Chapter 6

Risk To People From Development

Introduction

The Australian approach to the risks to people from development, especially hazardous industrial development, is handled through the Hazardous Industries Planning Task Force, which is a joint State Governments' technical body intended to share skills and information on managing the risks from hazardous facilities. Most of the States have produced guidelines, with those of Western Australia and New South Wales being the most detailed.

Western Australia

In May 1987 the Environmental Protection Authority published details of its requirements for the evaluation of risks and hazards (EPA, 1987). These were subsequently reviewed and extended (EPA, 1992a, b) to produce risk criteria as guidelines for assessing the acceptability of risks imposed upon surrounding land uses by new hazardous industry. These criteria were:

(a) A fatality risk level in residential zones of less than one in a million per year is so small as to be acceptable to the EPA.

(b) A fatality risk level for 'sensitive developments' such as hospitals, schools, child care facilities and aged care housing developments of between one half and one in a million per year is so small as to be acceptable to the EPA.

(c) Fatality risk levels from industrial facilities should not exceed a target of fifty in a million per year at the site boundary for each individual industry, and the cumulative fatality risk level imposed upon an industry should not exceed a target of one hundred in a million per year.

(d) A fatality risk level, for any non-industrial activity located in buffer zones between industrial facilities and residences, lower than ten in a million is so small as to be acceptable.

The fatality risk level of one in a million per year assumes that residents will be outdoors at their homes, exposed to the risk 24 hours a day, continuously day after day for the whole year and do nothing to avoid being harmed. The risk levels calculated under such assumptions are deliberately conservative and a similar spirit of environmental conservatism exists in most of the applications of risk analysis to the environment. Criterion (b) is excessively conservative. An LPG tank used for heating a hospital that is sited on the hospital grounds will have, according to the above definitions, an unacceptable level of risk immediately adjacent to the storage facility itself. Accordingly, a modified criterion for risk generators situated on the grounds of sensitive developments was produced (EPA, 1994).

New South Wales

Within New South Wales there has been a long-standing policy that development proposals for potentially hazardous industry should be subject to a comprehensive assessment of the risks, often as part of an overall impact assessment. The integrated approach to land use safety planning is set out in the Department of Planning's Hazardous Industry Advisory Paper Number 3 (Department of Planning, 1994) which was first issued in 1989 and is presently in its third edition.

The approach considers a development in the context of its siting and its technical and management controls. The assessment process includes a number of studies that need to be carried out at various stages of the development process — from concept, through initial design and examination of environmental impact, to detailed design and operation. Quantitative risk assessment criteria similar (but not identical) to those of Western Australia have also been produced (Department of Planning, 1992). The New South Wales criteria are summarised in Table 6.1

Table 6.1 New South Wales suggested individual fatality risk criteria for various land uses

Land use	Criterion (risk in a million per year)
Hospitals, schools, child-care, nursing homes	0.5
residential, hotels, motels, tourist resorts	1
commercial developments	5
sporting complexes and active open space	10
industrial	50

Department of Planning (1992), in setting the criteria of Table 6.1, took account of the various risks to which people are exposed during various activities. The basis of setting criteria is to determine a risk from a potentially hazardous installation that is below most risks being experienced by the community. Typical risks to individuals in New South Wales (extracted from Department of Planning, 1992, who quote Higson, 1990) are given in Table 6.2. Irrespective of the numerical value of any risk criterion level, certain qualitative principles are also set out:

- all avoidable risks should be avoided;
- the risk from a major hazard should be reduced wherever practicable, irrespective of the cumulative risk level from the whole installation;
- the effects of the more likely hazardous events should be contained within the installation; and
- where there is an existing high risk from a hazardous installation, additional hazardous developments should not be allowed if they add significantly to that existing risk.

