CONTENTS

NATIONAL AIRPORTS SAFEGUARDING FRAMEWORK

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Purpose

1. The purpose of the National Airports Safeguarding Framework (the Safeguarding Framework) is to enhance the current and future safety, viability and growth of aviation operations at Australian airports, by supporting and enabling:

   - the implementation of best practice in relation to land use assessment and decision making in the vicinity of airports;
   - assurance of community safety and amenity near airports;
   - better understanding and recognition of aviation safety requirements and aircraft noise impacts in land use and related planning decisions;
   - the provision of greater certainty and clarity for developers and land owners;
   - improvements to regulatory certainty and efficiency; and
   - the publication and dissemination of information on best practice in land use and related planning that supports the safe and efficient operation of airports.

2. The Safeguarding Framework provides the opportunity to drive improvements in planning outcomes consistently across all jurisdictions, and to improve the safety and viability of operations at all Australian airports.

3. The Safeguarding Framework covers planning for the larger civilian airports subject to the Commonwealth Airports Act 1996 as well as military airports and smaller regional and general aviation airports. The Safeguarding Framework accommodates differences in size, use and local circumstances of individual airports in its application.

4. The Safeguarding Framework supports the integration and coordination of on-site and off-site planning relating to airport operations.[1]

Context

5. Australian airports are significant contributors to jobs, economic development, national productivity and social connectivity.

6. Airports are important national infrastructure assets. They are essential transport hubs and contribute significantly to the national economy, as well as to the economies of the cities, regions, States and Territories where they are located.

7. Airports support trade and tourism and help to drive growth across the economy. They support the jobs of around 50,000 people directly employed in the air transport sector[2] and many more in the retail, hospitality and service industries on airport sites.

8. All sectors of the Australian economy rely directly or indirectly on the efficient movement of people and freight through airports. Over 120 million passengers pass through Australian airports annually. Domestic air travel has more than trebled over the last 20 years, with over 50 million passenger movements in 2008-09 through more than 180 domestic airports[3].

9. Australia's annual international freight task comprises over $100 billion worth of air freight, over 20 per cent of the total value of Australia's international cargo trade.

10. Military airfields support both military operational and training activities, in order to fulfil critical national security requirements. They may also support general aviation when not in active military use. Military airfields also contribute significantly to the economies of the regions where they are located. References to airports in this Principles document, is intended to also include military airfields.

11. Sites for airports are scarce and finding new land to replace or expand existing airports is difficult. Existing sites in many cases pre-dated significant urban development. More recently, urban expansion and densification has increased tensions between residential and industrial development and airport operations.

[1] One of the specific goals identified in the Australian Government's National Aviation Policy White Paper (page 3) is that planning at Australia's airports should facilitate effective integration and coordination with off –airport planning.
[2] ABS, Labour Force, Australia, Detailed, Quarterly, Aug 2009 (ABS cat. no. 6291.0.55.003, Table 6).
[3] Australian Government National Aviation White Paper, December 2009, page 7.

12. The Bureau of Infrastructure, Transport and Regional Economics has predicted that passenger movements though Australian airports will increase by 4 per cent per annum over the next twenty years resulting in a doubling of passenger movements over the period.[4]

13. The main challenge is to balance growing demand for aviation services with urban growth pressures and the continued amenity and safety of residents in surrounding areas. Population growth, development demands and increased aviation activity will necessitate more complementary planning nationwide.

International Air Safety Requirements

14. Australia is a signatory to international civil aviation agreements that require all developments in the vicinity of airports to meet internationally agreed criteria for protecting low level airspace from tall buildings and other structures, smoke and plumes.

15. These international regulatory requirements are currently implemented by the Commonwealth Airports (Protection of Airspace) Regulations 1996 (Airspace Protection Regulations), Civil Aviation Safety Regulations 1998, the Civil Aviation (Building Control) Regulations 1988 and the Civil Aviation Safety Authority's Manual of Standards Part 139.

Current regulatory and management arrangements in Australia

16. Regulatory and management arrangements for air safety and planning around airports are also addressed through a number of other Commonwealth, State and Territory legislative and regulatory provisions.

17. Under Part 12 of the Commonwealth *Airports Act 1996*, development on 19 federal airport sites is subject to Commonwealth planning controls. The operators of these airports are required to prepare 20 year Master Plans, and to update these Master Plans every five years. The *Airports Act 1996* applies to the Darwin, Townsville and Canberra airports that are used jointly for civilian and defence purposes.

18. Planning for the areas surrounding these federal airports is subject to State, Territory and Local Government control, as the Australian Constitution establishes that State and Territory Governments have principal responsibility for planning and land management[5]. State and Territory Governments also control "on-airport" development for the airports that they own and operate, whilst many smaller airports are owned by Local Governments or are privately owned.

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[4] Australian Government National Aviation White Paper, December 2009, page 157.

[5] Australian Government, Our Cities, Our Future – A National Urban Policy for a productive, sustainable and liveable future, 2011, p 11.

19. States and Territories generally work together with Local Governments in the implementation of their planning and urban development responsibilities. State and Territory Governments are able to control development around airports through legislation or policy. This may be, for example, through managing noise impacts, building height controls or environmental regulations.

20. State and Territory Governments in conjunction with Local Governments undertake strategic planning for urban and regional development with a typical timeframe for this planning being 30 years. Planning for transport infrastructure may be undertaken for 35-50 year timeframes. Review and updating of these strategic and transport infrastructure plans is generally undertaken every 4-10 years.

21. There is a need to maximise the alignment of airport Master Plans with these other planning processes and timeframes.

22. There is also a need to ensure the coordination of on-airport and off-airport planning for all airports. Regardless of who owns and operates an airport, planning on or in the vicinity of an airport needs to be conducted in a manner that is cognisant of all parties. For airports covered by the *Airports Act 1996*, there are regulatory provisions requiring this coordination. For other airports this coordination may not be mandated, but should be considered as part of the development of a "good neighbour" relationship.

National Airports Safeguarding Framework Guidelines

23. The National Airports Safeguarding Framework includes information to guide State, Territory and Local Governments in regulating and managing:

- measures for managing intrusion by aircraft noise (Attachment A);
- the risk of building generated windshear and turbulence at airports (Attachment B);
- the risk of wildlife strikes in the vicinity of airports (Attachment C);
- the risk of wind turbine farms as physical obstacles to air navigation (Attachment D);
- the risk of distractions to pilots from lighting in the vicinity of airports (Attachment E); and
- the risk of intrusions into the protected operational airspace of airports (Attachment F).

24. It is anticipated that Guidelines for Public Safety Zones, and the protection of Communications, Navigation and Surveillance infrastructure will also be considered at a later stage.

Implementation Plan

25. The National Airports Safeguarding Framework Implementation Plan will identify the processes through which jurisdictions will seek to implement the Guidelines in Attachments A to F taking into account:

    - existing Commonwealth, State and Territory legislation and regulatory processes;
    - responsibilities of each level of government;
    - local conditions and circumstances;
    - the need for efficiency, effectiveness and appropriate risk management; and
    - provision for evaluation and review of regulatory arrangements over time to accommodate changing circumstances and technologies.

PRINCIPLES FOR A NATIONAL AIRPORTS SAFEGUARDING FRAMEWORK

26. The following Principles for a National Airports Safeguarding Framework (the Principles) have been prepared by Federal, State and Territory Government planning and transport officials with the shared objective of developing a consistent and effective national framework to safeguard both airports and communities from inappropriate on and off-airport developments. The principles have been prepared for the consideration of the Standing Council on Transport and Infrastructure (SCOTI).

27. While the Safeguarding Framework was formally endorsed by SCOTI on 18 May 2012, the need to engage airport operators, businesses and communities in the vicinity of airports in the development and implementation of improved arrangements is recognised as being crucial to the success of such arrangements. All governments will conduct public consultation as is appropriate to their jurisdiction.

28. The Principles recognise that responsibility for land use planning rests primarily with State, Territory and Local Governments, but that a national approach can assist in improving planning outcomes near airports and under flight paths. Responsibility for the regulation of flight safety, however, rests with the Commonwealth so the principles must involve a co-operative approach to land use planning. Agencies at both State and local level will work with airport operators and relevant Commonwealth agencies to achieve a satisfactory outcome for both communities and continuing airport operations.

29. The following seven principles have been identified as fundamental to an effective National Airports Safeguarding Framework.

Principle 1. The safety, efficiency and operational integrity of airports should be protected by all governments, recognising their economic, defence and social significance.

i. It is important that governments recognise the roles that various airports play within their cities, regions and States/Territories for economic, transport or social reasons or in the case of military airfields, for national security purposes.

ii. There is benefit in ensuring that the particular considerations that arise in relation to airport operations are recognised in planning around these airports. These considerations include protection of existing aircraft flight corridors through complementary land use planning. Inappropriate development can not only lead to disturbance for residents, but for future calls for airport curfews or operational constraints.

iii. Airports vary widely in usage from major international passenger airports, major military operational staging bases, domestic, commuter, training and general aviation airports. In each case both on and off–airport planning requirements vary considerably.

iv. While safety will always be considered a priority, protection of the efficiency and operational integrity of airports will also need to take into account both the relative economic, military and social significance of the airport and the impact of restrictions on surrounding land uses.

Principle 2. Airports, governments and local communities[6] should share responsibility to ensure that airport planning is integrated with local and regional planning.

v. Responsibility for land use planning rests primarily with State, Territory and Local Governments. Responsibility for regulation of flight safety rests with the Australian Government as does airport planning for 19 leased federal airports. In carrying out respective planning responsibilities, a cooperative and collaborative approach will be taken by governments in the interests of achieving a balanced and integrated airport planning process and in achieving a satisfactory outcome for both local communities and continuing airport operations.[7]

vi. Operators of the larger airports are best placed to identify and document the airport's strategic role, to prepare operational plans and undertake an initial assessment of airport–related environmental impacts. Some airport operators are already required by legislation to take on this role. The airport's role within the region's planning regime and the need for better integration of airport planning with broader metropolitan and regional planning needs to be recognised. Planning at Australia's airports should also support effective integration and co-ordination with off-airport land use and transport network planning frameworks, and be undertaken in consultation with communities, State and local planning and transport agencies

i. It is recognised that, while operators of major airports have the capacity to undertake airport planning and associated consultation processes, operators of smaller airports may require some assistance to achieve comparable outcomes.

Principle 3. Governments at all levels should align land use planning and building requirements in the vicinity of airports.

i. Governments recognise that harmonisation, as far as practicable, between State and Territory land use planning and building regimes and Commonwealth airport and aviation policy, planning and regulations, will assist in improving planning outcomes

[6] Includes local residents, land owners, businesses and developers operating in the vicinity of airports.

[7] Implementation of the Framework may also need to take into account a recent report from the Productivity Commission on *Economic Regulation of Airport Services.* This report includes examination of the effectiveness of arrangements for the control of planning, operation and service quality monitoring of land transport access to major airports.

near airports and under flight paths. It will help enhance aviation and community safety; raise awareness of, and compliance with, Commonwealth and State/Territory requirements within Local Government; provide greater certainty and clarity for proponents and Local Governments in dealing with development proposals; and reduce unnecessary delays in development processes. This harmonisation should include the alignment of timeframes for development and review of airport master planning with State and Territory strategic land use planning timeframes.

ii. Harmonisation will also be of benefit in circumstances where the impact of an airport extends beyond the jurisdictional boundaries of the State/Territory or Local Government where the airport is located.

iii. In harmonising land use planning and building policies, jurisdictions will seek to maintain protective measures already in place, for example, Queensland's public safety zones.

Principle 4. Land use planning processes should balance and protect both airport/aviation operations and community safety and amenity expectations.

i. Governments at all levels will work cooperatively to ensure an appropriate balance is maintained between the social, economic and environmental needs of communities and the effective use of land on and around airports.

ii. This will be achieved through the adoption of a best practice, safety-related risk-based approach to land use planning on and in the vicinity of airports. All safety measures should be based on the reduction of risk, reducing the likelihood and impact of accidents. As noted above, protection of the efficiency and operational integrity of airports will also need to take into account both the relative economic, military and social significance of the airport and the impact of restrictions on surrounding land uses.

iii. In harmonising land use planning requirements, Governments will take into account that noise sensitive development proposed in zoning where it is currently permitted may be treated differently to such development in an area currently zoned for non-noise sensitive purposes.

Principle 5. Governments will protect operational airspace around airports in the interests of both aviation and community safety.

i. Whilst Australia has an excellent aviation safety record, there will always be an inherent risk associated with flying and the operation of aircraft at or around airports. State and Territory Government policies will support the Commonwealth's responsibility in regulating aviation safety.

ii. There is a need to ensure Australia's international obligations are understood, applied and incorporated in or linked to State, Territory and Local Government regulatory regimes.

iii. States and Territories can adopt a range of approaches for the protection of registered and certified airports and civil airfields that reinforce Commonwealth airspace protection provisions and improve developers', planners' and regulators'[8] knowledge of them. Ideally, State and Territory planning regulations will formally reference or incorporate Commonwealth requirements and avoid duplicative processes or multiple approvals. The Commonwealth can assist by widely distributing information about Commonwealth regulatory requirements to State and Territory regulators, planners and the development community.

iv. It is important to ensure airspace protection at regional and general aviation airports that are not Registered or Certified. This can be implemented by State and Territory law or through State and Territory planning policies.

Principle 6. Strategic and statutory planning frameworks should address aircraft noise by applying a comprehensive suite of noise measures.

i. Substantial research is available through organisations including the World Health Organization (WHO) and the International Civil Aviation Organization (ICAO) indicating that aircraft noise affects sleep, health and cognitive performance. According to ICAO, aircraft noise is the most significant cause of adverse community reaction to the operation and growth of airports. Noise can impact adversely on residents, workers and visitors in the vicinity of airports.

ii. The ANEF contours are a well established land use planning tool recognised by most jurisdictions and incorporated into land use planning decisions. This practice should continue, but be supplemented by additional measures where appropriate (see iii below).

iii. Disturbance perceived by aircraft noise varies widely between individuals irrespective of the metric used. Use of a broader suite of assessment metrics will allow more informed strategic planning by State and Territory Governments. These measures are sensible additions to best practice major city planning to avoid zoning of inappropriate residential or other noise-sensitive developments in corridors under flight paths. Further detail about additional aircraft noise metrics is provided in the *Guidelines For Managing Impacts of Noise Disturbance From Airports* (Guideline A), which provides additional guidance to assist regulators and planners and in Attachment 2 to Guideline A, *Alternative Aircraft Noise Metrics*.

Principle 7. Airports should work with governments to provide comprehensive and understandable information to local communities on their operations concerning noise impacts and airspace requirements.

i. Comprehensive and understandable public information is a critical aspect of managing aircraft noise. Limitations should not be imposed on information provided for public disclosure to existing and prospective residents of areas which may be exposed to

[8] In this context "planners and regulators" should be taken to include related professions having regulatory roles. .

aircraft noise. The Australian Noise Exposure Forecast (ANEF) system is the established land use planning tool for development around airports in Australia but is not designed for the purpose of public information on individual aircraft noise impacts and it will not provide the public, or those involved in development processes, with sufficient information to fully understand potential impacts. Airports, the broader aviation industry, the development industry and governments must encourage comprehensive and innovative approaches to providing aircraft noise information. This information should assist and inform planning by enabling the general public to clearly understand the impact of aircraft noise, and to inform their decision making.

ii. Airports and governments should provide clear information regarding airspace requirements in the interests of enhancing aviation and community safety and in providing greater certainty and clarity for proponents in dealing with development proposals.

iii. Transparency of information will assist Local Governments, businesses and residents to participate in an informed way in decision making processes, and assist confidence and goodwill associated with these processes.

GUIDELINE A

NATIONAL AIRPORTS SAFEGUARDING FRAMEWORK

MEASURES FOR MANAGING IMPACTS OF AIRCRAFT NOISE

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Feb 2012	1.1.1	Document Creation	NASAG
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15/7/12	1.1.3	Version control table added.	S. Stone, GM Aviation Environment, DOIT.

Purpose of guideline

1. This document provides guidance to Commonwealth, State, Territory and Local Government decision makers to manage the impacts of noise around airports including assessing the suitability of developments.
2. The document has been developed through the National Airports Safeguarding Advisory Group (NASAG). Further consideration is being given to the arrangements for implementation of the directions outlined. In addition, NASAG has recommended a review of Australian Standard AS 2021. Pending that further work, the document is provided as guidance or considerations that planners and decision-makers should take into account in conjunction with other factors.

Why it is important

3. The *Principles for a National Airports Safeguarding Framework* acknowledge the importance of airports to national, state, territory and local economics, transport networks and social capital.
4. Over the long term inappropriate development around airports can result in unnecessary constraints on airport operations and negative impacts on community amenity. These impacts need to be managed in a balanced and transparent way.
5. The established Australian Noise Exposure Forecast (ANEF) System and the Australian Standard AS 2021-2000 Acoustics – Aircraft Noise Intrusion – Building Siting and Construction (AS2021) have been recognised by a number of jurisdictions in land use planning decisions. However, the 20 ANEF and 25 ANEF zones do not capture all high noise affected areas around an airport, and AS2021 recognises that the ANEF contours are not necessarily an indicator of the full spread of noise impacts, particularly for residents newly exposed to aircraft noise.
6. Governments recognise the need to consider a complementary suite of noise measures in conjunction with the ANEF system to better inform strategic planning and to provide more

comprehensive and understandable information on aircraft noise for communities. Further information on the limitations of the ANEF system, and alternative aircraft noise metrics is provided at Attachments 1 and 2.

Roles and responsibilities

7. State/Territory and Local Governments are primarily responsible for land use planning.
8. The Australian Government is responsible for planning control at federally leased airports administered under the *Airports Act 1996* (the Airports Act). Planning on other airports is undertaken by State, Territory Governments and Local Governments or private operators.
9. Airport lease holders under the Airports Act have the responsibility of publishing as part of the five-yearly Master Plans, endorsed Aircraft Noise Exposure Forecast (ANEF) information. These ANEFs may be standard (up to 20 years) long range (20 year +) or ultimate capacity. The preference for land use planning purposes is to use ultimate capacity or long range forecasts.
10. The Department of Defence prepares ANEFs and related noise information for Defence owned airports and contributes to the ANEF development for joint user airports.

How it should be used

11. Some States/Territories already have planning guidelines or polices in place and this document provides guidance for any reviews of those documents. For those without policies in place, these Guidelines (in addition to the associated Safeguarding Framework) will provide guidance for new policies.
12. In preparing new local or regional Strategic Plans, existing airports should be clearly identified and noise modelling reports made available by the airport owners/operators. The modelling reports will allow the guidelines on noise sensitive developments to be applied in the vicinity of the relevant airports.
13. There is a need to treat future development and existing development differently. Where there is no *major* existing or approved development, there is scope to plan ahead to take account of potential noise disturbance and in particular to minimise the zoning of noise-exposed land for residential development. There may be less scope to avoid noise issues in situations of urban consolidation and infill or redevelopment of brownfield areas, but consideration should be given to the appropriate nature of that development and the balance of public interest. It is recognised that most State and Territory Governments have targets or policies that need to be met to achieve housing and employment area supply.
14. It is recognised that the pattern of flying at military airfield might not readily lend itself to the same suite of frequency based noise measurements. This is because military jets exhibit a pattern of lower frequency but higher individual noise events that may require different measures, such as N80s. These airfields might continue to rely more heavily on the ANEF.
15. This document gives guidance to planning officials when considering the following scenarios:

i. rezoning of greenfield areas for noise sensitive uses[1] (i.e. areas that are predominantly rural or non-urban, including specifically identified urban boundary areas around airport sites);

ii. rezoning of brown-field areas for noise sensitive uses (i.e. areas that are predominantly urban where changes of land use from industrial, commercial or low-density residential are being considered); and

iii. assessment of new developments applications for noise sensitive uses within existing residential areas.

I. Rezoning of greenfield areas to permit noise sensitive uses

16. This section applies where the introduction of new noise-sensitive uses is under consideration in areas that are predominantly rural or non-urban, including specifically identified urban boundary areas. This section does not apply to existing urban areas which have been developed.

17. Governments agree to ask Standards Australia to undertake a review of AS2021-2000, with the review to also consider (but not limited to) the application of the following approach to land use planning:

    i. There should be no new designations or zoning changes that would provide for noise sensitive developments within a 20 ANEF where that land was previously rural or for non urban purposes. Zoning for noise–sensitive development should be avoided where ultimate capacity or long range noise modelling for the airport indicates either:

    - 20 or more daily events greater than 70 dB(A);
    - 50 or more daily events of greater than 65 dB(A); or
    - 100 events or more daily events of greater than 60 dB(A).

    ii. Zoning for noise–sensitive development should take into account likely night time movements and their impact on residents' sleeping patterns. Specifically, where there are more than 6 events predicted between the hours of 11pm to 6am which create a 60 dB(A) or greater noise impact, measures for aircraft noise amelioration and restriction on noise sensitive development would be appropriate.

18. The above metrics could be used as guidance by strategic planners and weighed with other relevant considerations pending the finalisation of the Standards Australia process.

II. Rezoning of brownfield areas to permit noise sensitive uses

19. This section applies to urban land that is currently primarily designated for non-noise sensitive uses and is being considered for rezoning, for example, for residential infill or increasing residential densities, such as within a mixed use precinct near a transport corridor.

[1] Noise sensitive uses are residential, education establishments, offices, hospitals, aged care, churches, religious activities, theatres, cinemas, recording studios, court houses, libraries and galleries as specified as a 'noise sensitive developments' in AS2021 (see table 2.1 and 3.3)

20. In some instances, areas identified for urban consolidation can also be subject to aircraft noise impacts. In these circumstances, there is a need to balance the need to provide housing, economic growth and strategic planning outcomes against the operational needs of the airports. This approach may identify some adversely impacted parties and it can also identify where benefits outweigh the overall disadvantages.
21. Whilst it would not be appropriate to allow for development that would impact on the operational safety of an airport, there may be circumstances where increasing settlement in existing areas exposed to a significant degree of aircraft noise, would be acceptable given other benefits the site has to offer.
22. Consideration should be given to measures to manage the implications. This could include conditions that require development to be undertaken in a manner that physically reduces noise impacts (e.g. through appropriate construction techniques) and requirements for a disclosure processes that ensure future residents are made aware of these impacts prior to purchase.
23. In some circumstances, redevelopment of areas already exposed to aircraft noise can result in a better outcome through better design and construction responses.
24. In locations considered 'marginal' in terms of exposure to aircraft noise, a case-by-case assessment of development proposals should be used.
25. The additional noise metrics based on number-above events (paragraph 17) are available to be used as appropriate to assist in these assessments using modelling for specific airports.

III. Assessment of new developments applications for noise sensitive uses within existing residential areas

26. This section applies to urban land that is already designated for noise sensitive uses, primarily residential areas where development pre-dates the significant growth of airport traffic experienced following the introduction of jet aircraft in the late 1950s.
27. Whilst it would not be appropriate to allow for development that would impact on the operational safety of an airport, increasing densities or new developments in existing areas exposed to aircraft noise may be acceptable where the site provides other desirable outcomes such as providing housing near transport or meeting urban consolidation targets. In some circumstances, redevelopment of sites already exposed to aircraft noise can result in a better outcome through better design and construction responses.
28. Such development should be undertaken in a manner that physically reduces noise impacts (e.g. through appropriate construction techniques and adherence to AS2021) but also through a disclosure process that ensures future residents are aware of these impacts prior to purchase.
29. Commonwealth, State, Territory, Local Governments and airport operators should support effective disclosure of aircraft noise to prospective residents. This should be considered as broadly as possible but required where ultimate capacity noise modelling for the airport indicates either:
    - the area is within the 20 ANEF;

- 20 or more daily events greater than 70 dB(A);
- 50 or more daily events of greater than 65 dB(A);
- 100 events or more daily events of greater than 60 dB(A); or
- 6 or more events of greater than 60 dB(A) between the hours of 11pm and 6 am.

Measures for Airports without an ANEF

30. An ANEF may not be available at all general aviation airports or airports with low frequencies of scheduled flights. Whether or not an ANEF is prepared for these airports, land use planning should take account of flight paths, the nature of activity on airports and/or 'number above' contours if available.

31. For planning purposes, a zone of influence around airports should be taken into account, depending on the amount of traffic at the airport. The following zones are approximations and should be used as guidelines only:

    - Within 15 km of an international airport, major domestic airport, or major military aerodrome.
    - Within 10 km of a domestic airport with regular scheduled public transport services.
    - Within 5 km of any other type of aerodrome for which an ANEF chart is unavailable.

32. The metrics in paragraph 17 could also be considered as appropriate for use at these airports.

ATTACHMENT 1

ALTERNATIVE AIRCRAFT NOISE METRICS

Revision Date	Version Number	Changes Made	Approved By
April 2012	1.2.1	Document Creation	SCOTI
15/7/12	1.2.2	Version control table added. Page numbers added.	S. Stone, GM Aviation Environment, DOIT.

Background

Over the past three decades the Australian Noise Exposure Forecast (ANEF) system has been used as the primary measure of aircraft noise exposure in the vicinity of airports. The ANEF has been used in four key ways. It has been used to delineate where and what type of development can take place around airports; to determine which buildings have been eligible for insulation around Sydney and Adelaide airports; for technical assessments of airport operating options in Environmental Impact Statement (EIS) processes; and as a tool for providing information to the public on noise exposure patterns around airports.

Experience has shown a range of problems with relying solely on the ANEF to guide land use planning decisions. Importantly, there are also significant limitations in using the ANEF as a way to describe aircraft noise exposure to laypeople.

While the populations with the highest aircraft noise exposure often live within the 20 ANEF contour, the majority of noise complaints that are received are now coming from residents living outside the 20 ANEF contour. Traditionally the residents of these areas have been given little information on aircraft noise through the ANEF system other than that the area is considered ‘acceptable’ for housing. Some people living outside the 20 ANEF contour have been given an expectation of receiving little or indeed no aircraft noise and as a consequence find the levels of noise actually experienced to be unacceptable.

It is not recommend that the ANEF system be replaced as a planning tool in the short-term. The ANEF system is a well–established and technically complete means of portraying aircraft noise exposure. However, land use planning could be improved through recognition that aircraft noise does not suddenly stop at the 20 ANEF contour.

It is likely that no single standard will be appropriate for all airports but the concepts that follow can readily be adapted to meet local conditions. In particular, there is a need to improve the information used for assessment of proposed noise-sensitive development where residents will be newly exposed to aircraft noise. There is also a need to recognise the particular sensitivities of night–time noise in circumstances where neighbouring residents are not protected by airport curfews. There is a range of research pointing to the negative health impacts of sleep disturbance and the ANEF gives only limited recognition to the impact of night–time aircraft noise.

Why the ANEF?

In 1982, the National Acoustic Laboratories released a major study, Aircraft Noise in Australia: A Survey of Community Reaction (the NAL Study), regarding the impacts of aircraft noise on residential communities in Australia. The results were subsequently used in framing relevant Australian Standards and land use planning controls around Australia's airports.

The NAL study was a survey of 3,575 residents around the commercial airports in Sydney, Adelaide, Perth and Melbourne and the Richmond Air Force Base. From responses to a questionnaire, subjective reaction to aircraft noise was measured and correlated with existing and potential objective measures of aircraft noise.

Analysis of the survey showed that the best correlation between community reaction was achieved using a modified version of the existing Noise Exposure Forecast (NEF) which measures average daily sound pressure levels from aircraft. 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 would be affected by aircraft noise.

The study recommended the methodology establishing the ANEF and suggested that an ANEF value of 20 could be regarded as an 'excessive' amount of aircraft noise. This value has subsequently been enshrined in planning systems and in the relevant Australian Standard AS 2021-2000 Acoustics – Aircraft noise intrusion – Building siting and construction as a boundary, beyond which it is acceptable to site noise sensitive land uses such as residential properties.

AS 2021 states that the actual location of the 20 ANEF contour is difficult to define accurately, because of variations in aircraft flight paths, pilot operating techniques and the effect of meteorological and terrain conditions on noise propagation. For that reason, the 20 ANEF contour is shown as a broken line on ANEF plans.

How is the ANEF derived?

The ANEF system is a measure of the aircraft noise exposure levels around aerodromes. It is based on average daily sound pressure levels, which are measured in decibels. Noise exposure levels are calculated in ANEF units, which take into account the following factors of aircraft noise:

- the intensity, duration, tonal content and spectrum of audible frequencies of the noise of aircraft take offs, approaches to landing, and reverse thrust after landing (for practical reasons, noise generated on the aerodrome from aircraft taxiing and engine running during ground maintenance is not included);
- the forecast frequency of aircraft types and movements on the various flight paths, including flight paths used for circuit training; and
- the average daily distribution of aircraft arrivals and departures in both daytime and night-time (daytime defined as 0700 hours to 1900 hours, and night-time defined as 1900 hours to 0700 hours). Night time movements are represented with a 6 decibel adjustment in the ANEF calculation.

Decibels are a logarithmic unit. This is because the human ear is relatively insensitive to changes in sound pressure level and the decibel scale more helpfully reflects human reaction to sound. So, for example, a 70 decibel sound pressure level represents a ten-fold increase in sound energy compared to a 60 decibel event, but it will be perceived by the human ear to be only about twice as loud.

The following table[1] represents sound levels of a range of common events.

[1] Source: Noise Mapping Northern Ireland
http://www.noiseni.co.uk/index/glossary_of_noise_terms.htm

Noise Level dB(A)	Description
120	Threshold of pain
95	Pneumatic drill (un-silenced at 7m distance)
83	Heavy diesel lorry (40 km/h at 7m distance)
81	Modern twin-engine jet (at take-off at 152m distance)
70	Passenger car (60 km/h at 7m distance)
60	Office environment
50	Ordinary conversation
40	Library reading room
35	Quiet bedroom
0	Threshold of hearing

The ANEF measures total noise dose energy so, for example, a 70 decibel aircraft noise event will make the same contribution on the ANEF as 10 sixty decibel events while an 80 decibel event will make the same contribution on the ANEF as 100 sixty decibel events.

There are three different types of aircraft noise contour charts produced using the ANEF system. All three types of charts are prepared using the same computational procedures. The differences arise from the types of data which have been input to produce the maps. The noise exposure contours for each type of map are expressed in increments of five from 15 through to 40 (the higher the ANEF value the greater the forecast noise exposure).

The three categories of ANEF that may be used in an airport master plan under the Airports Act 1996 are:

Standard ANEF (5-20 years) - this is a forecast of expected aviation noise exposure levels during a specified period of 5-20 years. A standard ANEF includes a forecast of aircraft movement numbers and operating times, aircraft types, flight paths and anticipated use of runways at the aerodrome.

Long Range ANEF (20+ years) - This is a forecast of expected aviation noise exposure levels for a specified period greater than 20 years. Forecasts have regard to present and anticipated future trends and may take account of predicted future aircraft types, movement numbers, flight paths and any changes to runway configurations that are expected to occur within the projected period.

Inclusion of a long-range ANEF in a Master Plan is aimed at assisting the States and Territories with planning decisions around airports by identifying where future incompatible development might occur as a result of exposure to expected future levels of aircraft movements and flight paths.

Ultimate Practical Capacity ANEF - This is a forecast of aviation noise exposure levels that are expected to exist when the airport is developed to its ultimate practical capacity. An estimated date of when the airport is expected to reach its ultimate practical capacity must be stated. Forecasts have regard to present and anticipated future trends and may take account of predicted future aircraft types, movement numbers, flight paths and runway configurations that are expected to occur at the point of the airports ultimate practical capacity.

Limitations of the ANEF

The 1982 NAL study was a landmark study in terms of measuring community reaction to aircraft noise. But experience over the last 30 years has highlighted some limitations to the study's methodology and conclusions that are important to consider.

Firstly, although the study concluded that the ANEF system provided the 'closest fit' in terms of describing the propensity for residents to feel negatively impacted by aircraft noise, the correlation is relatively weak. Only 13 per cent of people's reaction to aircraft noise was related to the objective measure of aircraft noise. Most of the remaining variation in response was explained by factors such as negative attitudes toward the aviation industry or government, fears of aircraft crashes and overall sensitivity to noise.

The NAL Study found that a slightly improved correlation could be achieved by combining the ANEF value with an N70 value (explained on pages 8 and 9), however the computing technology of the day made this calculation unacceptably complex. Major improvements in computing power and reduced costs have made this limitation less relevant today than it was in the early 1980s.

Secondly, the 20 ANEF threshold for acceptability of residential housing was not a conclusion of the NAL study. Rather, the study's authors suggested that an ANEF value of 20 might be regarded as representing an 'excessive' amount of aircraft noise. The study's authors added that questions related 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.

> *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 prescribing regulations and standards relating to land-use around airports properly belongs to legislative and planning authorities*[2].

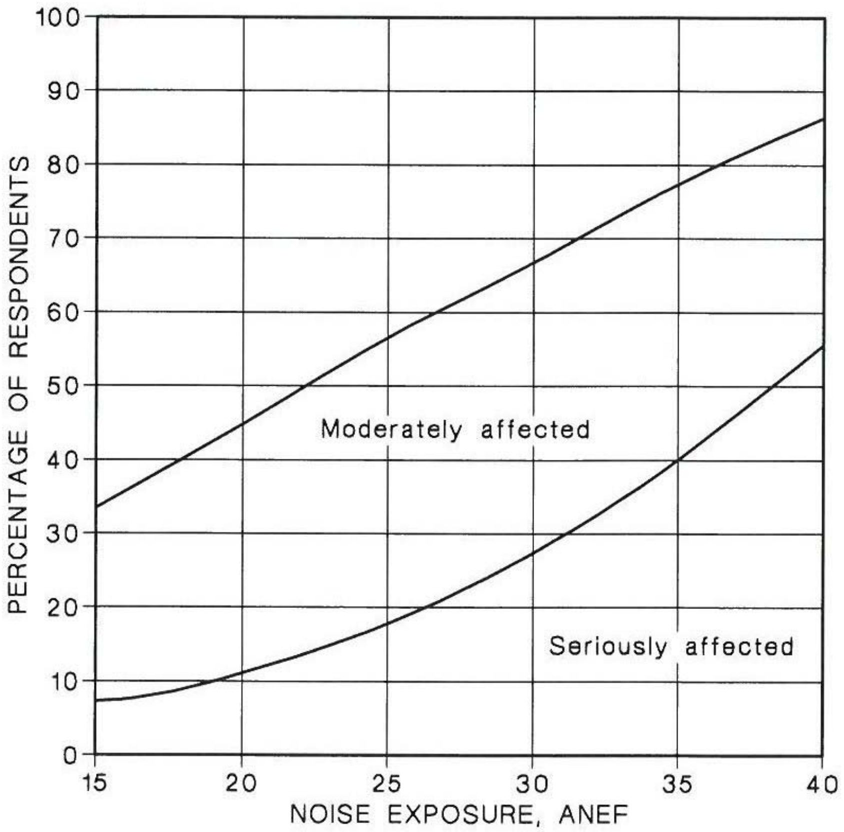
It is important to understand that the NAL study itself attached no particular significance to the 20 ANEF measure. At the 20 ANEF level, it is estimated that approximately 11 per cent of people will be seriously affected by aircraft noise and approximately 45 per cent of people moderately affected by aircraft noise. The figure on the page 5 also shows that at the 15 ANEF level, approximately 8 per cent of people will be seriously affected by aircraft noise and approximately 34 per cent of people moderately affected. The question of how many people should be subject to disturbing levels of aircraft noise through land use planning decisions clearly requires subjective judgements from land use planners as to what is an acceptable number of people expected to experience negative effects of aircraft noise, balanced against other relevant considerations.

AS 2021 makes this point and foreshadows use of alternative noise metrics for use as an additional tool for use in land use planning near airports:

> *Figure 1 shows the dose/response relationship between aircraft noise and community reaction derived from the NAL Report. This figure indicates that significant community reaction may occur for exposures below 20 ANEF. Experience has shown that newly exposed communities may exhibit a higher reaction than that suggested by the curves in [Figure 1]. ANEF values average noise exposure over a year and do not take account of variations in noise exposure patterns to which the community reacts on an hourly, daily, weekly or seasonal basis. To address this issue, other parameters such as maximum noise levels and*

[2] NAL Report, p154

frequency of noise events may be included in noise assessments of airports to supplement ANEF levels[3].



NOTE: This graph was derived from the National Acoustic Laboratories Report No. 88.

Figure 1: Reaction between noise exposure forecast level and community reaction in residential areas

There is evidence to suggest that an approach to measuring aircraft noise based on the number of aircraft movements has become more appropriate over time as individual aircraft events have become quieter, but the frequency of movements has increased.

For example, a 2007 study into Attitudes to Noise from Aviation Sources in England[4]compared average energy measures with frequency based measures of aircraft noise in two surveys from 1982 and 2005 respectively. The study found that in 1982, there was little relationship between annoyance and aircraft numbers, while in 2005, there was a strong relationship. This coincides with significant changes to both aircraft numbers, which have increased, and individual noise levels, which have decreased.

In Australia also, the mix of aircraft in the airline fleet is considerably different today than it was in 1980 (when the NAL survey was conducted). Modern aircraft are considerably quieter than aircraft of 30 years ago. At the same time, frequency has increased significantly. For example, in Sydney there were 138,000 aircraft movements in 1985-86, growing to over 290,000 in 2010-11.

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[3] AS2021-2000; Standards Australia, p 43

[4] ANASE (Attitudes to Noise from Aviation Sources in England) – MVA Consultancy for the Department for Transport in association with John Bates Services, Ian Flindell and RPS, October 2007

The number of aircraft movements also doubled at Brisbane, Canberra, Melbourne and Perth over the same period.

The following sections detail a range of additional aircraft noise metrics that have been developed over the past 15-20 years, many within Australia, to better describe aircraft noise. These measures were first developed in response to the Senate Select Committee on Aircraft Noise: Falling on Deaf Ears, which investigated these issues following the opening of the third runway at Sydney Airport in 1994.

The paper concludes with some suggested nominal levels of frequency based aircraft noise measures which could be used by land use planners to action the AS 2021 recommendation to more comprehensively assess the potential impact of aircraft noise on future noise sensitive development.

Alternative Measures

Following the opening of the third runway at Sydney Airport in December 1994, it was recognised that the ANEF, while a useful tool for land use planning, was deficient as a useful tool for describing information about aircraft noise to residents. Figure 2 shows the poor correlation between the 20 ANEI [5]contour and the aircraft noise complaints in the Sydney area. In fact, 90 per cent of the complaints at the time were found to have originated outside the 20 ANEI contour.

