question 29 In this question on complaint behaviour respondents are asked whether they have ever done anything to have the noise reduced. Those who answer "yes" are asked to say what they did. However, only a small percentage of people affected by aircraft noise ever take any action about it. The question asked 'if no' is designed to find out why this is the case.

Question 30 Another question on complaint. Respondents are asked whether they feel they would like to take any of a number of actions by way of complaint. They are not here being asked whether they have actually done or plan to do the things listed, although some respondents may interpret the question that way. In such a case interviewers are to repeat the operative part of the question (viz., "Do you feel you would like to...?").

NOTE Before asking the next question, interviewers are to quickly check the response given in Q.1. If the response was 'all of life' then the next question (Q.31) is omitted.

Question 31 The first part of this question asks whether R was aware of the noise before moving into the area. If the response is 'yes' then ask whether the noise was different from what was expected. The last part of the question is asked if R says 'no' to the first part or 'a bit more/much more' to the second part. Note that this question asks about the noise at the time R moved to the area - it is not a comparison of the noise then versus now. Interviewers should accept a DK response to the last part of the question from young respondents who would not have had a say in the decision to move to the area.

Question 32 This is a straightforward question on adaptation, inquiring whether the respondent has become used to aircraft noise. Interviewers are not to give any indication as to whether or not respondents are expected to have adapted to the noise.

Question 33 In this question on change in the amount of aircraft noise, respondents are being asked to make a subjective judgment not a categorical statement of fact. If R says "I don't know", interviewers are to probe with "Even if you don't know for certain, how do you think the noise now compares with what it was before?". Note that the substitute phrase "since you moved here" is used if R has lived there for less than five years, as indicated in response to Q.1.

Question 34 Many people think about moving house as a sort of vague wish for 'greener pastures'. This question asks whether R has seriously thought about moving. If R says 'yes' then ask the item on why he/she decided not to move. If R says 'no' ask the item on whether he/she would move if the noise increased, but be careful not to imply that it will increase. Again, with young respondents a DK response may be appropriate - such people are not to report what their parents might do.

Question 35 Fear of aircraft crashing is an important component of an individual's subjective reaction. However, it may not be the noise itself that is the operative factor, and this will be taken into account in the analysis. This question asks firstly, whether R has ever thought that a plane might crash in the area and secondly, if a positive response is given, for rating of how much R feels afraid. Of course, interviewers must not imply that there is any danger and must avoid being side-tracked into discussion of aircraft safety.

Question 36 This is a very important question on subjective rating of annoyance. It is crucial for the accurate interpretation of the opinion thermometer ratings. Respondents are asked to select which category describes their general feelings about the aircraft noise. Interviewers must not give any feedback about the ratings R gave in previous questions.

NOTE In those cases where the aircraft noise questions have been skipped, the interview resumes with the next question.

Question 37 The extent to which an individual is affected by aircraft noise will depend in no small part on his/her attitudes towards the aviation industry (or the Airforce in the case of Richmond airport - note that a slightly different form is used for Richmond respondents). This question consists of ten statements for which the respondent is required to indicate agreement or disagreement. Positive and negative attitude statements are mixed, but interviewers must take care to read each one in a neutral manner, with no hint as to their own opinions and no reaction to the responses given. If R simply says "yes" or "no" or uses any words other than those on the flash card, then interviewers are to probe by asking "Which one would you say from the card?". Some respondents may digress by trying to elaborate on the statements. In such cases, interviewers are not to discuss the matter but are to record any comments in the margin. Press on with the question by saying "The next statement is...".

Question 38 This is the final rating item. It is designed to assess the general reaction of dissatisfaction with aircraft noise.

Question 39 This is an open question inviting respondents to make any other comments about aircraft noise and about neighbourhood living conditions. Although it is not as important a question as some of the others, it may prove useful in providing insights into the variability of people's reactions to the environmental conditions in various neighbourhoods.

Question 40 The last six questions are needed to gather 'classification' information. Most people will not object to supplying the 'personal' information sought, but some may need to be reminded that the information is confidential and that names are not being recorded. The first question in this section asks R to indicate his/her age category from a flash card. If R refuses, do not insist on a response but simply tick the appropriate box.

Question 41 In this question on occupation interviewers are to make sure that an accurate description is given. Probe if a one-word response is given: "What sort of...?" (clerk, salesman, engineer, manager etc.). Probe further if the response is ambiguous (there is a story of a man who called himself a 'bank director'. His job was to usher customers in a bank!).

Question 42 Interviewers must be careful not to omit this item. Tick whether the respondent is male or female.

Question 43 This question asks about education level. The 'refuse' category is given here, but most people will not hesitate to answer from the flash card. If R is not sure of the category (e.g., overseas education) interviewers are to note the details and to leave the coding boxes blank. The probe about name of the institution is used if R says 'tertiary' (categories 5 or 6).

Question 44 This is a simple question on home ownership. If the category 'other' is appropriate, interviewers are to note the details in the margin.

Question 45 Interviewers are to complete this item on the type of dwelling. It is best to do so at the time of the interview rather than risking mistakes by relying on memory at a later time.

NOTE Interviewers are to complete the interview by thanking the respondent for his/her co-operation and pointing out that the information will be of great value in planning future community improvements. It is important that respondents feel that their time and effort has been worthwhile and is appreciated. Where necessary, interviewers should re-assure respondents about the confidentiality of the information.

APPENDIX B

AIRCRAFT MOVEMENTS

This section contains numbers of aircraft operations over each area included in the survey. The numbers given are based on counts from airport control tower flight strips, except in Sydney, where operations are recorded by the Sydney Airport Noise Monitoring Centre.

Periods over which counts were taken are:

Sydney: August 1979 - January 1980

Richmond: December 1980 - February 1981*

Adelaide: October 1979 - March 1980 (movements between 7 pm and 10 pm recorded for October 1980 - December 1980)

Perth: November 1979 - April 1980 (movements between 7 pm and 10 pm recorded for February 1980 - April 1980)

Melbourne: July 1980 - December 1980

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* Numbers corrected to give counts over a six-month period, with December counted only once.

SYDNEY AIRPORT

NORTHERN FLIGHT-PATH: Departures on runway 34, Arrivals on runway 16

Aircraft Type	DEPARTURES			ARRIVALS		
	Number/ Day	% 10pm-7am	% 7pm-10pm	Number/ Day	% 10pm-7am	% 7pm-10pm
B707	.213	2.3	2.3	.965	5.7	8.7
B727-100	.010	-	-	.604	7.4	33.6
B727-200	.307	1.6	25.8	14.386	2.7	18.7
B747	2.050	3.9	11.8	9.124	7.7	16.2
DC8	.089	5.6	-	1.228	7.7	10.1
DC9	.322	1.5	0.7	9.406	3.4	20.4
DC10	.337	19.1	1.5	2.708	3.7	8.8
F27	.396	3.8	6.3	20.153	3.7	21.4
F28	-	-	-	.109	-	-
Total	3.724	6.0	9.6	58.683	4.2	18.8

EASTERN FLIGHT-PATH: Departures on runway 07, Arrivals on runway 25

Aircraft Type	DEPARTURES			ARRIVALS		
	Number/ Day	% 10pm-7am	% 7pm-10pm	Number/ Day	% 10pm-7am	% 7pm-10pm
B707	.094	-	-	.084	-	-
B727-100	.257	9.6	21.2	.129	7.7	26.9
B727-200	5.050	2.9	29.2	3.861	8.2	41.5
B747	.955	2.6	14.0	1.198	2.5	23.6
DC8	.163	-	42.4	.609	2.4	15.4
DC9	3.975	3.6	20.3	2.807	8.8	37.7
DC10	.490	-	3.1	.827	2.4	14.4
F27	5.069	3.2	20.0	5.668	12.1	44.9
F28	.035	-	-	.010	-	-
Total	16.088	3.1	22.2	15.193	8.7	37.8