Table 6.2 Risks to individuals in New South Wales

Voluntary Risks	Chance of fatality per million persons per year
Smoking (20 per day) — all effects	5000
Swimming	50
Playing rugby football	30
Transport risks	
Travelling by car	145
Travelling by train	30
Travelling by aeroplane (risk of accident)	10
Risks averaged over the whole population	
Cancers from all causes	1800
Accidents in the home	380
Pedestrians being struck by motor vehicle	35
Lightning strikes	0.1

Organisations undertaking risk assessment in New South Wales

There is a number of risk assessment consultants in New South Wales with the experience and capability to undertake risk assessments of hazardous industry. The

Department of Planning has an in-house capacity to evaluate such consultancies through the Major Hazards Policy Unit of the New South Wales Department of Planning. This unit of five people also has the task of preparing and communicating the guidelines contained in the hazardous industry planning advisory papers. The unit has purchased the computer model SAFETI, developed by Technica, which it can use to assess possible hazardous industrial operations. A brief, open-literature description of SAFETI and its incorporation into a decision support system may be found in Fedra & Weigkricht (1995).

The University of Sydney, in conjunction with ANSTO, has established the only centre for risk engineering in Australia: the Australian Centre of Advanced Risk and Reliability Engineering. This centre is headed by an executive director who is also a Professor of Risk Engineering within the Department of Chemical Engineering. The centre thus acts as both a research body and a consultancy organisation.

Risk to the biophysical environment

The above discussion has concentrated on the risk to people. In part this perpetuates the health-risk aspect of traditional risk assessment and in part it is an accurate indication of the fact that the majority of Australians live in cities, so that the primary component of the ecosystem surrounding an urban industrial location consists of people. However, a proper risk assessment that is sufficiently general in scope should certainly consider the risk from accidental releases to the biophysical environment.

In fact, the principles of ecologically sustainable development (Commonwealth of Australia, 1992: page 60) require land use planners and decision makers to place risk-weighted values on goods and services while encouraging decision making that takes full account of all relevant land and natural resource values. The main concern here is with the effects on ecosystems, rather than with effects on individual plants or animals. The topic is complicated. Ecological risk assessment is a topic of active research which will be discussed in the next section.

