Chapter 13 Aircraft hazard and risk

This chapter describes the aircraft hazards and risks relevant to the project. The potential impacts of WSI's operations are described, together with the associated assessment methodology and, where relevant, measures to avoid, manage, mitigate or monitor these impacts are included.

The refinements to the preliminary flight path design since the exhibition of the Draft EIS would not change the conclusions of the overall hazards and risk assessment as presented in this chapter and supporting technical papers. Further detail is provided in Appendix G (Assessment of the refinements to the project) of the EIS.

This assessment has considered airspace conflicts, risks to people and critical infrastructure from aircraft crashes as well as other aircraft related risks associated with fuel jettisoning, meteorological hazards, objects falling from aircraft, aircraft wake vortex strike and wildlife strike.

In respect to airspace conflicts, the adopted safety aspects of the design process means that the proposed airspace is expected to be safe by design, meets the key goals of reducing aircraft conflict risk to 'as low as reasonably practicable' and achieves an acceptable level of safety.

Aircraft crash risks

The assessment of risk to people living, working or otherwise congregating in areas that may be subject to potential risks from aircraft crashes (also called third party risk) has considered the individual risk and the societal risk.

The individual fatality risk refers to the annual probability of fatality for a hypothetical resident present at any given location relative to the runway threshold and flight path to and from it. This is presented as risk contour plots at the north-east and south-west ends of the runway for 2033 and 2055. A risk of:

- 1 in 100,000 per annum is considered to be a risk that is of potential concern but one that can be considered acceptable, provided that the risk is managed to be as low as reasonably practicable
- 1 in 1,000,000 per annum is considered to be a low risk that is a generally acceptable level of exposure for members of the public.

For most residential properties in the vicinity of the Airport Site, the risks would be negligible which reflects the position of the runway and the design of the flight paths. For 2033, no dwellings are located within the 1 in 100,000 per annum risk contour and there are 6 dwellings housing 22 people within the 1 in 1,000,000 per annum risk contour. These risks are classified as slight effects, when considering the risk level and the number of people exposed to this risk. In 2055, a small number of people (5) are within the 1 in 100,000 per annum contour and 108 people are located between the 1 in 100,000 per annum and 1 in 1,000,000 per annum risk contour. As the number of people exposed to risks would increase, these risks are classified as being of moderate effect but are not significant based on the criteria applied.

Societal risk considers the annual probability of accidents causing any given number of fatalities in any area of development, taking account of the nature of the development, in particular the density of occupancy. The assessment found that societal risks in 2033 and 2055 are within the middle to lower risk part of the 'as low as reasonably practicable' region. These risks are considered acceptable, provided no further practicable means for mitigating these residual risks is available. In this regard, based on the runway location, airspace design requirements and the relative location of developed areas within Sydney, the preliminary airspace design has minimised these risks, as far as is practicable.

Critical infrastructure, such as hospitals, transport links, water storage and the Defence Establishment Orchard Hills, are located in the vicinity of the Airport Site. The typical event frequencies and scale of fatalities associated with aircraft crashes are consistent with risks that would be considered acceptable when assessed against the societal risk criteria that have been employed more generally to evaluate the significance of third-party fatality risks.

Operation of flight paths over the Greater Blue Mountains Area (GBMA) presents a very low risk of introducing fire through aircraft accidents. This is based on an estimate for the crash rate from aircraft during flight over the Blue Mountains ranging between approximately 1 in 1,700 to 1 in 2,400 years in 2055. The range in the crash rate risk reflects the likely distribution of traffic movements using the flight paths over the GBMA.

Fuel jettisoning

Fuel jettisoning is a rare occurrence in Australia. It is a relatively uncommon non-standard operational requirement that will generally have no ground level impacts if carried out in accordance with appropriate procedures. There are very limited occurrences of impacts at ground level associated with fuel jettisoning in the wider international incident record, confirming that the risk is very small. Fuel jettisoning associated with WSI operations will be carried out in accordance with the Aeronautical Information Publication Australia, Part 2 – En Route (AIP ENR), as per mitigation measure HR3. If possible, except in the case of emergencies, fuel jettisoning will be conducted at an altitude of at least 6,000 feet (ft) (approximately 1.8 kilometres (km)) above ground level to ensure total dissipation into the atmosphere prior to contacting the ground. There would be no significant adverse impact associated with fuel jettisoning associated with WSI operations. While it cannot be guaranteed that such impacts could never occur, the historical record indicates that they would be very rare events.