[5] The ANEI measures actual historic daily average noise dose whereas the ANEF measures forecast daily average noise dose

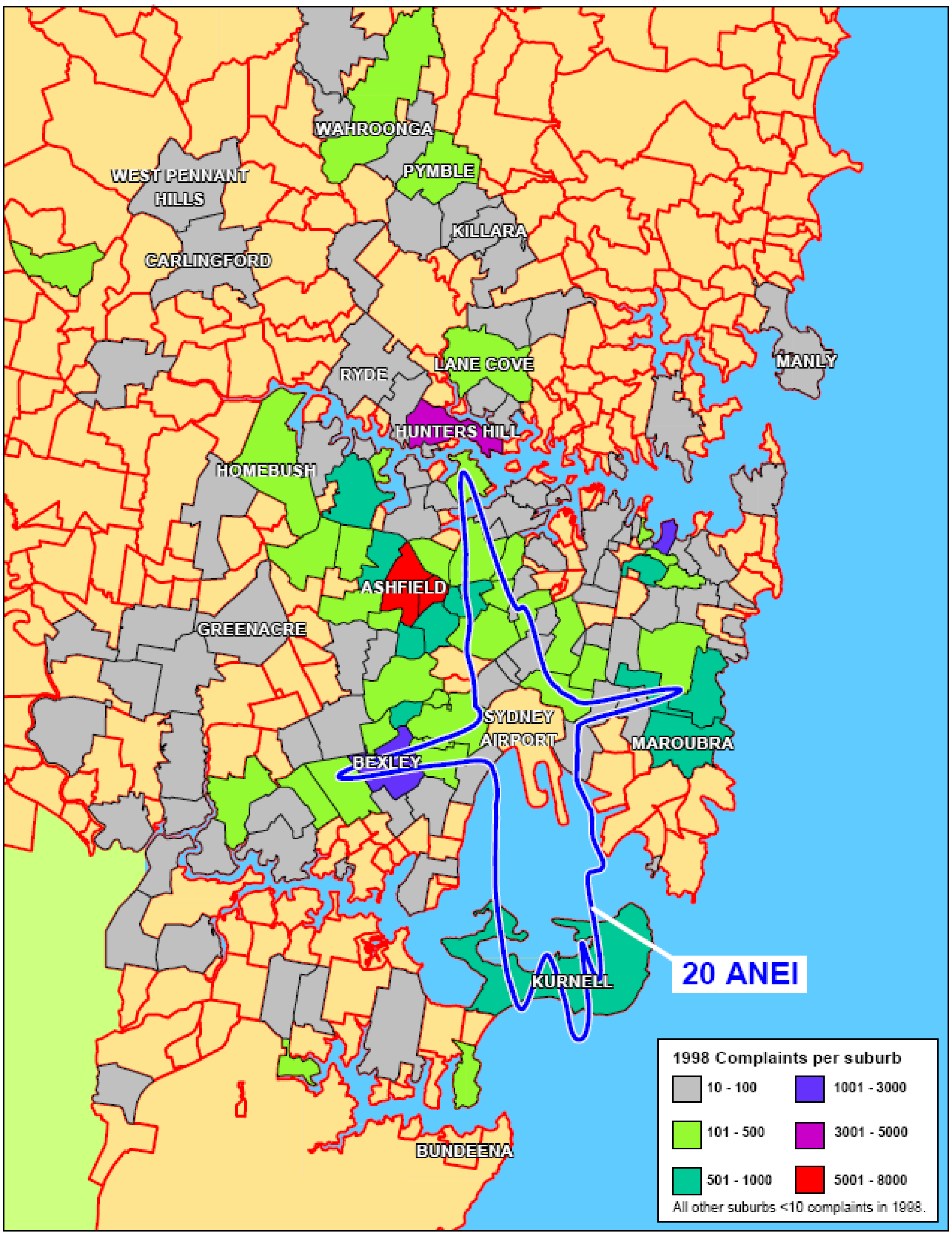


Figure 2: 1998 aircraft noise complaints vs 1998 20 ANEI contour

One important piece of information frequently sought by members of the public when looking to purchase a house is often the location of the flight paths. The Australian Government Department of Infrastructure and Transport, Airservices Australia and many airports have developed the use of flight path information over the last 15 years to provide a more meaningful summary of aircraft flight movements. Figure 3 illustrates this type of information for Sydney. However this information is of limited use in land use planning decisions.

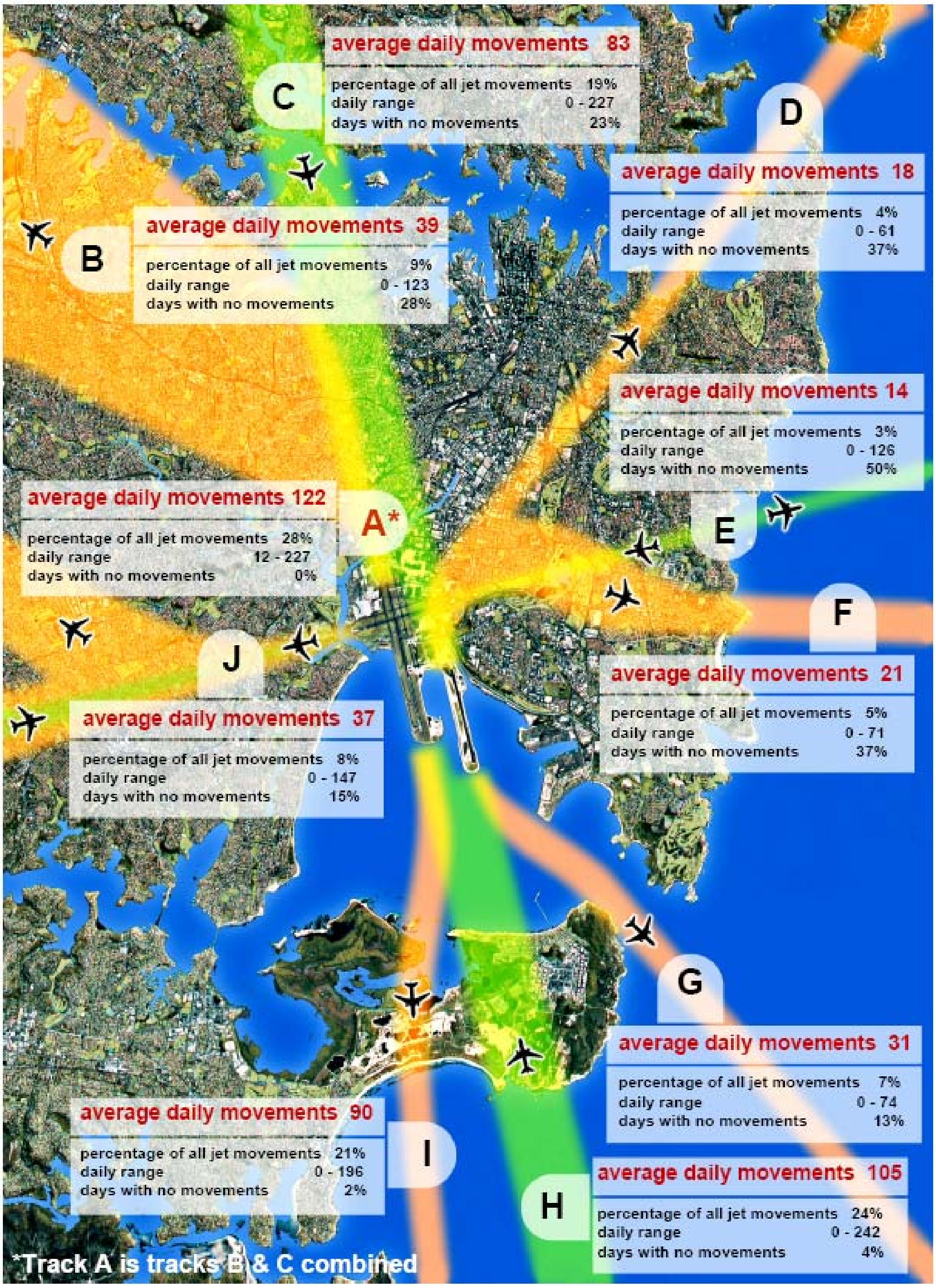


Figure 3: 1998 jet flight path movements – Sydney

While aircraft flight paths are a useful way of presenting information on aircraft activity, they do not include information on the actual noise level of flights. Another useful way of presenting the impact of aircraft noise is to show the noise level of individual flight movements through the use of single event noise contours. Figure 4 shows an example of a single event contour for a Boeing 767–300 departing from Sydney Airport's Runway 34R on a particular track. It is possible to give an indication of how many of these flights will occur in a typical day. However, it is also difficult to use the single event contour in a land use planning context as separate diagrams are needed for each aircraft type and each track.

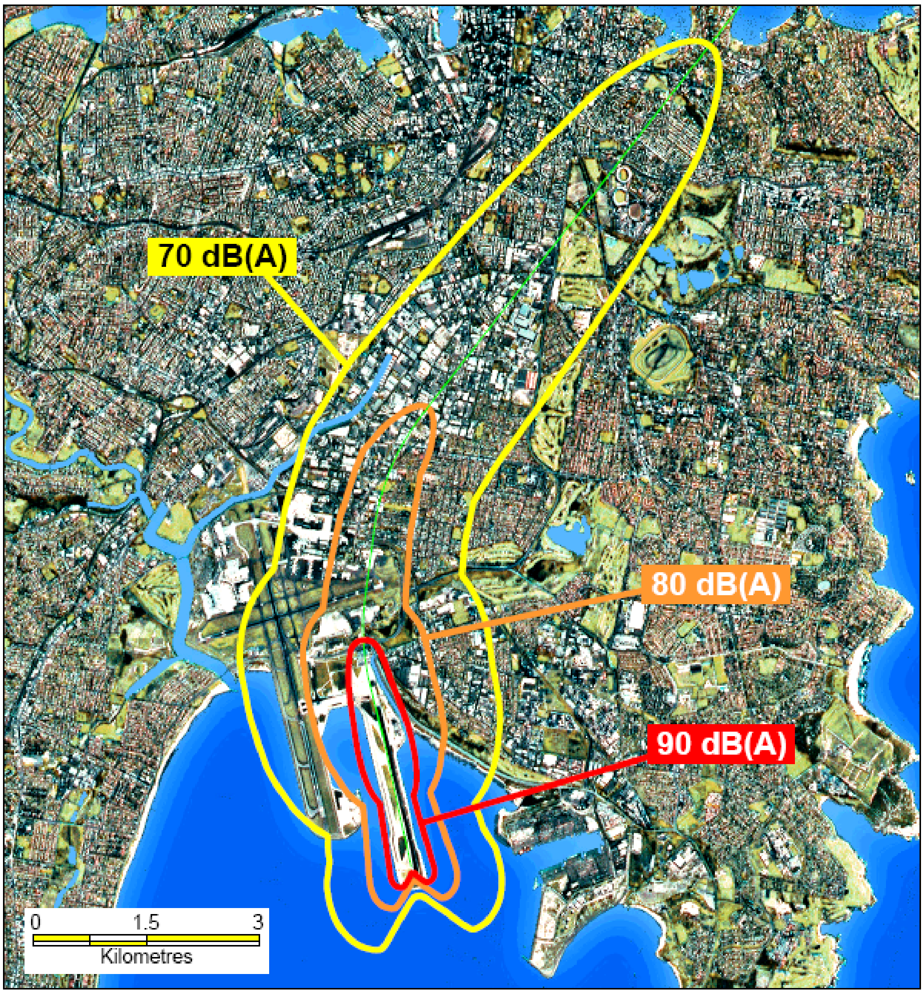


Figure 4: Single event contour

An approach that combines the information in a single event noise contour with the ability to consolidate this information into a description of high noise 'zones' is available. Information on the number of noise events is termed the 'Number Above' noise metric. In Australia, this is commonly called the N70 (or N65 or N60) where N70 is the number of aircraft noise events louder than 70 dB(A). Thus, residents can be informed in a way that is more intuitive, how many "noisy" events will be experienced within the illustrated zone. 70 dB(A) events have often been used to categorise an event as 'noisy' as these correspond to a 60 dB(A) noise level indoors, which can disturb conversation or other indoor activities such as watching television.

This concept can have direct applicability for land use planning. Figure 5 shows a typical day N70 contour for Sydney Airport in 1998.

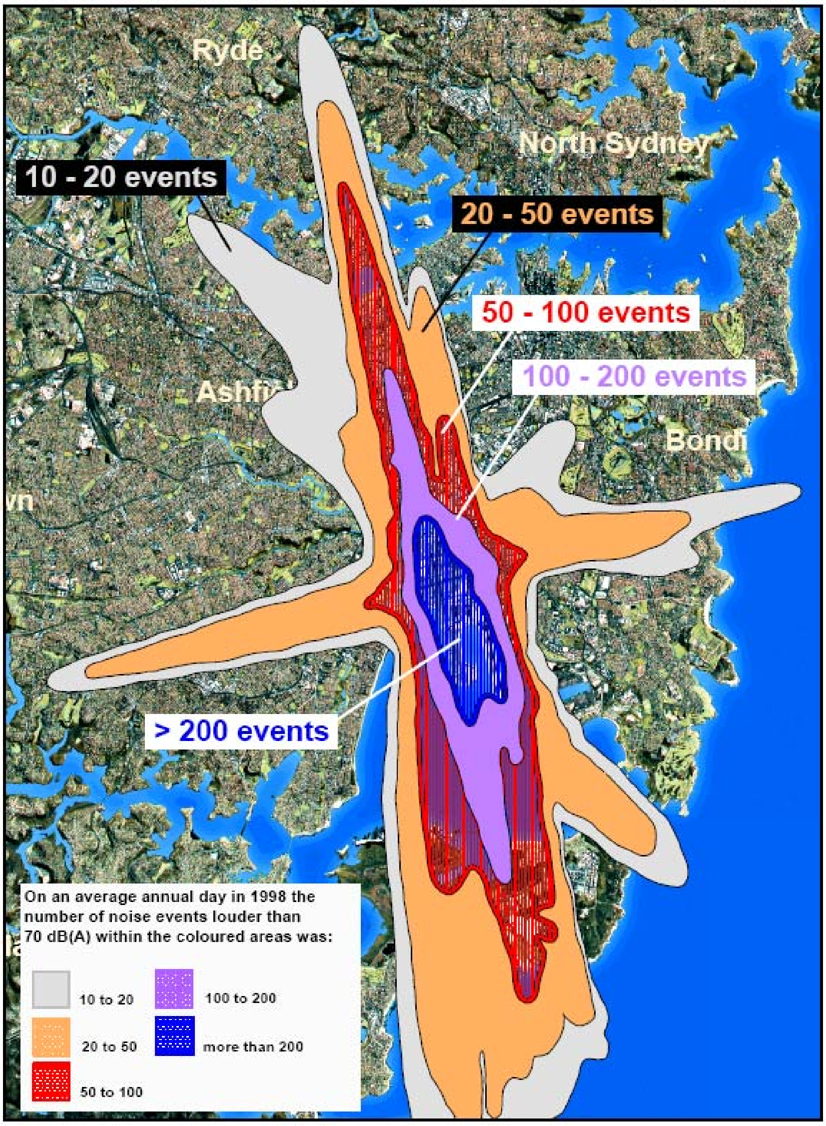


Figure 5: 1998 N70 – average day – Sydney

Case Study of the Applicability of this Concept at Brisbane

The ultimate capacity model from the 2009 Brisbane Airport Master has been used to model the effects of aircraft noise around the Brisbane Airport[6]. The model provides an illustration which complements the ANEF modelling. Figures 6, 7, and 8 show respectively, the 20 event N70 contour, the 50 event N65 contour and the 100 event N60 contour for the average day when the airport reaches its ultimate operating capacity. These measures recognise the variability in individuals' sensitivity to noise events. In particular, residents who value an outdoor lifestyle or those sensitive to sleep disturbing night–time noise events, may find the N60 measure more relevant to their concerns, and therefore useful for land use planning purposes. The blue baseline area in each map represent the 20 ANEF contour, outside of which there are currently no land use planning controls.

[6] Modelling carried out by the Australian Government Department of Infrastructure and Transport

Figure 6: 20 event N70 – ultimate capacity – Brisbane

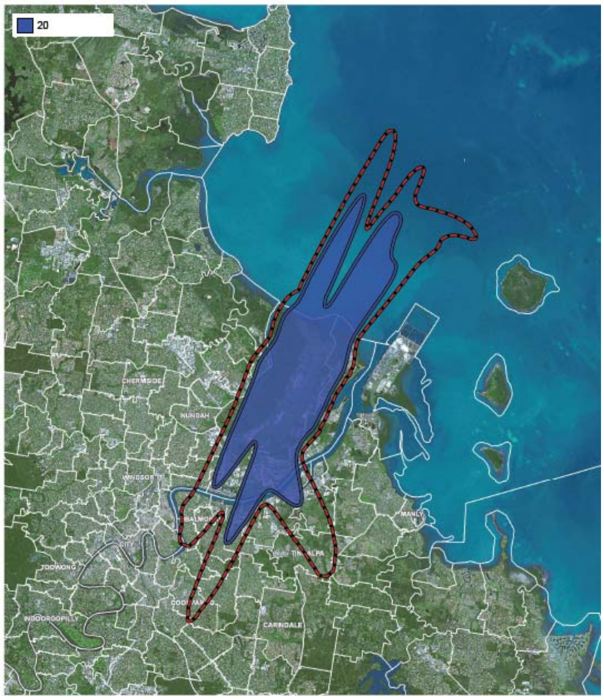


Figure 7: 50 event N65 – ultimate capacity – Brisbane

Figure 8: 100 event N60 – ultimate capacity – Brisbane

Night Time Noise

The ANEF provides for weighting of night time noise events to take account of residents' increased sensitivity during evening and sleeping hours. Specifically, sound pressure levels are weighted by 6 dB(A) in the ANEF model for events between 7pm and 7am, effectively treating them as having four times the impact of daytime events. However, this can still under–represent the impact that a relatively small number of moderately noisy events can have during sleeping hours, as the ANEF describes cumulative noise dose rather than disturbance.

The night time (10pm to 6am) noise exposure patterns at Brisbane have been illustrated using N60 contours, at the 3, 6 and 12 event levels, as illustrated in Figure 9.

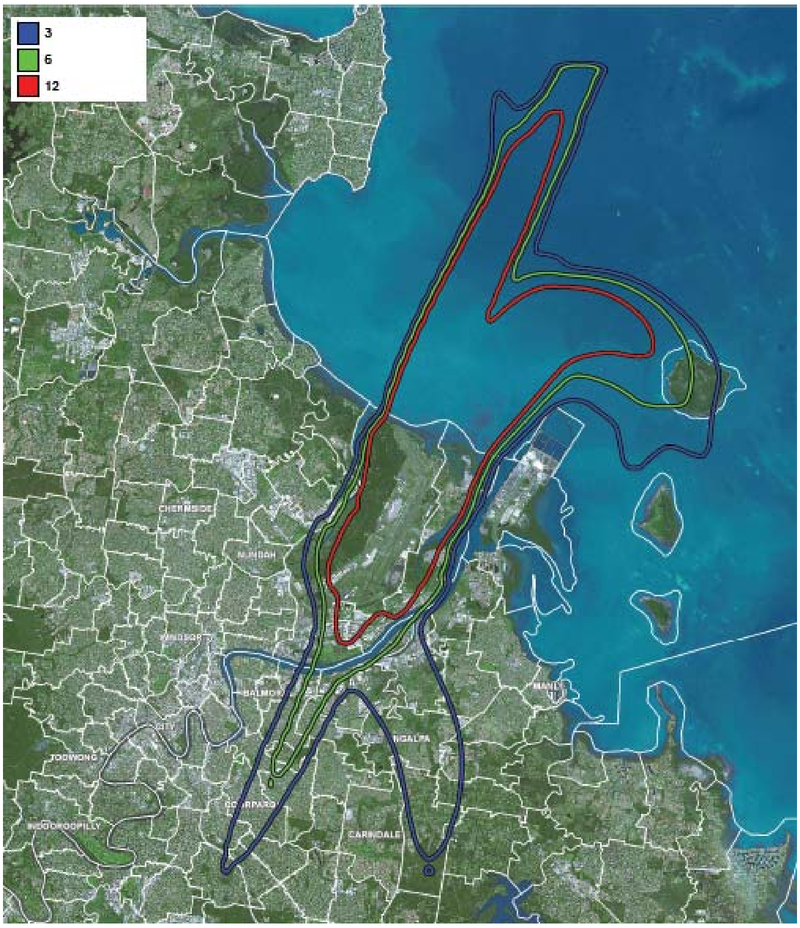


Figure 9: 3,6 and 12 event N60s, 10pm – 6am – ultimate capacity – Brisbane

Why 20 x N70, 50 x N65, 100 x N60?

The National Airports Safeguarding Advisory Group (NASAG), comprising Commonwealth, State and Territory transport and planning officials, has overseen a process to quantify a range of frequency-based aircraft noise events that might act as triggers in future land use planning processes. It has done this recognising that the ANEF has certain limitations and that the existing guidance under AS 2021 highlights the increased sensitivity to aircraft noise sensitivity for residents newly exposed to aircraft noise. AS 2021 recommends utilising frequency based measures as a supplement to the ANEF in these circumstances. The additional aircraft noise metrics articulated in this paper and in the draft guidelines have been considered by NASAG prior to public consultation.

Just as aircraft noise does not suddenly stop at the 20 ANEF level, there is no hard and fast line where aircraft noise suddenly changes from being acceptable to being unacceptable at the 20 x N70, 50 x N60 or 100 x N60 levels. Aircraft noise impacts follow a continuum and clearly, noise impacts close to, but outside an identified threshold will be almost indistinguishable to the impacts on the ‘the other side of the line’.

Therefore there is a need for land use planners to take a balanced view of land use planning decisions that recognises aircraft noise does not suddenly stop at a line on a map, no matter how that line has been derived.

That said, frequency based measures of aircraft noise offer an alternative and complementary tool for assessing aircraft noise impacts. Different airports exhibit different patterns of activity, so three related parameters are suggested for consideration. Used together, these measures should allow a more comprehensive assessment of noise impacts at most airports.

The 70 decibel (N70) measure has been the most commonly used frequency based aircraft noise measure to date because a 70 decibel outside noise will generally be experienced as a 60 decibel event inside a residence with the windows open. Sixty decibels is the sound level that will disturb a normal conversation or activities such as watching television.

There is also a strong case to consider the impact of 60 decibel aircraft events as worthy of consideration as an additional measure. Firstly, AS 2021 identifies 50 decibels as the level above which noise can be considered intrusive when defining building insulation requirements under the standard. This inside intrusion would generally be experienced by a 60 decibel outside noise. Secondly, around training airports where there is a high number of moderately noise events, the experience of many residents, evidenced through complaint data and community consultation, shows that there can be significant noise impacts from a high frequency of overflights in the 60 decibel range.

Thirdly, 60 decibels is likely to be more disturbing during sleeping hours. AS 2021 sets an acceptable standard of noise for sleeping areas of 50 decibels. This level of intrusion is likely to result from a 60 decibel outside event.

The 65 decibel threshold is used to present a more comprehensive picture of likely aircraft noise impacts. This recognises the subjectivity of individual responses to aircraft noise and the difficulty in predicting whether individuals will be more sensitive to a moderate frequency of relatively loud events (the N70 measure) or a high frequency of less noisy events (the N60 measure). The N65 is a compromise measure lying between these two levels.

NASAG recognises the valuable role the ANEF has played in assisting land use planners to form an assessment of aircraft noise impacts over the past three decades. But it has long been recognised, including in AS 2021 itself, that that the system fails to deal with certain scenarios, particularly the increased sensitivities that residents are likely to experience when newly exposed to aircraft noise.

Use of the 70, 65 and 60 decibel contours allows a balanced and comprehensive view of the impacts residents are likely to experience from aircraft noise. These measures better reflect high-frequency flight paths and known areas of sensitivity at existing airports, and are more easily understood by potential residents and land use planners who are not noise experts.

NASAG also recognises it is not possible, nor desirable to unnecessarily restrict land uses close to airports. The quantum of events nominated for the N70, N65 and N60 event contours respectively, aligns broadly to known areas of sensitivity around existing airports and gives some basis for guidance for areas close to, but outside, existing 20 ANEF contours.

The guidance material also provides assistance for the assessment of impacts from night time aircraft noise events, where a relatively small number of moderately noisy events can cause significant sleep disturbance for residents.

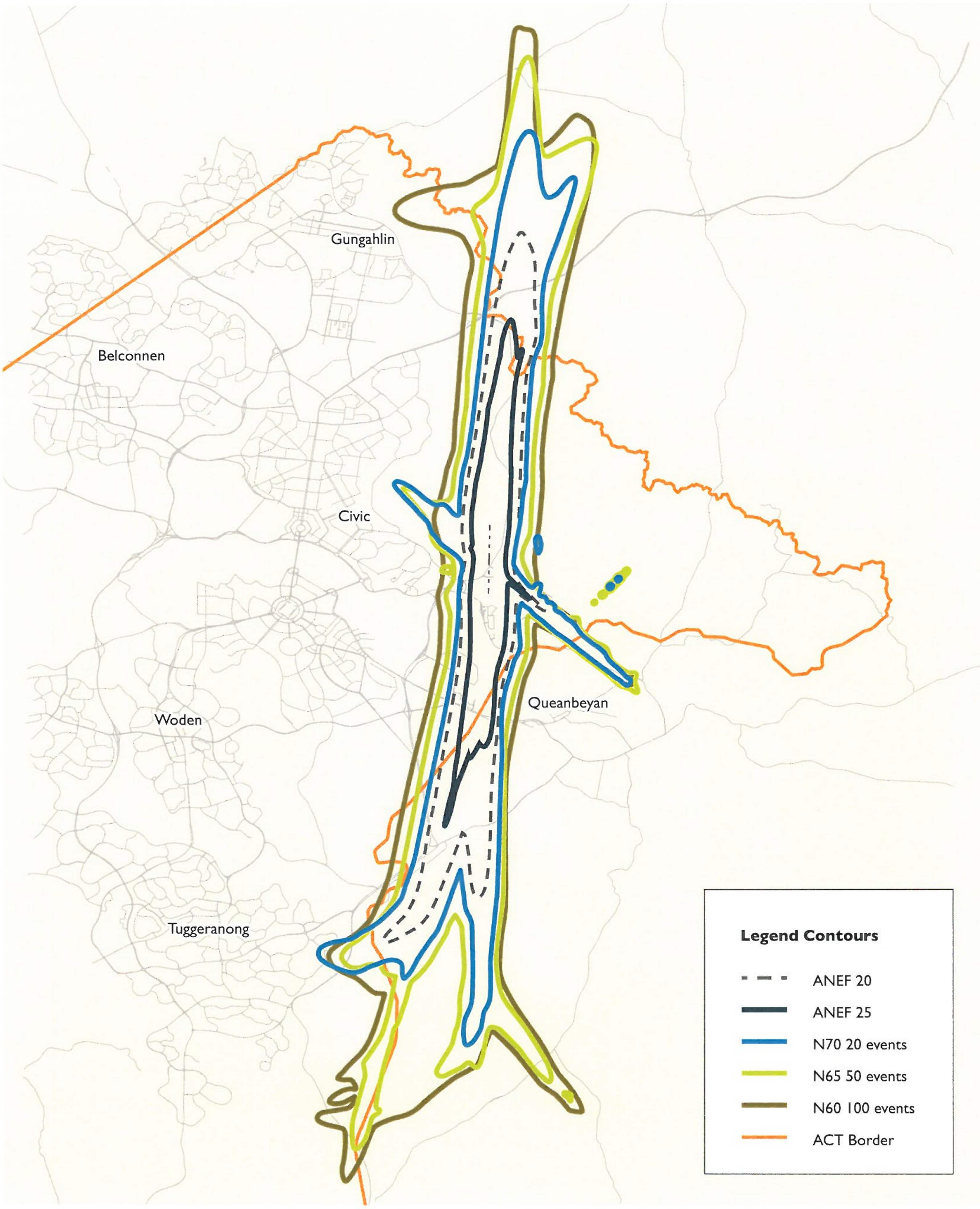
Like the 20 ANEF, there is no ‘magical line’ at the 20xN70, 50xN65 or 100xN60 contours that suddenly sees aircraft noise change from being unacceptable to acceptable. These complementary contours represent areas within which land use planners should give increased weighting than is presently the case to take account of aircraft noise impacts, particularly for new noise-sensitive developments.

Moorabbin Airport Contours

Attachment 2 to noise guideline

This diagram has been produced for illustrative purposes only. It has been neither verified or endorsed by Airservices Australia or Moorabbin Airport.

Canberra Airport Contours



Attachment 2 to noise guideline

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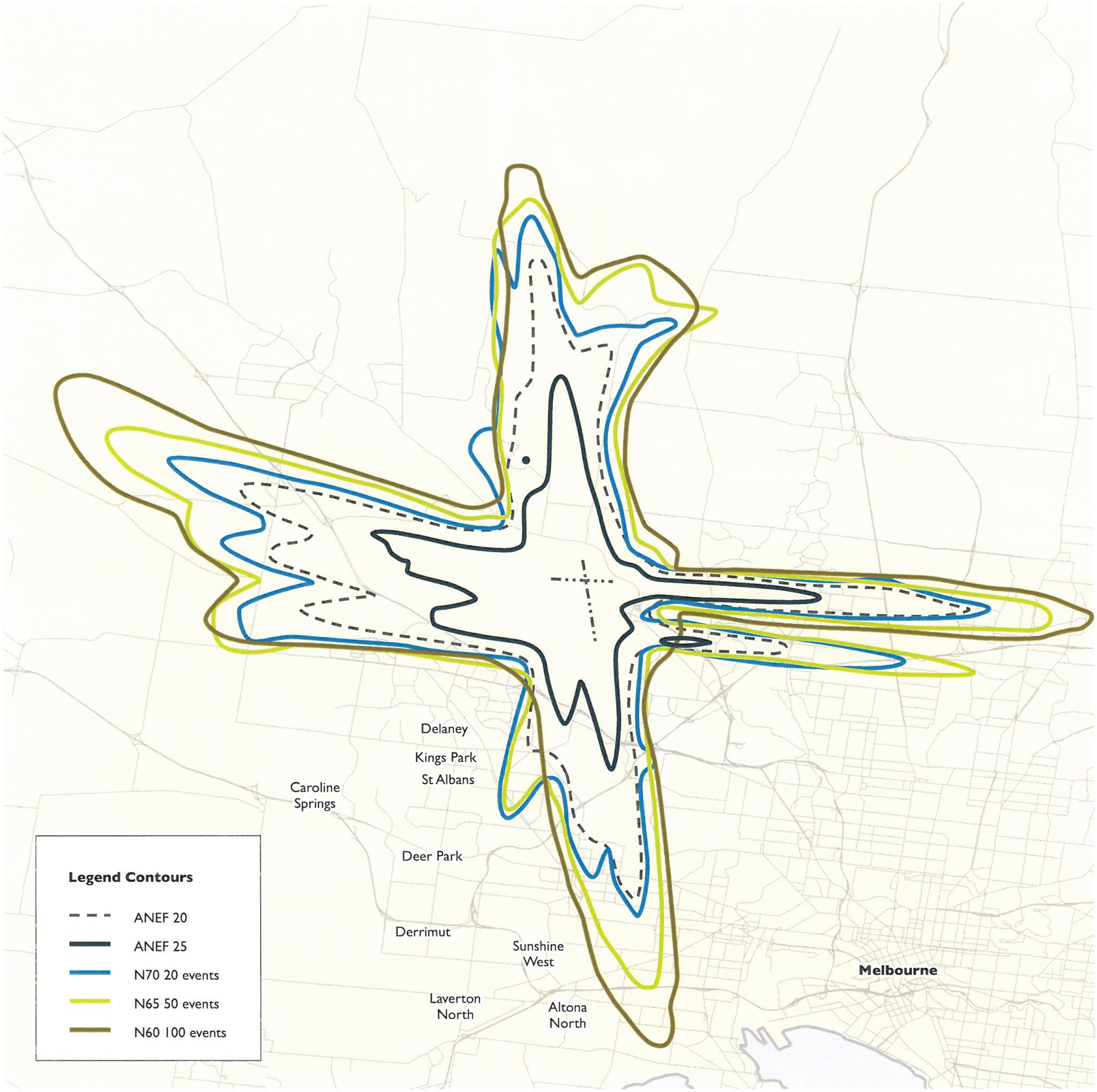
Melbourne Airport Contours



Attachment 2 to noise guideline

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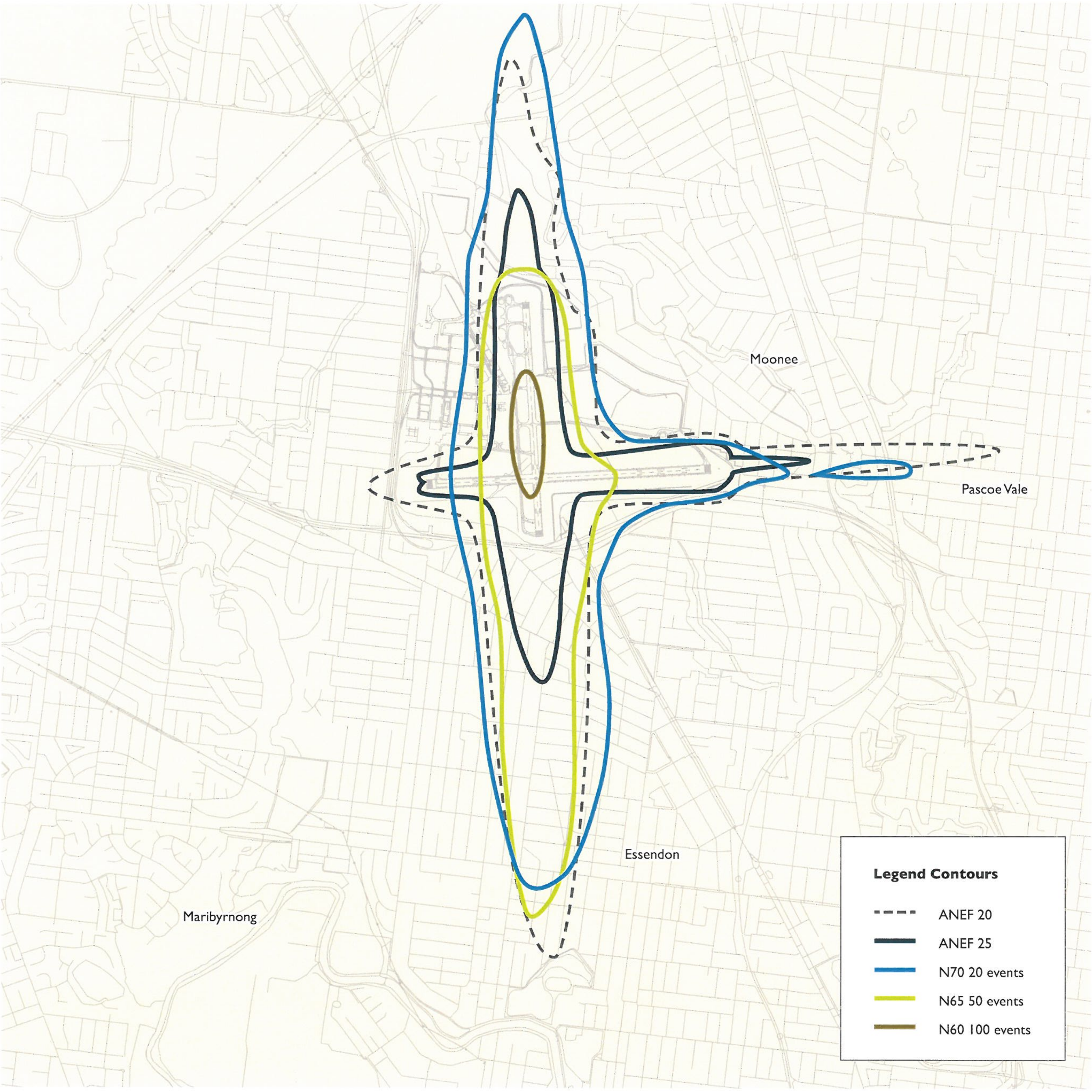
Essendon Airport Contours



Attachment 2 to noise guideline

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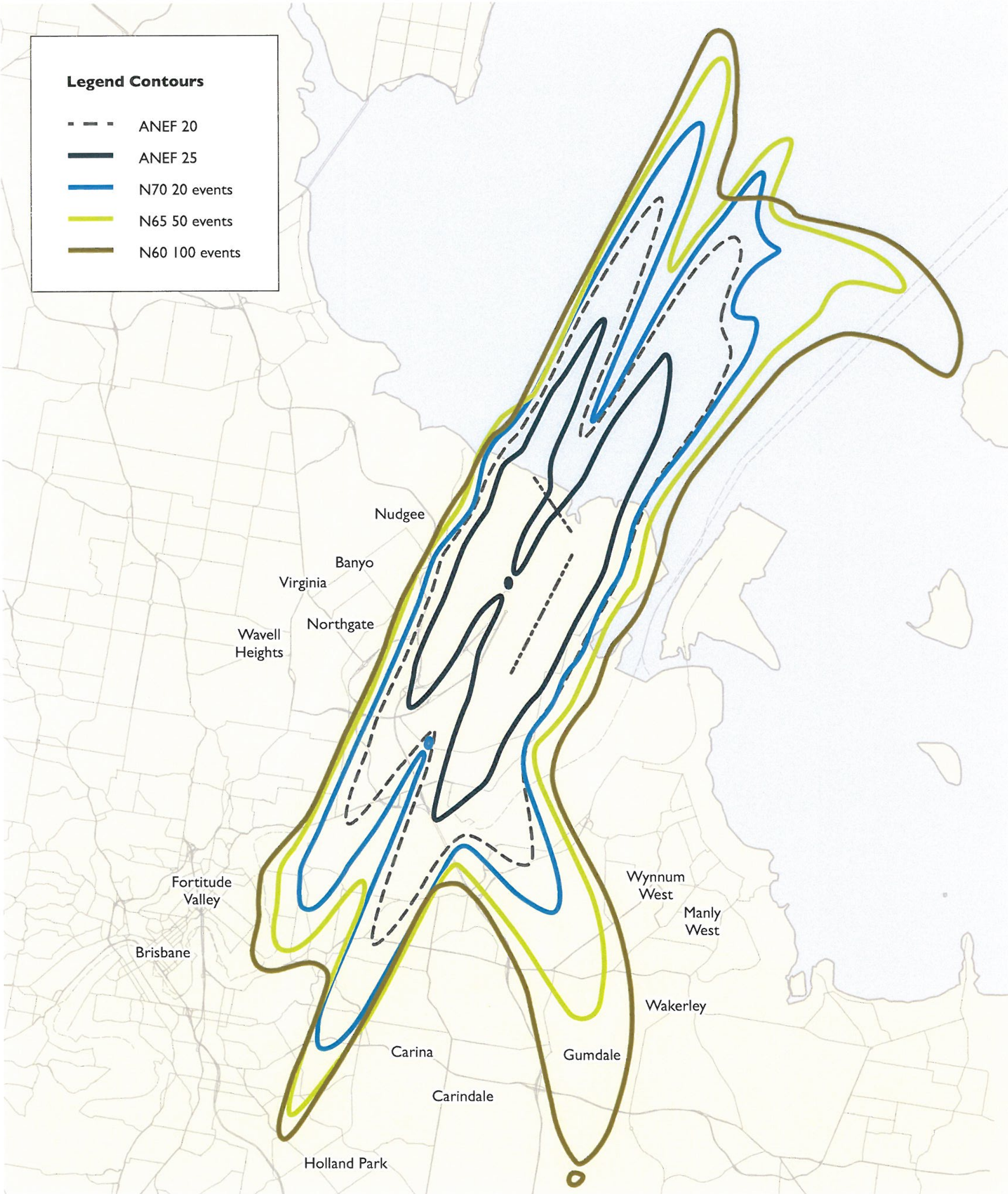
Brisbane Airport Contours