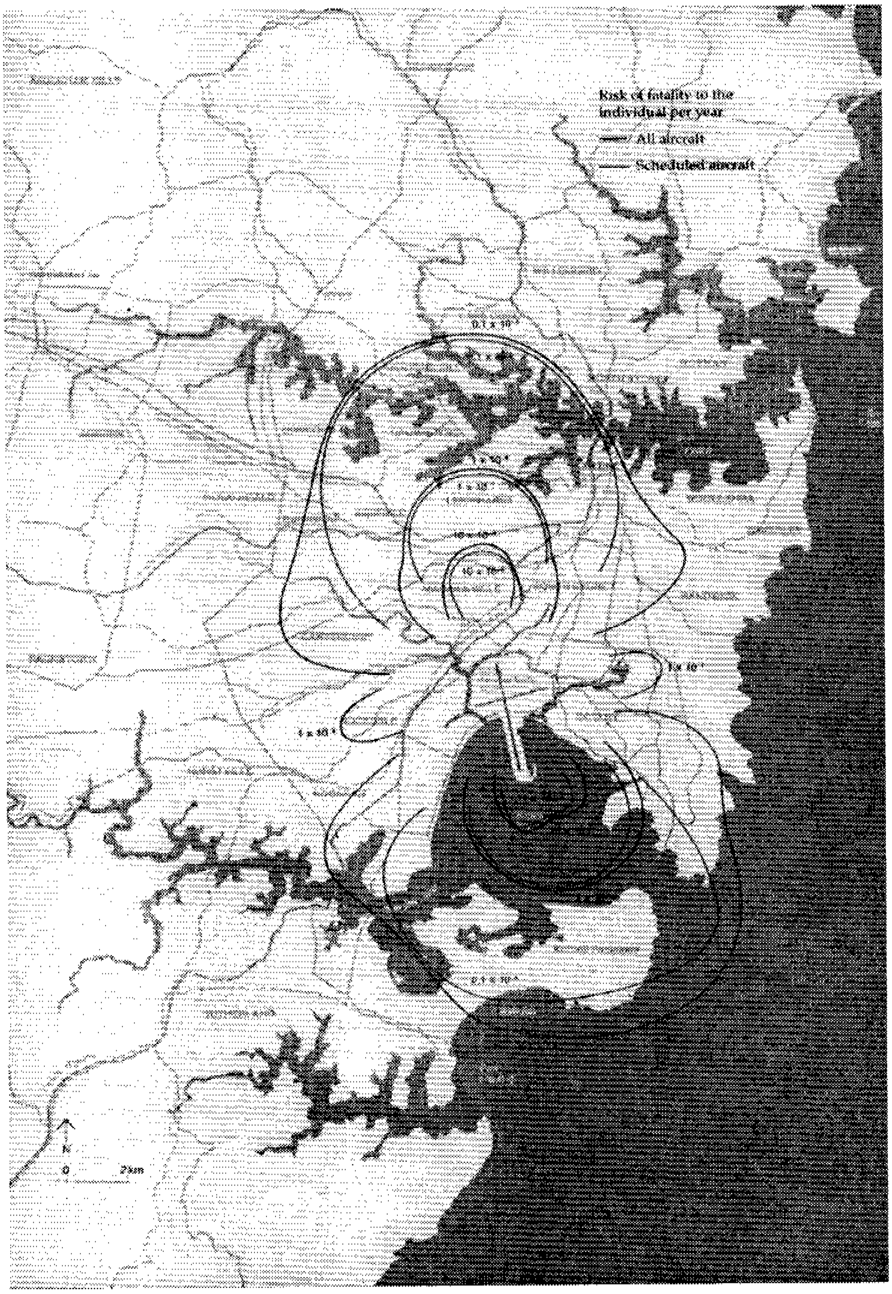
Individual risk and societal risk

Human fatality risk results are expressed in two forms: individual risk and societal risk. Individual risk is the risk of death to a person at a particular point. As an example, Figure 6.1 reproduces the fatality risk contours that formed part of the environmental impact statement for the Sydney Airport Third Runway proposal. The risk contours indicate the expected risk of fatality to an individual in residential areas surrounding the airport when the third runway is in operation.

Societal risk is the risk of a number of fatalities occurring. It combines the consequences and likelihood information with population information. The societal risk concept is based on the premise that society is more concerned with incidents that kill a larger number of people than incidents which kill fewer numbers. The societal risk contours for the Sydney Third Runway proposal are shown in Figure 6.2. This figure is presented as an F-N curve that indicates the cumulative frequency (F) of killing N or more people. Thus, Figure 6.2 indicates that there are, on average, about 1000 people killed in fatal road accidents in NSW (i.e. accidents that kill one or more people), but only about 100 people killed in road accidents that kill two or more people.

As an illustration of the care that is needed in interpreting risk statistics, this figure of 1000 per year differs slightly from the figure that can be obtained from Table 6.2. The chance of a fatal motor vehicle accident in NSW is 145 per million per year. The population of NSW in 1987/88 was 5.7 million people, so multiplying the two numbers indicates that the actual number of motor accidents involving one or more fatalities was 826. This figure represents drivers and passengers. When pedestrians are included (RTA, 1990) then the figure rises to 1029 fatalities in 1986, drops to 959 fatalities in 1987 and increases again to 1037 fatalities in 1988.