SYDNEY AIRPORT

SOUTHERN FLIGHT-PATH: Departures on runway 16, Arrivals on runway 34

Aircraft Type	DEPARTURES			ARRIVALS		
	Number/ Day	% 10pm-7am	% 7pm-10pm	Number/ Day	% 10pm-7am	% 7pm-10pm
B707	1.312	3.0	2.6	.173	60.0	2.9
B727-100	1.644	6.0	15.7	.094	36.8	15.8
B727-200	33.584	3.3	20.4	2.604	39.5	20.9
B747	13.475	4.1	10.0	3.386	51.3	13.2
DC8	1.891	9.9	18.3	.312	22.2	11.1
DC9	25.782	3.8	14.7	1.886	33.6	18.6
DC10	3.812	7.5	1.9	.802	37.0	14.2
F27	36.594	17.1	11.3	4.663	64.3	15.5
F28	.257	-	1.9	.035	-	-
Total	118.351	8.0	14.2	13.955	49.5	16.0

WESTERN FLIGHT-PATH: Departures on runway 25, Arrivals on runway 07

Aircraft Type	DEPARTURES			ARRIVALS		
	Number/ Day	% 10pm-7am	% 7pm-10pm	Number/ Day	% 10pm-7am	% 7pm-10pm
B707	.054	-	-	.455	5.4	4.3
B727-100	.124	-	8.0	1.223	3.6	23.9
B727-200	2.861	1.0	9.0	20.970	2.1	26.3
B747	.619	0.8	1.6	3.366	4.0	14.6
DC8	.119	-	12.5	.074	6.7	13.3
DC9	2.069	0.2	6.7	18.030	1.6	19.8
DC10	.396	-	1.3	.678	0.7	1.5
F27	2.802	1.8	6.7	14.366	2.2	26.2
F28	.020	-	-	.158	-	3.1
Total	9.064	1.0	6.9	59.320	2.1	23.1

RICHMOND AIR BASE

EASTERN FLIGHT-PATH: Departures on runway 10, Arrivals on runway 28

Aircraft Type	DEPARTURES			ARRIVALS		
	Number/ Day	% 10pm-7am	% 7pm-10pm	Number/ Day	% 10pm-7am	% 7pm-10pm
B707*	.321	-	-	.687	18.1	3.3
C130	9.511	0.9	9.6	15.682	4.4	10.6
CC08	4.503	-	14.7	3.791	1.8	9.5
C141	.264	-	-	.288	3.8	23.1
Total	14.599	0.6	10.8	20.448	4.4	10.3

WESTERN FLIGHT-PATH: Departures on runway 28, Arrivals on runway 10

Aircraft Type	DEPARTURES			ARRIVALS		
	Number/ Day	% 10pm-7am	% 7pm-10pm	Number/ Day	% 10pm-7am	% 7pm-10pm
B707*	.633	1.6	3.7	.294	3.1	-
C130	16.995	3.0	9.1	10.828	2.0	12.4
CC08	4.698	0.7	7.3	5.141	-	13.8
C141	.337	15.6	-	.326	-	18.2
Total	22.663	2.7	8.4	16.589	1.4	12.7

* Includes other military jet aircraft.

ADELAIDE AIRPORT

NORTHERN FLIGHT-PATH: Departures on runway 05, Arrivals on runway 23

Aircraft Type	DEPARTURES Number/Day			ARRIVALS Number/Day		
		% 10pm-7am	% 7pm-10pm		% 10pm-7am	% 7pm-10pm
B727*	2.923	11.0	12.3	15.967	6.0	27.1
DC9	.809	18.2	8.6	4.339	6.7	37.7
F27	1.519	18.4	4.8	5.399	10.4	20.1
F28	.022	-	-	.137	-	4.8
Total	5.273	14.2	9.5	25.842	7.0	27.3

EASTERN FLIGHT-PATH: Departures on runway 12, Arrivals on runway 30

Aircraft Type	DEPARTURES Number/Day			ARRIVALS Number/Day		
		% 10pm-7am	% 7pm-10pm		% 10pm-7am	% 7pm-10pm
B727*	-	-	-	.011	-	30.0
DC9	-	-	-	.016	-	100.0
F27	.202	5.7	10.0	.404	6.8	9.5
F28	-	-	-	-	-	-
Total	.202	5.7	10.0	.431	6.4	13.4

* B727-100 and B727-200 not distinguished on flight strips - both counted as B727-200.

ADELAIDE AIRPORT

SOUTHERN FLIGHT-PATH: Departures on runway 23, Arrivals on runway 05

Aircraft Type	DEPARTURES			ARRIVALS		
	Number/ Day	% 10pm-7am	% 7pm-10pm	Number/ Day	% 10pm-7am	% 7pm-10pm
B727*	16.038	9.5	17.8	2.973	13.8	22.4
DC9	4.055	19.5	18.3	.503	8.7	37.9
F27	9.077	16.0	8.2	2.072	24.2	11.2
F28	.164	-	-	.044	12.5	-
Total	29.334	12.8	14.8	5.592	17.2	19.5

WESTERN FLIGHT-PATH: Departures on runway 30, Arrivals on runway 12

Aircraft Type	DEPARTURES			ARRIVALS		
	Number/ Day	% 10pm-7am	% 7pm-10pm	Number/ Day	% 10pm-7am	% 7pm-10pm
B727*	.016	100.0	-	.016	-	-
DC9	.005	100.0	-	-	-	-
F27	.470	9.3	-	3.536	3.7	25.1
F28	.011	-	-	-	-	-
Total	.502	12.9	-	3.552	3.7	25.0

* B727-100 and B727-200 not distinguished on flight strips - both counted as B727-200.

PERTH AIRPORT

NORTHERN FLIGHT-PATH: Departures on runway 02, Arrivals on runway 20

Aircraft Type	DEPARTURES			ARRIVALS		
	Number/ Day	% 10pm-7am	% 7pm-10pm	Number/ Day	% 10pm-7am	% 7pm-10pm
B707	.187	8.8	-	.352	85.9	12.0
B727*	1.308	31.9	-	5.742	42.5	15.4
B747	.643	60.7	2.1	2.742	51.7	18.2
DC8	.011	-	-	.077	42.9	-
DC9	.016	100.0	-	.176	28.1	46.7
DC10	.110	-	14.3	.363	90.9	8.6
F27	.022	-	-	.626	21.1	37.5
F28	.495	21.1	-	8.599	13.0	22.9
Total	2.792	33.8	1.0	18.677	31.2	20.0

EASTERN FLIGHT-PATH: Departures on runway 06, Arrivals on runway 24

Aircraft Type	DEPARTURES			ARRIVALS		
	Number/ Day	% 10pm-7am	% 7pm-10pm	Number/ Day	% 10pm-7am	% 7pm-10pm
B707	.011	-	-	.005	100.0	-
B727*	.286	50.0	-	1.214	48.4	12.1
B747	.066	100.0	-	.088	6.3	-
DC8	-	-	-	-	-	-
DC9	.016	100.0	-	.060	36.4	-
DC10	-	-	-	.005	-	-
F27	.088	50.0	-	.319	37.9	20.0
F28	1.500	61.9	7.4	2.165	15.0	25.5
Total	1.967	60.9	5.6	3.856	27.6	19.8

* B727-100 and B727-200 not distinguished on flight strips - both counted as B727-200.