Attachment 2 to noise guideline

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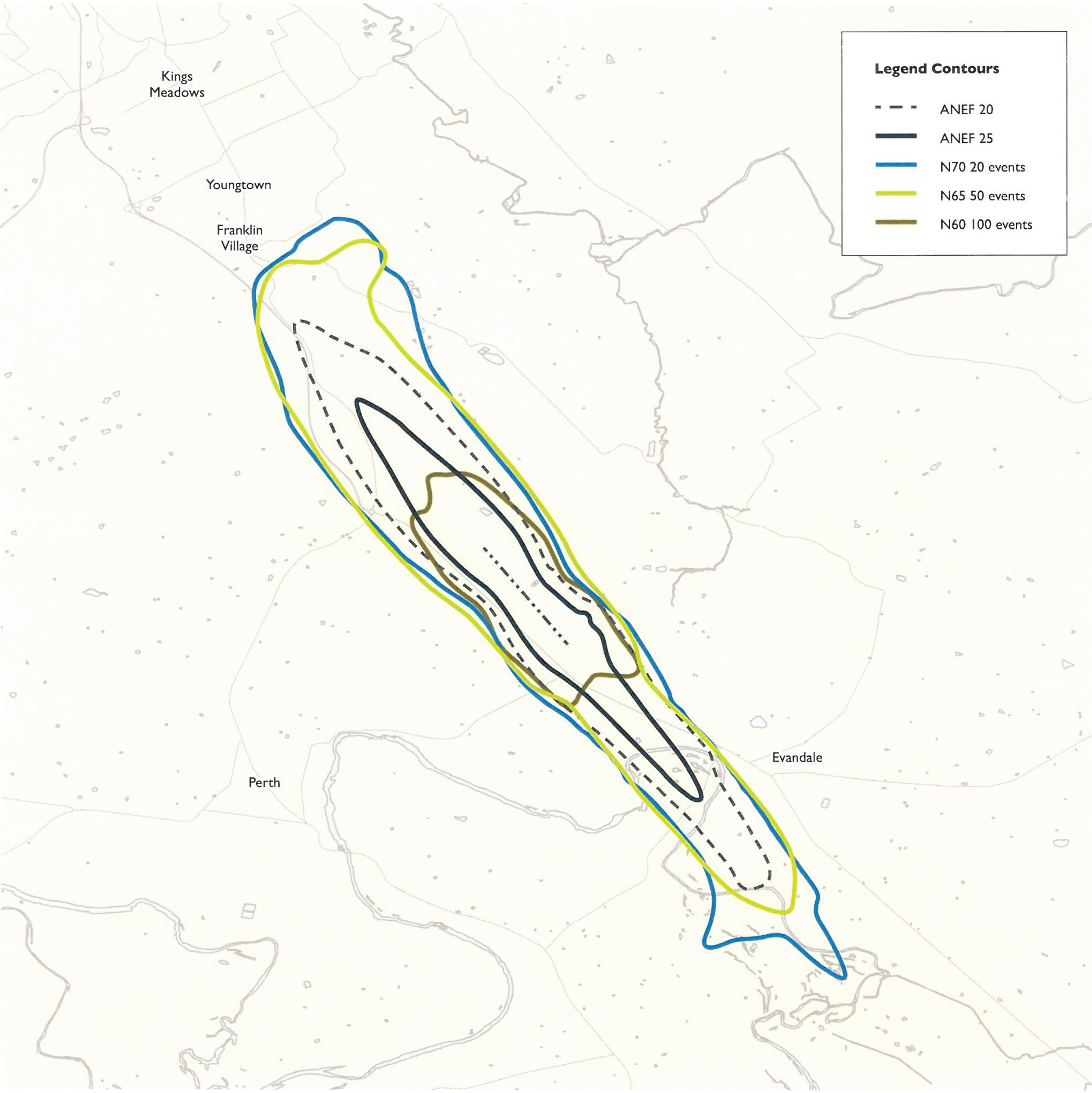
Launceston Airport Contours



Attachment 2 to noise guideline

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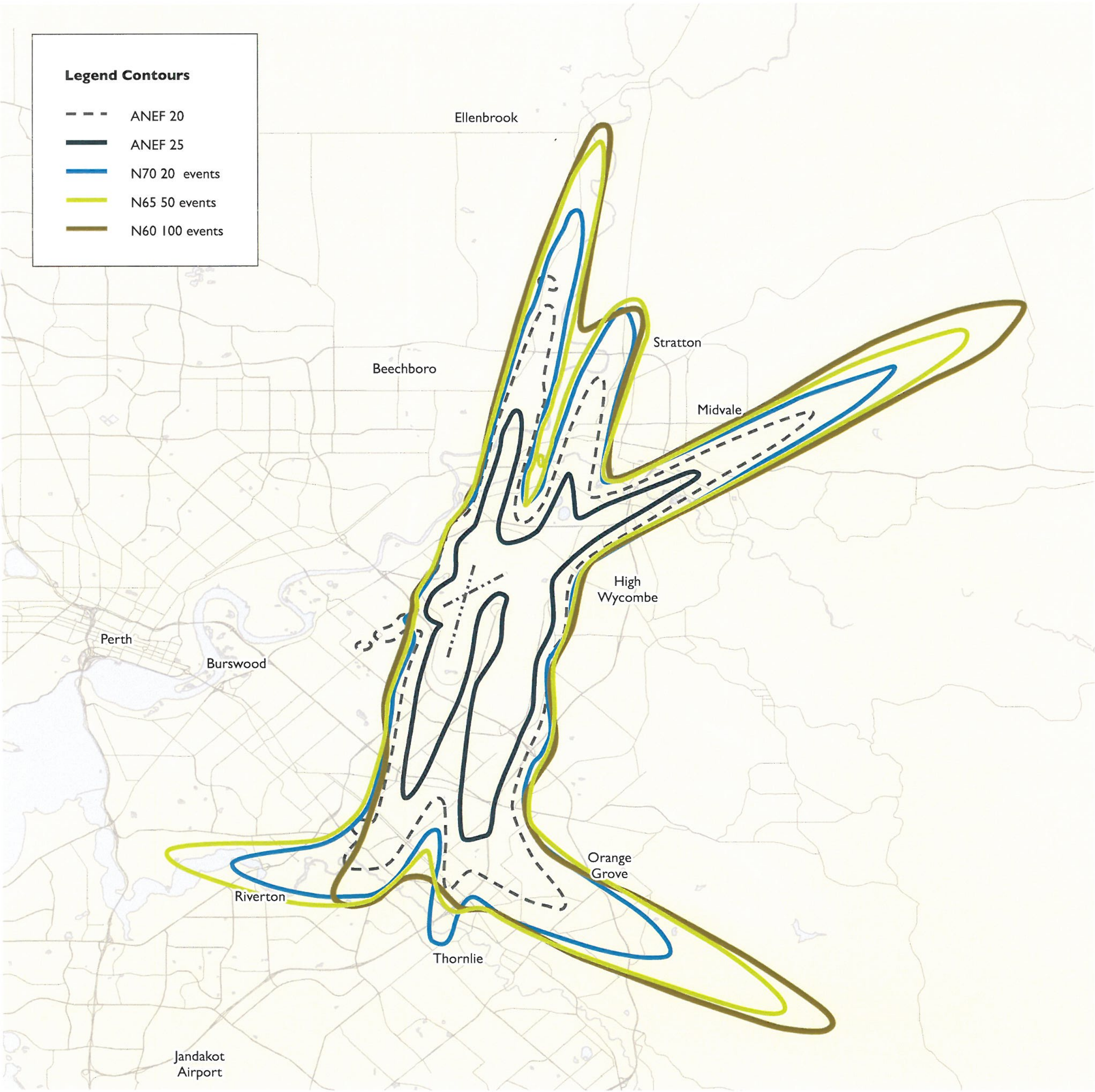
Perth Airport Contours



Attachment 2 to noise guideline

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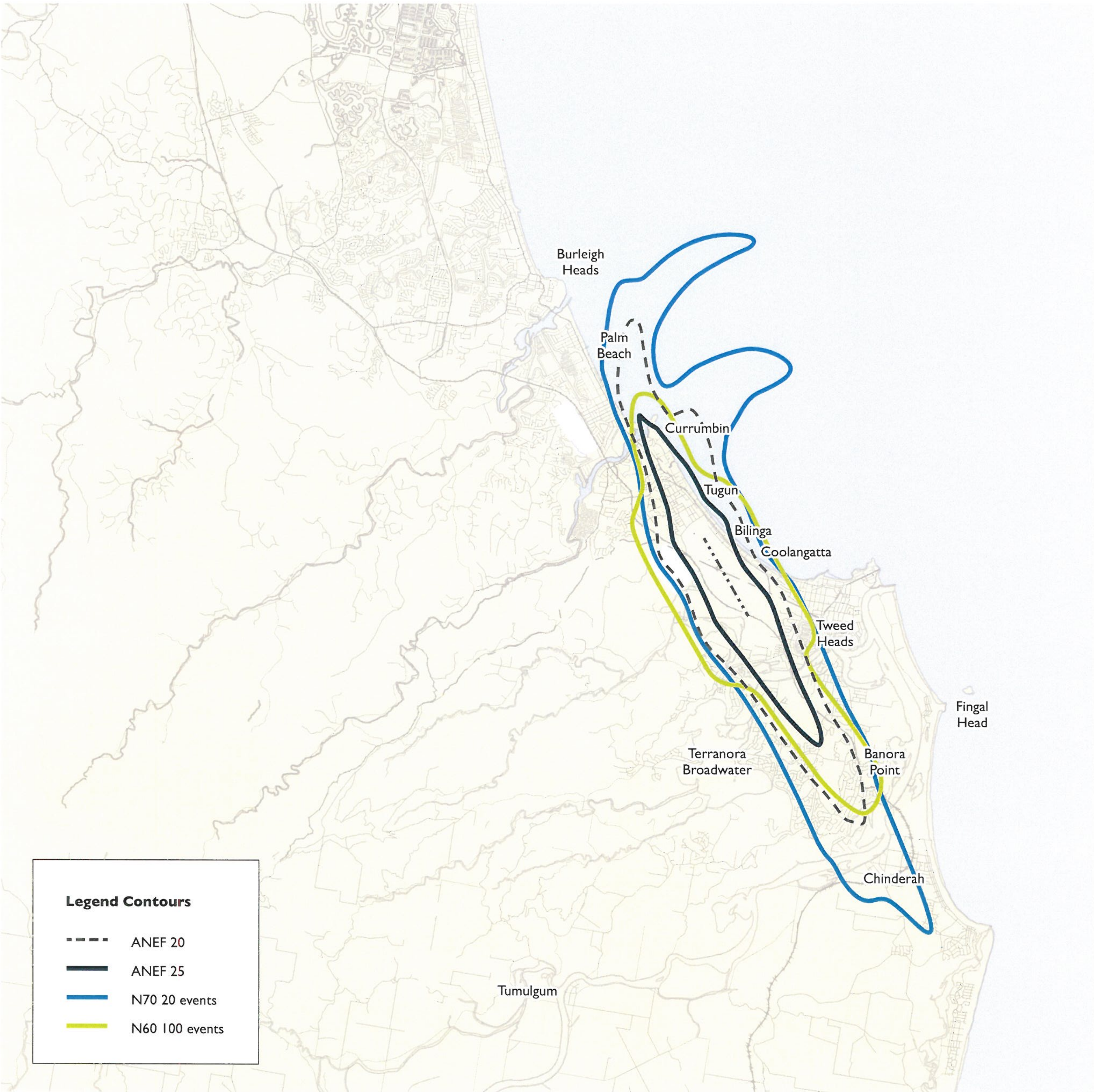
Adelaide Airport Contours

Attachment 2 to noise guideline

This diagram has been produced for illustrative purposes only. It has been neither verified or endorsed by Airservices Australia or Adelaide Airport.

Gold Coast Airport Contours



Attachment 2 to noise guideline

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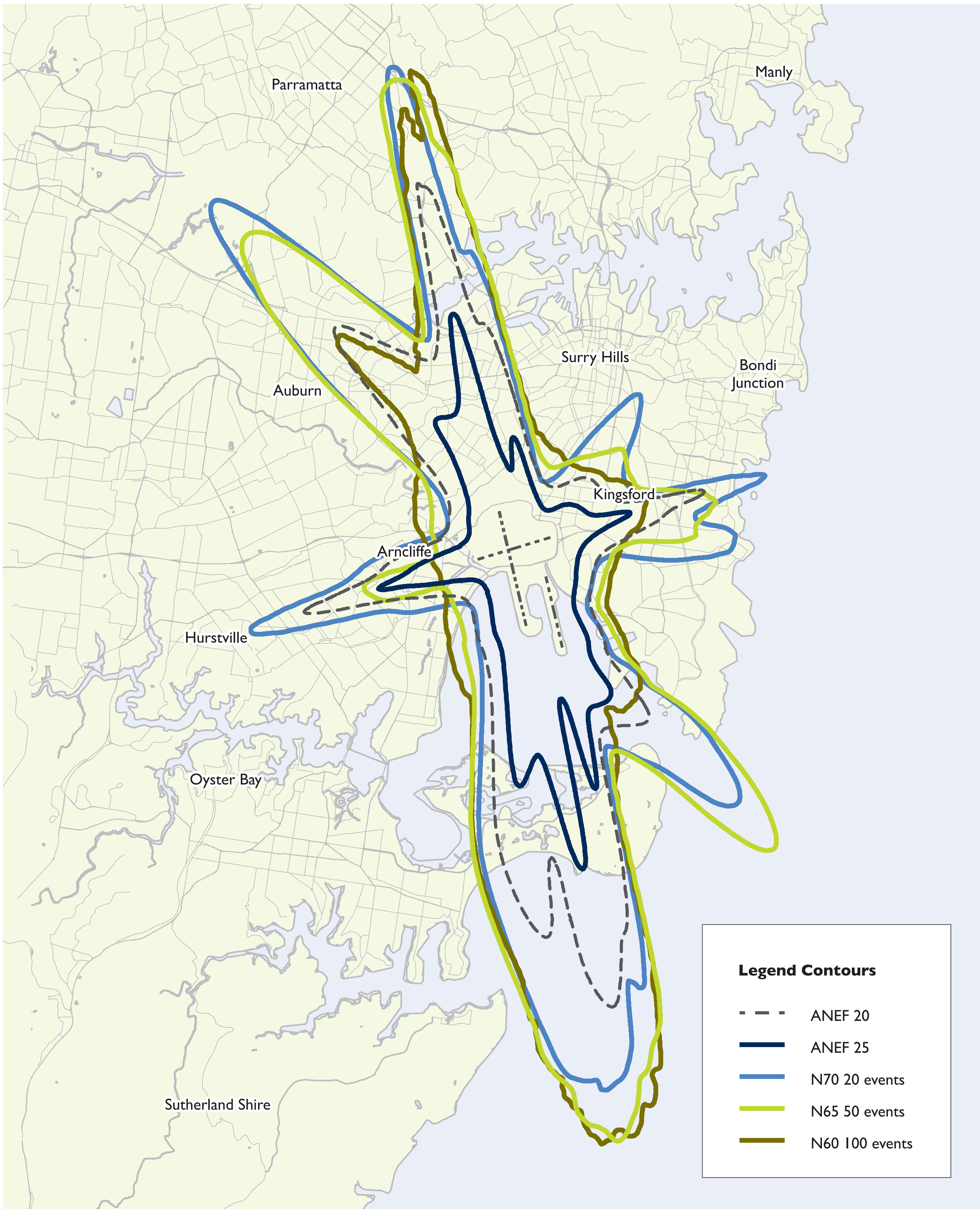
Sydney Airport Contours



This diagram has been produced for illustrative purposes only. It has been neither verified or endorsed by Airservices Australia or Sydney Airport.

NATIONAL AIRPORTS SAFEGUARDING FRAMEWORK

MANAGING THE RISK OF BUILDING GENERATED WINDSHEAR AND TURBULENCE AT AIRPORTS

REVISION DATE	VERSION NUMBER	CHANGES MADE	APPROVED BY
Feb 2012	2.2.1	Document Creation	NASAG
Apr 2012	2.2.2	Drafting changes post consultation process	SCOTI
15/7/12	2.2.3	Version control table added. Page numbers added.	S. Stone, GM Aviation Environment, DOIT.

Purpose of Guideline

1. This document provides guidelines to Commonwealth, State/Territory and local government decision makers to manage the risk of building generated windshear and turbulence at airports.

Why it is important

2. The Principles *for a National Airports Safeguarding Framework* acknowledge the importance of airports to national, state/territory and local economics, transport networks and social capital.
3. These guidelines are designed to assist land use planners and airport operators in their planning and development processes to reduce the risk of building generated windshear and turbulence at airports near runways.
4. Essentially, the building generated turbulence windshear / turbulence issue becomes safety critical when a significant obstacle, such as a building is located in the path of a cross-wind to an operational runway. The wind flow will be diverted around and over the buildings causing the cross-wind speed to vary along the runway.

How it should be used

5. Some States/Territories already have planning guidelines or polices in place and this document provides guidance for review. For those without policies in place, these Guidelines (in addition to the associated Safeguarding Framework) will provide input to new polices.
6. The guidelines can be applied by planners and regulators when evaluating building proposals on airports or by planners in consultation with airport operators in the immediate vicinity of airports.

Roles and Responsibilities

7. State/Territory and Local Governments are primarily responsible for land use planning in the vicinity of all airports.

8. Australia's 19 major airports are under Australian Government planning control and are administered under the Airports Act 1996 (the Airports Act). Planning on other airports is undertaken by State, Territory Governments and Local Governments or private operators.

Key Considerations For Managing the Risk of Building Generated Windshear and Turbulence at Airports

9. Research conducted by the Aeronautical Research Laboratory of the Netherlands (NLR) indicates that this safety risk is highest for buildings between the runway and 200ft above the runway. This research was conducted in response safety incidents at Amsterdam airport caused by building induced wind effects.

10. Buildings that could pose a safety risk are those located:

    a. 1200m or closer perpendicular to the runway centreline; or

    b. 900m or closer in front of runway threshold (i.e. towards the landside of the airport); or

    c. 500m or closer from the runway threshold along the runway.

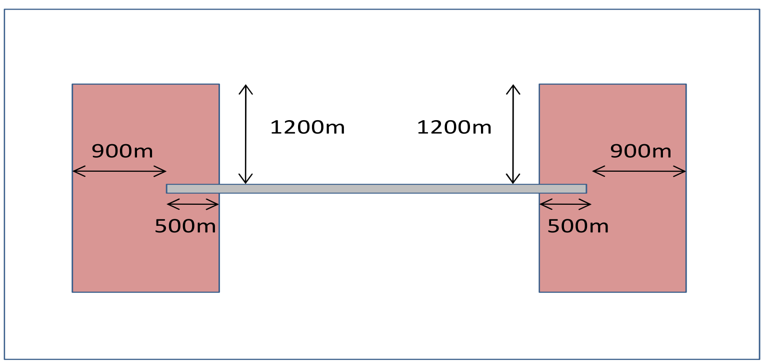


Figure A- envelope around runways within which buildings should be assessed

11. The guidelines present a simplified depiction of wind flows behind obstacles such as buildings and contain a synopsis of the technical issues surrounding building-induced wind effects.

12. The guidelines set out:

- empirically determined criteria for windshear and turbulence respectively;
- generic guidance on mitigating risks from proposed buildings;
- a methodology for assessment of proposed buildings; and
- options, where required, for subsequent detailed modelling of wind effects.
- options to mitigate wind effects of existing buildings where required

GUIDELINES FOR LAND USE PLANNERS AND AIRPORT OPERATORS TO MANAGE THE RISK OF BUILDING GENERATED WINDSHEAR AND TURBULENCE AT AIRPORTS

General

13. At airports, a combination of strong runway cross winds and obstacles to the prevailing wind flow such as large buildings can create:
    - low-level wind shear (horizontal and vertical);
    - additional (building-generated) turbulence, and
    - vortices.
14. According to the International Civil Aviation Organization (ICAO), wind shear is:
15. "A change in wind speed and/or direction in space, including updrafts and downdrafts ... any atmospheric phenomenon or any physical obstacle to the prevailing wind flow that produces a change in wind speed and/or direction, in effect, causes wind shear."
16. Turbulence is caused by rapid irregular motion of air. If turbulence is severe and unexpected, sudden changes in the flight path of aircraft may occur and pilots may lose control briefly.
17. Building-generated vortices are created when air flows start to spin after strong wind flow encounters a building at particular angles.
18. The effect that buildings have on the prevailing wind flow depends on a number of factors, the most important being:
    - the speed of the wind and upstream turbulence;
    - orientation of wind relative to the building;
    - the scale of the building in relation to the runway dimensions;
    - location of the building in relation to safety-critical zones such as touch-down zones, and
    - bulk, form and complexity of the building.
19. Although buildings near runways (such as offices, warehouse type buildings and hangars) are height–restricted to comply with the 'Obstacle Limitation Surfaces', they can potentially constitute obstacles of significant size relative to the prevailing surface wind flow. The wind flow is diverted around and over the buildings causing the surface wind to vary along the runway in both magnitude and direction (see **Figure 1**).

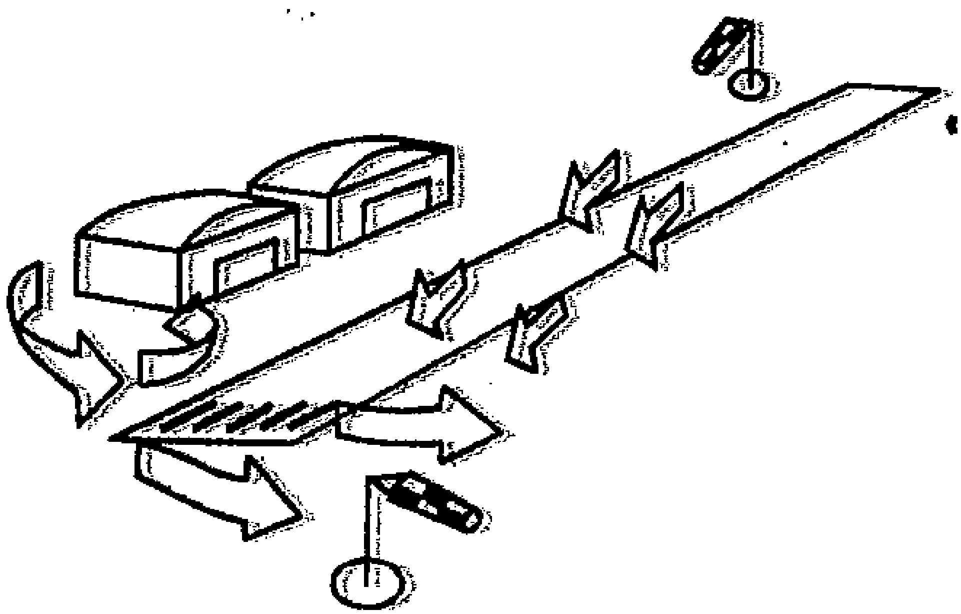


Figure 1

20. Such horizontal wind shear, which is usually localized and turbulent, poses risk to light aircraft in particular but has also been a factor in safety incidents involving large jet aircraft.
21. Windshear poses the greatest risk on approach, landing and take-off when an aircraft's speed is low and the pilot's ability to respond is limited. Flight conditions near the ground are complex, with accurate aircraft control required at a phase when significant changes in wind speed and direction can occur.
22. In particular this applies to large aircraft where the engine housing may strike the ground in turbulent or windshear conditions.
23. The Australian Government committed in the Aviation White Paper to develop guidance on the impact of turbulence and wind shear generated by buildings in the vicinity of runways. To date, no formal regulation exists in Australia or indeed anywhere in the world on the assessment and mitigation of turbulence and wind shear generated by buildings.
24. The Australian Government considers that these guidelines are important to better inform the siting and construction of on-airport buildings and in the immediate vicinity of airports to mitigate the risk of building-generated windshear and turbulence.

Existing Regulatory Controls

25. Leased federal airports are protected from tall buildings in the vicinity of airports based on standards established by the International Civil Aviation Organisation (ICAO). These standards form the basis of 'prescribed airspace' legislation under the Airports Act 1996 which is

administered by the Department of Infrastructure and Transport (DoIT). Under this legislation, airspace surrounding leased federal airports is regulated to ensure that obstacles to safe air transport are not built.

26. Research from the NLR indicates that the DoIT-administered prescribed airspace legislation protecting the OLS at leased federal airports has the effect of mitigating the risk of building-generated turbulence for aircraft between 200ft and 1,000ft above ground level. However, this legislation does not cover non-federal airports. In addition, airports certified under Part 139 of the Civil Aviation Safety Regulations 1998 are protected from tall buildings as the OLS is protected. However, OLS protection is inadequate to address the risk of building-generated wind effects below 200ft.

Regulatory provisions relating to building-generated windshear and turbulence

27. Australia has international obligations as a contracting state to the Convention on Civil Aviation to regulate aviation safety. As discussed previously, neither ICAO nor any other major aviation safety regulator has so far established wind impact assessment criteria.

Mitigation of risk – current practice

28. Current practice is generally to rely on standing warnings to pilots about the potential to encounter adverse wind effects. This is the approach in the UK as well as currently in Australia. For example, at Canberra Airport, there is a permanent notice in aviation publications advising pilots about the potential adverse wind effects that can be encountered because of a hangar. After extensive consultation and research, Australian governments have decided to take a pro-active approach on this issue and this option has been discarded.

Mitigation of risk by use of a 'height multiplier' option – only applicable to single buildings

29. For stand-alone buildings , the first step is to rely on a 'height multiplier' rule to determine the acceptability of buildings. The rule to be adopted in Australia is based on one developed in the Netherlands. This proposes that buildings with a distance to the runway centre-line that is less than 35 times the height of the building (the 1:35 rule) should be subject to aerodynamic modelling.

30. The 1: 35 rule can be applied to rule out buildings that will clearly not pose a risk. This rule will therefore be applied as the first test that will be applied when regulators are presented with a building to assess. This approach will enable the vast majority of developments at regional airports to be assessed very quickly. The rule is very conservative and any building that meets this test will not create unsafe wind effects.

Mitigation of risk – buildings that do not meet the 1:35 rule, buildings with complex shapes and/or multiple buildings

31. For buildings that do not meet the 1:35 rule, an alternative approach is required. This approach is:

    - the adoption of a windshear criterion to be applied as the basis of regulatory controls.

Establishing a practicable standard to control the risk of building generated windshear and turbulence at airports near runways

Windshear Criterion

32. In response to serious safety issues created by building-generated wind effects at Amsterdam airport, NLR has carried out considerable research on this issue.

33. Based on this research, NLR developed the following criterion:

34. The variation in mean wind **speed due to wind disturbing structures must remain below 7 knots** along **the aircraft trajectory at heights below 200ft. The speed deficit change of 7 knots must take place over a distance of at least 100m.**

35. This criterion will apply in Australia.

Buildings near runways: generic guidance to mitigate risk of building-induced wind effects

Building Location With Respect to the Runway

36. The aircraft instability which building-induced windshear and turbulence can cause is significantly reduced once the airplane has touched down or is above 200 feet off the ground after take-off.

37. The most critical zone (in plan view) for building positioning, with respect to potential (building-related) windshear problems, is close to the touch-down zones of runways.

38. Buildings should preferably not be sited in this zone near the touch-down zones of runways. Buildings that are sited in this zone should be examined with particular rigour for potential risk. The evidence from aircraft safety incidents for which building-induced windshear and turbulence was a factor shows that buildings in this critical zone induced the wind effects of concern.

Building Plan Form Aspect Ratio

39. The wake behind a building varies significantly with building (plan form) aspect ratio. A building with depth (the dimension in line with the wind) greater than width (dimension perpendicular to the wind), say by a factor of around 2:1, has a considerably smaller wake than a building whose width is equal to or greater than its depth.

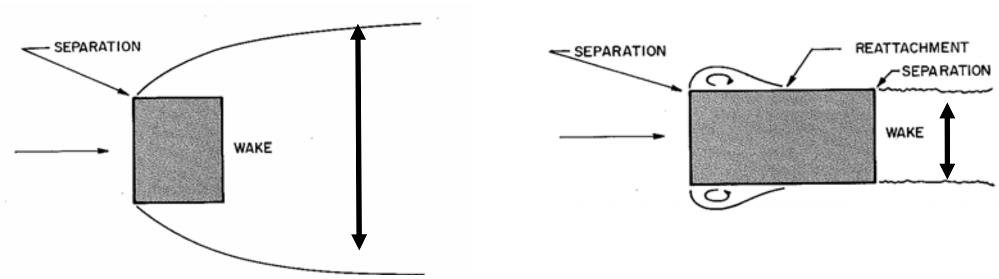


Figure 2:Influence of Building Plan Form Aspect Ratio on Wake Magnitude

40. Proponents of buildings should note that that a wide wake is created by buildings with width greater than the depth. Proponents should therefore consider aspect ratio with a view to minimising the size of the wake where possible.

Oblique Angle Delta Vortices

41. "Delta" vortices can form over sharp-edged rectangular buildings subject to oblique flow, i.e. oncoming flow at an angle of around 45º to the main façade orientations. These persist in the wind flow for many buildings dimensions downstream.

42. Wherever possible, buildings should avoid an orientation which puts it at 45º to the orientation of a nearby runway or where the potential for delta vortex formation is aligned with a prevailing wind direction. Figure 3 depicts the formation of a delta wing vortex.

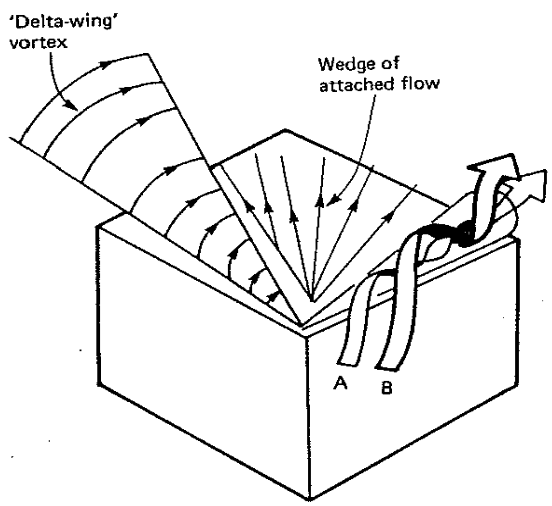


Figure 3 Delta Vortex Formation on Building at Oblique Angle to Wind Flow

Complexity of Building Shape

43. Buildings at airports generally have a fairly rectangular form, e.g. terminals, hangars, warehouse type buildings and offices.

44. This is not always the case. There can be significant variations in the wake disturbance for complex building shapes compared to simple rectangular forms. Complex building shapes have the potential to create unpredictable wind effects and are harder to analyse for risk. Amsterdam Airport reported a number of aviation safety incidents arising from the unusual extent of wake disturbance created by the Schiphol engine test facility. This facility has a complex shape which causes significant wind effects.

45. In the absence of detailed quantitative analysis, it will generally be difficult for even an experienced wind engineer to reliably predict the extent of a building wake and the magnitude of the disturbances contained within the wake, when confronted with complex geometry unless a significant degree of conservatism is employed.

Concept of Probability of Occurrence

46. Like all aviation safety incidents, building-induced windshear events involve a coincidence of factors including the following:

- There would need to be a building of shape and size able to generate wake disturbances large enough to exceed accepted windshear criteria, e.g. the NLR "7-knot criterion".
- The wind would need to be blowing in a more or less cross-wind orientation to the runway being used and of a magnitude able to generate conditions where the "7-knot criterion" could be exceeded.

47. The above suggests that the actual risk of a building-induced windshear event involves statistical analysis indicating the likelihood of occurrence of adverse events so that an informed decision can be made as to actual risk involved.

Preliminary assessment of the magnitude of building-induced windshear (measured as mean wind speed deficit (BWD))

48. The variation in mean wind speed encountered by an aircraft traversing a wake behind an airport building is termed the building-induced mean wind speed deficit, BWD.

49. Based on a range of empirical studies, it is possible to produce estimates of BWD values as a function of the mean velocity of the approach flow at the roof height (H) of the building of concern, VH.

50. For the purposes of a preliminary (i.e. non-quantitative) assessment of an airport building, it is important that these estimates are conservative in nature.

51. Accordingly, the preliminary assessment should be based on Table 1 below.

52. The building is assumed to be at typical airport height, e.g. up to 40 m (or even more) in height and rectangular in shape with an aspect ratio such that reattachment does not take place, i.e. the in-line length is less than the building width.

53. The values apply to the case of windflow striking the building perpendicular to the main façade "width" dimension, W, and assume reasonably open flat terrain upstream of the building.

54. The magnitude of BWD is given in terms of a percentage of VH. As an example, for a building of width-to-depth ratio, W/H = 4, the mean windspeed deficit (BWD) encountered by an object traversing the building's wake at a distance of 10 x building height would be equal to 0.22 VH i.e. 22% of VH.

BWD	W/H Ratios = 1	2	4	6	8
0.48 V_H	1.7 H	3.4 H	6.5 H	9.5 H	12.5 H
0.35 V_H	2.2 H	4.2 H	8 H	11.5 H	15 H
0.22 V_H	3 H	5.5 H	10 H	14 H	18 H
0.11 V_H	5 H	9 H	17 H	24.5 H	32 H

Table 1 BWD Values at various distances downstream for buildings with W/H ratios between 1 and 8)

55. The values provided in the Table 1 would be:

- greater for wind approaching at an oblique angle; and
- lower for an upstream terrain of greater roughness.

56. **Example Calculation:**

Building Dimensions: Width, W = 120 m; Height, H = 30 m; Length, L = 30 m;

hence W/H = 4

Approach Mean Speed: VH = 10 m/s (36 km/hr, 19.4 kt)

Upstream Terrain: Open, Flat Terrain

Approach Flow: Perpendicular to Width, W, façade of building

Mean velocity deficit, BMD:

= 4.8 m/s	9.5 kt	195 m downstream of the building
= 3.5 m/s	7 kt	240 m downstream of the building
= 2.2 m/s	4.5 kt	300 m downstream of the building
= 1.1 m/s	2 kt	510 m downstream of the building

Size of the wake: = 240 m (ie 2 x Width)

57. In the above example, the mean cross wind deficit experience by an aircraft landing on a runway whose centreline is located about 240 m from the nearest face of a building of dimensions 120 m (width), 30 m (length) and 30 m (height) would be of the order of 7 kt.

58. This wind speed deficit would be sustained over a distance of more than 200 m.

59. To obtain a complete understanding of the above example in terms of likelihood of occurrence, it would then be required to use the wind rose for the site to calculate the probability of occurrence of the wind having a magnitude of 10 m/s AND approaching the site from the worst-case wind direction (i.e. firstly over the building and then onto the runway).

Formal application of the building assessment methodology

Premise

60. A wind consultant or other suitably qualified professional should be asked to provide guidance on the acceptability or otherwise of a proposed building development in relation to the potential wake disturbance caused by the building on nearby runway operations.

61. This assessment will be premised on the acceptance criterion, viz. whether the "7-knot criterion", will be exceeded or not, and, if it is predicted to be exceeded, how often.

Key Factors to Consider

62. The key parameters of interest will be:

- Building Shape — Regular, Non-Regular
- Building Dimensions — Width, Depth, Height
- Perpendicular Distance of the Building from the Runway
- Building Position Relative to Touchdown / Take-Off Position
- Surrounding Terrain — Open, Suburban, Urban Built-Up
- Probability of Occurrence and Strength of Winds
  (particularly from the direction able to cause the cross wind conditions of concern)

Risk Classification

63. The recommended approach is summarised in **Table 2**.

64. The assessment methodology is based on risk categories.

<u>Initial assessment – use of a 'height multiplier' – the 1: 35 rule</u>

65. For stand-alone , regular-shaped (rectangular/square) buildings - in the first instance, the 1:35 rule is applied. If a building meets this rule, the building is deemed acceptable. For example, if a 10m tall building is located 350m from the runway centre-line, it meets the rule and no further assessment is required. See **Table 2** – Case A.

<u>Further assessment for buildings that do not meet the 1: 35 rule – hierarchy of assessment</u>

66. For buildings that do not meet the 1: 35 rule, the assessment hierarchy methodology is described in **Table 2- Cases B1, B2 and C**.

Table 2 Assessment Methodology Hierarchy

Category	Building Description	Assessment Methodology
Case A	**Building Shape:** Any Shape The building height satisfies the 1:35 rule, i.e. the horizontal distance of the building's closest point from the edge of the runway is more than 35 times the height of the building	In this instance, the building is deemed acceptable and no further assessment is required.
Case B1	**Building Shape:** Single, Regular Shape, e.g. Rectangular Buildings **Prevailing Wind-Building Angle:** Perpendicular to Building Facades	In this instance, all available techniques, including a Qualitative (Desktop) Study, could be used to address the acceptability of the proposal. The mean velocity deficit data provided in **Table 1** could be used in conjunction with the building height and local wind rose information to identify the potential (if any) for adverse cross wind conditions.
Case B2	**Building Shape:** Single, Regular Shape, e.g. Rectangular Buildings **Prevailing Wind-Building Angle:** Oblique to Building Facades	In this instance, a safety margin would need to be added to the mean velocity deficit data provided in **Table 1** in conjunction with the building height and local wind rose information to identify the potential (if any) for adverse cross wind conditions. The safety margin might be in the form of an increase in perceived distance downstream of the order of at least 25%.
Case C	**Building Shape:** Complex Building Shape AND/ OR Multiple Buildings	In this instance, unless a very conservative safety margin is added to the mean velocity deficit data provided in **Table 1**, one of the following quantitative modelling techniques should be used: 1. Wind Tunnel using Hot-Wire Sensors, 2. Wind Tunnel using Particle Image Velocimetry (PIV), or 3. Computational Fluid Dynamics (CFD).

Form of the Output for Assessment

67. The output of the consultant's wind assessment for cases B1, B2 and C will typically be of the form displayed in Figure 4.

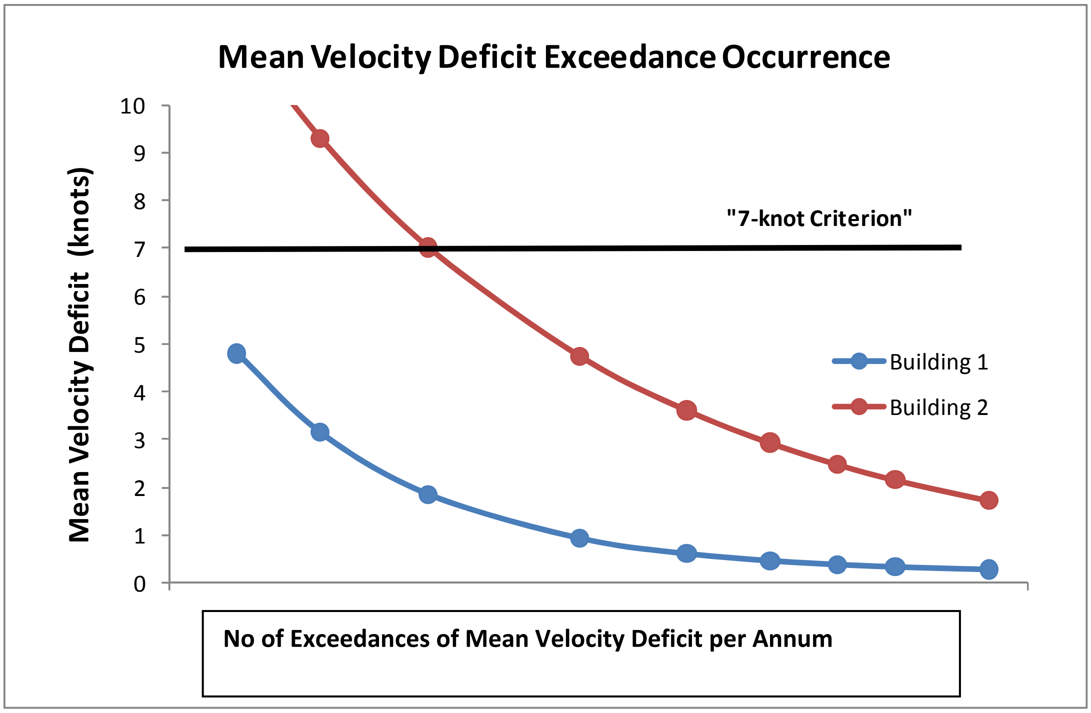


Figure 4 **Sample Output for Building-Generated Windshear Assessment**

68. In this example, two buildings were examined.

69. For Building 1, the NLR "7-knot criterion" is never exceeded. The building is therefore accepted with no consent conditions required to be specified in terms of airport operations etc, e.g. warnings to pilots or restrictions on runway operations under particular cross-wind conditions.