Objects from falling aircraft

Occurrences involving objects falling from aircraft are uncommon and typically involve small objects with limited hazard potential. Taking account of the relative size of the objects concerned and frequency of these occurrences compared with aircraft crashes, it may readily be concluded that the risks to people and sites on the ground are very small compared with the risks associated with aircraft crashes and hence can similarly be considered to be low and acceptable.

Wake vortex impacts

The number of properties located in areas where vortex damage would be expected is very limited and the risks of wake vortex damage due to WSI operations is low, given the limited number of buildings where wake vortex damage could occur and the nature of the buildings within this area. In the unlikely event of damage occurring, this can be effectively addressed by the compensation scheme operated by Airservices Australia.

Meteorological hazards

Compared with other airports which operate with an acceptable level of safety, there are no exceptional meteorological conditions at WSI that might lead to significant risks to operational safety. The most significant weather related factor is turbulence and windshear. However, the severity of the consequences of these occurrences is normally relatively limited, in particular for turbofan and turboprop powered aircraft of the types that would operate at WSI. The risks to safety and operational efficiency from meteorological hazards can be mitigated by provision of improved forecasting. The implementation of an Automated Thunderstorm Alert Service (ATSAS) at WSI would also provide improved thunderstorm forecasting.

Wildlife hazards

Wildlife strike risk mitigation for WSI providing an acceptable level of safety is achievable, provided that a site-specific wildlife management program is implemented.

Mitigation and management

Risk mitigation is provided by a wide variety of general measures adopted across the aviation industry that apply to operations at WSI. In particular, risks are mitigated by established operational measures supporting safe air traffic control and the design process would deliver an inherently safe design. Third party risks are also effectively mitigated by the location of the runway and associated flight paths which limits exposure to these risks and is further mitigated by the mode of operation, as well as through land use controls guided by the National Airports Safeguarding Framework (NASF) principles and guidelines and set within State Environmental Planning Policy (Precincts – Western City Parklands) 2021.

Additional project-specific mitigation measures have been identified to further mitigate the airspace conflicts, residual off-airport aircraft crash risks to third parties and critical infrastructure, aircraft fuel jettisoning, local meteorological hazards and local bird and bat strike hazards.

In conclusion, operations at WSI and the associated airspace in the Sydney Basin are being introduced within a well-established regulatory and management framework that places the utmost importance on safety, underpinned by key requirements that risks should be 'as low as reasonably practicable' and meet appropriate levels of safety. Assessment of the residual risks associated with WSI operations indicate that those key requirements would be met.

13.1 Introduction

This chapter considers the aircraft hazards and risks associated with the project. The full risk assessment is provided in Technical paper 4: Hazard and risk (Eddowes Aviation Safety Ltd) (Technical paper 4) and is supported by Technical paper 5: Wildlife strike risk (Avisure) (Technical paper 5). The purpose of the assessment is to demonstrate that the project achieves an acceptable level of safety when it becomes operational and to address the EIS Guidelines for the project.

Achievement of an acceptable level of safety means that any risks that may be associated with airspace operation have:

- been minimised so far as is reasonably practicable
- any residual risks are sufficiently small to be considered acceptable in return for the benefits associated with the activities giving rise to them.

The term 'so far as is reasonably practicable' is used in defining an obligation under the relevant safety legislation, whereas in related guidance and in the practical implementation of this legislation reference is often made to a requirement that risks are managed to be 'as low as reasonably practicable'. In general, the terms 'so far as reasonably practicable' and 'as low as reasonably practicable' are synonymous, and the latter term was employed in the remainder of this chapter, pursuant to its use in safety documentation supporting the design process.

While aircraft accidents are relatively rare events, those that do occur take place predominantly during landing and take-off and are more concentrated along flight paths and close to the ends of runways. It is therefore appropriate to give particular attention to these hazards and risks when considering the siting of new runway facilities and the associated flight paths. In that context, consideration of 2 distinct aspects of hazard and risk is required:

- review of potential hazards associated with the site specific environment and assurance that these are identified and appropriately managed, as far as practical by design
- assessment of any residual risks to people and other components of the environment and assurance that these risks are acceptable, given the benefits associated with WSI.