PERTH AIRPORT

SOUTHERN FLIGHT-PATH: Departures on runway 20, Arrivals on runway 02

Aircraft Type	DEPARTURES Number/ Day	% 10pm-7am	% 7pm-10pm	ARRIVALS Number/ Day	% 10pm-7am	% 7pm-10pm
B707	.275	2.0	-	.071	46.2	-
B727*	6.901	51.4	-	1.505	18.2	1.3
B747	2.703	50.2	6.7	.423	41.6	-
DC8	.104	47.4	-	.027	80.0	-
DC9	.225	92.7	-	.011	50.0	-
DC10	.297	3.7	-	.044	75.0	-
F27	.885	11.2	19.2	.016	-	-
F28	9.055	31.7	12.9	.407	4.1	-
Total	20.445	39.9	7.4	2.504	22.3	0.8

WESTERN FLIGHT-PATH: Departures on runway 24, Arrivals on runway 06

Aircraft Type	DEPARTURES Number/ Day	% 10pm-7am	% 7pm-10pm	ARRIVALS Number/ Day	% 10pm-7am	% 7pm-10pm
B707	-	-	-	.055	90.0	-
B727*	.066	-	-	.187	44.1	-
B747	-	-	-	.066	58.3	-
DC8	-	-	-	-	-	-
DC9	-	-	-	-	-	-
DC10	-	-	-	.005	100.0	-
F27	.005	-	-	.060	18.2	-
F28	.775	0.7	10.1	.516	19.1	23.5
Total	.846	0.6	9.3	.889	32.1	13.6

* B727-100 and B727-200 not distinguished on flight strips - both counted as B727-200.

MELBOURNE AIRPORT

EASTERN FLIGHT-PATH: Departures on runway 09, Arrivals on runway 27

Aircraft Type	DEPARTURES			ARRIVALS		
	Number/ Day	% 10pm-7am	% 7pm-10pm	Number/ Day	% 10pm-7am	% 7pm-10pm
B707	-	-	-	.217	10.0	5.0
B727	.022	25.0	-	21.293	12.5	22.9
B747	.005	-	-	3.141	8.1	10.2
DC8	-	-	-	.174	28.1	12.5
DC9	.005	-	-	19.353	10.4	17.9
DC10	-	-	-	1.000	12.0	10.3
F27	.016	-	-	11.272	14.8	15.8
F28	-	-	-	.125	-	-
Total	.048	11.5	-	56.575	12.0	18.7

SOUTHERN FLIGHT-PATH: Departures on runway 16, Arrivals on runway 34

Aircraft Type	DEPARTURES			ARRIVALS		
	Number/ Day	% 10pm-7am	% 7pm-10pm	Number/ Day	% 10pm-7am	% 7pm-10pm
B707	.022	-	25.0	.103	5.3	-
B727	4.038	2.8	24.0	11.429	7.8	12.7
B747	1.359	2.8	15.2	3.495	15.9	6.2
DC8	.049	11.1	11.1	.125	4.3	-
DC9	3.679	1.0	18.0	10.065	4.9	8.6
DC10	.413	1.3	11.8	1.310	15.8	5.0
F27	1.940	0.6	7.3	5.609	7.8	6.7
F28	.060	-	9.1	-	-	-
Total	11.560	1.8	17.7	32.136	8.1	9.3

APPENDIX C

MATHEMATICAL DERIVATIONS

C.1 Calculation of MEAN5

There is some ambiguity in the way in which this unit has been defined. The wording used (Rylander, 1981) is: "Measure the noise levels of fly-overs during 24 hours. Use the average of the five noisiest events as the dB(A) predictor." Measurements on different days will obviously give different results, and it is not clear how these should be combined. One possibility is to take the mean value of the resulting levels, over a large number of days. However, the calculation of this value involves quite complex formulae which are difficult to implement.

The approach taken was first to calculate the level exceeded by an average of five aircraft per day (that is, LX5) and then to calculate the mean level of all aircraft whose level exceeds this. That is, if $\phi(L)$ is the probability distribution of noise levels L,

$$\mathrm{MEAN5} = \frac{\int_{LX5}^{\infty} L\, \phi(L)\, dL}{\int_{LX5}^{\infty} \phi(L)\, dL}$$

$$= \frac{N}{5} \int_{LX5}^{\infty} L\, \phi(L)\, dL \qquad (C.1)$$

where N is the mean number of aircraft operations per day.

If the distribution of noise levels for a given aircraft type and operation is assumed to be normal, with mean μ_i and standard deviation σ_i, then

$$\phi\,(L) = \frac{1}{N} \sum_i \frac{N_i}{\sigma_i \sqrt{2\pi}}\, e^{-(L_i-\mu_i)^2/2\,\sigma_i^{\,2}} \qquad (C.2)$$

where N_i is the number of aircraft of a particular type and operation. Substituting into equation (C.1) leads to

$$\mathrm{MEAN5} = \frac{1}{5\sqrt{2\pi}} \sum_i N_i\, \sigma_i\, \exp\{-(LX5 - \mu_i)^2/2\,\sigma_i^{\,2}\}$$

$$+ \sum_i N_i\, \mu_i\, \mathrm{cerf}((LX5 - \mu_i)\,/\,\sigma_i) \qquad (C.3)$$

where $\mathrm{cerf}(x) = \frac{1}{\sqrt{2\pi}} \int_x^\infty e^{-\frac{1}{2} t^2} dt$. It was found (Section 4.7) that, to within a reasonable approximation, the σ_i were all equal to about 2.8 dB. Using this, and calculated values of μ_i, MEAN5 was found from equation (D.3).

C.2 Calculation of WMEAN

The unit WMEAN is required in analysis of the effect of changing the weighting given to louder aircraft in an equal-energy index (see Section C.3). It is defined as

$$\mathrm{WMEAN} = \frac{\int_{-\infty}^{\infty} L \ \phi(L)\ 10^{L/10}\ dL}{\int_{-\infty}^{\infty} \phi(L)\ 10^{L/10}\ dL} \qquad (C.4)$$

where ϕ (L) is the probability distribution of noise levels.

Writing $\phi(L) = \frac{1}{N} \sum_i \frac{N_i}{\sigma_i \sqrt{2\pi}} e^{-(L-\mu_i)^2/2\ \sigma_i^2}$ as in Section C.1

and substituting into equatiion (C.4) leads to

$$\mathrm{WMEAN} = \frac{\Sigma\ N_i\ 10^{\mu_i/10}\ (\mu_i + \sigma_i^2\ \ln(10)/10)}{\Sigma\ N_i\ 10^{\mu_i/10}} \qquad (C.5)$$

Putting σ_i = 2.8 dB, as in Section C.1 gives $\sigma_i^2\ \ln(10)/10 = 1.8$. With this substitution, equation (C.5) was used to calculate WMEAN.

C.3 Approximation to a General Noise Exposure Index

Consider the index given, for a sufficiently large value of K, by

$$I = 10C\ \log\{\frac{N}{K} \sum_{i=1}^{K} 10^{L_i/10C}\} \qquad (C.6)$$

where L_i represent noise levels of aircraft overflights and N is the number of overflights per day. An approximation to the value of this index is required for values of C close to 1 - that is, a first-order approximation in (1-C).

Expanding I in a Taylor series about C=1 gives

$$I \sim I\Big|_{C=1} + (C-1)\,\frac{dI}{dC}\Big|_{C=1}$$

$$= 10\ \log\{\frac{N}{K}\ \Sigma\ 10^{L_i/10}\} + (C-1)\ [10\ \log\{\frac{N}{K}\ \Sigma\ 10^{L_i/10}\} - \frac{\Sigma\ L_i\ 10^{L_i/10}}{\Sigma\ 10^{L_i/10}}]$$

$$= 10C\ \log\{\frac{N}{K}\ \Sigma\ 10^{L_i/10}\} + (1-C)\ \frac{\Sigma\ L_i\ 10^{L_i/10}}{\Sigma\ 10^{L_i/10}} \qquad (C.6)$$

Thus, the index can be approximated by C times its value with C=1 plus (1-C) times the variable which was computed as WMEAN.