70. For Building 2, the NLR "7-knot criterion" is exceeded a number of times per year. The number of exceedances will now play a role in terms of the consent process for the development.

- If the predicted number of annual exceedances is low (e.g. several exceedances per year only), the building may still be approved but with a Building Wake Management Plan required. Such a plan would specify a critical ambient wind condition (e.g. mean winds exceeding "Vcrit" m/sec and blowing from "θcrit" ±22.5º) under which landings or takeoffs on a particular runway are disallowed.
- If the predicted number of annual exceedances is significant (e.g. frequent exceedances per year), the building design may require amendment to be approved.

71. In the latter case, the regulator may decide that:

- The building height must be lowered, or
- The building design must be modified in a manner that will reduce the extent of the wake disturbance behind the building.

72. It is also possible that the regulator may conclude that the proposed building is not acceptable at a particular location.

73. From the perspective of pilots dealing with cross wind conditions, there is a need for pilots to respond to (rapidly fluctuating) turbulence during cross wind conditions as well as any associated (more sustained) windshear.

74. This suggests that any criterion related to potentially hazardous levels of building-induced windshear which are solely based on mean winds (e.g. the mean velocity deficit) should be applied in a conservative manner, to ensure that the potential for additional turbulence-related impacts is also addressed.

- It is currently not practical for the wind criterion to take into account the inherent levels of turbulence likely to be present. Turbulence levels will vary significantly depending upon building shape details, angle of attack of the approaching wind, upstream terrain, nearby obstacles, etc.

Mitigation options for existing buildings

75. In this section, guidance is provided on options to mitigate building generated turbulence and windshear for existing structures where safety risks are identified.

Wake Size Suppression - Building Shape Augmentation

76. Reference is made once again to one of the key features which influences the wake flow (and hence associated windshear) behaviour surrounding rectangular buildings, namely building plan form aspect ratio, as depicted in Figure 4.

77. The wake behind a building whose depth (the dimension in line with the wind) is greater than its width (dimension perpendicular to the wind) by a factor of 2:1 has a considerably smaller wake than a building whose width is equal to or greater than its depth.

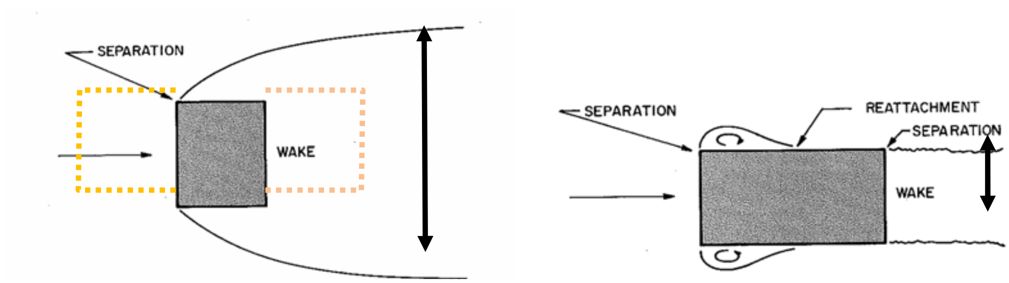


Figure 5 Wake Flow Characteristics Influence of Building Plan Form Aspect Ratio

78. The implied solution here would be to “create” the conditions where the building appears to have greater depth than is otherwise the case, e.g. to increase the building depth as shown by the orange or pink dotted lines in Figure 5

79. In many instances, the runway (leeward) side of the building would be an area reserved for airport operations and the opposite (windward) side might be needed for building access. Accordingly, the “orange/pink” building augmentation options may not be practical in specific applications. However, this is an option that could be explored in some specific cases.

Wake Disruption - Surrounding “Roughness”

80. “Smooth” flow as encountered over flat, open terrain tends to lead to well delineated wake regions. As the oncoming flow becomes more turbulent due to upstream obstacles, so the wake and associated disturbances become less well defined.

81. An option for disrupting the wake and therefore the impact of the mean velocity deficit behind an existing building could therefore involve adding roughness elements immediately upstream of the development. Such elements (e.g. trees, other buildings, hoardings such as signage, etc) would however need to be of significant magnitude relative to the building of concern. For example, a row of shrubs, 1 to 2 m in height, located immediately upstream of a building of height 30 m would have negligible impact on the resulting wake behind the building.

Wake Disruption - Leading Edge Roof Attachments

82. Another option for disrupting the wake is to consider attaching a screen or hoarding to the roof near the leading edge (i.e. the point where the wind first impacts on the building). Both the size of the wake and its accompanying velocity deficits would be potentially lessened with the addition of screens.

83. A quantitative investigation would be required to determine the efficacy of any specific recommended wake flow suppression design – screen size, location on roof, angle of orientation, etc.

84. The concept is based on sound aerodynamic reasoning and should in practice be feasible to implement as a building “retro-fit” solution, e.g. building signage.

Wake Suppression – Wing Concept

85. At an aircraft hangar which was potentially prone to very high leading edge suction pressures, a leading edge “wing” was attached to the building at roof height to reduce the resulting peak pressure loads on the roof. Apparently, a significant reduction in peak pressure did indeed occur, indicating that the entire wake flow disturbance downstream of the building associated with the changed flow separation conditions would likely have lessened as well.

86. The concept idea of such a leading edge wing is shown in Figure 6. The concept is aerodynamically identical to the leading edge devices successfully used in aircraft design which aim to achieve the same lessening of wake disturbance impact and hence drag force.

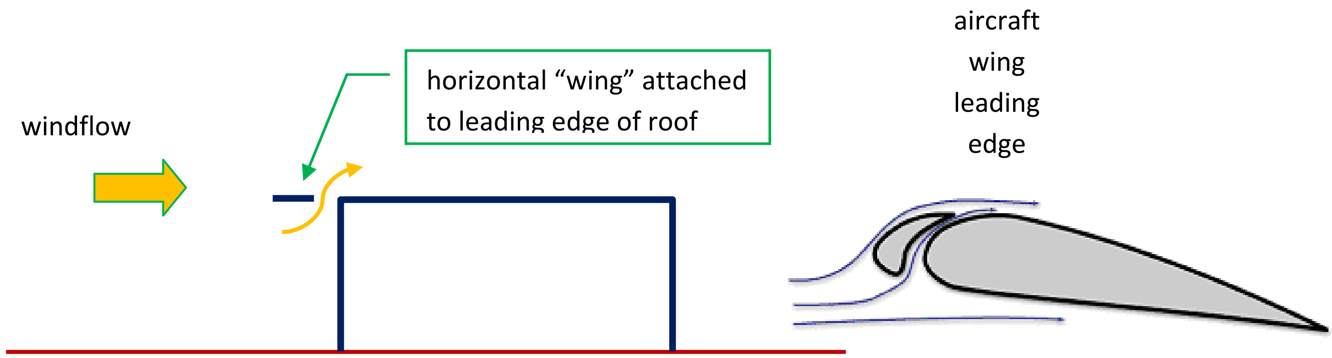


Figure 6 **Leading Edge Wing Concept for Vortex Suppression**

87. The leading edge wing idea is based on sound aerodynamic concepts and would appear to be potentially a cost-effective solution to wake flow mitigation. Aerodynamic modelling would be required to quantify the impacts of such a retro-fit.

Wake Suppression - Vane Concept

88. In a wind tunnel model study, prismatic buildings were fitted with vertical blade panels (vanes) at the building corners with a gap between the panel and the building which could vent the flow moving past the building. The purpose of these vanes was to disrupt the separation of windflow at the building corner associated with high localised (negative) pressure.

89. The wind tunnel tests used to carry out this investigation showed substantial reduction in the magnitude of the peak pressures near the corners of these buildings. It is inferred that the wake disturbance behind the buildings would also have decreased.

90. A quantitative investigation would be required to determine the efficacy of any specific recommended suppression design – size, gap width, angle of orientation, etc. The concept is based on sound aerodynamic reasoning and should in practice be feasible to implement as a building "retro-fit" solution, once again with possible commercial implications (e.g. vanes used for advertising)

Wake Suppression - Flow Relief by Building Openings Concept

91. The phenomenon of vortex shedding is well understood (as shown in the visualisation diagram on the left side of Figure 7 and its impact on the wind loading of tall buildings and towers is significant – it is not uncommon in tall, lightweight structures for the cross wind loads (perpendicular to the wind) caused by vortex shedding to be greater than the along wind loads (i.e. in line with the wind).

92. For this reason, much effort has gone into investigating solutions to minimise cross wind loading. For example, in the case of industrial steel cylinders, helical strakes are a common form of vortex suppression.

93. An alternative vortex suppression technique which has been successfully used in the design of several tall buildings (e.g. the Columbia Centre tower shown on the right side of Figure 7) has

been to introduce an opening into the building which enables oncoming windflow to pass directly into the wake behind the building.

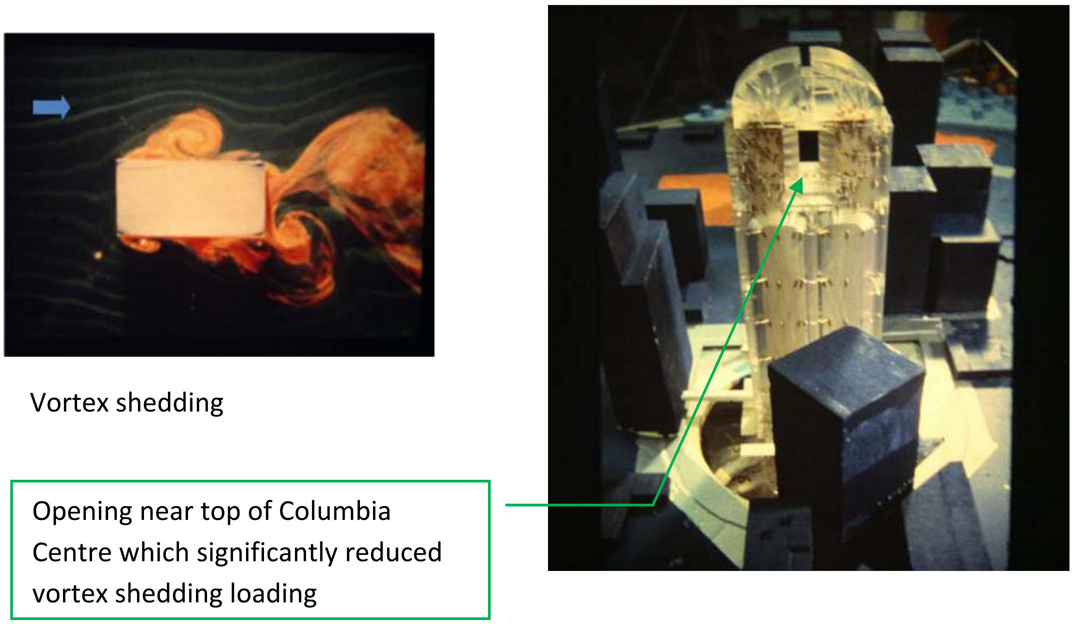


Figure 7 Vortex Shedding Flow Relief Option

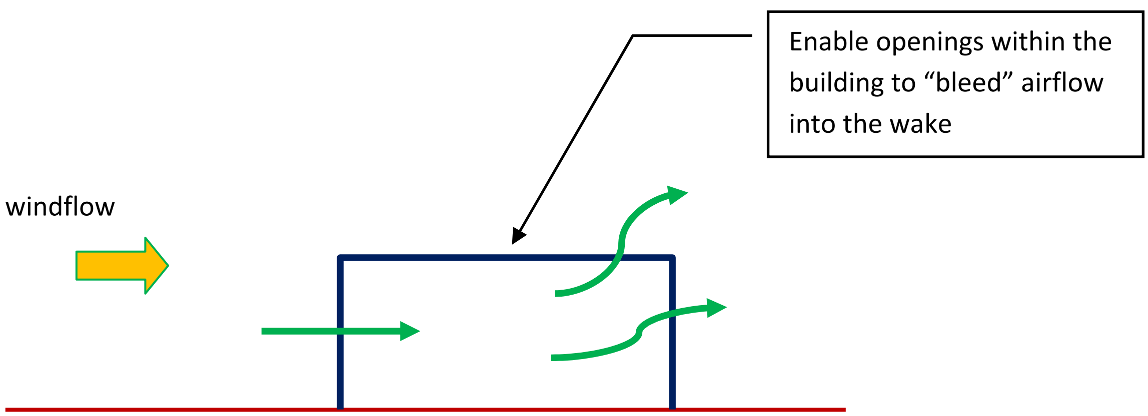
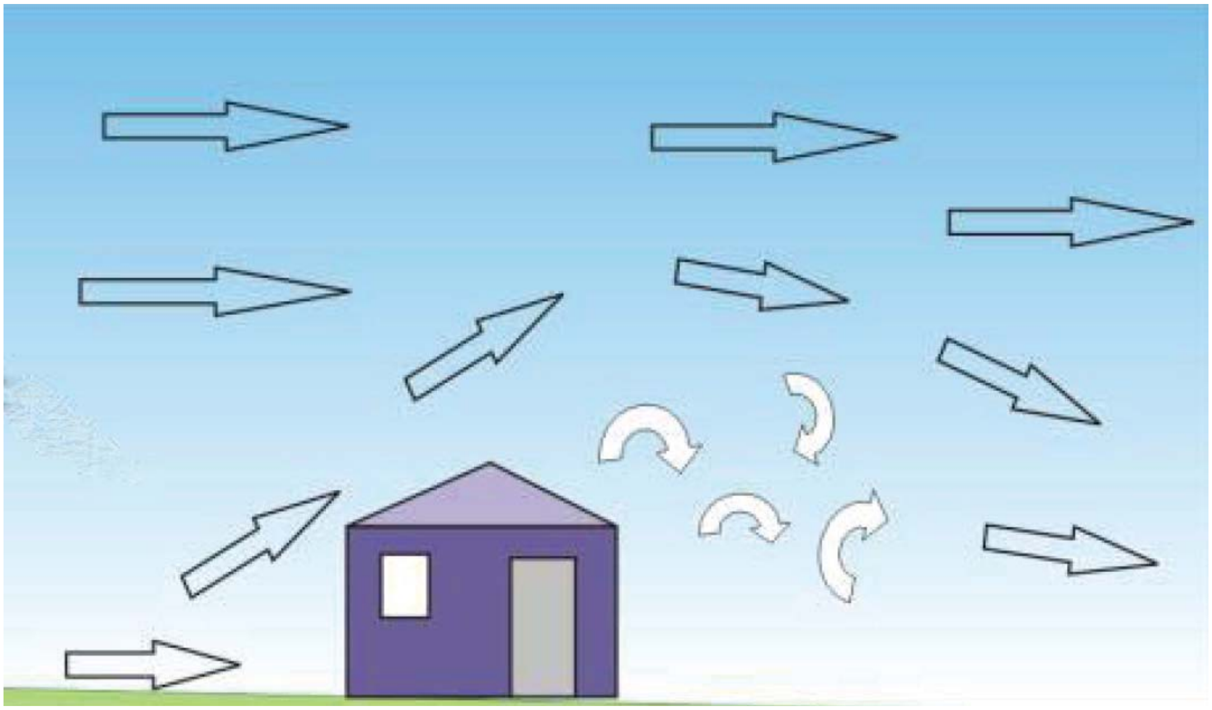


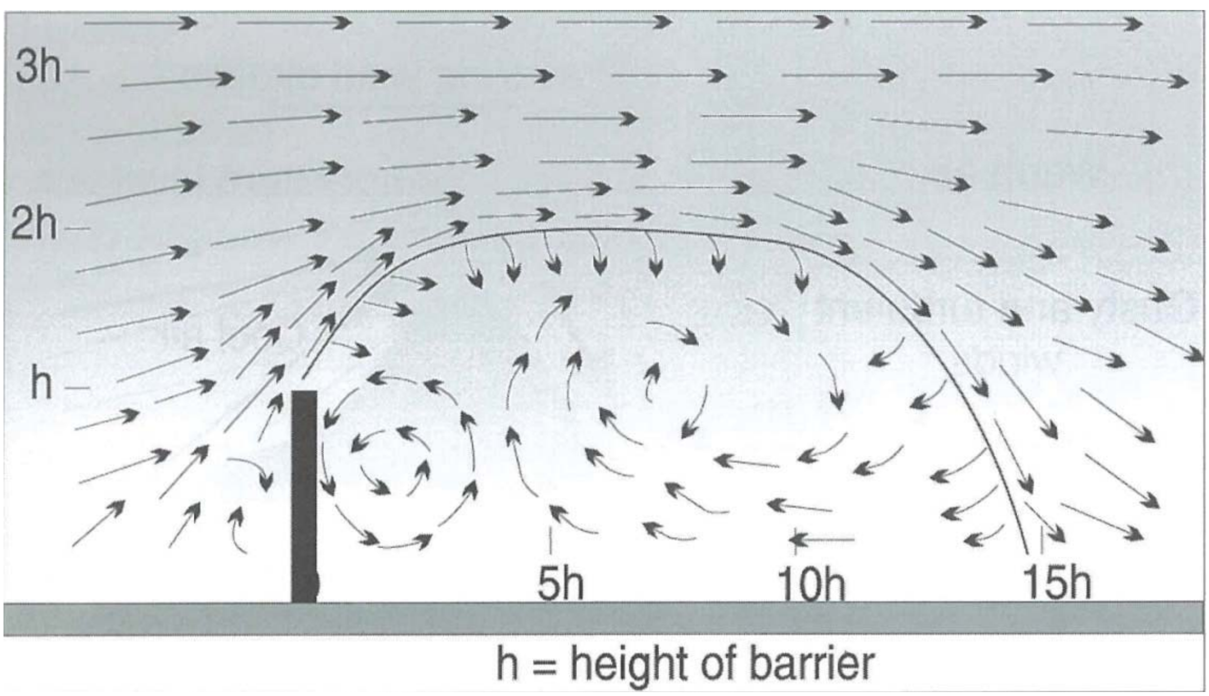
Figure 8 Relief Flow Concept

94. As in the case of the leading edge devices, the relief flow concept has a sound aerodynamic basis and may, depending upon the usage of the building of concern, be feasible. The idea may not be suitable for commercial buildings but may be feasible for hangars where large slot openings could be located on relevant facades.

95. Again, a quantitative aerodynamic investigation would be required to determine the efficacy of any specific suppression design.

ATTACHMENT 1





Source: Bureau of Meteorology

ATTACHMENT 2.

Synopsis of technical issues surrounding building-generated wind effects near runways

The wake flow behind a bluff body (e.g. a building) impacts both the mean speeds and the turbulence of the oncoming windflow. It comprises several readily identifiable features, most notably the **cavity region** immediately behind the building where **low speed, re-circulating flow** is apparent.

The cavity or **re-circulation** region typically extends up to **5 times the building height.** Wake effects (especially in relation to turbulence) however extend **well past** the recirculation zone, in some cases (depending upon building orientation) to beyond **20 times the building height**.

The extent of the wake (i.e. the region of disturbance to the upstream flow) – in terms of its physical dimension and the magnitude of the disturbance contained therein – will depend upon **building shape** (e.g. square, rectangular, etc), **building orientation** (i.e. building facades perpendicular to the wind, facades at 45º to the wind, etc), **aspect ratio** (height to building width ratio) and **surrounding terrain conditions** (open country terrain, suburban terrain, etc).

For a wide range of simple building shapes, changes to mean winds can occur up to 20 times the building height downstream, although the velocity deficit is usually **modest beyond 10 times the building height downstream**. For square and rectangular buildings with a wide range of building dimensions and oriented with their facades perpendicular to the windflow, the mean wind behind the building recovers to over 80% of its upstream level at a downstream distance less than 10 times the building height.

The disturbance to turbulence appears to be greater in both downstream extent and vertical extent (height above the building). While the disturbance to mean speeds extends not much more than 2 times the building height, noticeable turbulence changes occur up to **4 times the building height**.

All of the above wake effects (to both mean winds and turbulence levels) vary according to the upstream terrain profile. Relatively smooth windflow approaching a building over flat, open country terrain will experience the largest relative changes in the resulting building wake.

A particular case of interest is when certain building shapes (including rectangular buildings) are oriented at an **oblique angle** to the approaching windflow. In this case, a pronounced **delta-like vortex** forms at the leading corner of the building and persists in the flow for a considerable distance downstream. In this instance, turbulence levels can be elevated for distance well beyond the point where the mean wind is restored to its upstream (unaffected) level.

The results from wind tunnel tests of various simple building shapes and aspect ratios suggests that a simple “rule” for determining the magnitude of wake disturbance (for both mean winds and turbulence levels) based just on building height, and accurate for any building shape and any combination of building dimensions, is not apparent.

The consequence of this latter observation is highly significant. If it was desired to determine the extent of building wake effects using a simple prediction rule based for example on the number of building heights downstream, such a rule would have the potential to end up being **highly conservative** if it was required to cover a reasonable range of building shapes and dimensions.

GUIDELINE B

NATIONAL AIRPORTS SAFEGUARDING FRAMEWORK

MANAGING THE RISK OF BUILDING GENERATED WINDSHEAR AND TURBULENCE AT AIRPORTS

REVISION DATE	VERSION NUMBER	CHANGES MADE	APPROVED BY
Feb 2012	2.2.1	Document Creation	NASAG
Apr 2012	2.2.2	Drafting changes post consultation process	SCOTI
15/7/12	2.2.3	Version control table added. Page numbers added.	S. Stone, GM Aviation Environment, DOIT.

Purpose of Guideline

1. This document provides guidelines to Commonwealth, State/Territory and local government decision makers to manage the risk of building generated windshear and turbulence at airports.

Why it is important

2. The Principles *for a National Airports Safeguarding Framework* acknowledge the importance of airports to national, state/territory and local economics, transport networks and social capital.
3. These guidelines are designed to assist land use planners and airport operators in their planning and development processes to reduce the risk of building generated windshear and turbulence at airports near runways.
4. Essentially, the building generated turbulence windshear / turbulence issue becomes safety critical when a significant obstacle, such as a building is located in the path of a cross-wind to an operational runway. The wind flow will be diverted around and over the buildings causing the cross-wind speed to vary along the runway.

How it should be used

5. Some States/Territories already have planning guidelines or polices in place and this document provides guidance for review. For those without policies in place, these Guidelines (in addition to the associated Safeguarding Framework) will provide input to new polices.
6. The guidelines can be applied by planners and regulators when evaluating building proposals on airports or by planners in consultation with airport operators in the immediate vicinity of airports.

Roles and Responsibilities

7. State/Territory and Local Governments are primarily responsible for land use planning in the vicinity of all airports.

8. Australia's 19 major airports are under Australian Government planning control and are administered under the Airports Act 1996 (the Airports Act). Planning on other airports is undertaken by State, Territory Governments and Local Governments or private operators.

Key Considerations For Managing the Risk of Building Generated Windshear and Turbulence at Airports

9. Research conducted by the Aeronautical Research Laboratory of the Netherlands (NLR) indicates that this safety risk is highest for buildings between the runway and 200ft above the runway. This research was conducted in response safety incidents at Amsterdam airport caused by building induced wind effects.

10. Buildings that could pose a safety risk are those located:

    a. 1200m or closer perpendicular to the runway centreline; or

    b. 900m or closer in front of runway threshold (i.e. towards the landside of the airport); or

    c. 500m or closer from the runway threshold along the runway.

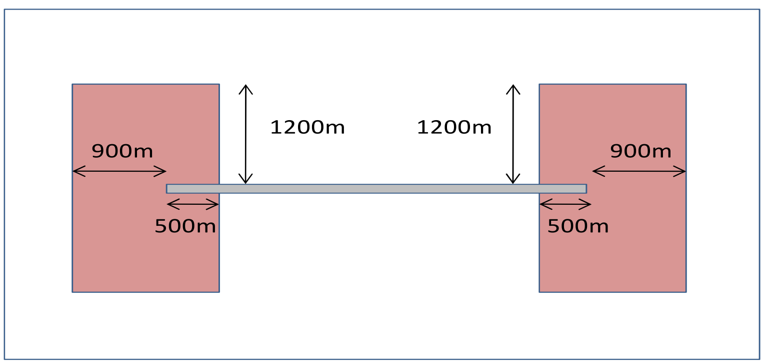


Figure A- envelope around runways within which buildings should be assessed

11. The guidelines present a simplified depiction of wind flows behind obstacles such as buildings and contain a synopsis of the technical issues surrounding building-induced wind effects.

12. The guidelines set out:

- empirically determined criteria for windshear and turbulence respectively;
- generic guidance on mitigating risks from proposed buildings;
- a methodology for assessment of proposed buildings; and
- options, where required, for subsequent detailed modelling of wind effects.
- options to mitigate wind effects of existing buildings where required

GUIDELINES FOR LAND USE PLANNERS AND AIRPORT OPERATORS TO MANAGE THE RISK OF BUILDING GENERATED WINDSHEAR AND TURBULENCE AT AIRPORTS

General

13. At airports, a combination of strong runway cross winds and obstacles to the prevailing wind flow such as large buildings can create:
    - low-level wind shear (horizontal and vertical);
    - additional (building-generated) turbulence, and
    - vortices.
14. According to the International Civil Aviation Organization (ICAO), wind shear is:
15. "A change in wind speed and/or direction in space, including updrafts and downdrafts ... any atmospheric phenomenon or any physical obstacle to the prevailing wind flow that produces a change in wind speed and/or direction, in effect, causes wind shear."
16. Turbulence is caused by rapid irregular motion of air. If turbulence is severe and unexpected, sudden changes in the flight path of aircraft may occur and pilots may lose control briefly.
17. Building-generated vortices are created when air flows start to spin after strong wind flow encounters a building at particular angles.
18. The effect that buildings have on the prevailing wind flow depends on a number of factors, the most important being:
    - the speed of the wind and upstream turbulence;
    - orientation of wind relative to the building;
    - the scale of the building in relation to the runway dimensions;
    - location of the building in relation to safety-critical zones such as touch-down zones, and
    - bulk, form and complexity of the building.
19. Although buildings near runways (such as offices, warehouse type buildings and hangars) are height–restricted to comply with the 'Obstacle Limitation Surfaces', they can potentially constitute obstacles of significant size relative to the prevailing surface wind flow. The wind flow is diverted around and over the buildings causing the surface wind to vary along the runway in both magnitude and direction (see **Figure 1**).

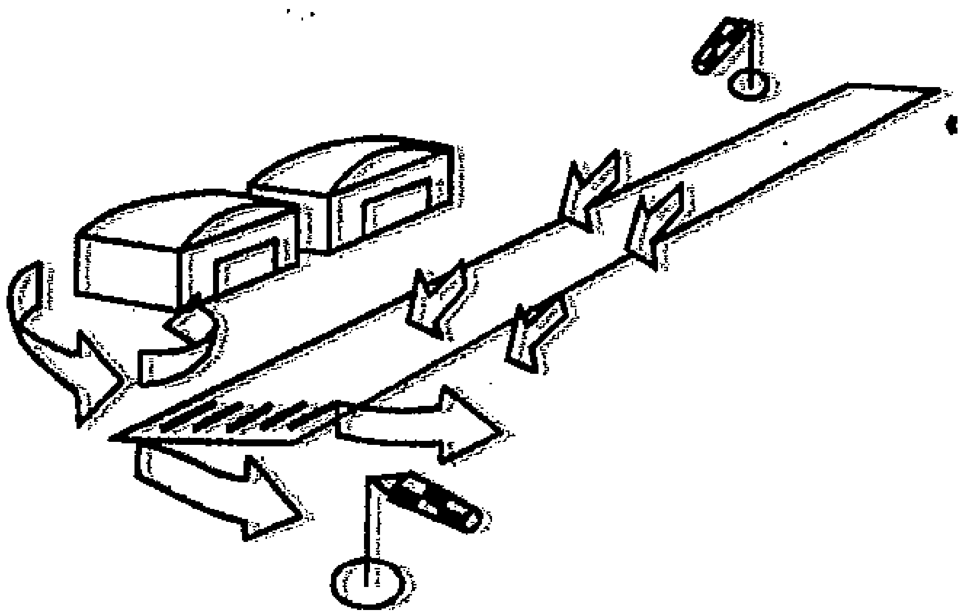


Figure 1

20. Such horizontal wind shear, which is usually localized and turbulent, poses risk to light aircraft in particular but has also been a factor in safety incidents involving large jet aircraft.

21. Windshear poses the greatest risk on approach, landing and take-off when an aircraft's speed is low and the pilot's ability to respond is limited. Flight conditions near the ground are complex, with accurate aircraft control required at a phase when significant changes in wind speed and direction can occur.

22. In particular this applies to large aircraft where the engine housing may strike the ground in turbulent or windshear conditions.

23. The Australian Government committed in the Aviation White Paper to develop guidance on the impact of turbulence and wind shear generated by buildings in the vicinity of runways. To date, no formal regulation exists in Australia or indeed anywhere in the world on the assessment and mitigation of turbulence and wind shear generated by buildings.

24. The Australian Government considers that these guidelines are important to better inform the siting and construction of on-airport buildings and in the immediate vicinity of airports to mitigate the risk of building-generated windshear and turbulence.

Existing Regulatory Controls

25. Leased federal airports are protected from tall buildings in the vicinity of airports based on standards established by the International Civil Aviation Organisation (ICAO). These standards form the basis of 'prescribed airspace' legislation under the Airports Act 1996 which is

administered by the Department of Infrastructure and Transport (DoIT). Under this legislation, airspace surrounding leased federal airports is regulated to ensure that obstacles to safe air transport are not built.

26. Research from the NLR indicates that the DoIT-administered prescribed airspace legislation protecting the OLS at leased federal airports has the effect of mitigating the risk of building-generated turbulence for aircraft between 200ft and 1,000ft above ground level. However, this legislation does not cover non-federal airports. In addition, airports certified under Part 139 of the Civil Aviation Safety Regulations 1998 are protected from tall buildings as the OLS is protected. However, OLS protection is inadequate to address the risk of building-generated wind effects below 200ft.

Regulatory provisions relating to building-generated windshear and turbulence

27. Australia has international obligations as a contracting state to the Convention on Civil Aviation to regulate aviation safety. As discussed previously, neither ICAO nor any other major aviation safety regulator has so far established wind impact assessment criteria.

Mitigation of risk – current practice

28. Current practice is generally to rely on standing warnings to pilots about the potential to encounter adverse wind effects. This is the approach in the UK as well as currently in Australia. For example, at Canberra Airport, there is a permanent notice in aviation publications advising pilots about the potential adverse wind effects that can be encountered because of a hangar. After extensive consultation and research, Australian governments have decided to take a pro-active approach on this issue and this option has been discarded.

Mitigation of risk by use of a 'height multiplier' option – only applicable to single buildings

29. For stand-alone buildings , the first step is to rely on a 'height multiplier' rule to determine the acceptability of buildings. The rule to be adopted in Australia is based on one developed in the Netherlands. This proposes that buildings with a distance to the runway centre-line that is less than 35 times the height of the building (the 1:35 rule) should be subject to aerodynamic modelling.

30. The 1: 35 rule can be applied to rule out buildings that will clearly not pose a risk. This rule will therefore be applied as the first test that will be applied when regulators are presented with a building to assess. This approach will enable the vast majority of developments at regional airports to be assessed very quickly. The rule is very conservative and any building that meets this test will not create unsafe wind effects.

Mitigation of risk – buildings that do not meet the 1:35 rule, buildings with complex shapes and/or multiple buildings

31. For buildings that do not meet the 1:35 rule, an alternative approach is required. This approach is:

- the adoption of a windshear criterion to be applied as the basis of regulatory controls.

Establishing a practicable standard to control the risk of building generated windshear and turbulence at airports near runways

Windshear Criterion

32. In response to serious safety issues created by building-generated wind effects at Amsterdam airport, NLR has carried out considerable research on this issue.

33. Based on this research, NLR developed the following criterion:

34. The variation in mean wind **speed due to wind disturbing structures must remain below 7 knots** along **the aircraft trajectory at heights below 200ft. The speed deficit change of 7 knots must take place over a distance of at least 100m.**

35. This criterion will apply in Australia.

Buildings near runways: generic guidance to mitigate risk of building-induced wind effects

Building Location With Respect to the Runway

36. The aircraft instability which building-induced windshear and turbulence can cause is significantly reduced once the airplane has touched down or is above 200 feet off the ground after take-off.

37. The most critical zone (in plan view) for building positioning, with respect to potential (building-related) windshear problems, is close to the touch-down zones of runways.

38. Buildings should preferably not be sited in this zone near the touch-down zones of runways. Buildings that are sited in this zone should be examined with particular rigour for potential risk. The evidence from aircraft safety incidents for which building-induced windshear and turbulence was a factor shows that buildings in this critical zone induced the wind effects of concern.

Building Plan Form Aspect Ratio

39. The wake behind a building varies significantly with building (plan form) aspect ratio. A building with depth (the dimension in line with the wind) greater than width (dimension perpendicular to the wind), say by a factor of around 2:1, has a considerably smaller wake than a building whose width is equal to or greater than its depth.

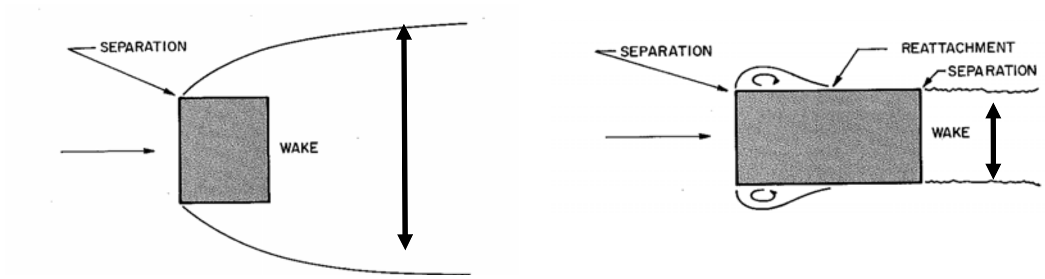


Figure 2:Influence of Building Plan Form Aspect Ratio on Wake Magnitude

40. Proponents of buildings should note that that a wide wake is created by buildings with width greater than the depth. Proponents should therefore consider aspect ratio with a view to minimising the size of the wake where possible.

Oblique Angle Delta Vortices

41. "Delta" vortices can form over sharp-edged rectangular buildings subject to oblique flow, i.e. oncoming flow at an angle of around 45º to the main façade orientations. These persist in the wind flow for many buildings dimensions downstream.

42. Wherever possible, buildings should avoid an orientation which puts it at 45º to the orientation of a nearby runway or where the potential for delta vortex formation is aligned with a prevailing wind direction. Figure 3 depicts the formation of a delta wing vortex.

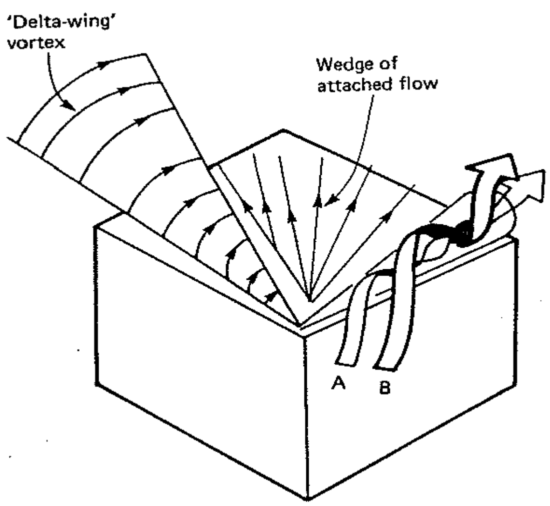


Figure 3 Delta Vortex Formation on Building at Oblique Angle to Wind Flow

Complexity of Building Shape

43. Buildings at airports generally have a fairly rectangular form, e.g. terminals, hangars, warehouse type buildings and offices.

44. This is not always the case. There can be significant variations in the wake disturbance for complex building shapes compared to simple rectangular forms. Complex building shapes have the potential to create unpredictable wind effects and are harder to analyse for risk. Amsterdam Airport reported a number of aviation safety incidents arising from the unusual extent of wake disturbance created by the Schiphol engine test facility. This facility has a complex shape which causes significant wind effects.

45. In the absence of detailed quantitative analysis, it will generally be difficult for even an experienced wind engineer to reliably predict the extent of a building wake and the magnitude of the disturbances contained within the wake, when confronted with complex geometry unless a significant degree of conservatism is employed.

Concept of Probability of Occurrence

46. Like all aviation safety incidents, building-induced windshear events involve a coincidence of factors including the following:

- There would need to be a building of shape and size able to generate wake disturbances large enough to exceed accepted windshear criteria, e.g. the NLR "7-knot criterion".
- The wind would need to be blowing in a more or less cross-wind orientation to the runway being used and of a magnitude able to generate conditions where the "7-knot criterion" could be exceeded.

47. The above suggests that the actual risk of a building-induced windshear event involves statistical analysis indicating the likelihood of occurrence of adverse events so that an informed decision can be made as to actual risk involved.

Preliminary assessment of the magnitude of building-induced windshear (measured as mean wind speed deficit (BWD))

48. The variation in mean wind speed encountered by an aircraft traversing a wake behind an airport building is termed the building-induced mean wind speed deficit, BWD.

49. Based on a range of empirical studies, it is possible to produce estimates of BWD values as a function of the mean velocity of the approach flow at the roof height (H) of the building of concern, VH.

50. For the purposes of a preliminary (i.e. non-quantitative) assessment of an airport building, it is important that these estimates are conservative in nature.

51. Accordingly, the preliminary assessment should be based on Table 1 below.

52. The building is assumed to be at typical airport height, e.g. up to 40 m (or even more) in height and rectangular in shape with an aspect ratio such that reattachment does not take place, i.e. the in-line length is less than the building width.

53. The values apply to the case of windflow striking the building perpendicular to the main façade "width" dimension, W, and assume reasonably open flat terrain upstream of the building.

54. The magnitude of BWD is given in terms of a percentage of VH. As an example, for a building of width-to-depth ratio, W/H = 4, the mean windspeed deficit (BWD) encountered by an object traversing the building's wake at a distance of 10 x building height would be equal to 0.22 VH i.e. 22% of VH.

BWD	W/H Ratios = 1	2	4	6	8
0.48 V_H	1.7 H	3.4 H	6.5 H	9.5 H	12.5 H
0.35 V_H	2.2 H	4.2 H	8 H	11.5 H	15 H
0.22 V_H	3 H	5.5 H	10 H	14 H	18 H
0.11 V_H	5 H	9 H	17 H	24.5 H	32 H

Table 1 BWD Values at various distances downstream for buildings with W/H ratios between 1 and 8)

55. The values provided in the Table 1 would be:

- greater for wind approaching at an oblique angle; and
- lower for an upstream terrain of greater roughness.

56. **Example Calculation:**

Building Dimensions: Width, W = 120 m; Height, H = 30 m; Length, L = 30 m;

hence W/H = 4

Approach Mean Speed: VH = 10 m/s (36 km/hr, 19.4 kt)

Upstream Terrain: Open, Flat Terrain

Approach Flow: Perpendicular to Width, W, façade of building

Mean velocity deficit, BMD:

= 4.8 m/s	9.5 kt	195 m downstream of the building
= 3.5 m/s	7 kt	240 m downstream of the building
= 2.2 m/s	4.5 kt	300 m downstream of the building
= 1.1 m/s	2 kt	510 m downstream of the building

Size of the wake: = 240 m (ie 2 x Width)

57. In the above example, the mean cross wind deficit experience by an aircraft landing on a runway whose centreline is located about 240 m from the nearest face of a building of dimensions 120 m (width), 30 m (length) and 30 m (height) would be of the order of 7 kt.