An overall account of hazards and risks associated with the project was provided in the 2016 EIS. This EIS builds on the 2016 EIS, focusing on hazards associated with airborne aircraft beyond the Airport Site boundary and having regard to the design of the proposed airspace. Technical paper 4 considers the following:

- airspace conflicts between aircraft and potential threats to safe inter-operability associated with the introduction of additional flight operations into the existing Sydney Basin airspace
- risks to people living, working or otherwise congregating in areas that may be subject to potential risks from aircraft crashes (also called third party risk)
- risks to critical infrastructure from aircraft crashes
- aircraft jettisoning of fuel and potential contamination events
- objects falling from aircraft

- aircraft wake vortex strikes
- meteorological hazards
- wildlife (bat and bird) strikes.

13.2 Legislative and policy context

13.2.1 Legislation

13.2.1.1 Work health and safety legalisation

The *Work Health and Safety Act 2011* (Cth) and *Work Health and Safety Act 2011* (NSW) place duties on persons responsible for facilities that may give rise to risks to eliminate risks to health and safety, so far as is reasonably practicable.

These Acts do not prescribe specific measures to be taken but instead identify a duty to take whatever measures are available and practicable. In addition to adhering to any technical measures identified in the *Civil Aviation Safety Regulations 1998* (Cth), it is necessary to demonstrate that there are no further practicable measures to further reduce the risks and that any residual risks are maintained at an acceptable level.

13.2.1.2 Aviation legislation

The primary legislation relating to aviation safety in Australia is set at the Commonwealth level and is overseen by the Civil Aviation Safety Authority (CASA). Requirements relating to the safety of all aspects of civil aviation are set out in the *Civil Aviation Safety Regulations 1998* (Cth).

The *Civil Aviation Safety Regulations 1998* (Cth) implement the standards and recommended practices of the International Civil Aviation Organization (ICAO), which regulates and supports international civil aviation worldwide.

Australia is a contracting State under the 1944 Convention on International Civil Aviation (also known as the Chicago Convention) and has an obligation to adopt these ICAO standards and practices. Licensing of aerodromes in accordance with these technical standards ensures that airports provide safe environments for the operation of the types of aircraft that they intend to serve.

Further regulations apply to the operation of aircraft and to air traffic management services to ensure safe and efficient air transport, including (but not limited to):

- *Civil Aviation Act 1988* (Cth)
- *Civil Aviation Regulations 1988* (Cth)
- *Air Navigation Act 1920* (Cth)
- *Airports Act 1996* (Cth) (Airports Act)
- *Airports (Protection of Airspace) Regulations 1996* (Cth)
- *Air Navigation Regulation 2016* (Cth)
- *Airport (Environment Protection) Regulations 1997* (Cth)
- *Airports Regulations 1997* (Cth)
- *Airports (Control of On-Airports Activities) Regulations 1997* (Cth)
- *Airports (Ownership and Interests in Shares) Regulations 1996* (Cth)
- *Aviation Transport Security Act 2004* (Cth)
- *Aviation Transport Security Regulations 2005* (Cth).

13.2.2 National Airports Safeguarding Framework

International standards and guidance seek to ensure that airports and associated flight paths are appropriately safeguarded in respect of future development. To address these requirements, the National Airports Safeguarding Advisory Group developed the NASF. The NASF provides guidance on planning requirements for development that affects aviation operations. It consists of the NASF principles and 9 topic-specific guidelines.

The NASF's main focus is controlling new development that might adversely affect the safety and efficiency of aircraft operations. This is achieved through:

- the physical safeguarding of flight paths from intrusion by new obstacles
- the technical safeguarding of navigational aids and radar systems from interference
- control of development that may attract wildlife and associated hazards
- control of potential distractions
- control of building and terrain induced wind shear.

The NASF principles and the 9 supporting guidelines can be found on the Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA) website.

13.2.3 Airport public safety area policy

International standards for airport design do not prescribe requirements for controlling new development near runways to manage the aircraft crash risk to the public. However, ICAO guidance advises that specific methodologies can be developed by contracting States for that purpose.

A risk based approach was adopted in Australia under the NASF *Guideline I: Managing the Risk in Public Safety Areas at the End of Runways* (NASF Guideline I) by the then Ministers at the Transport and Infrastructure Council in 2018. A Public Safety Area is a designated area of land at the end of an airport runway within which development may be restricted in order to control the number of people on the ground around runway ends. It places development restrictions in areas where an individual is exposed to an estimated fatality risk of 1 in 100,000 per annum. This quantitative risk standard defines the outer limit of Public Safety Areas. New residential development is generally discouraged within Public Safety Areas but some low density uses may be allowed.