APPENDIX D

RAW DATA ON DOSE/RESPONSE

This section contains the following tables:

TABLES D.1 - D.16: Mean values of the following variables in each sampling zone around each airport (minimum cell size = 40 respondents - see Table 3.3):

D.1 - SA (i.e. percentage "seriously affected")

D.2 - MA (i.e. percentage "moderately affected")

D.3 - GR	D.10 - LTYPE
D.4 - NEF1	D.11 - LX10
D.5 - NEF2	D.12 - LX5
D.6 - NEF3	D.13 - LX3
D.7 - NEF4	D.14 - LX10%
D.8 - $NEF_{3,6}$	D.15 - MEAN5'
D.9 - L_{dn}	D.16 - N70

TABLE D.17: Percentage of respondents reporting various activity disturbances for each airport and each NEF3 zone.

TABLE D.18: Percentage of respondennts selecting various activity disturbances as most worth eliminating, for each airport.

TABLE D.19: Percentage of respondents rating the neighbourhood as 'bad' or 'very bad' for various features, for each airport and each NEF3 zone.

TABLE D.20: Percentage of respondents annoyed (rating ≥ 4/10) by various noises, for each airport and each NEF3 zone.

TABLE D.21: Percentage of respondents reporting health symptoms caused by aircraft noise, for each airport and each NEF3 zone.

TABLE D.22: Number of respondents in each NEF3 zone for each airport.

TABLE D.23 Mean values of the variable NEGATT in each sampling zone around each airport.

TABLE D.24 Mean values of the variable CRASH in each sampling zone around each airport.

TABLE D.25 Mean values of the variable NOISE SENSITIVITY in each sampling zone around each airport.

NOTE: SAMPLING ZONES are based on nominal NEF contours:
1 = 20-24; 2 = 25-29; 3 = 30-34; 4 = 35-39.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	19.1	38.5	67.0	54.7
	E	15.7	23.9	26.8	-
	S	23.6	-	-	-
	W	26.4	40.0	42.5	61.1
Richmond	E	17.9	-	-	-
	W	11.9	16.7	28.6	35.7
Adelaide	N	16.9	29.7	46.2	50.8
	E	17.5	-	-	-
	S	10.9	21.0	30.8	-
	W	3.1	-	-	-
Perth	N	6.7	6.3	17.5	16.7
	E	8.3	6.3	-	-
	S	6.4	18.8	25.0	-
	W	2.1	6.3	10.4	-
Melbourne	E	18.8	8.9	-	-
	S	15.2	18.5	-	-

TABLE D.1 Percentage of respondents SERIOUSLY AFFECTED in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	61.9	80.7	94.5	87.7
	E	49.1	67.0	60.8	-
	S	61.8	-	-	-
	W	59.1	84.6	78.8	85.8
Richmond	E	58.9	-	-	-
	W	42.9	66.7	69.1	83.3
Adelaide	N	63.1	76.6	78.5	87.7
	E	60.3	-	-	-
	S	46.9	61.3	69.2	-
	W	34.4	-	-	-
Perth	N	51.1	31.3	47.5	50.0
	E	22.9	22.9	-	-
	S	36.2	60.4	70.8	-
	W	22.9	41.7	37.5	-
Melbourne	E	53.8	45.6	-	-
	S	57.0	64.2	-	-

TABLE D.2 Percentage of respondents MODERATELY AFFECTED in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	5.14	6.52	7.92	7.27
	E	4.21	5.39	5.12	-
	S	5.00	-	-	-
	W	5.05	6.81	6.49	7.56
Richmond	E	4.80	-	-	-
	W	3.64	4.83	5.70	6.72
Adelaide	N	4.87	6.10	6.73	7.22
	E	4.96	-	-	-
	S	4.09	5.09	5.60	-
	W	3.23	-	-	-
Perth	N	3.89	3.51	4.23	4.59
	E	2.78	2.57	-	-
	S	3.22	4.88	5.30	-
	W	2.49	3.39	3.45	-
Melbourne	E	4.52	3.80	-	-
	S	4.73	5.16	-	-

TABLE D.3 Mean values of GR in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	23.7	26.8	32.6	37.0
	E	27.0	30.2	35.5	-
	S	22.8	-	-	-
	W	24.7	29.5	33.5	38.0
Richmond	E	24.6	-	-	-
	W	23.6	28.9	33.3	37.1
Adelaide	N	25.7	31.3	35.9	40.5
	E	13.6	-	-	-
	S	29.0	32.3	37.5	-
	W	18.6	-	-	-
Perth	N	23.7	27.2	30.9	34.2
	E	20.4	22.3	-	-
	S	23.6	27.8	32.6	-
	W	16.7	21.2	27.6	-
Melbourne	E	24.1	27.3	-	-
	S	22.6	25.7	-	-

TABLE D.4 Mean values of exposure index NEF 1 in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	24.1	27.5	33.8	38.2
	E	24.6	27.6	33.5	-
	S	21.9	-	-	-
	W	23.2	29.0	33.5	38.6
Richmond	E	24.9	-	-	-
	W	23.3	28.9	33.0	36.7
Adelaide	N	23.8	29.9	34.8	39.9
	E	14.2	-	-	-
	S	27.6	30.9	36.3	-
	W	18.0	-	-	-
Perth	N	23.2	27.3	31.4	35.5
	E	20.5	23.0	-	-
	S	22.9	27.0	32.1	-
	W	18.0	22.8	29.6	-
Melbourne	E	24.8	28.2	-	-
	S	20.2	25.2	-	-

TABLE D.5 Mean values of exposure index NEF2 in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	24.5	28.0	33.9	38.6
	E	26.7	28.1	34.2	-
	S	22.0	-	-	-
	W	23.9	29.5	33.7	38.8
Richmond	E	28.3	-	-	-
	W	24.8	30.7	34.2	37.8
Adelaide	N	24.7	30.8	35.2	40.2
	E	25.8	-	-	-
	S	28.6	31.8	36.6	-
	W	27.2	-	-	-
Perth	N	27.0	28.8	31.9	35.7
	E	20.6	23.1	-	-
	S	23.0	27.0	32.1	-
	W	21.8	24.2	31.0	-
Melbourne	E	24.8	28.3	-	-
	S	21.4	25.4	-	-

TABLE D.6 Mean values of exposure index NEF3 in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	24.5	28.0	33.9	38.6
	E	26.4	28.0	34.2	-
	S	22.0	-	-	-
	W	23.8	29.5	33.7	38.8
Richmond	E	28.3	-	-	-
	W	24.8	30.4	34.2	37.8
Adelaide	N	24.7	30.8	35.2	40.3
	E	25.8	-	-	-
	S	28.5	31.9	36.6	-
	W	27.2	-	-	-
Perth	N	27.0	28.8	31.9	35.7
	E	20.6	23.1	-	-
	S	23.0	27.0	32.1	-
	W	21.8	24.2	31.0	-
Melbourne	E	24.8	28.3	-	-
	S	21.4	25.4	-	-

TABLE D.7 Mean values of expsoure index NEF4 in each sampling zone around each airport

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	23.1	26.5	32.9	37.3
	E	25.6	28.4	34.3	-
	S	21.0	-	-	-
	W	23.8	29.5	34.1	39.2
Richmond	E	23.7	-	-	-
	W	22.7	28.3	32.1	35.5
Adelaide	N	22.0	28.9	34.2	39.5
	E	16.7	-	-	-
	S	25.8	29.1	34.7	-
	W	15.1	-	-	-
Perth	N	17.0	21.2	25.5	30.0
	E	13.8	17.0	-	-
	S	15.6	19.5	24.7	-
	W	14.0	18.4	25.0	-
Melbourne	E	22.3	25.9	-	-
	S	18.9	23.2	-	-