58. This wind speed deficit would be sustained over a distance of more than 200 m.

59. To obtain a complete understanding of the above example in terms of likelihood of occurrence, it would then be required to use the wind rose for the site to calculate the probability of occurrence of the wind having a magnitude of 10 m/s AND approaching the site from the worst-case wind direction (i.e. firstly over the building and then onto the runway).

Formal application of the building assessment methodology

Premise

60. A wind consultant or other suitably qualified professional should be asked to provide guidance on the acceptability or otherwise of a proposed building development in relation to the potential wake disturbance caused by the building on nearby runway operations.

61. This assessment will be premised on the acceptance criterion, viz. whether the "7-knot criterion", will be exceeded or not, and, if it is predicted to be exceeded, how often.

Key Factors to Consider

62. The key parameters of interest will be:

- Building Shape — Regular, Non-Regular
- Building Dimensions — Width, Depth, Height
- Perpendicular Distance of the Building from the Runway
- Building Position Relative to Touchdown / Take-Off Position
- Surrounding Terrain — Open, Suburban, Urban Built-Up
- Probability of Occurrence and Strength of Winds (particularly from the direction able to cause the cross wind conditions of concern)

Risk Classification

63. The recommended approach is summarised in **Table 2**.

64. The assessment methodology is based on risk categories.

<u>Initial assessment – use of a 'height multiplier' – the 1: 35 rule</u>

65. For stand-alone , regular-shaped (rectangular/square) buildings - in the first instance, the 1:35 rule is applied. If a building meets this rule, the building is deemed acceptable. For example, if a 10m tall building is located 350m from the runway centre-line, it meets the rule and no further assessment is required. See **Table 2** – Case A.

<u>Further assessment for buildings that do not meet the 1: 35 rule – hierarchy of assessment</u>

66. For buildings that do not meet the 1: 35 rule, the assessment hierarchy methodology is described in **Table 2- Cases B1, B2 and C**.

Table 2 Assessment Methodology Hierarchy

Category	Building Description	Assessment Methodology
Case A	**Building Shape:** Any Shape The building height satisfies the 1:35 rule, i.e. the horizontal distance of the building's closest point from the edge of the runway is more than 35 times the height of the building	In this instance, the building is deemed acceptable and no further assessment is required.
Case B1	**Building Shape:** Single, Regular Shape, e.g. Rectangular Buildings **Prevailing Wind-Building Angle:** Perpendicular to Building Facades	In this instance, all available techniques, including a Qualitative (Desktop) Study, could be used to address the acceptability of the proposal. The mean velocity deficit data provided in **Table 1** could be used in conjunction with the building height and local wind rose information to identify the potential (if any) for adverse cross wind conditions.
Case B2	**Building Shape:** Single, Regular Shape, e.g. Rectangular Buildings **Prevailing Wind-Building Angle:** Oblique to Building Facades	In this instance, a safety margin would need to be added to the mean velocity deficit data provided in **Table 1** in conjunction with the building height and local wind rose information to identify the potential (if any) for adverse cross wind conditions. The safety margin might be in the form of an increase in perceived distance downstream of the order of at least 25%.
Case C	**Building Shape:** Complex Building Shape AND/ OR Multiple Buildings	In this instance, unless a very conservative safety margin is added to the mean velocity deficit data provided in **Table 1**, one of the following quantitative modelling techniques should be used: 1. Wind Tunnel using Hot-Wire Sensors, 2. Wind Tunnel using Particle Image Velocimetry (PIV), or 3. Computational Fluid Dynamics (CFD).

Form of the Output for Assessment

67. The output of the consultant's wind assessment for cases B1, B2 and C will typically be of the form displayed in Figure 4.

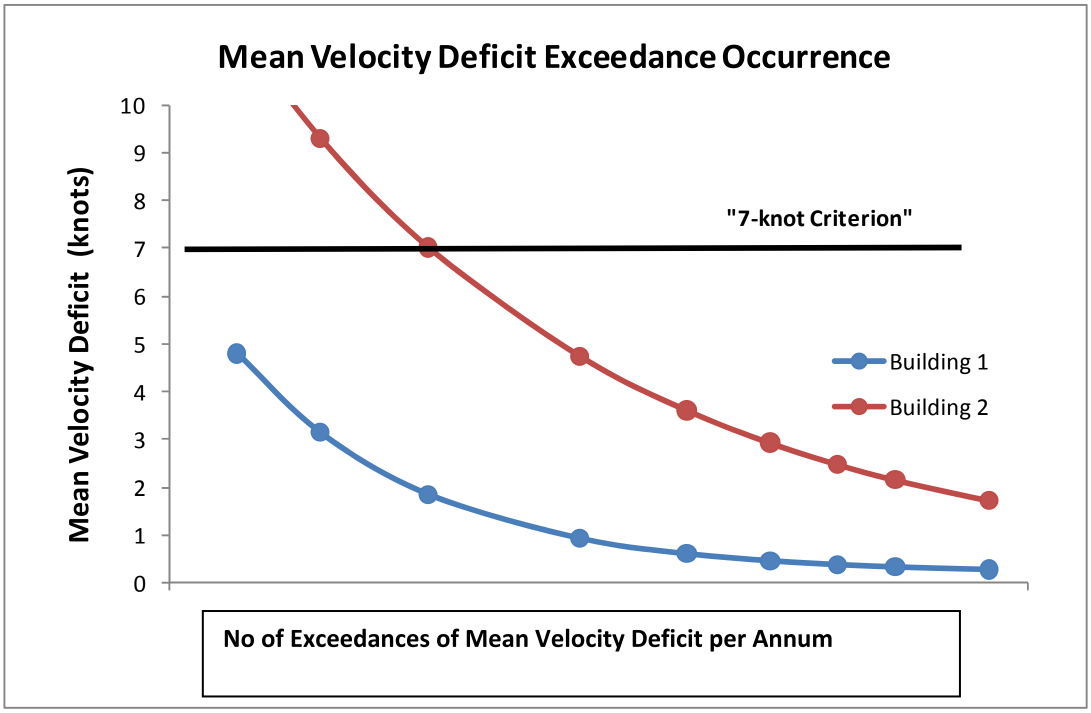


Figure 4 **Sample Output for Building-Generated Windshear Assessment**

68. In this example, two buildings were examined.

69. For Building 1, the NLR "7-knot criterion" is never exceeded. The building is therefore accepted with no consent conditions required to be specified in terms of airport operations etc, e.g. warnings to pilots or restrictions on runway operations under particular cross-wind conditions.

70. For Building 2, the NLR "7-knot criterion" is exceeded a number of times per year. The number of exceedances will now play a role in terms of the consent process for the development.

- If the predicted number of annual exceedances is low (e.g. several exceedances per year only), the building may still be approved but with a Building Wake Management Plan required. Such a plan would specify a critical ambient wind condition (e.g. mean winds exceeding "Vcrit" m/sec and blowing from "θcrit" ±22.5º) under which landings or takeoffs on a particular runway are disallowed.
- If the predicted number of annual exceedances is significant (e.g. frequent exceedances per year), the building design may require amendment to be approved.

71. In the latter case, the regulator may decide that:

- The building height must be lowered, or
- The building design must be modified in a manner that will reduce the extent of the wake disturbance behind the building.

72. It is also possible that the regulator may conclude that the proposed building is not acceptable at a particular location.

73. From the perspective of pilots dealing with cross wind conditions, there is a need for pilots to respond to (rapidly fluctuating) turbulence during cross wind conditions as well as any associated (more sustained) windshear.

74. This suggests that any criterion related to potentially hazardous levels of building-induced windshear which are solely based on mean winds (e.g. the mean velocity deficit) should be applied in a conservative manner, to ensure that the potential for additional turbulence-related impacts is also addressed.

- It is currently not practical for the wind criterion to take into account the inherent levels of turbulence likely to be present. Turbulence levels will vary significantly depending upon building shape details, angle of attack of the approaching wind, upstream terrain, nearby obstacles, etc.

Mitigation options for existing buildings

75. In this section, guidance is provided on options to mitigate building generated turbulence and windshear for existing structures where safety risks are identified.

Wake Size Suppression - Building Shape Augmentation

76. Reference is made once again to one of the key features which influences the wake flow (and hence associated windshear) behaviour surrounding rectangular buildings, namely building plan form aspect ratio, as depicted in Figure 4.

77. The wake behind a building whose depth (the dimension in line with the wind) is greater than its width (dimension perpendicular to the wind) by a factor of 2:1 has a considerably smaller wake than a building whose width is equal to or greater than its depth.

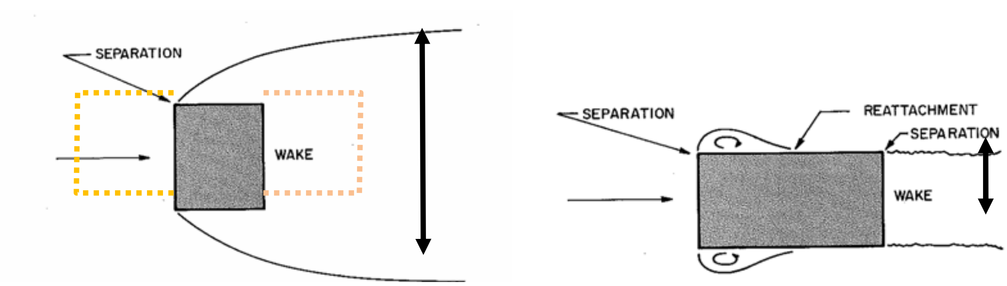


Figure 5 Wake Flow Characteristics Influence of Building Plan Form Aspect Ratio

78. The implied solution here would be to “create” the conditions where the building appears to have greater depth than is otherwise the case, e.g. to increase the building depth as shown by the orange or pink dotted lines in Figure 5

79. In many instances, the runway (leeward) side of the building would be an area reserved for airport operations and the opposite (windward) side might be needed for building access. Accordingly, the “orange/pink” building augmentation options may not be practical in specific applications. However, this is an option that could be explored in some specific cases.

Wake Disruption - Surrounding “Roughness”

80. “Smooth” flow as encountered over flat, open terrain tends to lead to well delineated wake regions. As the oncoming flow becomes more turbulent due to upstream obstacles, so the wake and associated disturbances become less well defined.

81. An option for disrupting the wake and therefore the impact of the mean velocity deficit behind an existing building could therefore involve adding roughness elements immediately upstream of the development. Such elements (e.g. trees, other buildings, hoardings such as signage, etc) would however need to be of significant magnitude relative to the building of concern. For example, a row of shrubs, 1 to 2 m in height, located immediately upstream of a building of height 30 m would have negligible impact on the resulting wake behind the building.

Wake Disruption - Leading Edge Roof Attachments

82. Another option for disrupting the wake is to consider attaching a screen or hoarding to the roof near the leading edge (i.e. the point where the wind first impacts on the building). Both the size of the wake and its accompanying velocity deficits would be potentially lessened with the addition of screens.

83. A quantitative investigation would be required to determine the efficacy of any specific recommended wake flow suppression design – screen size, location on roof, angle of orientation, etc.

84. The concept is based on sound aerodynamic reasoning and should in practice be feasible to implement as a building “retro-fit” solution, e.g. building signage.

Wake Suppression – Wing Concept

85. At an aircraft hangar which was potentially prone to very high leading edge suction pressures, a leading edge “wing” was attached to the building at roof height to reduce the resulting peak pressure loads on the roof. Apparently, a significant reduction in peak pressure did indeed occur, indicating that the entire wake flow disturbance downstream of the building associated with the changed flow separation conditions would likely have lessened as well.

86. The concept idea of such a leading edge wing is shown in Figure 6. The concept is aerodynamically identical to the leading edge devices successfully used in aircraft design which aim to achieve the same lessening of wake disturbance impact and hence drag force.

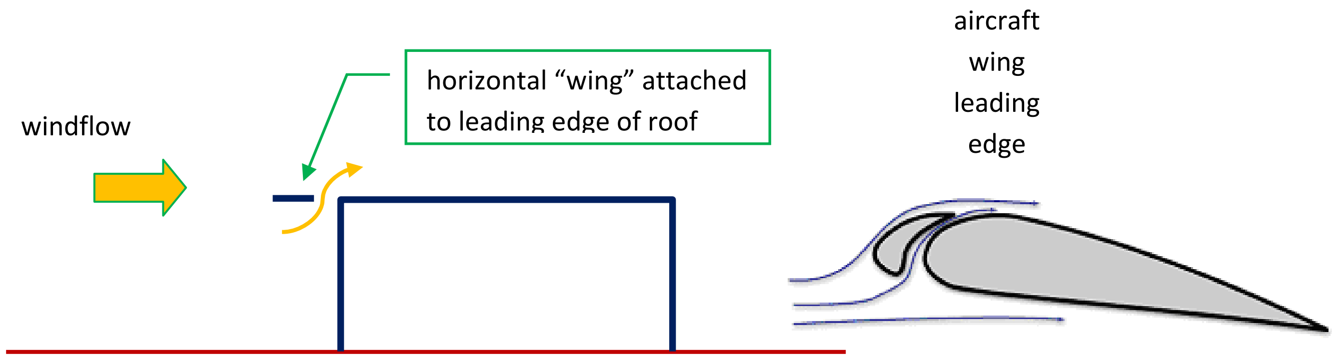


Figure 6 **Leading Edge Wing Concept for Vortex Suppression**

87. The leading edge wing idea is based on sound aerodynamic concepts and would appear to be potentially a cost-effective solution to wake flow mitigation. Aerodynamic modelling would be required to quantify the impacts of such a retro-fit.

Wake Suppression - Vane Concept

88. In a wind tunnel model study, prismatic buildings were fitted with vertical blade panels (vanes) at the building corners with a gap between the panel and the building which could vent the flow moving past the building. The purpose of these vanes was to disrupt the separation of windflow at the building corner associated with high localised (negative) pressure.

89. The wind tunnel tests used to carry out this investigation showed substantial reduction in the magnitude of the peak pressures near the corners of these buildings. It is inferred that the wake disturbance behind the buildings would also have decreased.

90. A quantitative investigation would be required to determine the efficacy of any specific recommended suppression design – size, gap width, angle of orientation, etc. The concept is based on sound aerodynamic reasoning and should in practice be feasible to implement as a building "retro-fit" solution, once again with possible commercial implications (e.g. vanes used for advertising)

Wake Suppression - Flow Relief by Building Openings Concept

91. The phenomenon of vortex shedding is well understood (as shown in the visualisation diagram on the left side of Figure 7 and its impact on the wind loading of tall buildings and towers is significant – it is not uncommon in tall, lightweight structures for the cross wind loads (perpendicular to the wind) caused by vortex shedding to be greater than the along wind loads (i.e. in line with the wind).

92. For this reason, much effort has gone into investigating solutions to minimise cross wind loading. For example, in the case of industrial steel cylinders, helical strakes are a common form of vortex suppression.

93. An alternative vortex suppression technique which has been successfully used in the design of several tall buildings (e.g. the Columbia Centre tower shown on the right side of Figure 7) has

been to introduce an opening into the building which enables oncoming windflow to pass directly into the wake behind the building.

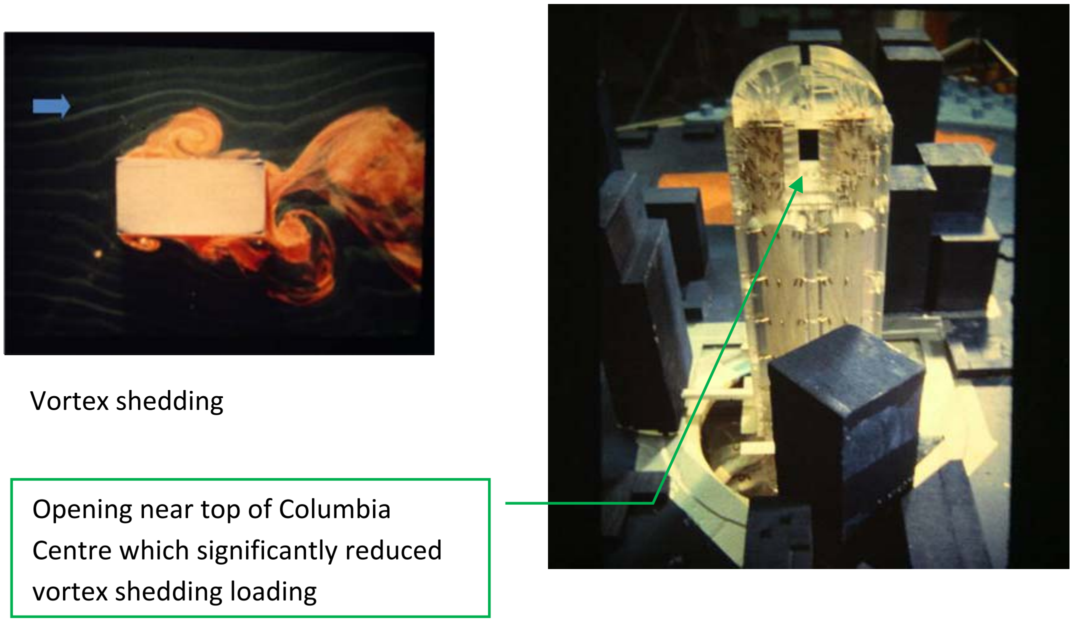


Figure 7 Vortex Shedding Flow Relief Option

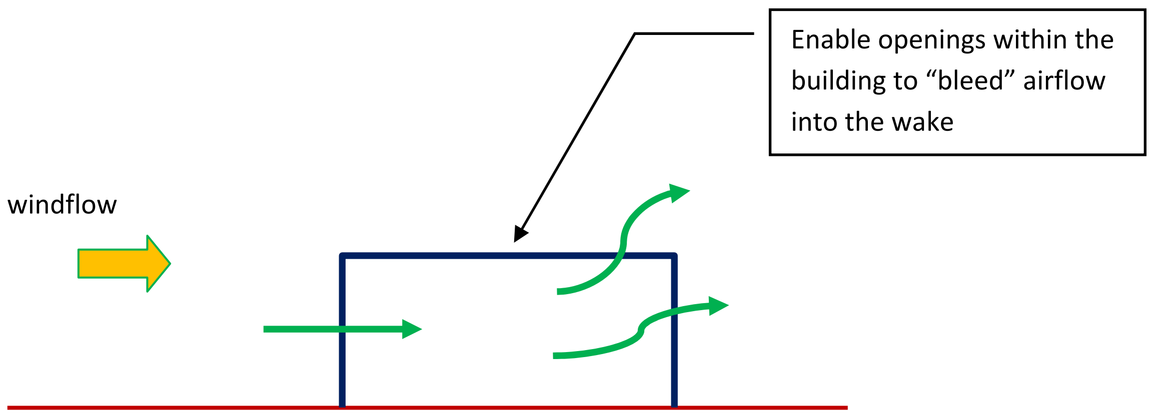
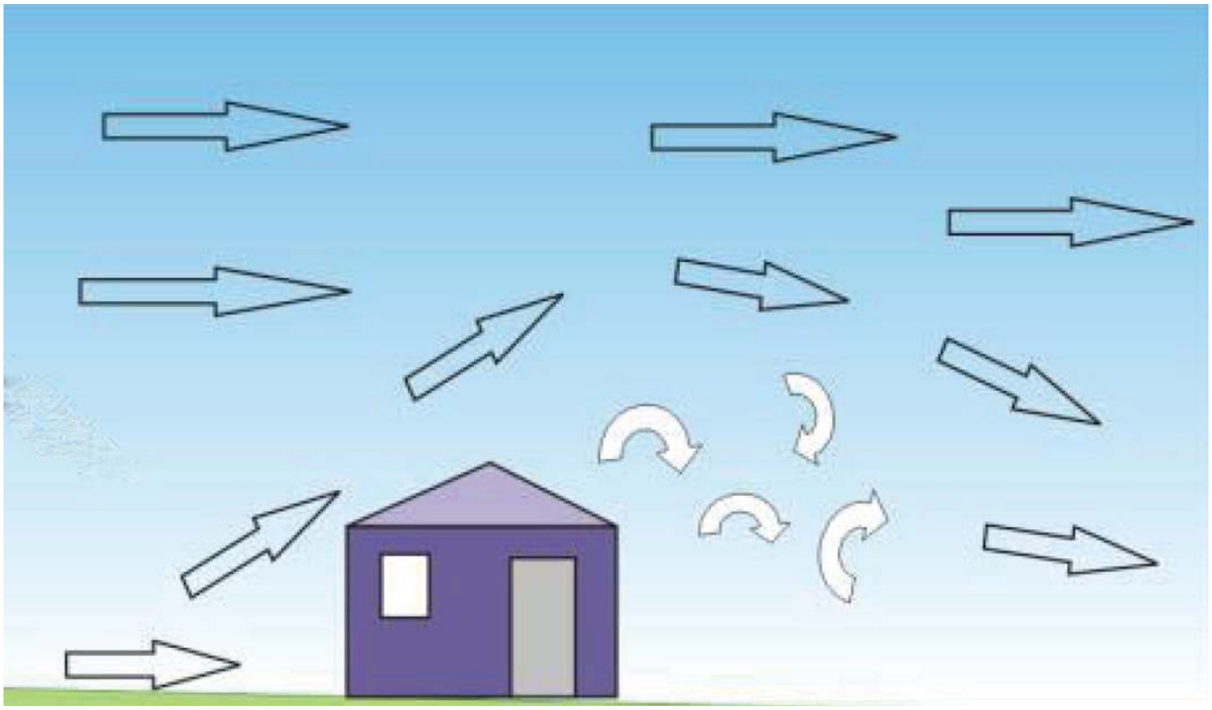


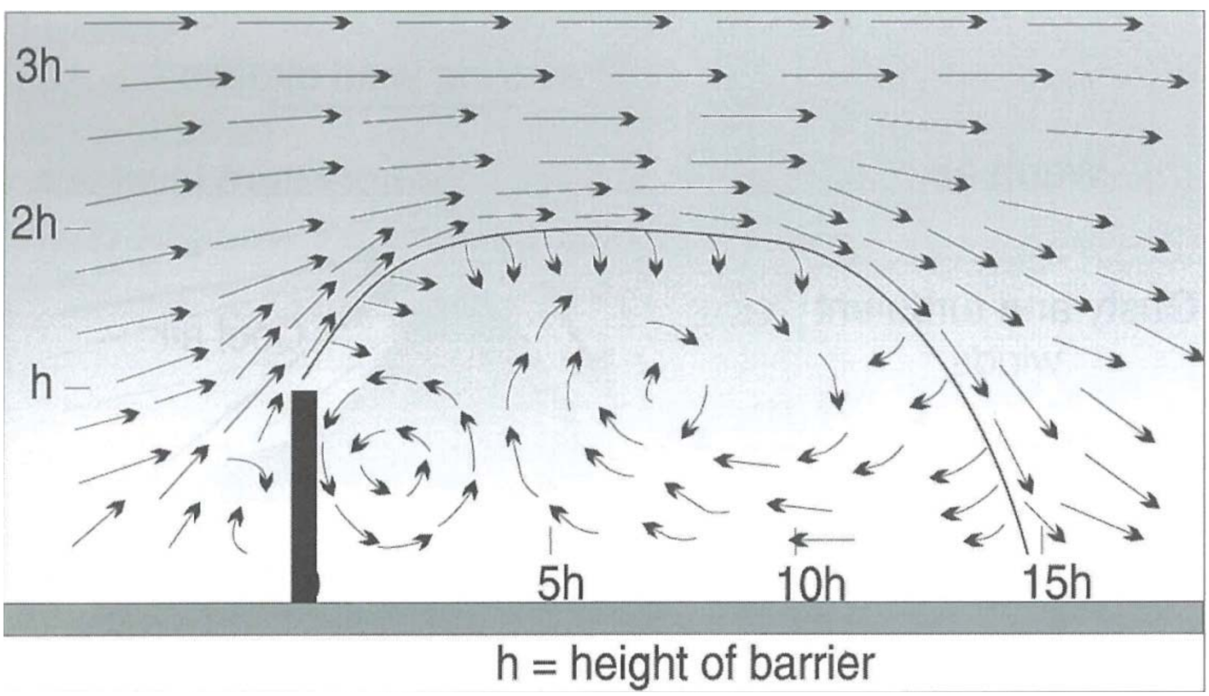
Figure 8 Relief Flow Concept

94. As in the case of the leading edge devices, the relief flow concept has a sound aerodynamic basis and may, depending upon the usage of the building of concern, be feasible. The idea may not be suitable for commercial buildings but may be feasible for hangars where large slot openings could be located on relevant facades.

95. Again, a quantitative aerodynamic investigation would be required to determine the efficacy of any specific suppression design.

ATTACHMENT 1





Source: Bureau of Meteorology

ATTACHMENT 2.

Synopsis of technical issues surrounding building-generated wind effects near runways

The wake flow behind a bluff body (e.g. a building) impacts both the mean speeds and the turbulence of the oncoming windflow. It comprises several readily identifiable features, most notably the **cavity region** immediately behind the building where **low speed, re-circulating flow** is apparent.

The cavity or **re-circulation** region typically extends up to **5 times the building height.** Wake effects (especially in relation to turbulence) however extend **well past** the recirculation zone, in some cases (depending upon building orientation) to beyond **20 times the building height**.

The extent of the wake (i.e. the region of disturbance to the upstream flow) – in terms of its physical dimension and the magnitude of the disturbance contained therein – will depend upon **building shape** (e.g. square, rectangular, etc), **building orientation** (i.e. building facades perpendicular to the wind, facades at 45º to the wind, etc), **aspect ratio** (height to building width ratio) and **surrounding terrain conditions** (open country terrain, suburban terrain, etc).

For a wide range of simple building shapes, changes to mean winds can occur up to 20 times the building height downstream, although the velocity deficit is usually **modest beyond 10 times the building height downstream**. For square and rectangular buildings with a wide range of building dimensions and oriented with their facades perpendicular to the windflow, the mean wind behind the building recovers to over 80% of its upstream level at a downstream distance less than 10 times the building height.

The disturbance to turbulence appears to be greater in both downstream extent and vertical extent (height above the building). While the disturbance to mean speeds extends not much more than 2 times the building height, noticeable turbulence changes occur up to **4 times the building height**.

All of the above wake effects (to both mean winds and turbulence levels) vary according to the upstream terrain profile. Relatively smooth windflow approaching a building over flat, open country terrain will experience the largest relative changes in the resulting building wake.

A particular case of interest is when certain building shapes (including rectangular buildings) are oriented at an **oblique angle** to the approaching windflow. In this case, a pronounced **delta-like vortex** forms at the leading corner of the building and persists in the flow for a considerable distance downstream. In this instance, turbulence levels can be elevated for distance well beyond the point where the mean wind is restored to its upstream (unaffected) level.

The results from wind tunnel tests of various simple building shapes and aspect ratios suggests that a simple "rule" for determining the magnitude of wake disturbance (for both mean winds and turbulence levels) based just on building height, and accurate for any building shape and any combination of building dimensions, is not apparent.

The consequence of this latter observation is highly significant. If it was desired to determine the extent of building wake effects using a simple prediction rule based for example on the number of building heights downstream, such a rule would have the potential to end up being **highly conservative** if it was required to cover a reasonable range of building shapes and dimensions.

NATIONAL AIRPORTS SAFEGUARDING FRAMEWORK

MANAGING THE RISK OF BUILDING GENERATED WINDSHEAR AND TURBULENCE AT AIRPORTS

REVISION DATE	VERSION NUMBER	CHANGES MADE	APPROVED BY
Feb 2012	2.2.1	Document Creation	NASAG
Apr 2012	2.2.2	Drafting changes post consultation process	SCOTI
15/7/12	2.2.3	Version control table added. Page numbers added.	S. Stone, GM Aviation Environment, DOIT.

Purpose of Guideline

1. This document provides guidelines to Commonwealth, State/Territory and local government decision makers to manage the risk of building generated windshear and turbulence at airports.

Why it is important

2. The Principles *for a National Airports Safeguarding Framework* acknowledge the importance of airports to national, state/territory and local economics, transport networks and social capital.
3. These guidelines are designed to assist land use planners and airport operators in their planning and development processes to reduce the risk of building generated windshear and turbulence at airports near runways.
4. Essentially, the building generated turbulence windshear / turbulence issue becomes safety critical when a significant obstacle, such as a building is located in the path of a cross-wind to an operational runway. The wind flow will be diverted around and over the buildings causing the cross-wind speed to vary along the runway.

How it should be used

5. Some States/Territories already have planning guidelines or polices in place and this document provides guidance for review. For those without policies in place, these Guidelines (in addition to the associated Safeguarding Framework) will provide input to new polices.
6. The guidelines can be applied by planners and regulators when evaluating building proposals on airports or by planners in consultation with airport operators in the immediate vicinity of airports.

Roles and Responsibilities

7. State/Territory and Local Governments are primarily responsible for land use planning in the vicinity of all airports.

8. Australia's 19 major airports are under Australian Government planning control and are administered under the Airports Act 1996 (the Airports Act). Planning on other airports is undertaken by State, Territory Governments and Local Governments or private operators.

Key Considerations For Managing the Risk of Building Generated Windshear and Turbulence at Airports

9. Research conducted by the Aeronautical Research Laboratory of the Netherlands (NLR) indicates that this safety risk is highest for buildings between the runway and 200ft above the runway. This research was conducted in response safety incidents at Amsterdam airport caused by building induced wind effects.

10. Buildings that could pose a safety risk are those located:

    a. 1200m or closer perpendicular to the runway centreline; or

    b. 900m or closer in front of runway threshold (i.e. towards the landside of the airport); or

    c. 500m or closer from the runway threshold along the runway.

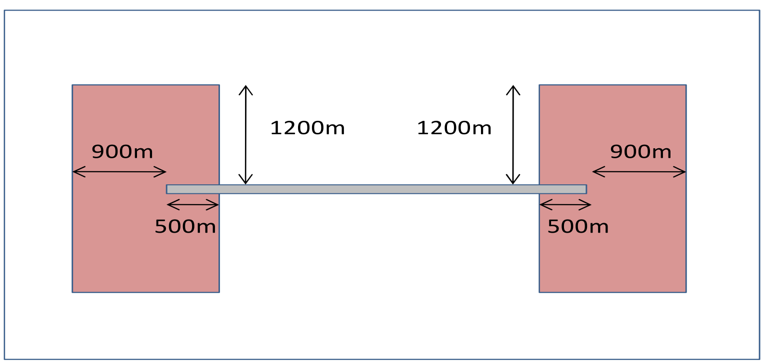


Figure A- envelope around runways within which buildings should be assessed

11. The guidelines present a simplified depiction of wind flows behind obstacles such as buildings and contain a synopsis of the technical issues surrounding building-induced wind effects.

12. The guidelines set out:

- empirically determined criteria for windshear and turbulence respectively;
- generic guidance on mitigating risks from proposed buildings;
- a methodology for assessment of proposed buildings; and
- options, where required, for subsequent detailed modelling of wind effects.
- options to mitigate wind effects of existing buildings where required

GUIDELINES FOR LAND USE PLANNERS AND AIRPORT OPERATORS TO MANAGE THE RISK OF BUILDING GENERATED WINDSHEAR AND TURBULENCE AT AIRPORTS

General

13. At airports, a combination of strong runway cross winds and obstacles to the prevailing wind flow such as large buildings can create:
    - low-level wind shear (horizontal and vertical);
    - additional (building-generated) turbulence, and
    - vortices.
14. According to the International Civil Aviation Organization (ICAO), wind shear is:
15. "A change in wind speed and/or direction in space, including updrafts and downdrafts ... any atmospheric phenomenon or any physical obstacle to the prevailing wind flow that produces a change in wind speed and/or direction, in effect, causes wind shear."
16. Turbulence is caused by rapid irregular motion of air. If turbulence is severe and unexpected, sudden changes in the flight path of aircraft may occur and pilots may lose control briefly.
17. Building-generated vortices are created when air flows start to spin after strong wind flow encounters a building at particular angles.
18. The effect that buildings have on the prevailing wind flow depends on a number of factors, the most important being:
    - the speed of the wind and upstream turbulence;
    - orientation of wind relative to the building;
    - the scale of the building in relation to the runway dimensions;
    - location of the building in relation to safety-critical zones such as touch-down zones, and
    - bulk, form and complexity of the building.
19. Although buildings near runways (such as offices, warehouse type buildings and hangars) are height–restricted to comply with the 'Obstacle Limitation Surfaces', they can potentially constitute obstacles of significant size relative to the prevailing surface wind flow. The wind flow is diverted around and over the buildings causing the surface wind to vary along the runway in both magnitude and direction (see **Figure 1**).

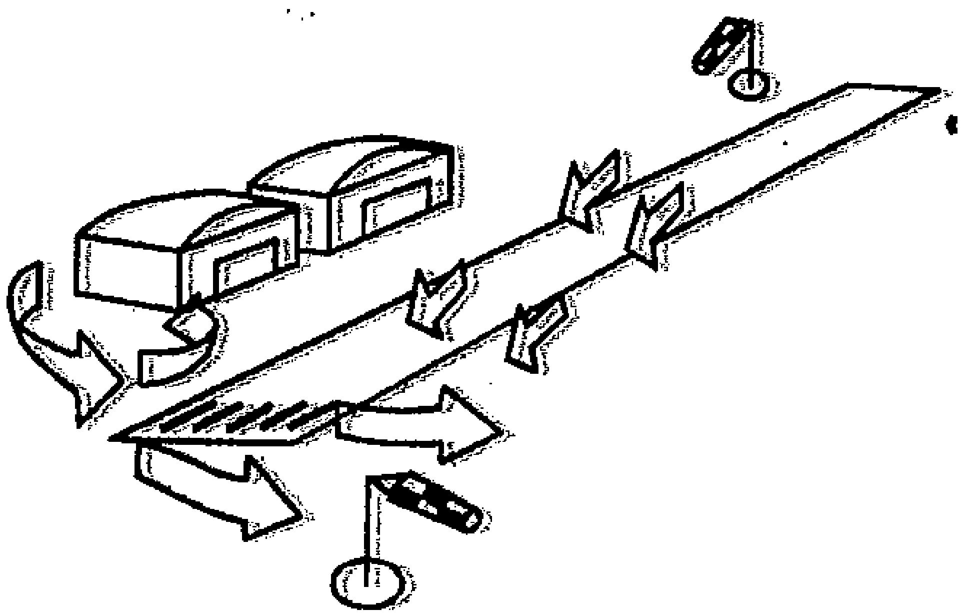


Figure 1

20. Such horizontal wind shear, which is usually localized and turbulent, poses risk to light aircraft in particular but has also been a factor in safety incidents involving large jet aircraft.
21. Windshear poses the greatest risk on approach, landing and take-off when an aircraft's speed is low and the pilot's ability to respond is limited. Flight conditions near the ground are complex, with accurate aircraft control required at a phase when significant changes in wind speed and direction can occur.
22. In particular this applies to large aircraft where the engine housing may strike the ground in turbulent or windshear conditions.
23. The Australian Government committed in the Aviation White Paper to develop guidance on the impact of turbulence and wind shear generated by buildings in the vicinity of runways. To date, no formal regulation exists in Australia or indeed anywhere in the world on the assessment and mitigation of turbulence and wind shear generated by buildings.
24. The Australian Government considers that these guidelines are important to better inform the siting and construction of on-airport buildings and in the immediate vicinity of airports to mitigate the risk of building-generated windshear and turbulence.

Existing Regulatory Controls

25. Leased federal airports are protected from tall buildings in the vicinity of airports based on standards established by the International Civil Aviation Organisation (ICAO). These standards form the basis of 'prescribed airspace' legislation under the Airports Act 1996 which is

administered by the Department of Infrastructure and Transport (DoIT). Under this legislation, airspace surrounding leased federal airports is regulated to ensure that obstacles to safe air transport are not built.

26. Research from the NLR indicates that the DoIT-administered prescribed airspace legislation protecting the OLS at leased federal airports has the effect of mitigating the risk of building-generated turbulence for aircraft between 200ft and 1,000ft above ground level. However, this legislation does not cover non-federal airports. In addition, airports certified under Part 139 of the Civil Aviation Safety Regulations 1998 are protected from tall buildings as the OLS is protected. However, OLS protection is inadequate to address the risk of building-generated wind effects below 200ft.

Regulatory provisions relating to building-generated windshear and turbulence

27. Australia has international obligations as a contracting state to the Convention on Civil Aviation to regulate aviation safety. As discussed previously, neither ICAO nor any other major aviation safety regulator has so far established wind impact assessment criteria.

Mitigation of risk – current practice

28. Current practice is generally to rely on standing warnings to pilots about the potential to encounter adverse wind effects. This is the approach in the UK as well as currently in Australia. For example, at Canberra Airport, there is a permanent notice in aviation publications advising pilots about the potential adverse wind effects that can be encountered because of a hangar. After extensive consultation and research, Australian governments have decided to take a pro-active approach on this issue and this option has been discarded.

Mitigation of risk by use of a 'height multiplier' option – only applicable to single buildings

29. For stand-alone buildings , the first step is to rely on a 'height multiplier' rule to determine the acceptability of buildings. The rule to be adopted in Australia is based on one developed in the Netherlands. This proposes that buildings with a distance to the runway centre-line that is less than 35 times the height of the building (the 1:35 rule) should be subject to aerodynamic modelling.

30. The 1: 35 rule can be applied to rule out buildings that will clearly not pose a risk. This rule will therefore be applied as the first test that will be applied when regulators are presented with a building to assess. This approach will enable the vast majority of developments at regional airports to be assessed very quickly. The rule is very conservative and any building that meets this test will not create unsafe wind effects.

Mitigation of risk – buildings that do not meet the 1:35 rule, buildings with complex shapes and/or multiple buildings

31. For buildings that do not meet the 1:35 rule, an alternative approach is required. This approach is:

- the adoption of a windshear criterion to be applied as the basis of regulatory controls.

Establishing a practicable standard to control the risk of building generated windshear and turbulence at airports near runways

Windshear Criterion

32. In response to serious safety issues created by building-generated wind effects at Amsterdam airport, NLR has carried out considerable research on this issue.

33. Based on this research, NLR developed the following criterion:

34. The variation in mean wind **speed due to wind disturbing structures must remain below 7 knots** along **the aircraft trajectory at heights below 200ft. The speed deficit change of 7 knots must take place over a distance of at least 100m.**

35. This criterion will apply in Australia.

Buildings near runways: generic guidance to mitigate risk of building-induced wind effects

Building Location With Respect to the Runway

36. The aircraft instability which building-induced windshear and turbulence can cause is significantly reduced once the airplane has touched down or is above 200 feet off the ground after take-off.

37. The most critical zone (in plan view) for building positioning, with respect to potential (building-related) windshear problems, is close to the touch-down zones of runways.

38. Buildings should preferably not be sited in this zone near the touch-down zones of runways. Buildings that are sited in this zone should be examined with particular rigour for potential risk. The evidence from aircraft safety incidents for which building-induced windshear and turbulence was a factor shows that buildings in this critical zone induced the wind effects of concern.

Building Plan Form Aspect Ratio

39. The wake behind a building varies significantly with building (plan form) aspect ratio. A building with depth (the dimension in line with the wind) greater than width (dimension perpendicular to the wind), say by a factor of around 2:1, has a considerably smaller wake than a building whose width is equal to or greater than its depth.