The use of this risk criterion is generally consistent with the practical interpretation of the principle under the *Work Health and Safety Act 2011* (NSW) that risks should be eliminated so far as is reasonably practicable. The NASF Guideline I identifies an individual risk of 1 in 100,000 per annum as a relatively low level of risk compared with other risks of daily life more familiar to the community. For example, the risk to an individual being killed in a road accident in Australia is about 5 times that level.

It should be recognised that the Public Safety Area approach to the control of new development in the vicinity of airports does not explicitly address the issues associated with a new runway development within an established built environment (as is the case with WSI). Nevertheless, this policy provides a useful reference point for this assessment.

13.2.4 Other policies and guidance

13.2.4.1 Hazardous Industry Planning Advisory Papers

Integrated land use planning has been an essential part of risk management in NSW. To manage safety risks from potentially hazardous developments, the NSW Government has released a series of advisory papers (the Hazardous Industry Planning Advisory Papers (HIPAP)). The HIPAPs guide the planning and design phases of potentially hazardous developments in NSW to ensure safety issues are thoroughly assessed and that controls are in place to give assurance that a project can be safely operated throughout its life. The papers include guidance and methods on:

- land use safety planning (HIPAP 10: Land Use Safety Planning (NSW Department of Planning, 2011a))
- risk assessments, including quantitative assessments where appropriate (HIPAP 4: Risk Criteria for Land Use Planning (NSW Department of Planning, 2011b))
- evaluation of risk against well-defined objective criteria (HIPAP 3: Risk Assessment (NSW Department of Planning, 2011c)).

The quantitative criteria provided in HIPAP 4 has been considered in this assessment to support the evaluation of the significance of estimated risks and their acceptability, in accordance with international best practice. This is discussed further in Section 13.3.2.

13.2.4.2 NSW planning documents

The *State Environmental Planning Policy (Precincts – Western Parkland City) 2021* (NSW) (Western Parkland City SEPP) and the supporting Western Sydney Aerotropolis Development Control Plan includes a number of airport safeguards that surrounding development or consent authorities must consider when seeking approval for future development. This includes requirements relating to the Public Safety Area, lighting, wind shear and turbulence, wildlife hazard management, and obstructions into airspace.

13.3 Methodology

13.3.1 Study area

The study area is the Sydney Basin. It includes the various established airports, heliports, military airports and associated flight paths in the Sydney Basin, as well as the enroute flight paths that cross the Sydney Basin and restricted airspace. The Sydney Basin encompasses airspace that extends out to Katoomba to the west, the Hawkesbury River to the north, the southern boundary of the Royal National Park to the south and the coastline to the east.