TABLE D.8 Mean values of exposure index NEF$_{3,6}$ in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	60.2	63.0	67.5	71.4
	E	61.0	61.8	68.7	-
	S	57.0	-	-	-
	W	59.2	64.0	67.6	72.0
Richmond	E	62.9	-	-	-
	W	60.5	65.2	68.2	71.5
Adelaide	N	58.2	64.4	68.7	73.3
	E	59.6	-	-	-
	S	62.6	66.1	71.1	-
	W	61.2	-	-	-
Perth	N	61.0	62.9	65.9	68.9
	E	53.7	56.2	-	-
	S	55.6	58.0	64.0	-
	W	54.7	56.8	62.9	-
Melbourne	E	60.4	63.2	-	-
	S	56.7	60.6	-	-

<u>TABLE D.9</u> Mean values of exposure index <u>L_{dn}</u> in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	77.3	81.5	89.0	94.2
	E	85.9	85.2	99.7	-
	S	75.1	-	-	-
	W	77.5	85.4	90.7	97.0
Richmond	E	82.3	-	-	-
	W	79.7	84.4	87.6	90.2
Adelaide	N	72.0	82.9	90.8	99.1
	E	-	-	-	-
	S	85.9	90.4	97.7	-
	W	76.1	-	-	-
Perth	N	67.9	73.5	79.2	85.8
	E	-	-	-	-
	S	76.4	82.0	88.7	-
	W	-	-	-	-
Melbourne	E	79.6	83.3	-	-
	S	79.4	82.4	-	-

<u>TABLE D.10</u> Mean values of exposure index <u>LTYPE</u> in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	78.1	82.0	89.3	94.6
	E	80.0	83.9	91.9	-
	S	76.3	-	-	-
	W	78.2	85.4	90.8	97.3
Richmond	E	80.8	-	-	-
	W	79.9	84.9	88.0	90.6
Adelaide	N	73.7	83.5	90.6	97.8
	E	-	-	-	-
	S	85.3	89.8	97.2	-
	W	-	-	-	-
Perth	N	68.6	74.4	80.1	86.3
	E	-	-	-	-
	S	69.6	72.7	79.8	-
	W	-	-	-	-
Melbourne	E	78.5	82.3	-	-
	S	74.5	80.9	-	-

TABLE D.11 Mean values of exposure index LX10 in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	80.1	83.9	90.9	96.4
	E	86.1	88.0	97.4	-
	S	77.2	-	-	-
	W	82.8	88.0	93.0	99.2
Richmond	E	83.1	-	-	-
	W	81.4	86.3	89.4	92.1
Adelaide	N	78.2	87.7	94.8	101.6
	E	-	-	-	-
	S	86.9	91.4	98.8	-
	W	-	-	-	-
Perth	N	70.9	76.7	82.4	88.5
	E	71.2	76.0	-	-
	S	75.9	80.9	87.5	-
	W	-	-	-	-
Melbourne	E	79.6	83.3	-	-
	S	79.1	82.7	-	-

TABLE D.12 Mean values of exposure index LX5 in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	81.9	85.4	92.0	97.8
	E	88.5	89.9	99.6	-
	S	77.9	-	-	-
	W	85.4	89.7	94.6	101.1
Richmond	E	84.3	-	-	-
	W	82.3	87.2	90.4	93.1
Adelaide	N	85.6	91.8	98.8	105.9
	E	-	-	-	-
	S	87.7	92.2	99.6	-
	W	75.0	-	-	-
Perth	N	74.7	80.7	86.2	91.1
	E	74.4	78.8	-	-
	S	77.4	82.4	89.0	-
	W	-	-	-	-
Melbourne	E	80.4	84.1	-	-
	S	81.0	83.8	-	-

TABLE D.13 Mean values of exposure index LX3 in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	79.4	83.2	90.4	95.8
	E	88.5	90.1	99.4	-
	S	75.8	-	-	-
	W	79.9	86.6	91.9	98.2
Richmond	E	83.9	-	-	-
	W	81.9	86.8	89.9	92.6
Adelaide	N	84.8	91.2	98.3	105.5
	E	86.8	-	-	-
	S	87.4	91.9	99.3	-
	W	80.2	-	-	-
Perth	N	79.3	83.9	88.8	93.4
	E	81.8	84.8	-	-
	S	79.2	83.7	90.3	-
	W	88.9	93.3	100.7	-
Melbourne	E	79.4	83.2	-	-
	S	79.8	83.1	-	-

TABLE D.14 Mean values of exposure index LX10% in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	83.8	86.9	93.1	99.1
	E	89.9	91.4	101.1	-
	S	80.8	-	-	-
	W	87.2	91.7	96.2	102.2
Richmond	E	86.9	-	-	-
	W	84.0	89.8	93.7	97.2
Adelaide	N	86.5	93.7	100.3	107.2
	E	82.1	-	-	-
	S	88.0	92.3	99.4	-
	W	76.9	-	-	-
Perth	N	79.0	83.8	88.7	93.6
	E	77.3	81.3	-	-
	S	79.1	83.9	90.7	-
	W	82.4	87.4	95.0	-
Melbourne	E	83.2	87.2	-	-
	S	82.5	84.9	-	-

TABLE D.15 Mean values of exposure index MEAN5' in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	44.0	55.9	62.7	62.7
	E	23.9	26.8	31.4	-
	S	60.1	-	-	-
	W	54.5	67.3	68.6	68.6
Richmond	E	33.6	-	-	-
	W	33.6	38.8	39.3	39.3
Adelaide	N	22.0	31.3	32.7	32.7
	E	0.7	-	-	-
	S	28.8	32.8	36.1	-
	W	3.7	-	-	-
Perth	N	7.0	17.4	21.5	21.9
	E	5.1	5.9	-	-
	S	9.9	11.0	12.2	-
	W	1.7	1.8	1.8	-
Melbourne	E	49.1	55.6	-	-
	S	25.4	39.7	-	-

TABLE D.16 Mean values of exposure index N70 in each sampling zone around each airport.

Activity	NEF3 zone	Overall	Syd	Rich	Adel	Perth	Melb
Conversation	Controls	14.9	12.5	32.1	15.6	4.3	21.9
	<20	39.8	58.3	-	-	20.7	-
	20-25	45.1	52.8	40.9	52.3	30.7	53.0
	25-30	57.6	68.0	53.8	48.9	53.1	52.9
	30-35	75.2	81.0	75.8	72.2	66.5	-
	35-40	82.4	83.0	86.3	88.6	67.9	-
	40+	89.3	91.0	-	90.0	-	-
Watching TV	Controls	31.2	39.3	64.3	12.5	10.9	40.6
	<20	47.0	41.7	-	-	44.8	-
	20-25	54.0	55.3	68.2	52.3	44.6	66.1
	25-30	62.4	68.7	63.8	55.8	45.6	71.7
	30-35	67.3	75.3	65.3	66.0	53.5	-
	35-40	72.0	75.3	78.1	70.2	58.0	-
	40+	74.7	75.9	-	74.3	-	-
Listening to TV/Radio	Controls	21.6	17.9	46.4	17.2	13.0	34.4
	<20	50.6	61.1	-	-	31.0	-
	20-25	52.1	57.4	50.0	61.4	40.6	58.3
	25-30	65.4	71.8	61.3	60.9	62.5	62.0
	30-35	75.1	78.2	76.8	76.4	68.4	-
	35-40	83.1	84.9	83.6	87.7	70.4	-
	40+	88.4	90.2	-	91.4	-	-
Sleeping	Controls	8.9	2.7	17.9	10.9	13.0	12.5
	<20	19.3	16.7	-	-	20.7	-
	20-25	24.6	22.6	18.2	22.7	23.3	33.0
	25-30	30.5	34.0	21.3	27.0	34.4	28.9
	30-35	37.6	39.6	40.0	37.5	32.9	-
	35-40	44.5	47.6	39.7	47.4	34.6	-
	40+	53.8	52.6	-	57.1	-	-
Relaxing	Controls	11.3	9.8	21.4	9.4	8.7	15.6
	<20	25.3	38.9	-	-	13.8	-
	20-25	26.2	31.5	31.8	25.0	14.9	34.8
	25-30	35.7	44.7	30.0	30.3	27.5	33.2
	30-35	42.5	48.7	47.4	37.5	32.3	-
	35-40	55.5	60.5	53.4	55.3	40.7	-
	40+	58.7	59.4	-	60.0	-	-
Reading/ Studying	Controls	12.1	10.7	28.6	10.9	4.3	15.6
	<20	19.3	22.2	-	-	17.2	-
	20-25	21.2	24.3	22.7	25.0	12.4	28.7
	25-30	30.0	38.3	31.3	24.1	26.3	23.0
	30-35	33.7	41.5	35.8	27.1	23.9	-
	35-40	42.5	46.1	37.0	46.5	29.6	-
	40+	48.4	47.4	-	54.3	-	-