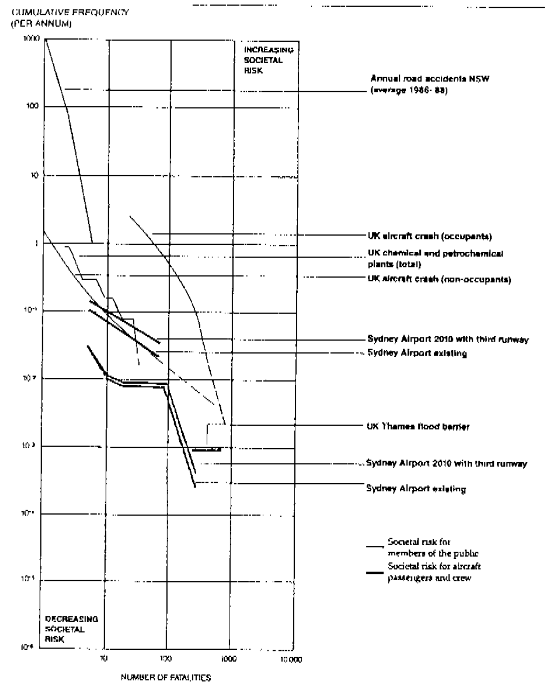
Figure 6.1 Predicted risk to the individual for long-term scenario (From Kinhill Engineers Pty Ltd, 1991)



Societal risk data on major natural and human-made accidents (Fig. 6.3) has been used by some authorities as the basis of deriving a societal risk acceptability criteria F-N curve. The Dutch National Environmental Plan (Directorate-General for Environmental Protection, 1988) sets limits for societal risk (or group risk as they are called in the Dutch document) on the basis of incremental risk, as follows (Fig. 6.4):

An increase in the number of deaths by a factor n in a given situation is only acceptable if the probability of this event occurring is a factor n^2 lower for both types of level. The maximum permissible risk levels for disasters are defined as 10^{-5} per year for $n = 10$ or more deaths and 10^{-7} per year for $n = 100$ or more deaths. The corresponding negligible levels are defined as 10^{-7} per year for $n = 10$ or more deaths and 10^{-9} per year for $n = 100$ or more deaths.

Figure 6.2 Predicted Societal Risks (From Kinhill Engineers Pty Ltd, 1991)



The NSW Department of Planning (1990, 1992) believes that much more research is needed before societal risk guidelines or criteria can be adopted. The major reason for this is that societal risk acceptability is specific to each society and it is very important that allowance be made to reflect differences between societies and cultures. Thus, judgements on societal risk need to be made on the basis of a qualitative approach on the merit of each case rather than on specifically set numerical values.

Figure 6.3 Societal risk curves for some human-caused events in the USA

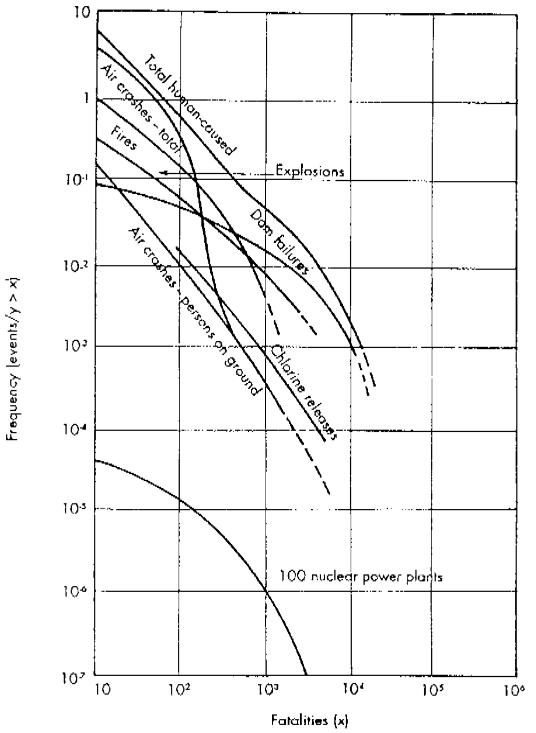
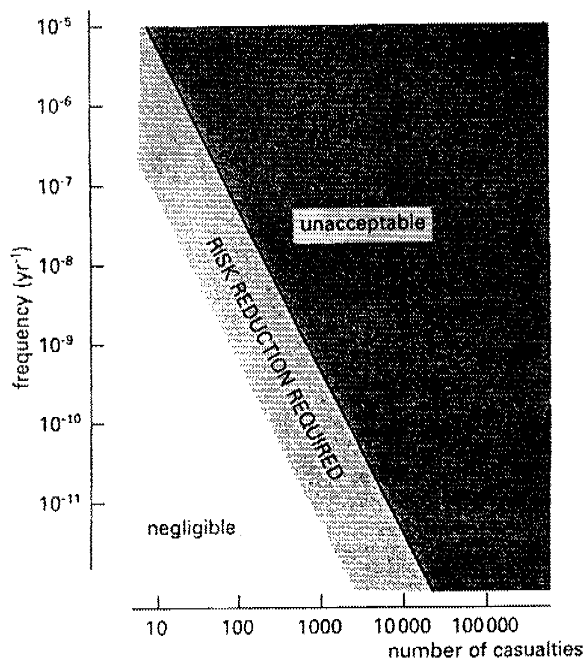