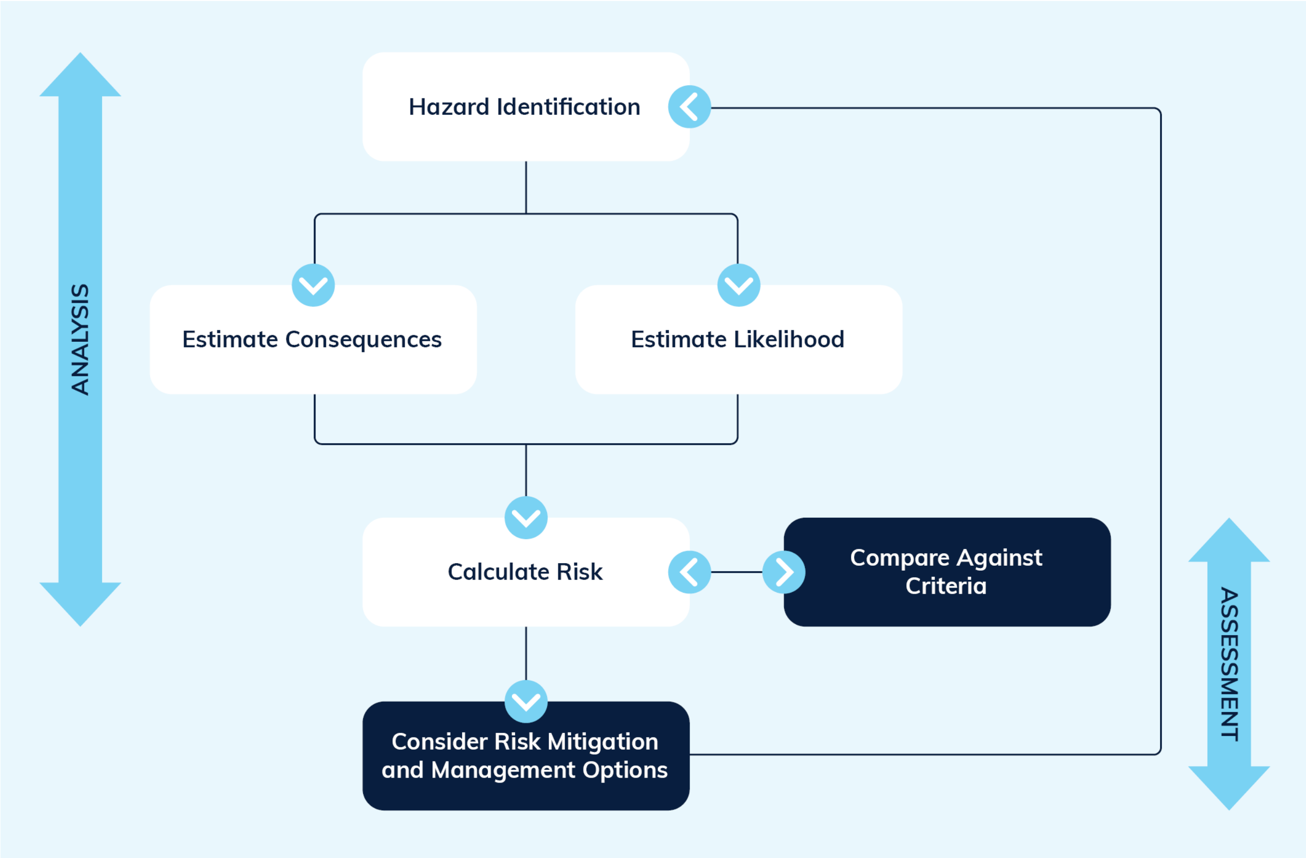
A more discrete study area was applied in the assessment of wildlife strike risks, being the Airport Site in addition to natural or human made structures or land uses within a 13 kilometre (km) radial distance from the runway boundary. The 13 km distance aligns with the NASF's safeguarding limit to manage risks to airport operations. The study area was extended up to 30 km from the runway boundary due to the foraging behaviour and/or the potential strike risk of Flying-foxes and the Australian White Ibis.

13.3.2 Approach

13.3.2.1 Methodology outline

The hazard analysis process that provides the basis for this assessment is summarised in Figure 13.1. While this process is derived from the HIPAP, equivalent processes are identified in aviation-specific risk assessment guidance including:

- CASA 2014 Safety Risk Management SMS 3 Second Edition (CASA, 2014)
- ICAO 2018 Safety Management Manual Fourth Edition Doc 9859 AN/474 (ICAO, 2018).



Source: reproduced from State of Hazardous Industry Planning Advisory Paper No 3 Risk Assessment (NSW Department of Planning, 2011c)

Figure 13.1 Generic hazard analysis and risk assessment process

This EIS is focused on hazards associated with airborne aircraft beyond the Airport Site and having regard to the proposed airspace and flight path design. It builds upon the assessment completed in the 2016 EIS and considered the EIS Guidelines issued for the project. This identified the following hazards as requiring consideration:

- airspace conflicts between aircraft that might result in mid-air collisions and other potential threats to safe inter-operability associated with:
  - the introduction of additional flight operations into the existing Sydney Basin airspace
  - interfaces with military and emergency services operations
  - current commercial and private civil aircraft operations
  - concerns relating to mid-air collision with other aircraft

- general off-airport aircraft crash risks to people and critical infrastructure (referred to as third-party risks)
- aircraft fuel jettisoning
- objects falling from aircraft
- aircraft wake vortex strikes
- local meteorological hazards
- local bird and bat strike hazards.

It has not considered the following hazards, which were considered in the 2016 EIS:

- airspace obstruction and high velocity gas discharges on the basis that these matters have been safeguarded by current arrangements and controls
- drone and model aircraft operations on the basis that appropriate arrangements would apply so that they do not adversely impact the safety of aircraft operations
- targeted terrorism incidents. However, a terrorist incident that may lead to off-site aircraft impacts has been treated as part of the off-airport aircraft crash risk model as one of many factors that may lead to aircraft impacts with the ground.