TABLE D.17 Percentage of respondents reporting various activity disturbances around each airport.

Activity	NEF3 zone	Overall	Syd	Rich	Adel	Perth	Melb
Entertaining	Controls	7.1	5.4	14.3	6.3	2.2	15.6
	<20	24.1	30.6	-	-	17.2	-
	20-25	25.6	29.8	13.6	25.0	16.8	34.8
	25-30	32.6	42.2	27.5	28.1	30.0	22.5
	30-35	49.5	55.4	50.5	49.3	38.7	-
	35-40	63.1	69.0	57.5	62.3	49.4	-
	40+	68.9	72.9	-	67.1	-	-
Other	Controls	2.5	3.6	7.1	0.0	2.2	0.0
	<20	2.4	2.8	-	-	3.4	-
	20-25	4.4	7.7	0.0	2.3	2.5	2.6
	25-30	7.5	9.7	11.3	8.4	3.1	3.2
	30-35	12.0	14.6	10.5	11.1	9.0	-
	35-40	13.7	11.4	15.1	13.2	21.0	-
	40+	18.7	14.3	-	27.1	-	-

TABLE D.17 (Cont'd) Percentage of respondents reporting various activity disturbances around each airport.

Activity Disturbance	Overall	Syd	Rich	Adel	Perth	Melb
Conversation	19.7	19.9	20.5	22.2	18.2	15.4
T.V. Flicker	25.8	26.2	35.1	19.6	21.0	36.7
TV/Radio/Music	19.6	20.5	15.8	26.3	16.8	10.1
Sleeping	19.1	15.1	14.3	17.4	31.5	25.1
Relaxing	6.4	7.2	8.1	5.7	4.4	6.0
Read/Study	3.3	3.9	2.3	2.5	3.5	2.6
Entertaining	4.1	5.5	0.4	3.2	4.2	3.0
Other	1.9	1.9	3.4	3.0	0.4	1.1

TABLE D.18 Percentage of respondents selecting various activity disturbances as most worth eliminating, from each airport. Respondents who do not report any activity disturbance are not included.

Feature	NEF3 zone	Overall	Syd	Rich	Adel	Perth	Melb
Public Transport	Controls	20.6	21.9	44.4	11.3	2.2	48.4
	<20	50.6	72.2	-	-	7.7	-
	20-25	27.7	30.2	50.0	2.3	12.4	60.7
	25-30	21.7	13.4	43.4	18.2	14.5	47.0
	30-35	13.8	9.3	45.3	9.5	10.9	-
	35-40	13.5	11.0	47.7	8.0	6.7	-
	40+	12.4	15.6	-	5.8	-	-
Shopping Centres	Controls	15.6	17.0	50.0	3.1	4.3	21.9
	<20	15.7	25.0	-	-	6.9	-
	20-25	15.7	14.3	9.1	20.5	5.4	36.5
	25-30	10.0	7.3	11.5	7.7	11.3	17.7
	30-35	13.1	13.0	7.4	12.5	16.9	-
	35-40	16.1	14.4	12.5	16.7	24.7	-
	40+	17.8	18.8	-	15.7	-	-
Parks & Playgrounds	Controls	25.5	20.4	25.0	16.4	23.3	71.9
	<20	6.0	2.9	-	-	16.0	-
	20-25	19.9	12.7	31.8	18.6	27.4	26.1
	25-30	21.9	17.7	12.0	11.2	35.5	46.9
	30-35	15.9	18.3	7.4	12.9	24.1	-
	35-40	17.6	19.1	1.5	19.1	34.6	-
	40+	24.0	26.9	-	25.4	-	-
Pollution	Controls	22.3	37.8	3.7	12.5	11.1	21.9
	<20	22.9	45.7	-	-	7.4	-
	20-25	23.6	37.9	0.0	39.5	13.0	16.7
	25-30	26.2	39.2	11.5	20.6	19.6	22.0
	30-35	32.2	48.4	19.6	28.5	13.8	-
	35-40	34.9	49.2	18.8	30.1	17.3	-
	40+	48.4	64.6	-	27.1	-	-
Traffic	Controls	37.6	53.6	22.2	19.0	19.6	59.4
	<20	33.7	25.0	-	-	27.6	-
	20-25	31.9	34.0	18.2	43.2	27.5	33.9
	25-30	38.7	49.8	36.3	25.2	39.4	35.3
	30-35	44.2	47.3	38.9	39.6	45.2	-
	35-40	44.2	55.4	24.7	35.1	37.0	-
	40+	40.4	56.4	-	15.7	-	-
Rates	Controls	18.4	20.0	35.7	22.8	24.4	46.2
	<20	19.3	9.7	-	-	30.0	-
	20-25	16.7	16.1	30.0	5.4	26.4	30.7
	25-30	15.4	29.6	29.2	7.9	16.9	27.6
	30-35	14.5	23.2	16.1	11.6	25.0	-
	35-40	17.1	26.6	23.1	17.1	25.0	-
	40+	12.9	18.3	-	17.9	-	-

TABLE D.19 Percentage of respondents rating neighbourhood as 'bad' or 'very bad' for various features around each airport.

Feature	NEF3 zone	Overall	Syd	Rich	Adel	Perth	Melb
Aircraft Noise	Controls	13.1	6.3	32.1	12.5	15.2	18.8
	<20	44.6	69.4	-	-	17.2	-
	20-25	48.7	58.4	18.2	47.7	36.8	57.4
	25-30	59.1	70.9	57.5	44.5	57.5	57.8
	30-35	74.0	79.9	81.9	70.8	63.2	-
	35-40	83.3	88.5	79.5	79.8	75.3	-
	40+	87.6	91.7	-	82.9	-	-
Schools & Colleges	Controls	4.6	3.7	12.0	0.0	0.0	21.9
	<20	7.2	9.4	-	-	4.3	-
	20-25	6.8	5.6	0.0	7.0	3.9	18.8
	25-30	6.0	5.3	8.7	3.5	7.9	12.3
	30-35	6.2	7.0	9.0	5.8	5.9	-
	35-40	5.2	6.5	6.1	6.2	5.5	-
	40+	9.8	9.6	-	16.7	-	-
Safety	Controls	15.6	18.9	18.5	9.4	13.0	18.8
	<20	24.1	36.1	-	-	20.7	-
	20-25	20.4	22.2	13.6	22.7	21.1	17.4
	25-30	20.9	19.8	18.2	15.7	28.8	26.7
	30-35	21.1	23.3	12.6	18.8	24.8	-
	35-40	23.0	31.0	16.9	14.2	16.3	-
	40+	19.6	24.0	-	12.9	-	-

TABLE D.19 (Cont'd) Percentage of respondents rating neighbourhood as 'bad' or 'very bad' for various features around each airport.