Figure 6.4 Incremental group risk limits for major accidents (From Directorate-General for Environmental Protection 1988: VROM Publication No. 90569/12-89)



Case Study: Sydney Third Runway

Background

On 4 November 1994 a third runway at Sydney Airport was opened for traffic. As a result, airport operations changed to accommodate the new runway by maximising north-south traffic flow and greatly reducing use of the east-west runway.

The increase in noise levels in areas north of the airport that arose as a result of the use of the third runway caused consternation among the local populace and resulted in community protest and demonstrations, including a mass blockade of the airport on 17 December 1994 which consisted of a group variously estimated as being 6 000 to 15 000 strong (Canberra Times, 18 December, 1994). The protest by residents and local councils from the northern areas attracted considerable media coverage, especially the use of loudspeakers, mounted on a truck, that were taken to locations such as Parliament House in Canberra and used to direct amplified aircraft noise at politicians so as to make them aware of the problems faced by the local populace.

The Environmental Impact Statement

The Federal Airports Corporation prepared an environmental impact statement (EIS) for the proposed third runway (Kinhill, 1990, 1991). Environmental agencies in Australia have long adopted an issues-based approach to environmental impact assessment, as opposed to the checklist-based approach that was used in the early days of environmental impact assessment. Thus, any properly constituted EIS should itself constitute a risk assessment of the issue, within the framework established by the United States National Research Council or that of the Asian Development Bank. It is a risk assessment in that the role of an EIS is (amongst others) to identify the hazards associated with the activity and to determine whether these hazards pose a risk to the environment.

The Sydney 3rd runway EIS examined 17 issues which were divided into three parts. These were:

- *issues relating to project layout* — heritage, hydrology (groundwater and surface), terrestrial ecology, aesthetics, interrelated issues;
- *issues relating to project construction* — sources of bulk fill, coastal hydrodynamics of Botany Bay, marine ecology of Botany Bay, effects of extraction on other fill sources, other construction issues; and
- *issues relating to project operation* — aircraft noise, economics and land use, social and demographic environment, hazards of airport operation, air quality, surface transport, other issues.

The section of the EIS that dealt with the hazards of aircraft operation consisted of a quantitative risk assessment using the traditional engineering approach to risk assessment. This was an important issue that had been identified as being of public concern. In addition, there was substantial public concern over the issue of noise.

The effect of noise was the single issue that was of overwhelming concern to people opposed to the proposed third runway. During the consultation phase of the EIS, it was raised as an issue 594 times. The next most contentious issue among opponents was the risk of aircraft crashes, which was raised 321 times. Publication of the EIS did not allay these concerns. The preface to the supplement to the draft EIS (Kinhill, 1991) lists the concerns raised during the public review phase of the draft EIS. Of the above list of issues, social and demographic issues topped the list of concerns, but when these are examined they primarily relate to the social disruption arising from excessive aircraft noise. Aircraft noise, *per se*, was the issue of next-highest concern, followed by hazards.

The aims of this case study are to examine the following questions:

1. Despite the formal process of an EIS, public review and Commonwealth assessment; the ensuing aircraft noise was unacceptable to a large and influential section of the public. Were the needs and concerns of the affected population adequately considered in the original framing of the issues?
2. Was there a technical deficiency in the assumptions made in evaluating aircraft noise contours, the methodology used or in the interpretations of the results?
3. Could the use of a quantitative risk assessment process have predicted such a problem?
4. What guidelines could be implemented that would cover both the traditional engineering risk assessment, as well as the risk assessment of an issue such as the public response to excessive noise?