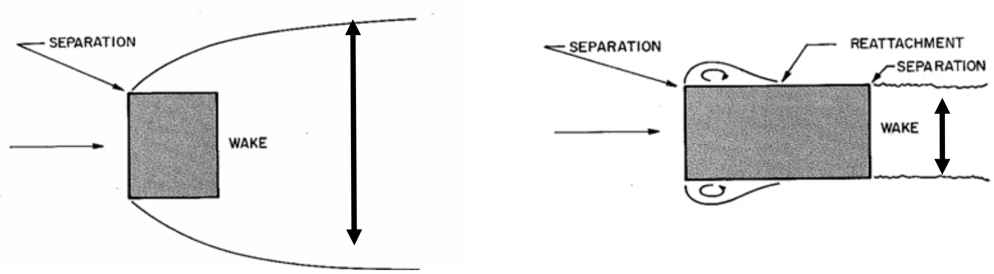


Figure 2:Influence of Building Plan Form Aspect Ratio on Wake Magnitude

40. Proponents of buildings should note that that a wide wake is created by buildings with width greater than the depth. Proponents should therefore consider aspect ratio with a view to minimising the size of the wake where possible.

Oblique Angle Delta Vortices

41. "Delta" vortices can form over sharp-edged rectangular buildings subject to oblique flow, i.e. oncoming flow at an angle of around 45º to the main façade orientations. These persist in the wind flow for many buildings dimensions downstream.

42. Wherever possible, buildings should avoid an orientation which puts it at 45º to the orientation of a nearby runway or where the potential for delta vortex formation is aligned with a prevailing wind direction. Figure 3 depicts the formation of a delta wing vortex.

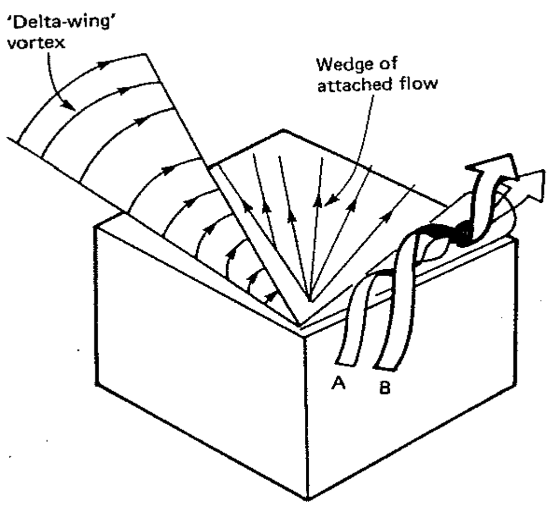


Figure 3 Delta Vortex Formation on Building at Oblique Angle to Wind Flow

Complexity of Building Shape

43. Buildings at airports generally have a fairly rectangular form, e.g. terminals, hangars, warehouse type buildings and offices.

44. This is not always the case. There can be significant variations in the wake disturbance for complex building shapes compared to simple rectangular forms. Complex building shapes have the potential to create unpredictable wind effects and are harder to analyse for risk. Amsterdam Airport reported a number of aviation safety incidents arising from the unusual extent of wake disturbance created by the Schiphol engine test facility. This facility has a complex shape which causes significant wind effects.

45. In the absence of detailed quantitative analysis, it will generally be difficult for even an experienced wind engineer to reliably predict the extent of a building wake and the magnitude of the disturbances contained within the wake, when confronted with complex geometry unless a significant degree of conservatism is employed.

Concept of Probability of Occurrence

46. Like all aviation safety incidents, building-induced windshear events involve a coincidence of factors including the following:

- There would need to be a building of shape and size able to generate wake disturbances large enough to exceed accepted windshear criteria, e.g. the NLR "7-knot criterion".
- The wind would need to be blowing in a more or less cross-wind orientation to the runway being used and of a magnitude able to generate conditions where the "7-knot criterion" could be exceeded.

47. The above suggests that the actual risk of a building-induced windshear event involves statistical analysis indicating the likelihood of occurrence of adverse events so that an informed decision can be made as to actual risk involved.

Preliminary assessment of the magnitude of building-induced windshear (measured as mean wind speed deficit (BWD))

48. The variation in mean wind speed encountered by an aircraft traversing a wake behind an airport building is termed the building-induced mean wind speed deficit, BWD.

49. Based on a range of empirical studies, it is possible to produce estimates of BWD values as a function of the mean velocity of the approach flow at the roof height (H) of the building of concern, VH.

50. For the purposes of a preliminary (i.e. non-quantitative) assessment of an airport building, it is important that these estimates are conservative in nature.

51. Accordingly, the preliminary assessment should be based on Table 1 below.

52. The building is assumed to be at typical airport height, e.g. up to 40 m (or even more) in height and rectangular in shape with an aspect ratio such that reattachment does not take place, i.e. the in-line length is less than the building width.

53. The values apply to the case of windflow striking the building perpendicular to the main façade "width" dimension, W, and assume reasonably open flat terrain upstream of the building.

54. The magnitude of BWD is given in terms of a percentage of VH. As an example, for a building of width-to-depth ratio, W/H = 4, the mean windspeed deficit (BWD) encountered by an object traversing the building's wake at a distance of 10 x building height would be equal to 0.22 VH i.e. 22% of VH.

BWD	W/H Ratios = 1	2	4	6	8
0.48 V_H	1.7 H	3.4 H	6.5 H	9.5 H	12.5 H
0.35 V_H	2.2 H	4.2 H	8 H	11.5 H	15 H
0.22 V_H	3 H	5.5 H	10 H	14 H	18 H
0.11 V_H	5 H	9 H	17 H	24.5 H	32 H

Table 1 BWD Values at various distances downstream for buildings with W/H ratios between 1 and 8)

55. The values provided in the Table 1 would be:

- greater for wind approaching at an oblique angle; and
- lower for an upstream terrain of greater roughness.

56. **Example Calculation:**

Building Dimensions: Width, W = 120 m; Height, H = 30 m; Length, L = 30 m;

hence W/H = 4

Approach Mean Speed: VH = 10 m/s (36 km/hr, 19.4 kt)

Upstream Terrain: Open, Flat Terrain

Approach Flow: Perpendicular to Width, W, façade of building

Mean velocity deficit, BMD:

= 4.8 m/s	9.5 kt	195 m downstream of the building
= 3.5 m/s	7 kt	240 m downstream of the building
= 2.2 m/s	4.5 kt	300 m downstream of the building
= 1.1 m/s	2 kt	510 m downstream of the building

Size of the wake: = 240 m (ie 2 x Width)

57. In the above example, the mean cross wind deficit experience by an aircraft landing on a runway whose centreline is located about 240 m from the nearest face of a building of dimensions 120 m (width), 30 m (length) and 30 m (height) would be of the order of 7 kt.

58. This wind speed deficit would be sustained over a distance of more than 200 m.

59. To obtain a complete understanding of the above example in terms of likelihood of occurrence, it would then be required to use the wind rose for the site to calculate the probability of occurrence of the wind having a magnitude of 10 m/s AND approaching the site from the worst-case wind direction (i.e. firstly over the building and then onto the runway).

Formal application of the building assessment methodology

Premise

60. A wind consultant or other suitably qualified professional should be asked to provide guidance on the acceptability or otherwise of a proposed building development in relation to the potential wake disturbance caused by the building on nearby runway operations.

61. This assessment will be premised on the acceptance criterion, viz. whether the “7-knot criterion”, will be exceeded or not, and, if it is predicted to be exceeded, how often.

Key Factors to Consider

62. The key parameters of interest will be:

- Building Shape — Regular, Non-Regular
- Building Dimensions — Width, Depth, Height
- Perpendicular Distance of the Building from the Runway
- Building Position Relative to Touchdown / Take-Off Position
- Surrounding Terrain — Open, Suburban, Urban Built-Up
- Probability of Occurrence and Strength of Winds
  (particularly from the direction able to cause the cross wind conditions of concern)

Risk Classification

63. The recommended approach is summarised in **Table 2**.

64. The assessment methodology is based on risk categories.

<u>Initial assessment – use of a ‘height multiplier’ – the 1: 35 rule</u>

65. For stand-alone , regular-shaped (rectangular/square) buildings - in the first instance, the 1:35 rule is applied. If a building meets this rule, the building is deemed acceptable. For example, if a 10m tall building is located 350m from the runway centre-line, it meets the rule and no further assessment is required. See **Table 2** – Case A.

<u>Further assessment for buildings that do not meet the 1: 35 rule – hierarchy of assessment</u>

66. For buildings that do not meet the 1: 35 rule, the assessment hierarchy methodology is described in **Table 2- Cases B1, B2 and C**.

Table 2 Assessment Methodology Hierarchy

Category	Building Description	Assessment Methodology
Case A	**Building Shape:** Any Shape The building height satisfies the 1:35 rule, i.e. the horizontal distance of the building's closest point from the edge of the runway is more than 35 times the height of the building	In this instance, the building is deemed acceptable and no further assessment is required.
Case B1	**Building Shape:** Single, Regular Shape, e.g. Rectangular Buildings **Prevailing Wind-Building Angle:** Perpendicular to Building Facades	In this instance, all available techniques, including a Qualitative (Desktop) Study, could be used to address the acceptability of the proposal. The mean velocity deficit data provided in **Table 1** could be used in conjunction with the building height and local wind rose information to identify the potential (if any) for adverse cross wind conditions.
Case B2	**Building Shape:** Single, Regular Shape, e.g. Rectangular Buildings **Prevailing Wind-Building Angle:** Oblique to Building Facades	In this instance, a safety margin would need to be added to the mean velocity deficit data provided in **Table 1** in conjunction with the building height and local wind rose information to identify the potential (if any) for adverse cross wind conditions. The safety margin might be in the form of an increase in perceived distance downstream of the order of at least 25%.
Case C	**Building Shape:** Complex Building Shape AND/ OR Multiple Buildings	In this instance, unless a very conservative safety margin is added to the mean velocity deficit data provided in **Table 1**, one of the following quantitative modelling techniques should be used: 1. Wind Tunnel using Hot-Wire Sensors, 2. Wind Tunnel using Particle Image Velocimetry (PIV), or 3. Computational Fluid Dynamics (CFD).

Form of the Output for Assessment

67. The output of the consultant's wind assessment for cases B1, B2 and C will typically be of the form displayed in Figure 4.

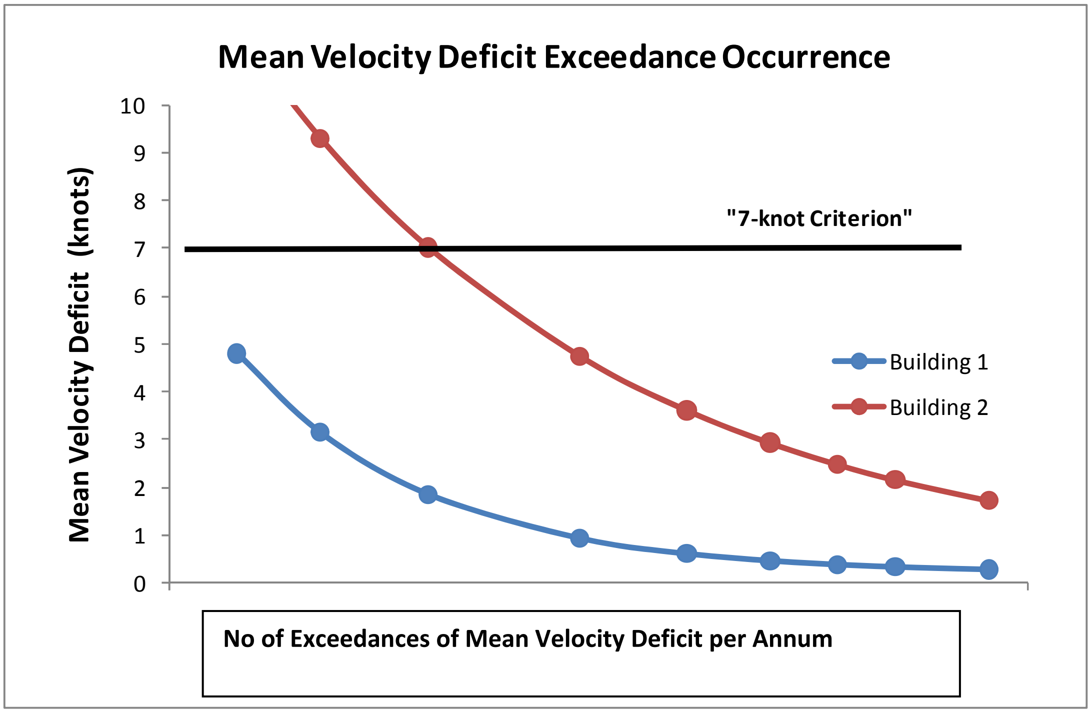


Figure 4 Sample Output for Building-Generated Windshear Assessment

68. In this example, two buildings were examined.

69. For Building 1, the NLR "7-knot criterion" is never exceeded. The building is therefore accepted with no consent conditions required to be specified in terms of airport operations etc, e.g. warnings to pilots or restrictions on runway operations under particular cross-wind conditions.

70. For Building 2, the NLR "7-knot criterion" is exceeded a number of times per year. The number of exceedances will now play a role in terms of the consent process for the development.

- If the predicted number of annual exceedances is low (e.g. several exceedances per year only), the building may still be approved but with a Building Wake Management Plan required. Such a plan would specify a critical ambient wind condition (e.g. mean winds exceeding "Vcrit" m/sec and blowing from "θcrit" ±22.5º) under which landings or takeoffs on a particular runway are disallowed.
- If the predicted number of annual exceedances is significant (e.g. frequent exceedances per year), the building design may require amendment to be approved.

71. In the latter case, the regulator may decide that:

- The building height must be lowered, or
- The building design must be modified in a manner that will reduce the extent of the wake disturbance behind the building.

72. It is also possible that the regulator may conclude that the proposed building is not acceptable at a particular location.

73. From the perspective of pilots dealing with cross wind conditions, there is a need for pilots to respond to (rapidly fluctuating) turbulence during cross wind conditions as well as any associated (more sustained) windshear.

74. This suggests that any criterion related to potentially hazardous levels of building-induced windshear which are solely based on mean winds (e.g. the mean velocity deficit) should be applied in a conservative manner, to ensure that the potential for additional turbulence-related impacts is also addressed.

- It is currently not practical for the wind criterion to take into account the inherent levels of turbulence likely to be present. Turbulence levels will vary significantly depending upon building shape details, angle of attack of the approaching wind, upstream terrain, nearby obstacles, etc.

Mitigation options for existing buildings

75. In this section, guidance is provided on options to mitigate building generated turbulence and windshear for existing structures where safety risks are identified.

Wake Size Suppression - Building Shape Augmentation

76. Reference is made once again to one of the key features which influences the wake flow (and hence associated windshear) behaviour surrounding rectangular buildings, namely building plan form aspect ratio, as depicted in Figure 4.

77. The wake behind a building whose depth (the dimension in line with the wind) is greater than its width (dimension perpendicular to the wind) by a factor of 2:1 has a considerably smaller wake than a building whose width is equal to or greater than its depth.

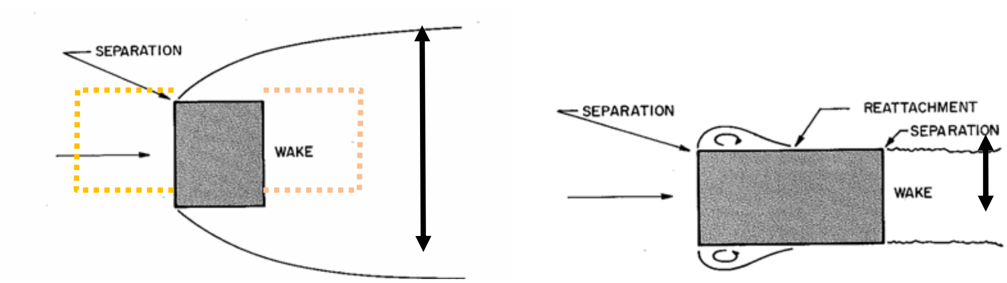


Figure 5 Wake Flow Characteristics Influence of Building Plan Form Aspect Ratio

78. The implied solution here would be to “create” the conditions where the building appears to have greater depth than is otherwise the case, e.g. to increase the building depth as shown by the orange or pink dotted lines in Figure 5

79. In many instances, the runway (leeward) side of the building would be an area reserved for airport operations and the opposite (windward) side might be needed for building access. Accordingly, the “orange/pink” building augmentation options may not be practical in specific applications. However, this is an option that could be explored in some specific cases.

Wake Disruption - Surrounding “Roughness”

80. “Smooth” flow as encountered over flat, open terrain tends to lead to well delineated wake regions. As the oncoming flow becomes more turbulent due to upstream obstacles, so the wake and associated disturbances become less well defined.

81. An option for disrupting the wake and therefore the impact of the mean velocity deficit behind an existing building could therefore involve adding roughness elements immediately upstream of the development. Such elements (e.g. trees, other buildings, hoardings such as signage, etc) would however need to be of significant magnitude relative to the building of concern. For example, a row of shrubs, 1 to 2 m in height, located immediately upstream of a building of height 30 m would have negligible impact on the resulting wake behind the building.

Wake Disruption - Leading Edge Roof Attachments

82. Another option for disrupting the wake is to consider attaching a screen or hoarding to the roof near the leading edge (i.e. the point where the wind first impacts on the building). Both the size of the wake and its accompanying velocity deficits would be potentially lessened with the addition of screens.

83. A quantitative investigation would be required to determine the efficacy of any specific recommended wake flow suppression design – screen size, location on roof, angle of orientation, etc.

84. The concept is based on sound aerodynamic reasoning and should in practice be feasible to implement as a building “retro-fit” solution, e.g. building signage.

Wake Suppression – Wing Concept

85. At an aircraft hangar which was potentially prone to very high leading edge suction pressures, a leading edge “wing” was attached to the building at roof height to reduce the resulting peak pressure loads on the roof. Apparently, a significant reduction in peak pressure did indeed occur, indicating that the entire wake flow disturbance downstream of the building associated with the changed flow separation conditions would likely have lessened as well.

86. The concept idea of such a leading edge wing is shown in Figure 6. The concept is aerodynamically identical to the leading edge devices successfully used in aircraft design which aim to achieve the same lessening of wake disturbance impact and hence drag force.

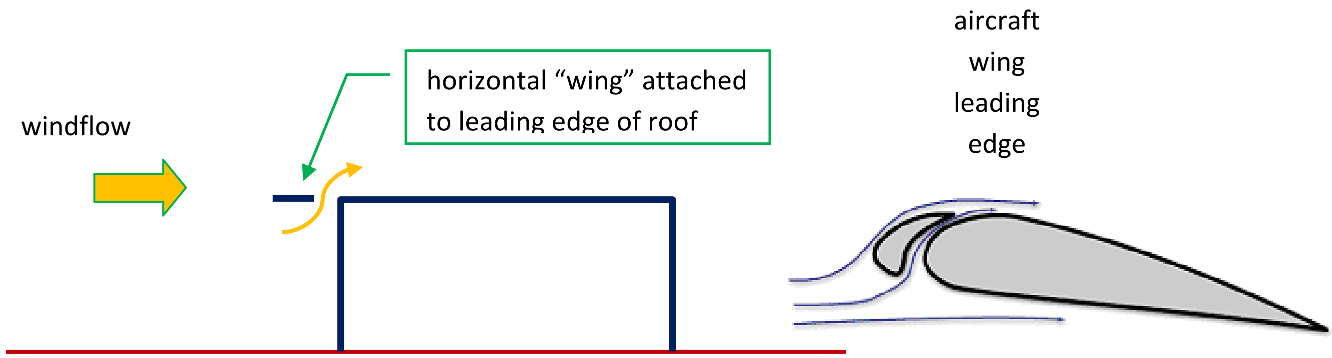


Figure 6 Leading Edge Wing Concept for Vortex Suppression

87. The leading edge wing idea is based on sound aerodynamic concepts and would appear to be potentially a cost-effective solution to wake flow mitigation. Aerodynamic modelling would be required to quantify the impacts of such a retro-fit.

Wake Suppression - Vane Concept

88. In a wind tunnel model study, prismatic buildings were fitted with vertical blade panels (vanes) at the building corners with a gap between the panel and the building which could vent the flow moving past the building. The purpose of these vanes was to disrupt the separation of windflow at the building corner associated with high localised (negative) pressure.

89. The wind tunnel tests used to carry out this investigation showed substantial reduction in the magnitude of the peak pressures near the corners of these buildings. It is inferred that the wake disturbance behind the buildings would also have decreased.

90. A quantitative investigation would be required to determine the efficacy of any specific recommended suppression design – size, gap width, angle of orientation, etc. The concept is based on sound aerodynamic reasoning and should in practice be feasible to implement as a building “retro-fit” solution, once again with possible commercial implications (e.g. vanes used for advertising)

Wake Suppression - Flow Relief by Building Openings Concept

91. The phenomenon of vortex shedding is well understood (as shown in the visualisation diagram on the left side of Figure 7 and its impact on the wind loading of tall buildings and towers is significant – it is not uncommon in tall, lightweight structures for the cross wind loads (perpendicular to the wind) caused by vortex shedding to be greater than the along wind loads (i.e. in line with the wind).

92. For this reason, much effort has gone into investigating solutions to minimise cross wind loading. For example, in the case of industrial steel cylinders, helical strakes are a common form of vortex suppression.

93. An alternative vortex suppression technique which has been successfully used in the design of several tall buildings (e.g. the Columbia Centre tower shown on the right side of Figure 7) has

been to introduce an opening into the building which enables oncoming windflow to pass directly into the wake behind the building.

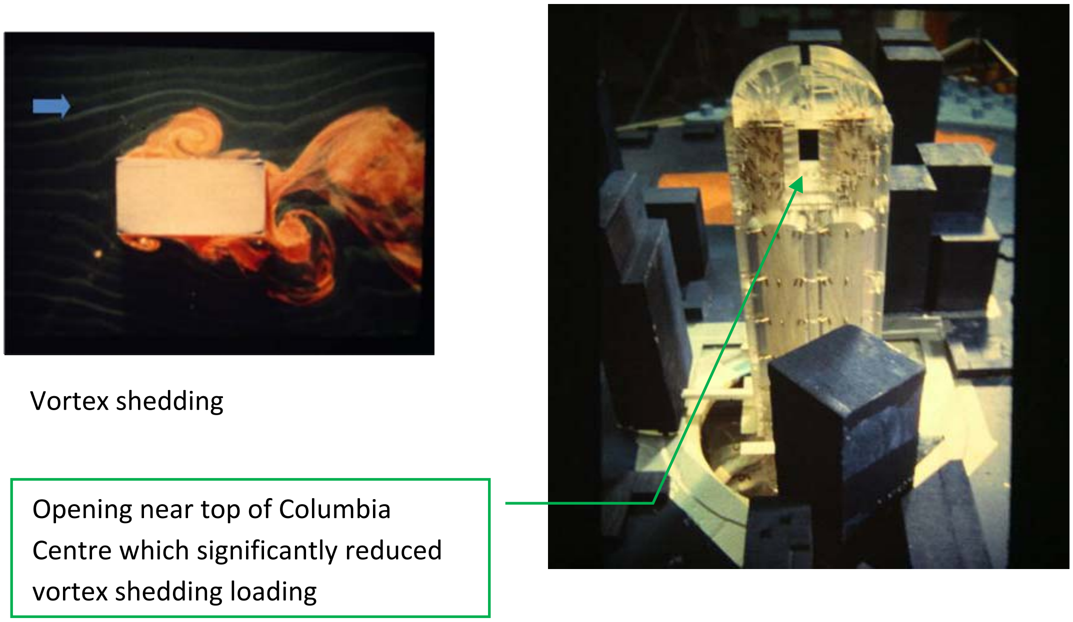


Figure 7 Vortex Shedding Flow Relief Option

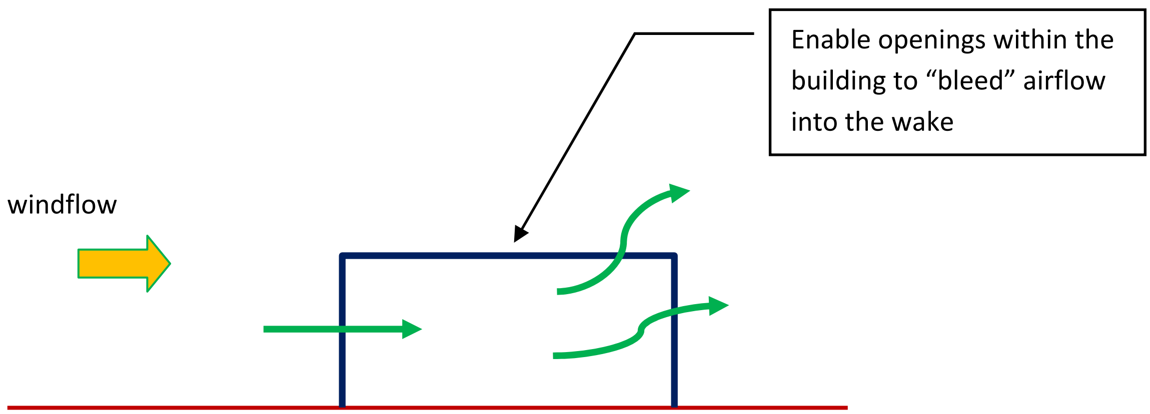
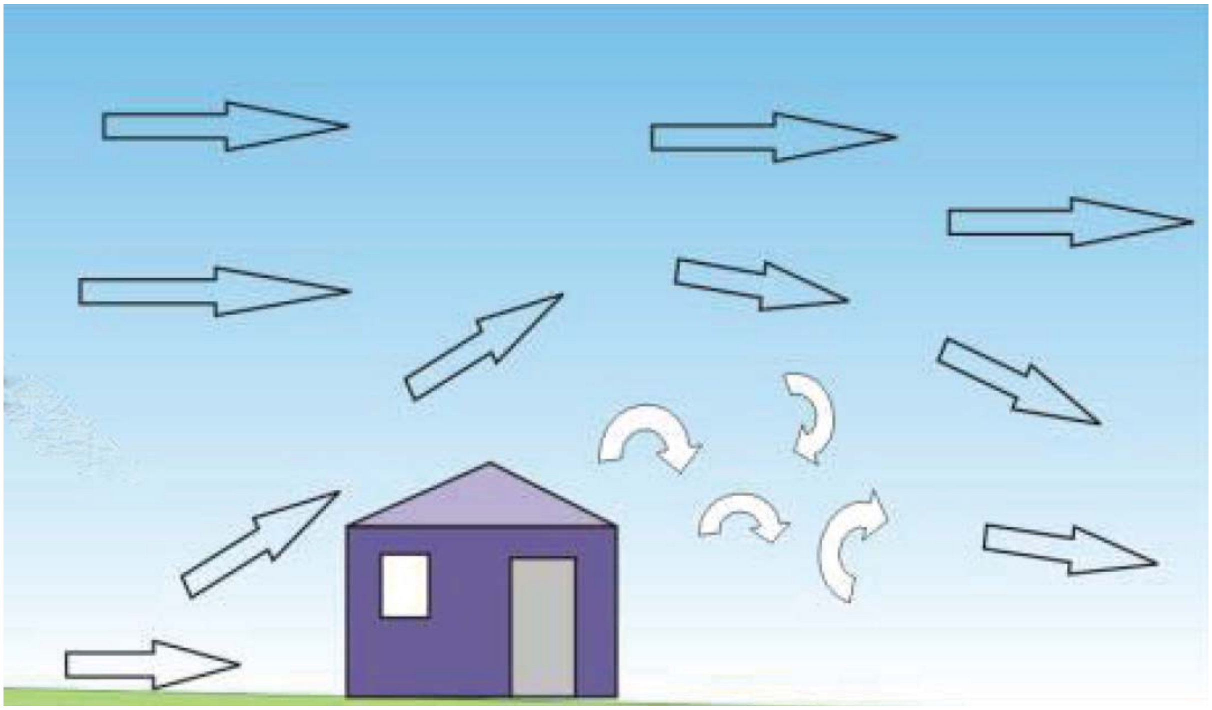


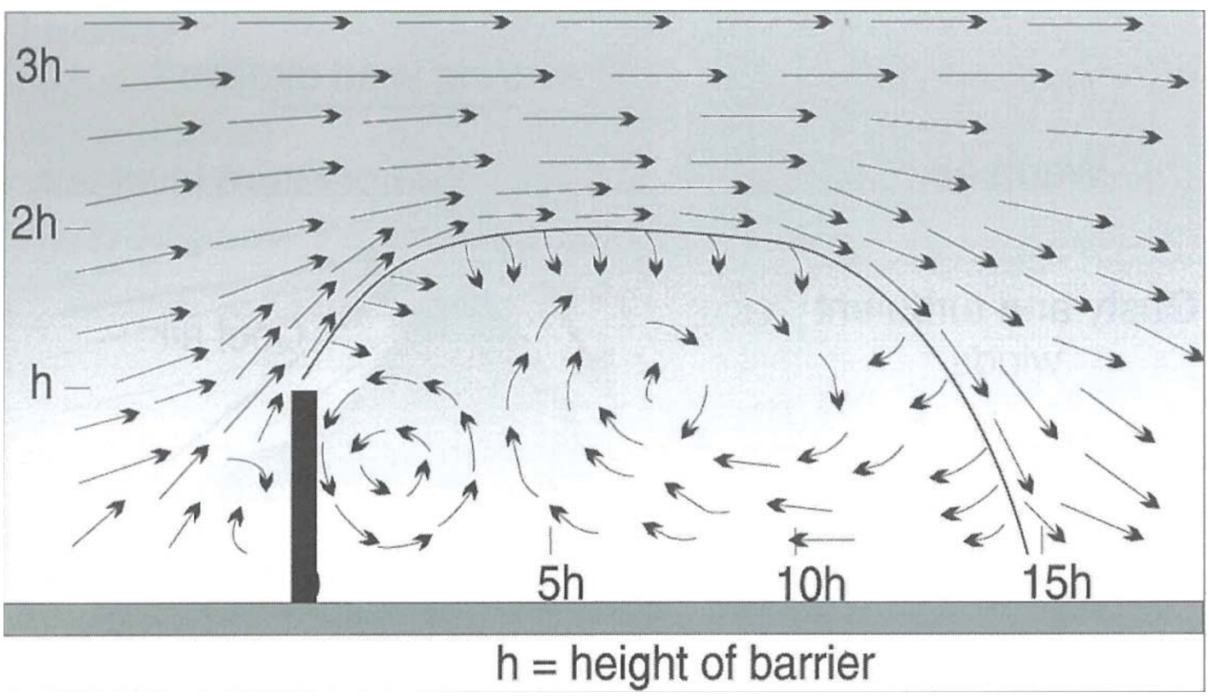
Figure 8 Relief Flow Concept

94. As in the case of the leading edge devices, the relief flow concept has a sound aerodynamic basis and may, depending upon the usage of the building of concern, be feasible. The idea may not be suitable for commercial buildings but may be feasible for hangars where large slot openings could be located on relevant facades.

95. Again, a quantitative aerodynamic investigation would be required to determine the efficacy of any specific suppression design.

ATTACHMENT 1





Source: Bureau of Meteorology

ATTACHMENT 2.

Synopsis of technical issues surrounding building-generated wind effects near runways

The wake flow behind a bluff body (e.g. a building) impacts both the mean speeds and the turbulence of the oncoming windflow. It comprises several readily identifiable features, most notably the **cavity region** immediately behind the building where **low speed, re-circulating flow** is apparent.

The cavity or **re-circulation** region typically extends up to **5 times the building height.** Wake effects (especially in relation to turbulence) however extend **well past** the recirculation zone, in some cases (depending upon building orientation) to beyond **20 times the building height**.

The extent of the wake (i.e. the region of disturbance to the upstream flow) – in terms of its physical dimension and the magnitude of the disturbance contained therein – will depend upon **building shape** (e.g. square, rectangular, etc), **building orientation** (i.e. building facades perpendicular to the wind, facades at 45º to the wind, etc), **aspect ratio** (height to building width ratio) and **surrounding terrain conditions** (open country terrain, suburban terrain, etc).

For a wide range of simple building shapes, changes to mean winds can occur up to 20 times the building height downstream, although the velocity deficit is usually **modest beyond 10 times the building height downstream**. For square and rectangular buildings with a wide range of building dimensions and oriented with their facades perpendicular to the windflow, the mean wind behind the building recovers to over 80% of its upstream level at a downstream distance less than 10 times the building height.

The disturbance to turbulence appears to be greater in both downstream extent and vertical extent (height above the building). While the disturbance to mean speeds extends not much more than 2 times the building height, noticeable turbulence changes occur up to **4 times the building height**.

All of the above wake effects (to both mean winds and turbulence levels) vary according to the upstream terrain profile. Relatively smooth windflow approaching a building over flat, open country terrain will experience the largest relative changes in the resulting building wake.

A particular case of interest is when certain building shapes (including rectangular buildings) are oriented at an **oblique angle** to the approaching windflow. In this case, a pronounced **delta-like vortex** forms at the leading corner of the building and persists in the flow for a considerable distance downstream. In this instance, turbulence levels can be elevated for distance well beyond the point where the mean wind is restored to its upstream (unaffected) level.

The results from wind tunnel tests of various simple building shapes and aspect ratios suggests that a simple “rule” for determining the magnitude of wake disturbance (for both mean winds and turbulence levels) based just on building height, and accurate for any building shape and any combination of building dimensions, is not apparent.

The consequence of this latter observation is highly significant. If it was desired to determine the extent of building wake effects using a simple prediction rule based for example on the number of building heights downstream, such a rule would have the potential to end up being **highly conservative** if it was required to cover a reasonable range of building shapes and dimensions.

Guidelines for Land Use Planners and Airport Operators to Manage the Risk of Building Generated Windshear and Turbulence at Airports

Revision Date	Version Number	Changes Made	Approved By
April 2012	2.1.1	Document Creation	SCOTI
15/7/12	2.1.2	Version control table added. Page numbers added.	S. Stone, GM Aviation Environment, DOIT.

Quick guide

1. At airports, a combination of strong runway cross winds and large buildings near runways can create wind effects that could affect aviation safety.

2. This guide sets out a short summary of steps to follow when assessing this risk from proposed buildings located near the threshold of runways. It should be used in conjunction with National Airports Safeguarding Framework Guideline B – Managing the Risk of Building Generated Windshear and Turbulence at Airports.

3. The steps detailed below allow a simple risk based analysis of building induced wind shear risk in many circumstances. In some circumstances more detailed desk top modelling will be required, taking account of historic wind conditions at the relevant airport. In further cases, physical wind tunnel modelling or computational fluid dynamics modelling may be necessary.

Step 1

4. For each end of the runway, is the building or buildings to be constructed outside the following boundaries? (See Figure A)
   a. more than 1200m perpendicular to the runway centreline; or
   b. more than 900 m beyond the runway threshold towards the landside of airports; or
   c. more than 500 m from the runway threshold along the runway.

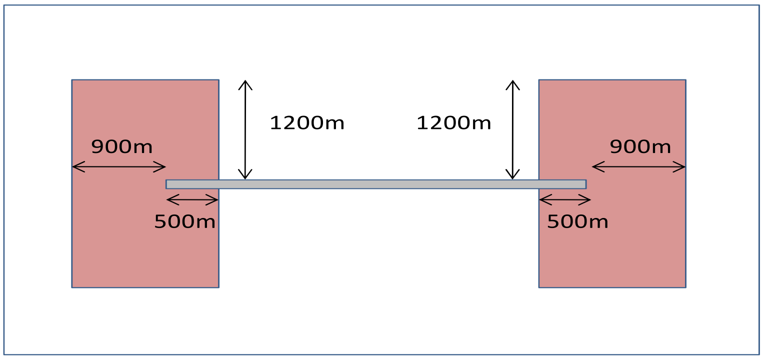


Figure A- envelope around runways within which buildings should be assessed

5. If yes the building is acceptable and no further assessment is required, if no go to Step 2.

Step 2

6. For single, buildings only: Is the distance from the proposed building to the runway centre-line more than 35 times the proposed height of the building?

7. If yes the building is acceptable and no further assessment is required, if no go to Step 3.

Step 3

8. Is this a single, regular-shaped (i.e. rectangular/ square shaped) building?

9. If yes, the building is suitable for a desktop assessment beginning with Step 4. If not, it will need assessment using the quantitative methods described in Step 5.

Step 4

10. Use Table 1 on Page 9 of Guideline B to estimate the magnitude of building-induced windshear. Note that if the prevailing wind is oblique to the building facade, a safety margin of 25 per cent should be added.

11. If this analysis shows that the mean wind speed deficit (the measure of windshear) is less than or equal to 7 knots, the building is acceptable. If this figure is greater than 7 knots, quantitative modelling techniques should be used following Step 5.

Step 5

12. Quantitative modelling using wind tunnel testing or computational fluid dynamics is required if the building proposal fails to comply with the tests in Steps 1 to 4. It is important to note that multiple buildings and buildings with complex shapes that do not meet the 1:35 rule must be subject to quantitative modelling.

13. The objective of the quantitative modelling should be to provide definitive results on whether the building will meet the 7 knot criterion for acceptability of building-induced wind shear.

Step 6:

14. If the assessment above indicates that the building will create unacceptable wind-effects, airport operator/planning authorities/regulators should consider the likely frequency of occurrence. For example, if historic records indicate that this will only occur a few times a year and aircraft will be able to use alternative runways, it is possible the building could still be accepted and the risks managed through operational procedures.
15. If the risk is determined to be unacceptable, the building proposal should be modified or discontinued to ensure the safety of aviation operations at the airport.

GUIDELINE C

NATIONAL AIRPORTS SAFEGUARDING FRAMEWORK

MANAGING THE RISK OF WILDLIFE STRIKES IN THE VICINITY OF AIRPORTS

Revision Date	Version Number	Changes Made	Approved By
Feb 2012	3.1.1	Document Creation	NASAG
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15/7/12	3.1.3	Version control table added. Page numbers added.	S. Stone, GM Aviation Environment, DOIT.

Purpose of Guideline

1. This document provides guidelines to State/Territory and local government decision makers to manage the risk of collisions between wildlife and aircraft at or near airports where that risk may be increased by the presence of wildlife-attracting land uses.

Why it is important

2. The *Principles for a National Airports Safeguarding Framework* acknowledge the importance of airports to national, state/territory and local economics, transport networks and social capital.

3. Wildlife strikes and / or avoidance can cause major damage to aircraft and / or reduction of safety. The consequences of wildlife strike can be influenced by the number and size of wildlife involved, phase of flight and the aircraft part hit by the wildlife.

4. Land use planning decisions and the way in which existing land use is managed in the vicinity of airports can significantly influence the risk of wildlife hazards. Many existing airports are surrounded by areas which are attractive to wildlife, especially birds. As examples, land uses such as agriculture, wildlife sanctuaries, wetlands and land fill sites can attract a high number of birds which increase the risk of interference with aviation activity.

5. The number of wildlife strikes and the attendant risk of fatalities, injuries, aircraft damage and operational delays can be reduced by managing land use around airports to minimise the potential for wildlife to be in conflict with aircraft operations.

How it should be used

6. Some States/Territories already have planning guidelines or polices in place and this document provides guidance for review. For those without policies in place, these Guidelines (in addition to the associated Safeguarding Framework) will provide input to new policies.