Noise	NEF3 zone	Overall	Syd	Rich	Adel	Perth	Melb
Traffic	Controls	52.0	59.5	53.6	48.4	37.0	53.1
	<20	58.7	48.6	-	-	53.6	-
	20-25	46.5	54.5	40.9	47.7	44.6	34.2
	25-30	52.2	59.6	57.5	46.0	49.1	45.5
	30-35	50.6	50.5	62.1	45.1	49.7	-
	35.40	47.6	51.5	46.6	45.6	38.3	-
	40+	50.7	55.6	-	45.7	-	-
Lawn Mowers	Controls	31.7	31.5	46.4	39.1	10.9	34.4
	<20	24.4	33.3	-	-	7.1	-
	20-25	25.6	31.2	31.8	13.6	21.3	25.4
	25-30	32.4	35.0	36.3	32.9	20.8	34.2
	30-35	23.7	25.7	29.5	20.8	19.4	-
	35-40	24.9	20.7	35.6	29.8	22.2	-
	40+	23.1	23.3	-	22.9	-	-

TABLE D.20 Percentage of respondents annoyed (rating $\geq 4/10$) by various noises around each airport.

Noise	NEF3 zone	Overall	Syd	Rich	Adel	Perth	Melb
Aircraft	Controls	35.2	36.0	57.1	32.8	23.9	34.4
	<20	50.0	68.6	-	-	24.1	-
	20-25	58.8	69.8	54.6	61.4	42.6	64.9
	25-30	69.3	79.6	58.8	65.7	61.6	63.1
	30-35	77.5	83.1	79.0	74.8	67.7	-
	35-40	32.3	85.9	76.7	86.8	69.1	-
	40+	92.0	94.0	-	90.0	-	-
Dogs/Cats	Controls	45.0	41.8	57.1	42.2	45.7	50.0
	<20	45.0	61.8	-	-	39.3	-
	20-25	43.6	41.5	38.1	40.9	40.8	55.4
	25-30	42.2	38.8	40.0	44.5	39.0	49.7
	30-35	38.2	39.2	39.0	36.1	37.8	-
	35-40	36.0	31.0	41.1	38.6	44.4	-
	40+	40.0	36.8	-	35.7	-	-
Road Works	Controls	14.7	12.6	17.9	1.6	6.5	6.3
	<20	6.0	0.0	-	-	10.3	-
	20-25	9.7	5.1	4.6	15.9	8.4	20.0
	25-30	8.0	9.2	11.3	9.5	5.6	3.8
	30-35	8.1	10.8	5.3	9.0	3.9	-
	35-40	6.3	8.5	0.0	5.3	6.2	-
	40+	4.5	6.1	-	2.9	-	-
Trains	Controls	2.5	2.7	0.0	0.0	0.0	12.5
	<20	0.0	0.0	-	-	0.0	-
	20-25	10.2	10.7	0.0	11.4	7.9	14.9
	25-30	9.8	3.4	28.8	0.4	10.7	29.2
	30-35	5.0	4.1	11.6	0.7	8.4	-
	35-40	6.7	8.2	6.9	0.0	11.1	-
	40+	8.9	13.5	-	0.0	-	-
Neighbour's TV/Radio	Controls	17.7	23.2	28.6	10.9	13.0	9.4
	<20	18.1	22.2	-	-	17.2	-
	20-25	15.1	18.4	13.6	13.6	12.9	13.0
	25-30	15.9	19.9	17.5	14.6	10.0	13.5
	30-35	14.4	14.0	25.3	13.2	10.3	-
	35-40	16.0	14.8	20.6	14.0	18.5	-
	40+	14.2	14.3	-	14.3	-	-
Garbage Collection	Controls	17.3	20.9	39.3	12.5	6.7	9.7
	<20	7.3	5.6	-	-	7.1	-
	20-25	15.0	19.7	52.4	15.9	6.5	13.0
	25-30	18.0	24.6	30.0	15.7	4.4	13.4
	30-35	17.1	19.1	40.0	9.7	6.5	-
	35-40	15.8	14.8	39.7	12.3	2.5	-
	40+	13.3	12.0	-	14.3	-	-

TABLE D.20 (cont'd) Percentage of respondents annoyed (rating ≥ 4/10) by various noises around each airport.

Noise	NEF3 zone	Overall	Syd	Rich	Adel	Perth	Melb
Other	Controls	18.2	18.0	24.0	25.0	8.7	13.8
	<20	20.7	28.6	-	-	20.7	-
	20-25	15.8	17.6	5.0	4.6	11.4	12.2
	25-30	14.9	13.1	19.2	13.2	15.8	18.4
	30-35	11.7	11.8	19.0	7.6	11.0	-
	35-40	10.9	9.4	15.5	7.9	16.3	-
	40+	11.8	14.8	-	5.7	-	-

TABLE D.20 (cont'd) Percentage of respondents annoyed (rating ≥ 4/10) by various noises around each airport.

Criterion for Determining Health Effects	NEF3 Zone	Overall	Syd	Rich	Adel	Perth	Melb
Effect reported in all of Q.8, Q.9 and Q.25	Controls	0.4	0.0	0.0	1.6	0.0	0.0
	<20	2.5	5.9	-	-	0.0	0.0
	20-25	1.6	1.7	0.0	0.0	0.0	5.3
	25.30	3.0	5.0	2.5	3.3	0.6	0.5
	30.35	5.1	7.7	4.3	3.5	1.9	-
	35-40	7.7	8.7	4.2	9.7	5.0	-
	40+	12.3	16.7	-	4.5	-	-
Effect reported in at least two of Q.8, Q.9 and Q.25	Controls	1.1	1.8	0.0	1.6	0.0	0.0
	<20	4.9	11.8	-	-	0.0	0.0
	20-25	5.7	7.7	0.0	7.0	0.5	11.4
	25-30	11.2	16.1	12.5	9.5	6.9	6.5
	30-35	15.0	18.9	10.6	14.8	10.3	-
	35-40	21.5	26.4	12.5	21.9	12.5	-
	40+	31.8	37.1	-	23.9	-	-
Effect reported in at least one of Q.8, Q.9 and Q.25	Controls	6.5	5.5	18.5	6.3	2.2	6.3
	<20	16.1	26.5	-	-	6.9	11.1
	20-25	16.5	20.6	9.1	16.3	10.9	19.3
	25-30	23.7	32.7	22.5	17.2	17.0	20.0
	30-35	31.1	39.1	28.7	24.7	21.3	-
	35-40	40.5	45.3	41.7	37.7	27.5	-
	40+	52.7	59.9	-	43.3	-	-

TABLE D.21 Percentage of respondents reporting health effects due to aircraft noise in Q.8 (open question), Q.9 (neutral question) and Q.25 (noise-worded question)

NEF3 zone	Overall	Syd	Rich	Adel	Perth	Melb
Controls	282	112	28	64	46	32
<20	83	36	0	0	29	18
20-25	618	235	22	44	202	115
25-30	1113	412	80	274	160	187
30-35	715	316	95	144	155	5
35-40	539	271	73	114	81	0
40+	225	133	13	70	9	0

TABLE D.22 Number of respondents in NEF3 zones for each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	5.43	5.88	6.31	6.25
	E	5.20	5.40	5.57	-
	S	5.59	-	-	-
	W	5.31	5.69	5.64	6.39
Richmond	E	4.79	-	-	-
	W	4.74	4.96	5.29	5.77
Adelaide	N	5.40	5.68	5.81	6.20
	E	5.52	-	-	-
	S	4.86	5.23	5.64	-
	W	4.46	-	-	-
Perth	N	5.06	5.20	4.91	5.29
	E	4.65	4.63	-	-
	S	4.80	5.22	5.13	-
	W	4.18	5.07	4.65	-
Melbourne	E	5.27	4.69	-	-
	S	5.24	5.83	-	-

TABLE D.23 Mean values of the variable NEGATT in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	2.65	3.80	4.95	4.39
	E	2.97	3.50	2.91	-
	S	3.77	-	-	-
	W	2.74	4.12	4.21	6.37
Richmond	E	2.68	-	-	-
	W	2.71	3.14	3.81	5.20
Adelaide	N	1.52	3.72	4.28	4.75
	E	3.91	-	-	-
	S	1.55	1.32	2.82	-
	W	2.67	-	-	-
Perth	N	1.48	2.08	2.45	2.54
	E	2.04	1.52	-	-
	S	1.98	2.06	2.65	-
	W	0.81	2.27	2.88	-
Melbourne	E	3.36	3.15	-	-
	S	3.16	4.94	-	-

TABLE D.24 Mean values of the variable CRASH in each sampling zone around each airport.