The engineering risk assessment

Full details of the engineering risk assessment may be found in a working paper (ACARRE, 1990) which is summarised in the draft EIS. Four hazards were identified and quantitatively evaluated: (i) fuel spills, (ii) collisions, (iii) crashes, and (iv) fires and explosions. The predicted risks to individuals were presented as contour plots of probability that overlay a map of the general area. The overall result, which was reproduced in both the draft EIS and the environmental assessment report (DASETT, 1991), estimated that, under airport operations prior to the 3rd runway, the risk of fatality to the individual per year at a near-north location such as Marrickville, was 42 chances in a million (4.2×10^{-5}) (ACARRE, p. 81). These risks increased by about a factor of 2.5, to 103 chances per million, after the third runway was in operation though at the same time, because use of the third runway would reduce use of the east-west runway, the risk of a crash into a residential area in the east-west direction was reduced by a factor of about ten.

There are a number of aspects of this analysis of relevance to a Commonwealth position on quantitative environmental risk assessment. The first is the usefulness of the analysis for determining priorities for the most fruitful areas for risk reduction. Three areas emerged from the formal risk analysis of ACARRE (1990):

- emergency procedures;

- flight paths over hazardous industrial facilities; and
- risk posed to residential areas.

A disturbing aspect of the risk assessment is that the risk to populations immediately to the north of the airport far exceed the levels deemed acceptable for industrial risks imposed on various forms of land use (Department of Planning, 1990). These risks are given in Table 6.1. Three different approaches seem to have been taken to deal with this:

Bell (1990) undertook a study of areas in which risks may have been understated. His review of the data and assumptions implies (but does not actually state) that, if the situation without the third runway already exceeds risk guidelines, then no further development should be allowed. In fact, Fig. 5 of Bell (1990) contains contours indicating areas unsuitable for residential purposes at present and an even larger area considered unsuitable for schools and hospitals. The implication is that present usage of the airport should be reduced.

The Environmental Assessment Report (DASETT, 1991, p. 148) looks at the incremental risk, which is the increase in fatality risk levels. The implication here is that, in a proposal that consists of an upgrade of a facility in which the existing risk level is high, it is acceptable to reduce the risk but not to increase it.

The NSW Department of Planning (DASETT, 1991, Appendix 4) emphasised that risk estimates are themselves uncertain and that the values given in the EIS were 'cautious best estimates'. By thus implicitly reducing the risk estimates it was then possible to argue that the benefits of access to air travel outweigh the risk implications. Though the justification for doing this was not spelt out in the response it seems to hinge on two issues.

Firstly, the NSW Department of Planning quantitative criteria are for industrial development. The implication is that the crtieria apply to a development such as a factory, from which the affected public do not receive immediate benefit (unlike, say, the owners of the factory). In the case of Sydney airport, the people at risk derive direct benefit from its existence because it provides the only means of rapid interstate and international communication.

The second issue is that, by not having set criteria for societal risk, it is possible to argue, as was done by the NSW Department of Planning, that "it is generally accepted that the benefits of access to air travel in major cities outweigh the societal risk implications". It is certainly the case that the societal risk contours presented in the EIS indicate that the societal risk for members of the public that arises from Sydney airport (with or without the third runway) is much less than the societal risk for UK aircraft crashes.

The noise assessment

Full details of the noise study may be found in a two volume working paper (Vipac, 1990) which is summarised in the draft EIS. The noise study used the Australian Noise Exposure Forecast (ANEF) system. This provided an index that has been incorporated into a dose-response relationship by the National Acoustic Laboratories (Fig. 1 in the paper). The EIS measured the social impact of noise in terms of the number of people affected by the noise. It used a complex measure to determine whether people were moderately or seriously affected. As a rough guide, 15 ANEF values approximate moderate disturbance and 25 ANEF values approximate serious disturbance.