Roles and Responsibilities

7. State/Territory and Local Governments are primarily responsible for land use planning in the vicinity of all airports.
8. Australia's 19 major airports are under Australian Government planning control and are administered under the Airports Act 1996. Planning on other airports is undertaken by State/Territory and Local Governments or private operators.
9. As a contracting state to the Convention on International Civil Aviation (the Convention) Australia has international obligations regarding the regulation and management of aviation safety. The International Civil Aviation Organisation (ICAO), which was established by the Convention, has established Standards and Recommended Practices covering all aspects of civil aviation safety.
10. Australian civil aviation safety legislation includes provisions to meet Australia's international obligations. Part 139 of the Civil Aviation Safety Regulations 1998 (the Regulations) imposes an obligation on airports to reduce the risks of wildlife strikes. These regulations are administered by the Civil Aviation Safety Authority (CASA). All Certified Airports are required to document procedures for wildlife hazard management in their Aerodrome Manual. Certified Airports with a confirmed wildlife hazard are also required to develop and implement wildlife hazard management plans. CASA regulates and conducts surveillance of all regulated airports to ensure that that airport operators are adequately managing the risk of on-airport wildlife strikes.
11. Under the Regulations, CASA can address the risk of waste foodstuffs being dumped near airports that may pose a risk to aviation safety by attracting wildlife. When CASA identifies a property that is being used to dump waste food stuffs, it has powers to make it an offence to dump waste foodstuffs there. CASA can also require the property owner to remove waste foodstuffs from the property and can, if necessary, make arrangements to remove the waste material.

Key considerations for managing risk of wild life strikes in the vicinity of airports

12. Most wildlife strikes occur on and in the vicinity of airports, where aircraft fly at lower elevations. The risk of a strike on airport relates to the level and form of wildlife activity both within the boundary of an airport and in surrounding areas. Wildlife attracted to land uses around airports can migrate onto the airport or across flight paths, increasing the risk of strikes. Airports actively reduce wildlife populations and manage the risk of strikes on airport land. Such on-airport activities are underpinned by current aviation safety regulations.
13. Australia's international aviation safety obligations as a contracting state to the Convention on Civil Aviation include responsibilities to take action to manage the risk from wildlife hazards. Specifically, the following standards and recommendations relating to wildlife hazards apply. Clauses 9.4.3 and 9.4.4 and 9.4.5 of Annex 14 of ICAO state:

- Action shall be taken to decrease the risk to aircraft operations by adopting measures to minimize the likelihood of collisions between wildlife and aircraft;
- The appropriate authority shall take action to eliminate or to prevent the establishment of garbage disposal dumps or any source which attracts wildlife to the aerodrome, or its vicinity, unless an appropriate wildlife assessment indicates that they are unlikely to create conditions conducive to a wildlife hazard problem. Where the elimination of existing sites is not possible, the appropriate authority shall ensure that any risk to aircraft posed by these sites is assessed and reduced to as low as reasonably practicable; and
- States should give due consideration to aviation safety concerns related to land developments in the vicinity of the aerodrome that may attract wildlife.

GUIDELINES FOR MANAGING THE RISK OF WILD LIFE STRIKES IN THE VICINITY OF AIRPORTS

14. Aviation safety regulations do not address the risk of wildlife strikes occurring outside the boundary of airports in the same way as they address on-airport risk. The risk of a strike off airport relates mostly to wildlife activity in areas surrounding the airport. There is a need to strengthen arrangements to address the risk of wildlife hazards that occur off airport and ensure Australia is in step with its local and international obligations.

15. The International Civil Aviation Organisation (ICAO) has developed specific advice on land uses with the potential to become high risk wildlife attractants. These include:

- food garbage disposal;
- sewage treatment and disposal;
- artificial and natural lakes;
- abattoirs and freezing works;
- fish processing plants;
- bird sanctuaries; and
- outdoor theatres.

16. The table at **Attachment 1** aligns with international benchmarks set by ICAO and other international aviation regulators. It provides guidance on the land uses that present a risk of attracting wildlife and triggers (based on distance from an airport) for adopting active measures to mitigate that risk. Attachment 1 is a tool to assess plans for new or revised land uses within 3km, 8km and 13km of an airport.

17. The guidelines recognise that at many existing airports it may be difficult or impossible to change the existing usage of the land which serves as a wildlife attractant. In such cases, airport operators should work with land use planning authorities to mitigate the risk of wildlife strike.

18. The guidelines can also be used when considering the establishment of new airports. When a greenfields site is being considered for a new airport, selection agencies can consider the degree of incompatible land usage, including wildlife attracting land usage, in the vicinity of potential sites.

Managing on-airport wildlife strike risk

19. All certified airports (airports certified under Part 139 of the Civil Aviation Safety Regulations 1998 – CASR Part 139) are required to document procedures for wildlife hazard management in their aerodrome manual. Certified airports with a confirmed wildlife hazard are also required to have a wildlife hazard management plan (WHMP). The role foreshadowed for aerodrome operators in these guidelines should form part of future WHMPs and be incorporated in revisions of existing WHMPs.

Managing off-airport wildlife strike risk -general

20. There are many existing locations where there would be advantages in mitigating existing risk. It is also essential that new land uses and changes to land zoning within 13 km of the airport property are regularly monitored and action plans created to mitigate any unacceptable increase in the risk of bird strike. For example, the ICAO document 'Airport Services Manual- Bird Control and Reduction' suggests that dumps should be not be sited within 13km of airport property.

Managing off-airport wildlife strike risk – the role of airport operators and council/land use planning authorities

21. Airport operators should work with local councils (or the relevant land-use planning authority) to establish mechanisms that will identify land uses and prevent the creation of land uses that would cause hazardous wildlife attraction or activity at or across the airport and/or its approaches and departures. This can be accomplished through the following:

- airport operators and land use planning authorities should use the guidance at Attachment 1 as the criteria for deciding on appropriate action in relation to a particular existing or proposed development within a 13 km radius of an aerodrome. Airport operators should conduct ongoing and regular consultation with planning authorities on land uses of concern;
- airport operators should conduct ongoing consultation with bodies such as national /state wildlife and parks management and wetlands management agencies on land uses of concern;
- land use planning authorities should ensure that airport operators are given adequate opportunity to formally comment on planning applications for new or revised land uses that fall within the guidance provided in **Attachment 1**. Airport operators will be expected to respond with comments on how the proposed changes to land use might increase the risk of wildlife strike and on any regulatory actions that could increase the risk of wildlife strike, such as permits related to land uses of concern;
- airport operators should conduct regular outreach/education activities to sensitise relevant stakeholders and the surrounding community to bird strike hazards and land uses that may increase these hazards;
- airport operators should be in a position to provide assistance or advice to relevant stakeholders on bird and wildlife mitigation measures, drawing on knowledge obtained in managing this issue on the airport site; and
- airport operators should include relevant external stakeholders (including, but not limited to, planning authorities, relevant landowners, national /state wildlife and parks

management and wetlands management agencies) on the Airport's Bird and Animal Hazard Management Committee or equivalent group.

22. Airport operators should negotiate with land use planning authorities and land owners if required on agreed action plans for monitoring and, where necessary, reducing wildlife attraction to areas in the vicinity of airports, in accordance with **Attachment 1**. These plans could include:

- regular monitoring surveys;
- wildlife hazard assessments by qualified ornithologists or biologists;
- wildlife awareness and management training for relevant staff;
- establishment of bird population triggers;
- implementation of activities to reduce hazardous bird populations; and
- adoption of wildlife deterrent technologies to reduce hazardous bird populations.

23. Airport operators should maintain files to track all contacts with land use planning authorities regarding land uses near the airport that could attract birds. The log should be used to conduct the reviews below and maintain contact with relevant parties. Under the WHMP, airport operators should consult this log annually to:

- review the status of individual bird attractants sites and any changes required;
- identify existing/potential flyways (regular bird flight paths) between separate bird attractant sites;
- identify measures and on-airport wildlife management procedures that would address risk; and
- document the participants in the review, items discussed and changes identified.
- Airport operators should document the procedures provided here in their WHMP as well as in any relevant documentation required under CASR Part 139, such as the airport's Safety Management System.

Managing risk when new land uses are to be established which increase risk of wildlife strike

24. Where local authorities seek to establish land uses which may increase the risk of wildlife strike near existing airports, steps should be taken to mitigate risk in consultation with the airport operator and qualified bird and wildlife management experts. Risk mitigation measures that should be considered in such cases include:

- a requirement for a Wildlife Management Program;
- the establishment of wildlife management performance standards;
- allowance for changes to design and/or operating procedures at places/plants where land use has been identified as increasing the risk of wildlife strike to aircraft;
- establishment of appropriate habitat management at incompatible land uses;
- creation of performance bonds to ensure clean–up and compensation should obligations not be met;
- authority for airport operators to inspect and monitor properties close to airports where wildlife hazards have been identified; and
- consistent and effective reporting of wildlife events in line with Australian Transport Safety Bureau (ATSB) guidelines.

25. Attached to these guidelines are the following:

- **Attachment 1**: Wildlife attraction risk and actions by land use: This identifies the risk posed by a range of land uses and the actions required , if any.
- **Attachment 2**: Brisbane Airport Buffers: Using Brisbane airport as an example, this is a depiction of the proposed buffers. The shape of the buffers would vary depending on the runway layouts.

Background information on managing the risk of wildlife strike

26. The vast majority of wildlife strikes take place at or close to airports. Almost all involve birds and flying mammals (such as bats and flying foxes). Land animal (mainly terrestrial mammals) strikes are relatively rare and the risk of these has been reduced by the implementation of stringent fencing requirements to keep out unauthorised persons.

27. There would be safety benefits if airport operators and land use planning authorities follow a common, coordinated approach to managing existing wildlife hazards at, and within the vicinity of, airports. Managing wildlife attractants is a key strategy in discouraging wildlife on and around airports.

28. In essence, the guidelines propose distance separation benchmarks between airports and land use practices that attract wildlife species which may be hazardous to aviation. Proposed separation distances based on the radial distances of 3km, 8km and 13 km respectively are proposed. This is consistent with advice from ICAO.

29. The guidelines provide examples of land uses that are acceptable and those that require mitigation measures. In the case of land uses that need to be mitigated, advice regarding appropriate risk mitigation measures is provided.

30. The guidelines recognise that it can be impractical to consider changing existing land use or zoning around established airports which are often located in built up areas and where options for alternative land use can be limited. However, the guidelines allow for improved planning for land uses which may attract wildlife around new airports and new land uses proposed around existing airports.

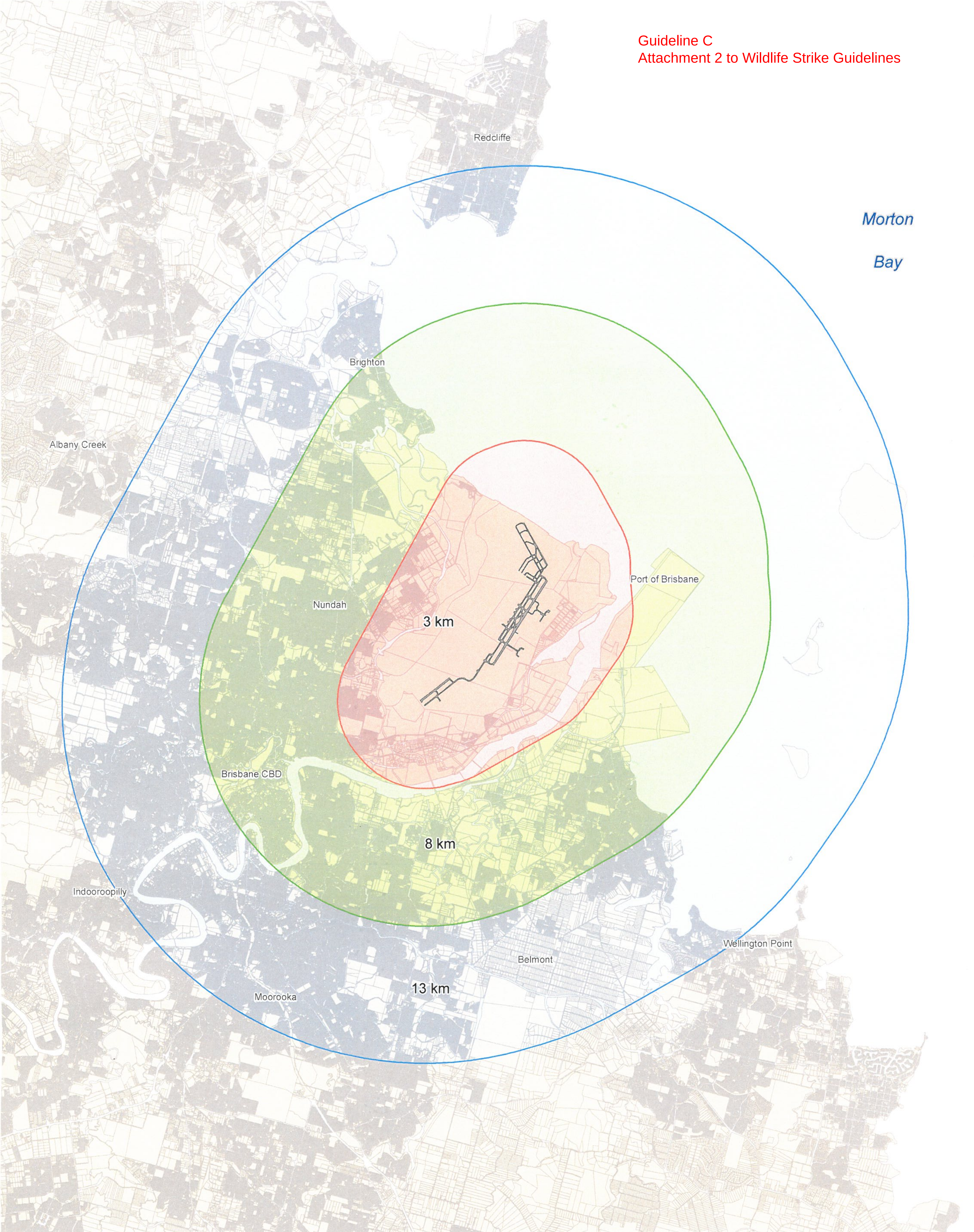
31. Airport operators already have legislative obligations under aviation safety legislation to manage the risk of on-airport wildlife hazards. They do actively manage and deter wildlife, often reducing wildlife numbers. Given that aviation safety legislation regarding management of wildlife applies only on airport land, there is an opportunity to improve land use management in the vicinity of airports to further minimise the risk of wildlife hazards to aviation.

GLOSSARY

Airport operators	These include operators, managers and owners at both regional and major airports.
ATSB	Australian Transport Safety Bureau
CASA	Civil Aviation Safety Authority
Flying mammals	Animals with vertebrae, having the body more or less covered with hair, nourishing the young with milk from the mammary glands, and, with the exception of the egg-laying monotremes, giving birth to live young which are able to fly. For example, bats and flying foxes.
High capacity air transport operations	A high capacity air transport operation involves an aircraft that is certified as having a maximum seating capacity exceeding 38 seats or a maximum payload exceeding 4,200 kg.
ICAO	International Civil Aviation Organization
Land Managers	These include local governments, local planning authorities, state governments, national park/wetland management agencies, private landowners and owners of properties.
SARP	Standards and Recommended Practices
Terrestrial mammals	Animals with vertebrae, having the body more or less covered with hair, nourishing the young with milk from the mammary glands, and, with the exception of the egg-laying monotremes, giving birth to live young which dwell on land. For example, kangaroos and foxes.
WHMP	Wildlife Hazard Management Plan

Land Use	Wildlife Attraction Risk	Actions for Existing Developments			Actions for Proposed Developments/ Changes to Existing Developments		
		3 km radius (Area A)	8 km radius (Area B)	13 km radius (Area C)	3 km radius (Area A)	8 km radius (Area B)	13 km radius (Area C)
Agriculture							
Turf farm	High	Mitigate	Mitigate	Monitor	Incompatible	Mitigate	Monitor
Piggery	High	Mitigate	Mitigate	Monitor	Incompatible	Mitigate	Monitor
Fruit tree farm	High	Mitigate	Mitigate	Monitor	Incompatible	Mitigate	Monitor
Fish processing /packing plant	High	Mitigate	Mitigate	Monitor	Incompatible	Mitigate	Monitor
Cattle /dairy farm	Moderate	Mitigate	Monitor	Monitor	Mitigate	Mitigate	Monitor
Poultry farm	Moderate	Mitigate	Monitor	Monitor	Mitigate	Mitigate	Monitor
Forestry	Low	Monitor	Monitor	No Action	Monitor	Monitor	No Action
Plant nursery	Low	Monitor	Monitor	No Action	Monitor	Monitor	No Action
Conservation							
Wildlife sanctuary / conservation area - wetland	High	Mitigate	Mitigate	Monitor	Incompatible	Mitigate	Monitor
Wildlife sanctuary / conservation area - dryland	Moderate	Mitigate	Monitor	Monitor	Mitigate	Mitigate	Monitor
Recreation							
Showground	High	Mitigate	Mitigate	Monitor	Incompatible	Mitigate	Monitor
Racetrack / horse riding school	Moderate	Mitigate	Monitor	Monitor	Mitigate	Mitigate	Monitor
Golf course	Moderate	Mitigate	Monitor	Monitor	Mitigate	Mitigate	Monitor
Sports facility (tennis, bowls, etc)	Moderate	Mitigate	Monitor	Monitor	Mitigate	Mitigate	Monitor
Park / Playground	Moderate	Mitigate	Monitor	Monitor	Mitigate	Mitigate	Monitor
Picnic / camping ground	Moderate	Mitigate	Monitor	Monitor	Mitigate	Mitigate	Monitor
Commercial							
Food processing plant	High	Mitigate	Mitigate	Monitor	Incompatible	Mitigate	Monitor
Warehouse (food storage)	Low	Monitor	Monitor	No Action	Monitor	Monitor	No Action
Fast food / drive-in / outdoor restaurant	Low	Monitor	Monitor	No Action	Monitor	Monitor	No Action
Shopping centre	Low	Monitor	Monitor	No Action	Monitor	Monitor	No Action
Office building	Very Low	Monitor	No Action	No Action	Monitor	No Action	No Action
Hotel / motel	Very Low	Monitor	No Action	No Action	Monitor	No Action	No Action
Car park	Very Low	Monitor	No Action	No Action	Monitor	No Action	No Action
Cinemas	Very Low	Monitor	No Action	No Action	Monitor	No Action	No Action
Warehouse (non-food storage)	Very Low	Monitor	No Action	No Action	Monitor	No Action	No Action
Petrol station	Very Low	Monitor	No Action	No Action	Monitor	No Action	No Action
Utilities							
Food / organic waste facility	High	Mitigate	Mitigate	Monitor	Incompatible	Mitigate	Monitor
Putrescible waste facility - landfill	High	Mitigate	Mitigate	Monitor	Incompatible	Mitigate	Monitor
Putrescible waste facility - transfer station	High	Mitigate	Mitigate	Monitor	Incompatible	Mitigate	Monitor
Non-putrescible waste facility - landfill	Moderate	Mitigate	Monitor	Monitor	Mitigate	Mitigate	Monitor
Non-putrescible waste facility - transfer station	Moderate	Mitigate	Monitor	Monitor	Mitigate	Mitigate	Monitor
Sewage / wastewater treatment facility	Moderate	Mitigate	Monitor	Monitor	Mitigate	Mitigate	Monitor
Potable water treatment facility	Low	Monitor	Monitor	No Action	Monitor	Monitor	No Action

Guideline C
Attachment 2 to Wildlife Strike Guidelines



Airport Buffers - Brisbane Airport

Scale at A3 1:125,000

0 1.5 3 6

Legend

Airport Runways

Airport Buffer Zones

3 km

8 km

13 km

DCDB

Date: 4 March, 201

Map Details:

Geographic Datum Australia (GDA) 199
MGA Zone 54

IMPORTANT WARNING AND DISCLAIME

The information shown may be incomplet or incorrect, and is to be regarded as indicativ only. AAL does not warrant or guarantee th

NATIONAL AIRPORTS SAFEGUARDING FRAMEWORK

MANAGING THE RISK TO AVIATION SAFETY OF WIND TURBINE INSTALLATIONS (WIND FARMS)/WIND MONITORING TOWERS.

REVISION DATE	VERSION NUMBER	CHANGES MADE	APPROVED BY
Feb 2012	4.1.1	Document Creation	NASAG
Apr 2012	4.1.2	Drafting changes post consultation process	SCOTI
15/7/12	4.1.3	Version control table added. Page numbers added.	S. Stone, GM Aviation Environment, DOIT.

Purpose of Guideline

1. This document provides guidance to State/Territory and local government decision makers, airport operators and developers of wind farms to jointly address the risk to civil aviation arising from the development, presence and use of wind farms and wind monitoring towers.

Why it is important

2. The *Principles for a National Airports Safeguarding Framework* acknowledge the importance of airports to national, state/territory and local economics, transport networks and social capital.
3. Wind farms can be hazardous to aviation as they are tall structures with the potential to come into conflict with low flying aircraft. Temporary and permanent wind monitoring towers can be erected in anticipation of, or in association with, wind farms and can also be hazardous to aviation, particularly given their low visibility. These structures can also affect the performance of Communications, Navigation and Surveillance equipment operated by Airservices Australia (Airservices) and the Department of Defence (Defence).

How it should be used

4. Some States/Territories already have planning guidelines or polices in place and this document provides guidance for review. For those without policies in place, these Guidelines (in addition to the associated Safeguarding Framework) will provide input to new polices.
5. These guidelines provide general information and advice to:
   a) proponents of wind farms (including single wind turbines); and
   b) planning authorities with jurisdiction over the approval of such structures.
6. These guidelines also provide specific advice on measures to reduce hazards to aviation, and how to implement them.

7. The guidelines are intended to provide information to proponents of wind farms and planning authorities to help identify any potential safety risks posed by wind turbine and wind monitoring installations from an aviation perspective.
8. The guidelines rely on an approach of risk identification and management to ensure risks to aviation are minimised in the most effective and efficient manner possible. It is not the intention to adopt an overly restrictive approach to wind farm development, rather to ensure risks are identified early and mitigation measures are able to be planned and implemented at an early stage.

Roles and Responsibilities

9. State/Territory and local governments are primarily responsible for land use planning in the vicinity of all airports.
10. Australia's 19 major airports are under Australian Government planning control and are administered under the Airports Act 1996 (the Airports Act). Planning on other airports is undertaken by State, Territory Governments and Local Governments or private operators.
11. Commonwealth airports are protected from tall structures in the vicinity of airports based on standards established by the International Civil Aviation Organization (ICAO). These standards have been implemented in Australia by the Airports Act 1996 and the Airports (Protection of Airspace) Regulations 1996 which apply at leased Commonwealth airports, and by the Defence (Areas Control) Regulations 1989 which apply at Defence airports.
12. This legislation can be used to ensure wind farms hazardous to aviation are not erected in the vicinity of Commonwealth airports. The implementation of these guidelines will have the outcome of conferring a similar level of protection to non-Commonwealth airports.
13. Australia is a signatory to the Convention on International Civil Aviation. Signatories are obliged to implement ICAO Standards unless they lodge a formal difference. ICAO Annex 14 specifically addresses the issue of wind turbines. In summary, ICAO has recommended the need for lighting of wind turbines if determined to be an obstacle.
14. Annex 14 includes a provision for an aeronautical study as to the need, or otherwise, for marking and/or lighting. This is consistent with provisions in Australia for risk-based assessments of potential hazards to aviation safety. These guidelines are consistent with ICAO Annex 14.

Key considerations for managing risks to aviation safety of wind turbine installations (wind farms)/wind monitoring towers

15. The guidelines apply to:

    (a) a single wind turbine;

    (b) a group of wind turbines, referred to as a wind farm, which may be spread over a relatively large area; and

    (c) wind monitoring towers.

16. The height of a wind turbine is defined as the maximum height reached by the tip of the turbine blades at their highest point above ground level. The marking and lighting described in this document addresses aviation requirements only. For offshore wind farms, in addition

to these requirements, separate lighting and marking may be required for the safety of marine navigation.

17. Implementation of the guidelines will have the additional benefit of being applicable in areas away from airports to address the risk posed by wind farms to air navigation in those areas.
18. Adoption of the guidelines will ensure that aviation safety agencies can examine and address the risk to aviation safety from proposed wind turbine farms at the planning stage. This will enable the use of wind energy to continue to grow, while protecting aviation safety.
19. Wind farm operators should check if proposed wind turbines and wind monitoring towers will be located near areas where low flying operations are likely to be conducted, and if so, consider their duty of care to such activities.

GUIDELINES FOR LAND USE PLANNERS AND DEVELOPERS TO MANAGE THE RISK TO AVIATION SAFETY OF WIND TURBINE INSTALLATIONS (WIND FARMS) /WIND MONITORING TOWERS

20. When wind turbines over 150 metres above ground level are to be built within 30 kms of a certified or registered aerodrome, the proponent should notify the Civil Aviation Safety Authority (CASA) and Airservices. If the wind farm is within 30km of a military aerodrome, Defence should be notified.

CASA should be notified through the nearest CASA Regional or Field Office. Location and contact details of CASA Aerodrome Inspectors may be obtained by calling CASA on 131 757. Airservices should be notified through the Airports Relations Team on 02-6268-4111. Defence should be notified through the Defence Support Group on 02-6266-8191.

21. The Aeronautical Information Service of the Royal Australian Air Force (RAAF AIS) maintains a database of tall structures in the country. The RAAF AIS should be notified of all tall structures meeting the following criteria:

- 30 metres or more above ground level for structures within 30km of an aerodrome; or
- 45 metres or more above ground level for structures located elsewhere.

22. The contact details for the RAAF AIS are: Tel- 03-9282-5750; ais.charting@defence.gov.au.
23. Operators of certified aerodromes are required to notify CASA if they become aware of any development or proposed construction near the aerodrome that is likely to create an obstacle to aviation, or if an object will infringe the Obstacle Limitation Surfaces (OLS) or Procedures for Air Navigation Services –Operations (PANS-OPS) surfaces of an aerodrome. Operators of registered aerodromes should advise CASA if the proposal will infringe the OLS; CASA will ask Airservices to determine if there is an impact on published flight procedures for the aerodrome.
24. ***Note:*** *Obstacle Limitation Surfaces are a complex of virtual surfaces associated with an aerodrome. They are designed to protect aircraft flying in good weather conditions from colliding with tall structures. PANS-OPS surfaces are designed to protect aircraft flying in poor weather conditions from colliding with tall structures. Aerodrome operators can provide details for their particular aerodrome.*

Consultation

25. Consultation with aviation stakeholders is strongly encouraged in the early stages of planning for wind turbine developments. This should include:

a) early identification of any nearby certified or registered aerodromes;

b) immediate consultation with any nearby aerodrome owners;

c) preliminary assessment by an aviation consultant of potential issues;

d) confirmation of the extent of the OLS for any nearby aerodromes;

e) registration of all wind monitoring towers on the RAAF AIS database;

f) consultation with local agricultural pilots and nearby unlicensed airstrip owners; and

g) consultation with CASA and Airservices.

Risk assessment

26. Following preliminary assessment by an aviation consultant of potential issues, proponents should expect to commission a formal assessment of any risks to aviation safety posed by the proposed development. This assessment should address any issues identified during stakeholder consultation.

27. The risk assessment should address the merits of installing obstacle marking or lighting. The risk assessment should determine whether or not a proposed structure will be a hazardous object. CASA may determine, and subsequently advise a proponent and relevant planning authorities that the structure(s) have been determined as:

(a) hazardous, but that the risks to aircraft safety would be reduced by the provision of approved lighting and/or marking; or

(b) hazardous and should not be built, either in the location and/or to the height proposed as an unacceptable risk to aircraft safety will be created; or

(c) not a hazard to aircraft safety.

28. If CASA advice is that the proposal is hazardous and should not be built, planning authorities should not approve the proposal. If a wind turbine will penetrate a PANS-OPS surface, CASA will object to the proposal. Planning decision makers should not approve a wind turbine to which CASA has objected.

29. In the case of military aerodromes, Defence will conduct a similar assessment to the process described above if required. Airservices or in the case of military aerodromes, Defence, may object to a proposal if it will adversely impact Communications, Navigations or Surveillance (CNS) infrastructure. Airservices /Defence will provide detailed advice to proponents on request regarding the requirements that a risk assessment process must meet from the CNS perspective.

Marking of wind turbines in the vicinity of an aerodrome

30. During the day, large wind turbines are sufficiently conspicuous due to their shape and size, provided the colour of the turbine is of a contrasting colour to the background. Rotor blades, nacelle and upper 2/3 of the supporting mast of wind turbines should be painted white,

unless otherwise indicated by an aeronautical study. Other colours are also acceptable, unless the colour of the turbine is likely to blend in with the background.

Lighting of wind turbines in the vicinity of an aerodrome

31. Siting of wind turbines in the vicinity of an aerodrome is strongly discouraged, as these tall structures can pose serious hazards to aircraft taking-off and landing. Where a wind turbine is proposed that will penetrate the OLS of an aerodrome, the proponent should conduct an aeronautical risk assessment. The risk assessment, to be conducted by a suitably qualified person(s), should examine the effect of the proposed wind turbines on the operation of aircraft. The study should be made available to CASA to assist assessment of any potential risk to aviation safety.
32. CASA may determine that the proposal is:

(a) hazardous and should not be built, either in the location and/or to the height proposed, as an unacceptable risk to aircraft safety will be created; or

(b) hazardous, but that the risks to aircraft safety would be reduced by the provision of approved lighting and/or marking.

Lighting of wind turbines not in the vicinity of an aerodrome, with a height of 150m or more

33. Where a wind turbine 150m or taller in height is proposed away from aerodromes, the proponent should conduct an aeronautical risk assessment.
34. The risk assessment, to be conducted by a suitably qualified person(s), should examine the effect of the proposed wind turbines on the operation of aircraft. The study must be submitted to CASA to enable an assessment of any potential risk to aviation safety. CASA may determine that the proposal is:

(a) hazardous, but that the risks to aircraft safety would be reduced by the provision of approved lighting and/or marking; or

(b) not a hazard to aircraft safety.

Obstacle lighting standards for wind turbines

35. When lighting has been recommended by CASA to reduce risk to aviation safety, medium-intensity obstacle lights should be used. Where used, lighting on wind farms should be installed:

(a) to identify the perimeter of the wind farm;

(b) respecting a maximum spacing of 900m between lights along the perimeter, unless an aeronautical study shows that a greater spacing can be used;

(c) where flashing lights are used, they flash simultaneously; and

(d) within a wind farm, any wind turbines of significantly higher elevation are identified wherever located.

36. To minimise the visual impact on the environment, obstacle lights may be partially shielded, provided it does not compromise their operational effectiveness. Where obstacle lighting is

provided, lights should operate at night, and at times of reduced visibility. All obstacle lights on a wind farm should be turned on simultaneously and off simultaneously.

37. Where obstacle lighting is provided, proponents should establish a monitoring, reporting and maintenance procedure to ensure outages, including loss of synchronisation, are detected, reported and rectified. This would include making an arrangement for a recognised responsible person from the wind farm to notify the relevant CASA office, so that CASA can advise pilots of light outages.

Alternatives to fixed obstacle lighting

38. In some circumstances, it may be feasible to install obstacle lights that are activated by aircraft in the vicinity. This involves the use of radar to detect aircraft within a defined distance that may be at risk of colliding with the wind farm. When such an aircraft is detected, the wind farm lighting is activated. This option may allow aviation safety risks to be mitigated where obstacle lighting is recommended while minimising the visual impact of the wind farm at night.

Marking and lighting of wind monitoring towers

39. Before developing a wind farm, it is common for wind monitoring towers to be erected for anemometers and other meteorological sensing instruments to evaluate the suitability or otherwise of a site. These towers are often retained after the wind farm commences operations to provide the relevant meteorological readings. These structures are very difficult to see from the air due to their slender construction and guy wires. This is a particular problem for low flying aircraft including aerial agricultural operations. Wind farm proponents should take appropriate steps to minimise such hazards, particularly in areas where aerial agricultural operations occur. Measures to be considered should include:

a) the top 1/3 of wind monitoring towers to painted in alternating contrasting bands of colour. Examples of effective measures can be found in the Manual of Standards for Part 139 of the Civil Aviation Safety Regulations 1998. In areas where aerial agriculture operations take place, marker balls or high visibility flags can be used to increase the visibility of the towers;

b) marker balls or high visibility flags or high visibility sleeves placed on the outside guy wires;

c) ensuring the guy wire ground attachment points have contrasting colours to the surrounding ground/vegetation; or

d) a flashing strobe light during daylight hours.

Reporting of structures less than 150m in height

40. There is no requirement for CASA to be notified if a proposed wind turbine or wind monitoring tower is less than 150m in height and does not infringe the OLS of an aerodrome. However, they should still be reported for inclusion in the national database of tall structures maintained by the Royal Australian Air Force (RAAF). Information on reporting of tall structures may be found in an advisory circular issued by CASA 'AC 139-08(0) Reporting of Tall Structures'.

Voluntary provision of obstacle lights

41. CASA's regulatory regime for obstacle lighting provides an appropriate level of safety for normal aircraft operations. Certain flying operations, by their nature, involve lower than normal flying, for example aerial agricultural spraying, aerial mustering, power line inspection, helicopter operations including search and rescue, some sports aviation, and some military training. Pilots conducting such operations require special training and are required to take obstacles into account when planning and conducting low flying operations.
42. In making decisions regarding the marking and lighting of wind farms and wind monitoring towers, wind farm operators should take into account their duty of care to pilots and owners of low flying aircraft.

Turbulence

43. Wind farm operators should be aware that wind turbines may create turbulence which noticeable up to 16 rotor diameters from the turbine. In the case of one of the larger wind turbines with a diameter of 125 metres, turbulence may be present two kilometres downstream. At this time, the effect of this level of turbulence on aircraft in the vicinity is not known with certainty. However, wind farm operators should be conscious of their duty of care to communicate this risk to aviation operators in the vicinity of the wind farm. CASA will also raise awareness of this risk with representatives of aerial agriculture, sport aviation and general aviation.

GUIDELINE E

NATIONAL AIRPORTS SAFEGUARDING FRAMEWORK

MANAGING THE RISK OF DISTRACTIONS TO PILOTS FROM LIGHTING IN THE VICINITY OF AIRPORTS

REVISION DATE	VERSION NUMBER	CHANGES MADE	APPROVED BY
Feb 2012	5.1.1	Document Creation	NASAG
Apr 2012	5.1.2	Drafting changes post consultation process	SCOTI
15/7/12	5.1.3	Version control table added. Page numbers added.	S. Stone, GM Aviation Environment, DOIT.

Purpose of Guideline

1. This document provides guidance to assist local governments and airport operators to jointly address the risk of distractions to pilots of aircraft from lighting and light fixtures near airports.

Why it is important

2. The *Principles for a National Airports Safeguarding Framework* acknowledge the importance of airports to national, state/territory and local economics, transport networks and social capital.
3. Pilots are reliant on the specific patterns of aeronautical ground lights during inclement weather and outside daylight hours. These aeronautical ground lights, such as runway lights and approach lights, play a vital role in enabling pilots to align their aircraft with the runway in use. They also enable the pilot to land the aircraft at the appropriate part of the runway.
4. It is therefore important that lighting in the vicinity of airports is not configured or is of such a pattern that pilots could either be distracted or mistake such lighting as being ground lighting from the airport.

How it should be used

5. Some States/Territories already have planning guidelines or polices in place and this document provides guidance for review. For those without policies in place, these Guidelines (in addition to the associated Safeguarding Framework) will provide input to new polices.
6. When planning applications are made that involve significant lighting, planning authorities should assess them first by drawing on these guidelines and second, where necessary, by referring them to the Civil Aviation Safety Authority (CASA) for detailed advice and assessment.

Roles and Responsibilities

7. State/Territory and Local Governments are primarily responsible for land use planning in the vicinity of all airports.

8. Australia's 19 major airports are under Australian Government planning control and are administered under the Airports Act 1996 (the Airports Act). Planning on other airports is undertaken by State, Territory Governments and Local Governments or private operators.

9. As a contracting state to the Convention on International Civil Aviation (the Convention) Australia has international obligations regarding the regulation and management of aviation safety. The International Civil Aviation Organisation (ICAO), which was established by the Convention, has established Standards and Recommended Practices covering all aspects of civil aviation safety.

10. CASA has powers under the Civil Aviation Act 1988 to regulate potential sources of distractions from lighting. Under Regulation 94 of the Civil Aviation Regulations 1988 (CAR 1988), CASA can require lights which may cause confusion, distraction or glare to pilots in the air, to be extinguished or modified.

Key considerations for managing risk of distractions to pilots from lighting in the vicinity of airports

11. It is important that these guidelines are consulted or CASA advice sought when new sources of significant lighting are being planned in the vicinity of airports. Examples of such developments include:

- motorway/freeway lighting
- sea container yards
- wharves
- refinery flare plumes
- stadium flood lighting
- construction lighting.

GUIDELINES FOR MANAGING RISK OF DISTRACTIONS TO PILOTS FROM LIGHTING IN THE VICINITY OF AIRPORTS

12. The following guidelines are provided to assist development proponents and planning authorities to ensure that lighting in the vicinity of airports does not compromise aviation safety. They should assist also in maintaining compliance with Regulation 94 of the Civil Aviation Regulations 1988.

13. Advice for the guidance of designers and installation contractors is provided for situations where lights are to be installed within a 6km radius of a known aerodrome. Lights within this area fall into a category most likely to be subject to the provisions of regulation 94 of CAR 1988.

14. Within this large area there exists a primary area which is divided into four light control zones: A, B, C and D. These zones reflect the degree of interference ground lights can cause as a pilot approaches to land.

15. The primary area is shown at **Attachment 1**. This drawing also nominates the intensity of light emission above which interference is likely. Lighting projects within this area should be closely examined to ensure that they do not infringe the provisions of regulation 94 of CAR 1988.

16. The fact that a certain type of light fitting already exists in an area is not necessarily an indication that more lights of the same type can be added to the same area. Even though a proposed installation is designed to comply with the zone intensities shown in **Attachment**

1, designers are advised to consult CASA as there may be overriding factors which require more restrictive controls to avoid conflict.

17. Light fittings chosen for an installation should have their iso-candela diagram examined to ensure the fitting will satisfy the zone requirements. In many cases the polar diagrams published by manufacturers do not show sufficient detail in the sector near the horizontal, and therefore careful reference should be made to the iso-candela diagram. For installations where the light fittings are selected because their graded light emission above horizontal conform to the zone requirement, no further modification is required.
18. For installations where the light fitting does not meet the zone requirements, a screen should be fitted to limit the light emission to zero above the horizontal. The use of a screen to limit the light to zero above the horizontal is necessary to overcome problems associated with movement of the fitting in the wind or misalignment during maintenance.
19. Coloured lights are likely to cause conflict irrespective of their intensity as coloured lights are used to identify different aerodrome facilities. Proposals for coloured lights should be referred to CASA for detailed guidance. Proponents should check with the nearest CASA office by calling on 131 757 for advice on the likely effect on aircraft operations of proposed lighting in the vicinity of an aerodrome.
20. The potential for glare caused by reflected sunlight from structures such as buildings has been raised in some quarters as a potential source of distraction to pilots. However, CASA has advised that glare from buildings tend to be momentary and therefore unlikely to be a source of risk. The potential for risk from building glare is further attenuated by the use of sunglasses which pilots normally wear in bright daylight.