Airport	Flight Path	Sampling Zone			
		1	2	3	4
Sydney	N	4.62	4.74	4.64	3.76
	E	3.74	4.16	2.79	-
	S	4.53	-	-	-
	W	4.51	4.02	3.84	4.68
Richmond	E	4.96	-	-	-
	W	3.94	4.56	3.71	4.70
Adelaide	N	4.30	4.69	4.19	5.31
	E	4.71	-	-	-
	S	3.89	3.87	4.44	-
	W	4.94	-	-	-
Perth	N	4.22	3.77	4.23	3.94
	E	4.33	4.42	-	-
	S	4.36	4.68	4.78	-
	W	4.31	4.20	4.24	-
Melbourne	E	4.81	4.49	-	-
	S	4.36	4.75	-	-

TABLE D.25 Mean values of the variable NOISE SENSITIVITY in each in each sampling zone around each airport.

APPENDIX E

DATA ON POPULATION AFFECTED

Airport & Flight Path	Exposure Zone ($NEF_{3,6}$)	Dwelling Count	No. per Dwelling	Seriously Affected		Moderately Affected	
				%	Number	%	Number
Sydney North	15-20	17,000	3.07	10.2	5,323	55.1	28,757
	20-25	10,908		24.5	8,204	62.8	21,030
	25-30	6,780		30.5	6,348	69.7	14,508
	30-35	3,586		43.2	4,756	78.6	8,653
	35-40	730		52.3	1,172	84.8	1,900
	40+	270		64.8	537	87.2	723
Sydney East	15-20	22,000	2.93	10.2	6,575	55.1	35,517
	20-25	14,277		24.5	10,249	62.8	26,270
	25-30	9,352		30.5	8,357	69.7	19,099
	30-35	1,516		43.2	1,919	78.6	3,491
	35-40	306		52.3	469	84.8	760
	40+	80		64.8	152	87.2	204
Sydney South	15-20	150	3.07	10.2	47	55.1	254
	20-25	241		24.5	181	62.8	465
	25-30	-					
	30-35	-					
	35-40	-					
	40+	-					
Sydney West	15-20	15,500	2.97	10.2	4,696	55.1	25,365
	20-25	11,088		24.5	8,068	62.8	20,681
	25-30	6,576		30.5	5,957	69.7	13,613
	30-35	2,761		43.2	3,542	78.6	6,445
	35-40	1,206		52.3	1,873	84.8	3,037
	40+	215		64.8	414	87.2	557

TABLE E.1 Dwelling counts and estimates of population affected around SYDNEY airport.

Airport & Flight Path	Exposure Zone(NEF$_{3,6}$)	Dwelling Count	No. per Dwelling	Seriously Affected		Moderately Affected	
				%	Number	%	Number
Adelaide North	15-20	11,000	2.75	8.7	2,632	44.4	13,431
	20-25	6,934		17.1	3,261	60.7	11,575
	25-30	3,546		13.7	1,336	56.2	5,480
	30-35	1,482		41.3	1,683	77.0	3,138
	35-40	545		44.7	670	83.0	1,244
	40+	78		53.3	114	84.4	181
Adelaide East	15-20	4,750	3.39	8.7	1,401	44.4	7,150
	20-25	1,165		17.1	675	60.7	2,397
	25-30	95		13.7	44	56.2	181
	30-35	-					
	40+	-					
Adelaide South	15-20	6,450	2.17	8.7	1,218	44.4	6,214
	20-25	3,015		17.1	1,119	60.7	3,971
	25-30	762		13.7	227	56.2	929
	30-35	312		41.3	280	77.0	521
	35-40	75		44.7	73	83.0	135
	40+	11		53.3	13	84.4	20
Adelaide West	15-20	4,400	3.48	8.7	1,332	44.4	6,799
	20-25	845		17.1	503	60.7	1,785
	25-30	15		13.7	7	56.2	29
	30-35	-					
	35-40	-					
	40+	-					

TABLE E.2 Dwelling counts and estimates of population affected around ADELAIDE airport.

Airport & Flight Path	Exposure Zone ($NEF_{3,6}$)	Dwelling Count	No. per Dwelling	Seriously Affected		Moderately Affected	
				%	Number	%	Number
Perth North	15-20	228	3.21	6.3	46	35.3	258
	20-25	244		16.7	131	51.6	404
	25-30	266		20.1	172	50.4	430
	30-35	181		22.0	128	58.5	340
	35-40	24		37.5	29	62.5	48
	40+	-					
Perth East	15-20	80	3.40	6.3	17	35.3	96
	20-25	27		16.7	15	51.6	47
	25-30	4		20.1	3	50.4	7
	30-35	1		22.0	1	58.5	2
	35-40	-					
	40+	-					
Perth South	15-20	4,100	3.28	6.3	847	35.3	4,747
	20-25	2,984		16.7	1,635	51.6	5,050
	25-30	1,374		20.1	906	50.4	2,271
	30-35	32		22.0	23	58.5	61
	35-40	1		37.5	1	62.5	2
	40+	-					
Perth West	15-20	1,550	3.06	6.3	299	35.3	1,674
	20-25	542		16.7	277	51.6	856
	25-30	186		20.1	114	50.4	287
	30-35	4		22.0	3	58.5	7
	35-40	-					
	40+	-					

TABLE E.3 Dwelling counts and estimates of population affected around PERTH airport.

Airport & Flight Path	Exposure Zone (NEF$_{3,6}$)	Dwelling Count	No. per Dwelling	Seriously Affected		Moderately Affected	
				%	Number	%	Number
Richmond East	15-20	540	2.48	10.5	141	47.3	633
	20-25	355		13.0	114	54.6	481
	25-30	85		25.4	54	58.2	123
	30-35	115		26.9	77	66.4	189
	35-40	-					
	40+	-					
Richmond West	15-20	735	2.95	10.5	228	47.3	1,026
	20-25	623		13.0	239	54.6	1,003
	25-30	243		25.4	182	58.2	417
	30-35	149		26.9	118	66.4	292
	35-40	94		24.1	67	86.2	239
	40+	-					
Melbourne East	15-20	1,950	3.97	16.7	1,293	54.5	4,219
	20-35	1,355		16.1	866	58.0	3,120
	25-30	479		10.9	207	45.3	861
	30-35	-					
	35-40	-					
	40+	-					
Melbourne South	15-20	3,600	3.81	16.7	2,291	54.5	7,475
	20-25	1,877		16.1	1,151	58.0	4,148
	35-30	34		10.9	14	45.3	59
	30-35	-					
	35-40	-					
	40+	-					

TABLE E.4 Dwelling counts and estimates of population affected around RICHMOND and MELBOURNE airports.