Table 6.3 Estimated numbers of people affected by aircraft noise

	1988 Base case		Long-term (2010) scenario	
	Moderate	Serious	Moderate	Serious
South	1 100	300	800	200
West	60 100	19 000	1 000	200
North	61 600	19 800	65 100	20 500
East	47 300	15 600	3 300	600
Total	**170 100**	**54 700**	**70 200**	**21 500**

The figures published in the draft EIS for the number of people affected by noise were revised downward in the supplement to the EIS on the basis of a revised fleet mix using newer, quieter planes. The number of people estimated to be moderately or seriously affected are given in Table 6.3.

Even though there is a sizeable decrease in the total number of people affected, as shown in Table 6.3, the numbers affected to the north increase. Nevertheless, if these figures are taken at face value then one would expect the 1988 base case group to have acclimatised to the present noise regime, so that it would be realistic to expect complaints to come only from the 4 200 people newly exposed to noise. It is unanimously agreed that more than this number protested during the December blockade of Sydney airport. Thus, either the numbers in Table 6.3 misrepresent the short-term situation, or a sizeable number of existing residents were not acclimatised to the noise and were willing to protest.

An internal report of the NSW Environment Protection Authority (Environment Protection Authority, 1995), released to the media in January 1995, states that

> *"There appears to be a general community feeling that the information provided did not adequately inform the community about the magnitude and location of the noise impacts under the interim operation regime."*

The major problem that was identified was a greatly increased frequency of aircraft noise events over that predicted for take-offs to the north. The ANEF contours were based on 13% of daily movements being to the north. However, during summer months, as a result of expected northerly wind conditions, over 25% of all movements, on average, are predicted to take-off to the north during afternoons and evenings.

Over a period of a few days, the variation in the percentage of take-offs to the north can be even higher. This occurred with the opening of the third runway, which coincided with a period of winds from the northerly direction. The average daily ANEF, derived from annual averages, is not well suited to predicting the short term impacts experienced since the new runway was opened. The NSW Environment Protection Authority expects, however, that over a period of time the level of impact will converge to that originally assessed.

Discussion

The case study began by asking a number of questions. In hindsight it appears that the needs and concerns of the affected population were not adequately considered. For example, there was no public hearing on the EIS. In part this probably reflects the fact that the benefits associated with improvement in air services was a major influence in determining the acceptable options for airports in Sydney. The development of the third runway is one of three elements of a strategy announced by the Commonwealth Government in March 1989 to meet the airport needs of the Sydney Basin into the next century. The issue of whether the expression of such benefits in the form of political factors count as risks and, if so, how to deal with them will be discussed in the Chapter on risks of political decision making.

The inadequacy of the process appears to have been a direct result of the environmental impact statement noise contours being based on an annual average, whereas the community has reacted very strongly to the impact over a very much shorter period. In retrospect, the annual average ANEF contours are inappropriate for estimating community reaction. Worst-case contours should have been presented for periods of persistent northerly winds.

Had the noise study been done with risk assessment techniques in mind then such a worst-case scenario would have been expected. Such considerations have been built into accepted practice in air dispersion modelling. The air quality contours (Kinhill, 1990, p. 26-15) give predicted maximum one-hour concentration contours for January, April, July and October. The emphasis is to look at the worst-case and to look at seasonal variability. The lack of a similar level of sophistication in the approach to noise assessment led to some of the ensuing problems.

The issue of guidelines that could be implemented to cover both the traditional engineering risk assessment, as well as the risk assessment of an issue such as the public response to excessive noise, will be considered later. However, this case study has indicated the need for risk assessments within the EIS process to be more wide-ranging than just engineering risk assessments of fatality risk. In fact, a full risk assessment and risk communication process considering public health problems (including noise) and alternative land use plans conducted within a strategic planning context (i.e. considering the options of other airport locations) would have improved both the environmental impact assessment and the basis for eventual decision-making.

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