MAXIMUM INTENSITY OF LIGHT SOURCES MEASURED AT 3° ABOVE THE HORIZONTAL

ZONE A	0 cd
ZONE B	50 cd
ZONE C	150 cd
ZONE D	450 cd

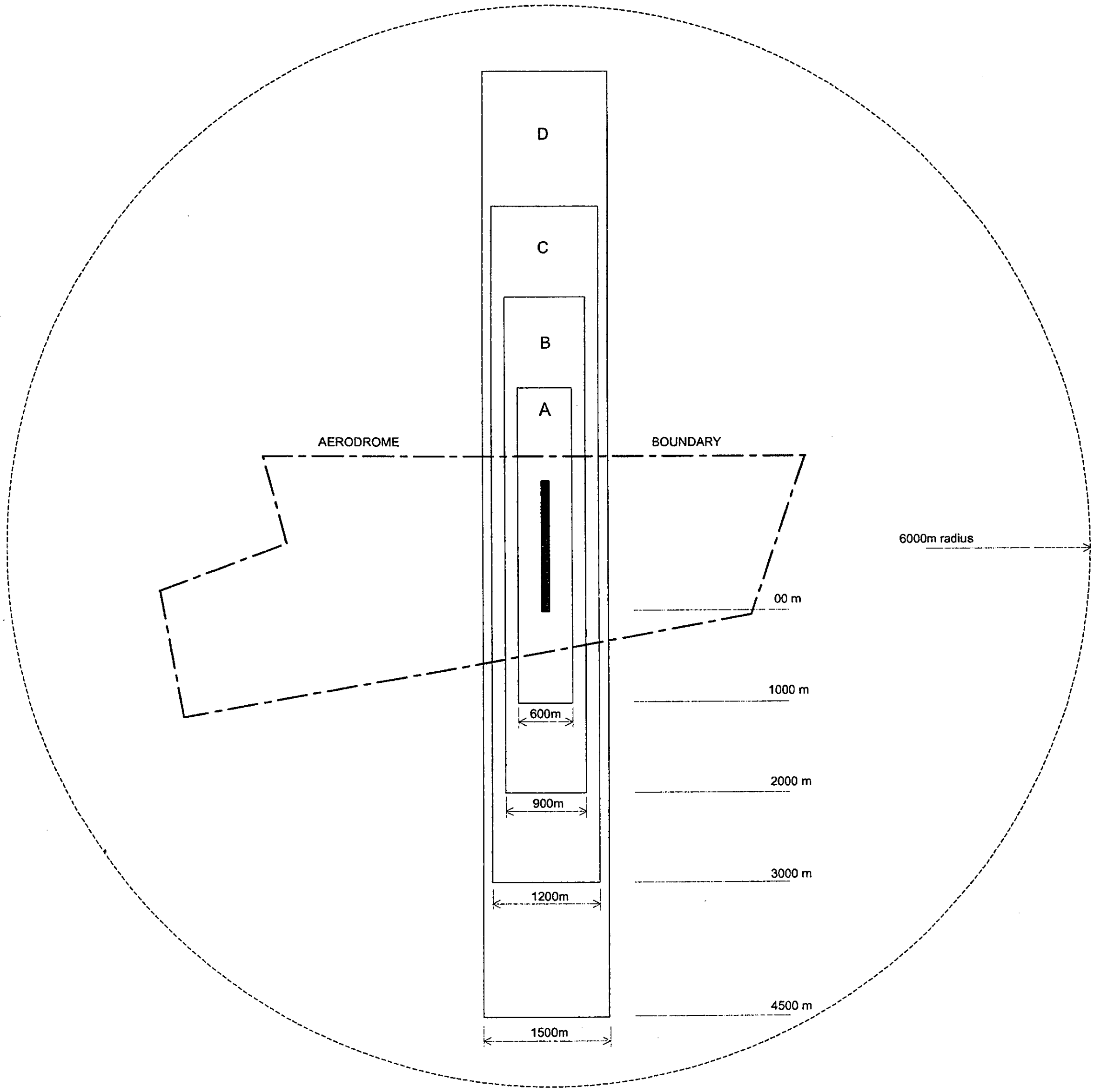


Figure 1

GUIDELINE F

NATIONAL AIRPORTS SAFEGUARDING FRAMEWORK

MANAGING THE RISK OF INTRUSIONS INTO THE PROTECTED OPERATIONAL AIRSPACE OF AIRPORTS

REVISION DATE	VERSION NUMBER	CHANGES MADE	APPROVED BY
Feb 2012	5.1.1	Document Creation	NASAG
Apr 2012	5.1.2	Drafting changes post consultation process	SCOTI
15/7/12	5.1.3	Version control table added. Page numbers added.	S. Stone, GM Aviation Environment, DOIT.

Purpose of Guideline

1. This document provides guidance to State/Territory and local government decision makers as well as airport operators to jointly address the issue of intrusions into the operational airspace of airports by tall structures, such as buildings and cranes, as well as trees in the vicinity of airports.

2. The guidelines are also designed to address the following risks:

   (a) activities that could cause air turbulence, where the turbulence could affect the normal flight of aircraft operating in the prescribed airspace; and

   (b) activities that could cause the emission of steam, other gas, smoke, dust or other particulate matter, where the smoke, dust or particulate matter could affect the ability of aircraft to operate in the prescribed airspace in accordance with Visual Flight Rules (VFR).

Why it is important

3. The *Principles for a National Airports Safeguarding Framework* acknowledge the importance of airports to national, state/territory and local economics, transport networks and social capital.

4. The operational airspace of airports is the volume of airspace above a set of imaginary surfaces, the design of which is determined by criteria established by the International Civil Aviation Organisation (ICAO). These surfaces are established with the aim of protecting aircraft from obstacles or activities that could be a threat to safety.

5. Intrusions into operational airspace affect airport operations. The operational efficiency of safe operations at airports is affected by geographical features such as surrounding hills and artificial structures and activities such as those outlined in paragraph 2 (c) above. Tall structures and other activities that intrude into operational airspace have the potential to lower safety levels of aviation operations at airports. If these activities are not regulated, the aviation safety regulator may have to mitigate risk by placing restrictions on operations at affected airports.

6. The Civil Aviation Safety Authority (CASA) could choose to mitigate risk by imposing restrictions on the runway distance that can be used. The minimum descent altitude for aircraft approaching during inclement weather may have to be lifted to account for a new, taller obstacle, with the result that fewer aircraft may be able to land under such conditions.
7. This would affect the operational efficiency of airport operations in a number of ways. It could mean that the airport may not be open during inclement weather conditions. Reduced runway length could result in operational penalties and inefficiencies as aircraft operators may have to reduce:
   - aircraft fuel carried
   - number of passengers
   - weight of cargo.
8. The dimensions and volumes of operational airspace required are determined using two separate groups of criteria. The first group of criteria define surfaces that protect flights being operated visually. Most general aviation operations, such as recreational flying, are conducted visually. In addition, during good weather conditions, regular public transport operations can be conducted visually near airports.
9. The second group of criteria protect aircraft operations that are solely reliant on the aircraft's navigation instruments, without reliance on the pilot being able to navigate visually.

How it should be used

10. Some States/Territories already have planning guidelines or polices in place and this document provides guidance for review. For those without policies in place, these Guidelines (in addition to the associated Safeguarding Framework) will provide input to new polices.

Roles and Responsibilities

11. State/Territory and Local Governments are primarily responsible for land use planning in the vicinity of all airports.
12. Australia's 19 major airports are under Australian Government planning control and are administered under the *Airports Act 1996* (the Airports Act). Within 15km of major Defence airfields, the Defence (Areas Control) Regulations 1989 (D (AC) R) apply.
13. Planning around other airports is undertaken by State, Territory Governments and Local Governments or private operators.

Key considerations for managing risk of intrusions into the protected operational airspace of airports

Protection of visual operations - Obstacle limitation surfaces

14. The first group of criteria are used to determine the obstacle limitation surfaces (OLS) for a runway. Criteria for determining these surfaces are established by the International Civil Aviation Organisation (ICAO). In Australia, CASA publishes these criteria in the Manual of Standards for Part 139 of the Civil Aviation Safety Regulations.

15. Structures, trees or other activities that intrude into the OLS could constitute obstacles to aircraft taking off or approaching to land. The OLS for an airport charts the volume and dimensions of operational airspace that should be kept free of obstacles to aircraft operations being conducted under VFR or during the visual stages of IFR operations.

16. It is important to note that the OLS does not prohibit all intrusions. The aim is to ensure that all objects that intrude into the OLS can be identified and assessed for their potential impact on aircraft operations. The assessment will enable a determination on whether the intrusion is permissible, and if so, a determination on whether any risk mitigation requirements should be imposed.

17. The requirements to protect operational airspace will be enforced most rigorously along the extended centrelines of runways in the approach and takeoff areas. This could extend up to 15 kilometres from the ends of runways at major airports. Other OLS surfaces that protect aircraft circling to land may also extend up to 15 kilometres from major airports.

18. The effects of individual obstacles may be relatively minor, but together a number of obstacles may seriously limit runway utilisation, cause airspace congestion and reduce the effective handling capacity of the airport. It is therefore important to understand that the pre-existence of a structure or other intrusion into operational airspace does not necessarily mean that a new proposal to penetrate operational airspace will be approved under Commonwealth legislation.

19. Land use planning authorities and state/territory governments should be aware that all intrusions into the OLS have the potential to create aviation safety risks and to limit the scope of aviation operations into and out of the airport. **Attachment 1** includes charts to demonstrate an example of an OLS chart as well as its constituent parts.

Protection of instrument operations - Procedures for Air Navigation Services – Operations (PANS-OPS) surfaces

20. A second group of criteria is used to determine the volumes and dimensions of airspace required to protect the safety of IFR operations. Under IFR operations, pilots fly aircraft relying on instruments for navigation. Airspace protection for IFR operations cannot allow for any long-term penetrations.

21. ICAO established these criteria which are published in a document titled 'Procedures for Air Navigation Services – Operations (PANS-OPS)'. The surfaces determined by using the criteria in the PANS-OPS publication are called PANS-OPS surfaces.

22. The PANS-OPS surfaces are used in the construction of take-off, landing and approach procedures based entirely on navigation with sole reference to aircraft instruments. They are designed to protect aircraft from colliding with obstacles when flying on instruments. Minimum safe altitudes are established for each segment of an instrument procedure.

23. If it is agreed by all stakeholders that a long-term penetration of the PANS-OPS surfaces is essential, the PANS-OPS surfaces must be raised so they are clear of the development causing the penetration. However, this may also have operational penalties for airport operations and could have community impacts, such as re-design of flight paths that increase the population exposed to high levels of aircraft noise.

24. **Attachment 2** includes charts to demonstrate an example of a PANS-OPS chart.

GUIDELINES FOR MANAGING RISK OF INTRUSIONS INTO THE PROTECTED OPERATIONAL AIRSPACE OF AIRPORTS

25. Operational airspace above and around airports needs to be protected from intrusions by objects or activities that could interfere with safe aviation operations. These guidelines set out a series of steps that should be adhered to by proponents wishing to conduct an activity or construct a structure that may penetrate prescribed airspace.

26. The activity that is proposed to be carried out will generally require an approval by state or local government authorities. Larger projects may require an Environmental Impact Statement, while most projects will require the issue of a building permit by the local council. Local councils in the vicinity of an airport's protected airspace are required to review all building and development applications they receive for any infringements of protected airspace. These local councils should refer proposals to the airport operator if an infringement is likely to occur. The proponent will then need to apply through the airport operator for approval.

27. Airport operators will make charts of the OLS and PANS-OPS surfaces available to the land use planning authorities. Ideally, these charts should be incorporated into the local council's planning information overlays. Proponents of objects/activities near airports (e.g. developers, builders and crane operators) should check with the airport operator or their local council at an early date.

The role of airport operators, governments and proponents

28. Local councils around airports should have an overlay map indicating the building heights in the relevant planning document. This overlay map could either be the OLS chart or a simplified version of the OLS chart. This could be used to trigger the need for a formal assessment of penetration of prescribed airspace. Local councils should then take the following steps when they receive an application proposing a development or activity around an airport:

29. Check to see if the proposal involves an intrusion into prescribed airspace as shown in the overlay map. If the proposal appears to intrude into prescribed airspace, notify the relevant airport operator. If the airport operator determines that an intrusion will definitely occur, it will advise the proponent to lodge a formal application to penetrate prescribed airspace.

30. On recept of the application, the airport operator will seek advice from the Civil Aviation Safety Authority (CASA), Airservices Australia (Airservices) and airlines regarding impacts on aviation safety. The airport operator will also seek advice from relevant parties such as the local council.

31. In the case of Commonwealth leased civil airports, the airport operator will provide consolidated advice from Airservices, CASA airlines and other parties to the Department of Infrastructure and Transport (DoIT). DoIT will make an assessment on whether to permit the proposal, and if so, whether any conditions should be imposed.

32. In the case of Defence airports, the Department of Defence (Defence) will make its own assessments under its legislation. Defence will make an assessment on whether to permit the proposal, and if so, whether any conditions should be imposed.

33. In the case of non-Commonwealth airports, councils should take account of advice from Airservices, CASA and airlines in determining whether to permit an intrusion into prescribed airspace.

Details of the assessment process

34. In the case of Commonwealth leased airports, applications to carry out a controlled activity are to be made to the airport operator in writing. The information required in the application must include:

- a description of the proposed controlled activity (building construction, crane operation, plume rise, etc);
- its precise location (longitude/latitude; MGA 94 coordinates); and
- the purpose of the controlled activity.
- if the controlled activity consists of the erection of a building or structure:
- the proposed maximum height of the structure above the Australian Height Datum (including any antennae or towers); and
- the proposed maximum height of any temporary structure or equipment (e.g. cranes) intended to be used in the erection of the structure.
- The airport operator will conduct the initial assessment of the application to check:
- whether the activity results in an intrusion into the OLS or PANS-OPS surface;
- the extent of the intrusion; and
- the precise location of the development or activity.

35. If the airport operator determines that there would be an intrusion into operational airspace, it should invite the following organisations to assess or comment on the application:

- CASA - for an assessment of the impact on aviation safety;
- Airservices - for assessments of proposals resulting in a penetration of the PANS-OPS surfaces or temporary redirection of flight paths;
- the local land use planning authority, e.g. the council, responsible for building approvals; and
- Defence in the case of Defence or joint-user airports.

36. In the case of Commonwealth leased airports, the approval process varies depending on the type of controlled activity:

- short-term controlled (up to 3 months) activities can be approved/refused by the airport operator after consultation with CASA and Airservices, or referred by the airport to DoIT for a decision;
- long-term controlled activities (longer than 3 months) penetrating the OLS are referred by the airport to DoIT for a decision after consultation with CASA, Airservices and the relevant building authority; and
- long-term controlled activities (longer than 3 months) penetrating the PANS-OPS airspace are not permitted and the airport operator can notify the refusal of such controlled activities.

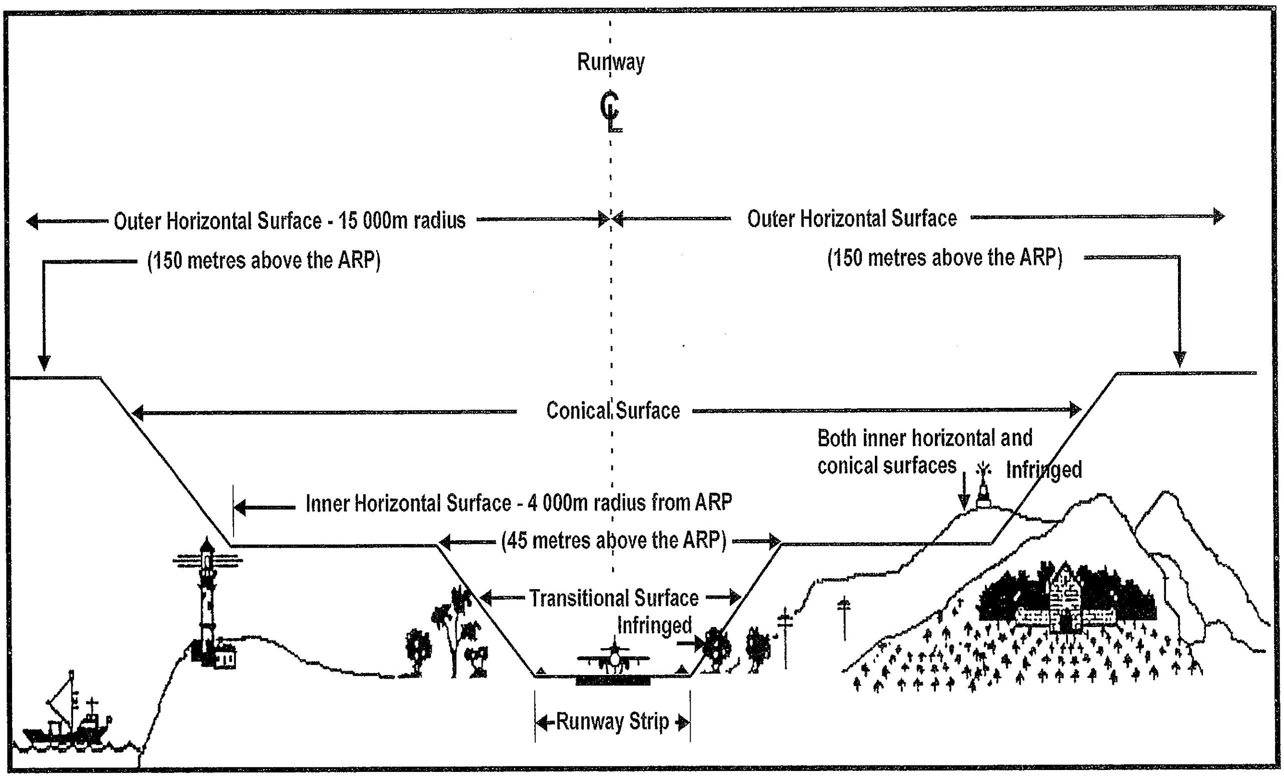
37. DoIT will determine applications based on the safety, efficiency or regularity of existing or future air transport operations into or out of the airport. In the case of Defence airports, a similar process is applied to assess applications to intrude Defence OCS.

38. Councils and other land use decision making bodies should follow a similar assessment process at non-Commonwealth airports. Adelaide City Council uses an assessment process that could serve as a model for other land use planning authorities.

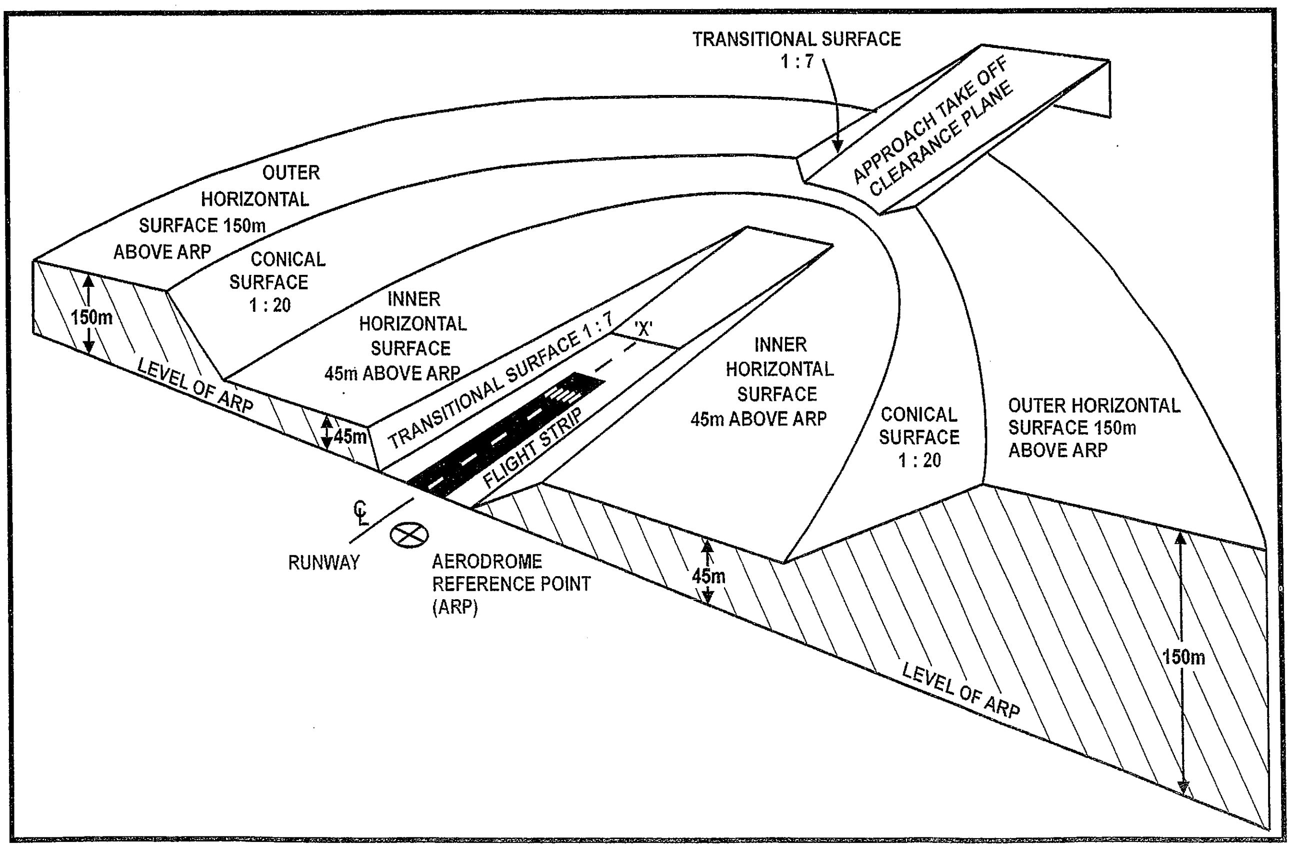
39. **Attachment 3** is a summary of the process that should be followed by planning authorities in the vicinity of the following three categories of airports to ensure the protection of operational airspace.

- Federal leased airports
- Defence airfields
- Other airports

Cross section of OLS



Isometric view of OLS



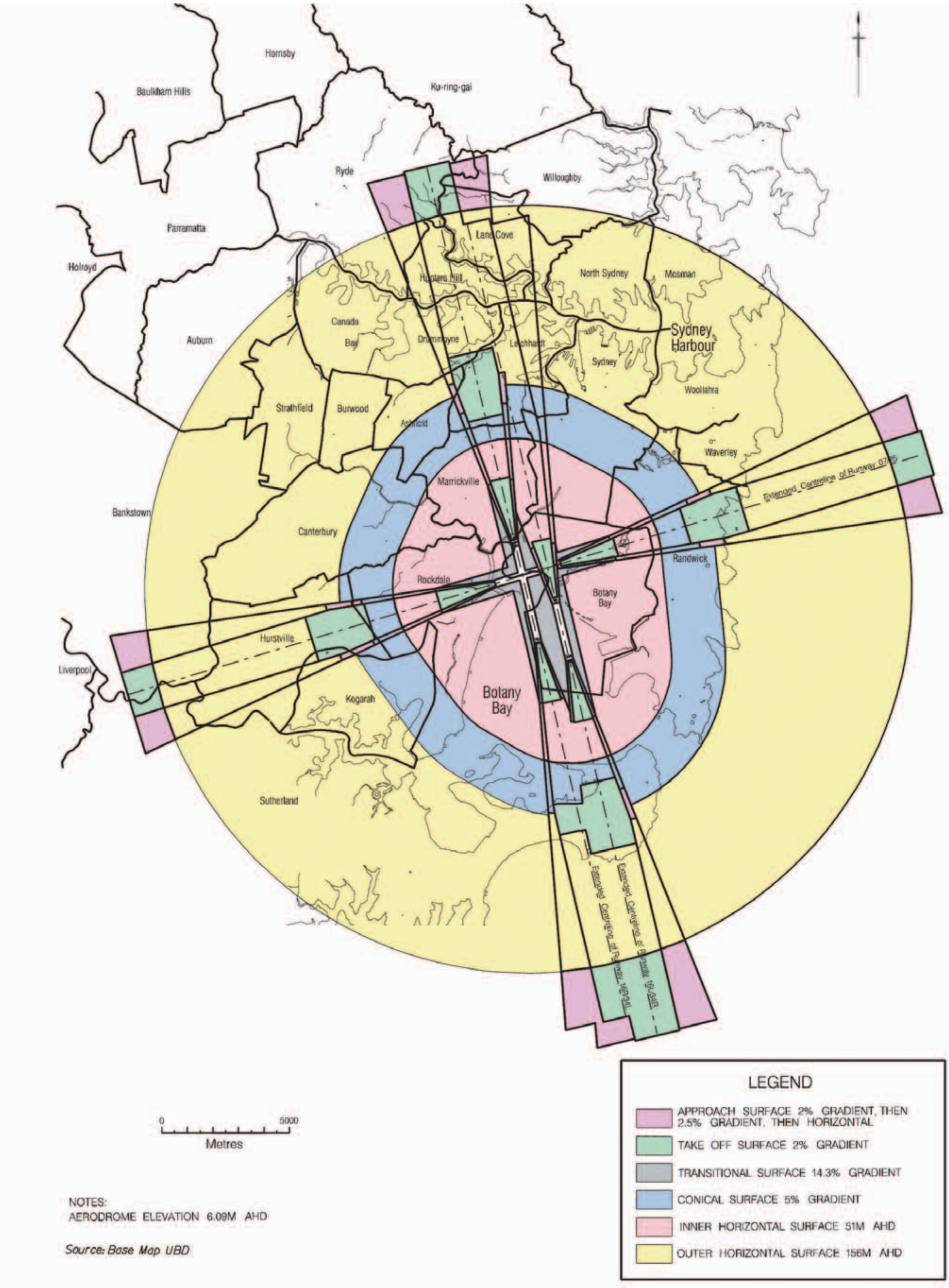
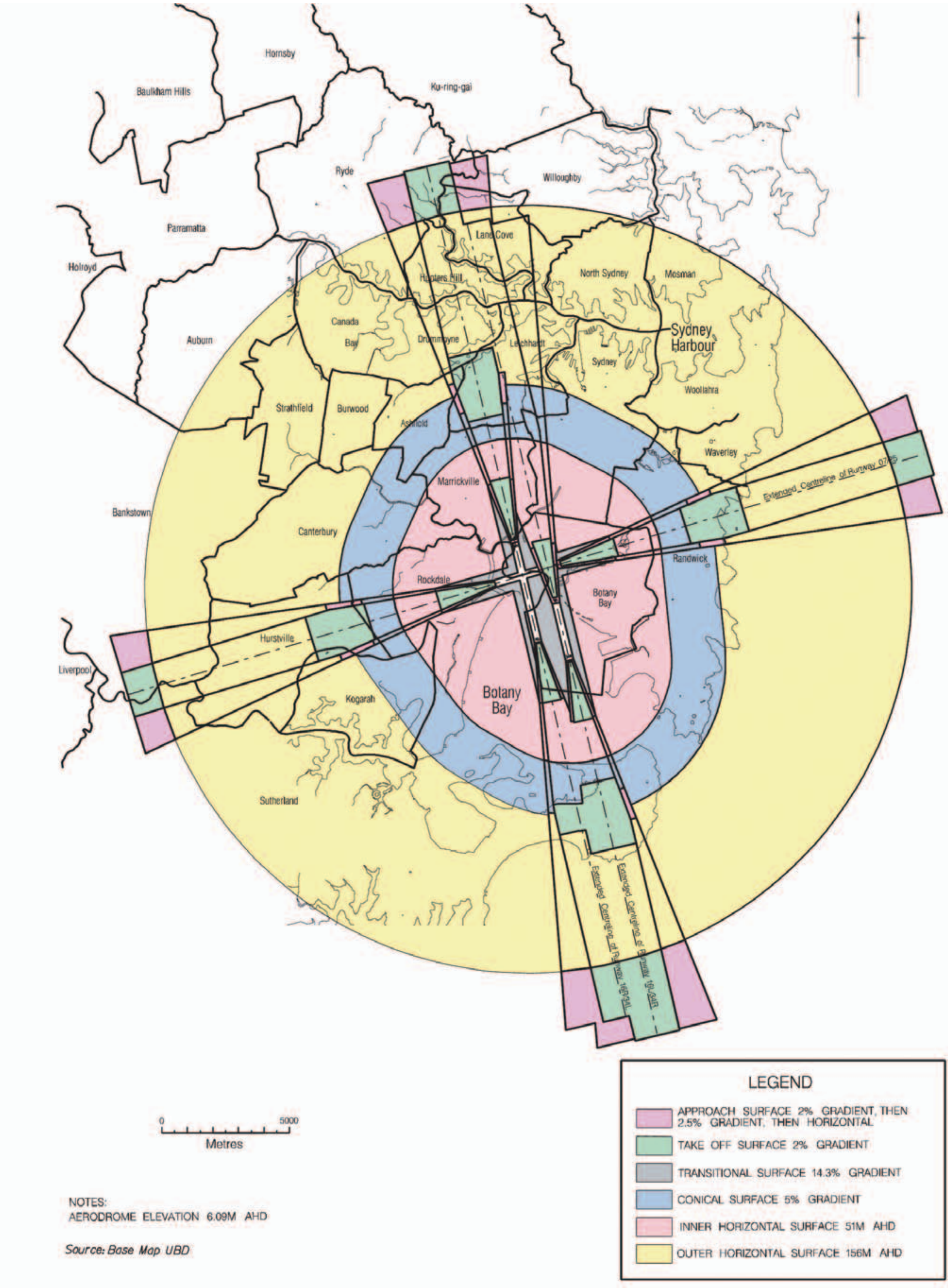


Figure 13.1
Obstacle Limitation Surfaces (OLS)
Current and Future OLS

This drawing has been prepared to illustrate the Sydney Airport Master Plan and is not intended to serve any other purpose. The drawing must be read in conjunction with the Master Plan.



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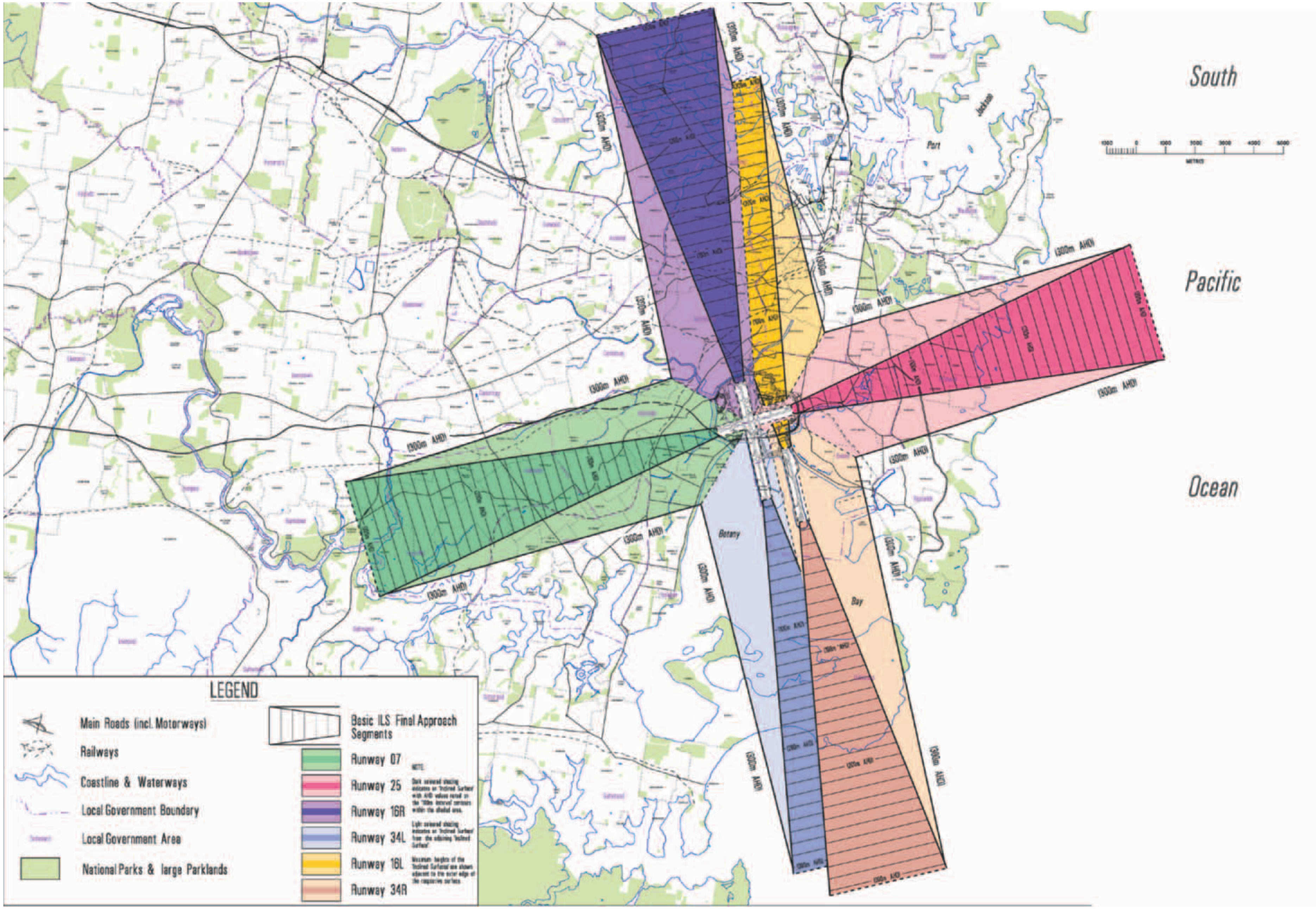

Figure 13.2
Current and Future PANS-OPS Surfaces
Basic ILS

ATTACHMENT 3

Federal Leased Airports

1. If a building or structure penetrates 'prescribed airspace' of a federal leased airport, a 'controlled activity' approval is required from the Australian Department of Infrastructure and Transport pursuant to the *Airports Act 1995* (the Act).
2. Controlled activities are defined in section 182 of the Act and include the following:

- structures such as buildings, antennas and cranes; and
- in some circumstances, activities causing non-structural intrusions into the protected airspace of artificial light, reflected sunlight, air turbulence, smoke, dust, steam or other gases or particulate matter.

3. Carrying out a controlled activity without approval is an offence under Section 183 of the Act punishable by a fine of up to 250 penalty units.

Step 1

4. On receipt of a proposal to construct a building or other structure, such as aerials, chimneys, power poles etc, the planning authority will examine prescribed airspace charts developed by the airport. In some jurisdictions, these charts may be incorporated into Development Plans, Local Environment Plans, or similar legal instruments.
5. This examination will show if the building will penetrate prescribed airspace. If in doubt, the planning authority will seek advice from the airport.

Step 2

6. If your building does penetrate prescribed airspace, it is referred to the airport. If your building does not penetrate prescribed airspace, the planning authority will not refer it to the airport and will continue to apply its normal processes to the application.

Step 3

7. The airport will seek comments from the Civil Aviation Safety Authority (CASA), Airservices Australia, airlines and the planning authority.

Step 4

8. The airport will forward the application to the Department of Infrastructure and Transport, including comments from CASA, Airservices Australia, airlines and from the planning authority.

Step 5

9. Within 28 days of receiving your building proposal, the Department of Infrastructure and Transport will make a decision, unless further information is required.
10. In making a decision, the Department of Infrastructure and Transport:

- will consider the effect the building, aerial or structure will have on the safety, efficiency or regularity of existing or future airport operations, taking into account the comment of the proponent, the airport, CASA, Airservices, the planning authority and any other matters Department of Infrastructure and Transport considers relevant.

- may issue an approval subject to conditions.
- must not approve a building, aerial or structure if CASA has advised that it would have an unacceptable effect on the safety of existing or future airport operations.

11. If the building does not penetrate prescribed airspace, no approval from the Department of Infrastructure and Transport is needed. However, advisory notes will be added to any planning authority consent flagging the need for Department of Infrastructure and Transport approval for future extensions, aerials, masts and the like.

Step 6

12. On receipt of approval from the Department of Infrastructure and Transport will make a decision, the planning authority will proceed with its normal process for consideration of applications.

Defence airfields

13. Around Defence airfields, the Defence (Areas Control) Regulations 1989 (the D (AC) R) apply.
14. If a building or structure penetrates height restrictions prescribed in the D (AC) R, an approval is required from the Department of Defence (Defence).
15. The height restrictions may limit the height of new structures or additions to existing structures to ground level or to heights of 7.5, 15, 45 or 90 metres above ground level in accordance with the gazetted D (AC) R map.

Step 1

16. On receipt of a proposal to construct a building or other structure, such as aerials, telecommunications facilities, power poles etc, the planning authority will examine the applicable height restrictions.
17. This examination will asses if the building will penetrate the height restrictions. If in doubt, the planning authority will seek advice from Defence.

Step 2

18. Where the planning authority determines that a structure is likely to exceed the D(AC)R, a formal application under the D(AC)R will need to be made to Defence.
19. Where a structure is unlikely to exceed the D(AC)R, no application under the Regulations will be required and normal planning authority assessment processes can continue.
20. If the planning authority is uncertain whether or not the proposal will exceed the D(AC)R, it should seek advice from Defence.

Step 3

21. Defence will assess the proposal for impacts on aviation safety and Defence operations.

Step 4.

22. Under the Regulations Defence may approve, approve subject to conditions or reject an application to exceed the D(AC)R.
23. If Defence approves the application Council processes can continue (subject to any subsequent approval incorporating Defence conditions).

24. If Defence rejects the application, Council should refuse the proposal or should seek amendments to make the proposal compliant with the D(AC)R.

Other Airports – aerodromes certified or registered under Part 139 of the Civil Aviation safety Regulations (CASR)

25. Pursuant to CASR Part 139, the operator of a certified or registered aerodrome must inform CASA if it becomes aware that a proposed building or other structure is likely to infringe the airport's OLS.
26. CASA may make a written determination that the proposed structure is a hazardous object. CASA must give a copy of its determination to the proponent and to the planning authority whose approval is required for the construction of the proposed structure.

Step 1

27. On receipt of a proposal to construct a building or other structure, such as aerials, telecommunications facilities, power poles etc, the planning authority will examine OLS (and if any, PANS-OPS) charts developed by the aerodrome operator. The relevant planning authority can often be a council located at some distance from the aerodrome, not just the council within whose jurisdiction the aerodrome is sited.

28. In some jurisdictions, these charts may be incorporated into Development Plans, Local Environment Plans, or similar legal instruments.

29. If the examination shows that the proposed structure is likely to infringe the OLS or PANS-OPS surfaces, the planning authority will seek advice from the aerodrome operator. If the building or structure does not penetrate OLS or PANS-OPS surfaces, the planning authority will not refer it to the aerodrome and will continue to apply its normal processes to the application.

Step 2

30. The aerodrome operator must refer any proposed structure to CASA if it becomes aware that it is likely to infringe the OLS or any PANS-OPS surfaces.

Step 3

31. If CASA determines that the proposal will be a hazardous object it must give notice of its determination to the proposal's proponent and the planning authority. The determination must include advice on any conditions that would reduce the risk from the proposed structure to acceptable levels, without affecting the regularity or efficiency of aerodrome operations. This means that making changes to aerodrome operations, such as displacing thresholds, is not an option.

32. Conditions that CASA propose would normally relate to advice on marking and/or lighting the proposed structure.

Step 4

33. The planning authority should consider approving the proposal with conditions recommended by CASA , if CASA has determined that the although the proposal will be a hazardous object , the risk can be mitigated, without affecting aerodrome operations in any way, by imposing conditions such as requirements for lighting and/or marking.

34. It is also open to planning authorities to approve proposals if it is able to establish through a safety study that the hazard from a proposal can be mitigated such that the safety and operating efficiency of the aerodrome is not affected. If that proves to be the case, then the mitigation measures identified should be conditions of the proposal's approval. Authorities should ensure that such a safety study addresses the recommendations of CASA and any other aviation safety agencies where appropriate i.e. Airservices and Defence.

35. The planning authority should not approve the proposal if CASA has determined that the proposal will create an unacceptable risk to aviation safety.