Further detail on the assessment methodology is provided in Sections 13.3.2.2 to 13.3.2.4.

13.3.2.2 Aircraft crash risk assessment

Site specific risks to the public in the vicinity of airports can be estimated quantitatively using an empirical model, based on historical accident data. For this assessment, the UK Department for Transport (DfT) model, with limited modification, has been applied. This risk assessment is informed by 3 key parameters:

- The likelihood or probability (frequency per annum) of an aircraft crash occurring during landing or take-off operations, anywhere in the vicinity of an airport, having regard to the number of movements and different aircraft types. Based on the crash rates per movement for each aircraft type and the anticipated annual number of movements at WSI, the model provides an estimated annual crash rate for operations.
- The probability of impact at any specific location at or near an airport relative to the runway ends and flight paths, using crash location information from historical accident data (involving aircraft types that are generally representative of those expected to operate at WSI).
- The severity of the consequences of an impact on the ground, according to the size of the aircraft and using historical accident data. The crash consequences for the anticipated operations at WSI are expected to cover a range of severities.

One runway mode of operation at WSI in 2033 and 2055 was assessed. The selected mode of operation assumes no preference being given to the use of Runway 05 or Runway 23, and no reciprocal runway operations (RRO) during the night. This was selected as it was considered the worst case of the 7 scenarios developed for the assessment.

Further details on the selected model and methodology can be found in Section 3.1.3 of Technical paper 4.

The following section provides further information on the 2 measures applied in the assessment (individual and societal risk).

Individual and societal risk

Two measures have been applied to characterise the risks as a result of aircraft crashes to the health and safety of persons on the ground whose presence is not associated with the activities of WSI (also known as third parties):

- individual risk: the annual probability of fatality for a hypothetical resident present at any given location relative to the runway threshold and flight path to and from it
- societal risk: the annual probability of accidents causing any given number of fatalities in any area of development, taking account of the nature of the development, in particular the density of occupancy.

Individual risk

Individual risk is the measure employed for the definition of Public Safety Areas. Three different levels of risk are typically used in the assessment of individual risk:

- a risk of 1 in 10,000 per annum, considered to be a relatively high risk and at the limit of what is an acceptable level of risk exposure for members of the public
- a risk of 1 in 100,000 per annum, considered to be a risk that is of potential concern but one that can be considered acceptable in return for the economic benefits derived from the activity giving rise to the risk, provided that the risk is managed to be as low as reasonably practicable
- a risk of 1 in 1,000,000 per annum, considered to be a low risk that is a generally acceptable level of exposure for members of the public.

These identified risk levels provide a well-defined set of internationally recognised quantitative criteria. In addition to the risk levels, the relative number of people exposed to these risk levels can also provide a further criterion for evaluating risk significance.

As such, this assessment has applied criteria for individual risk significance that combine these 2 factors (refer to Table 13.1).

Table 13.1 Assessment criteria for individual risk significance

Significance of impact	Topic specific criteria
Negligible[1]	Individual fatality risk < 1 in 1,000,000 per annum across all areas of development and major transport links
Slight effects	1 in 1,000,000 per annum < Individual fatality risk < 1 in 100,000 per annum Low numbers (up to a few tens) of people exposed
Moderate effects[2]	1 in 1,000,000 per annum < Individual fatality risk < 1 in 100,000 per annum High numbers (hundreds to thousands) of people exposed Or 1 in 100,000 per annum < Individual fatality risk < 1 in 10,000 per annum Low numbers (up to a few tens) of people exposed
Significant effects	1 in 100,000 per annum < Individual fatality risk < 1 in 10,000 per annum High numbers of people exposed
Very Significant effects	Individual fatality risk > 1 in 10,000 per annum Low numbers (up to a few tens) of people exposed
Profound effects	Individual fatality risk > 1 in 10,000 per annum High numbers (hundreds to thousands) of people exposed

1. The term negligible is typically employed in safety regulation for risk levels that are below regulatory concern and this category can be considered to equate essentially with the not significant impact significance category often employed in environmental assessment.
2. There will be some overlap between scenarios meeting the criteria identified for moderate effects, according to the level of risk within the identified bands and the numbers of people exposed.

Societal risk

Societal risk is characterised quantitatively in terms of the estimated frequency of accidents leading to a defined number of fatalities. Societal risk estimates typically consider the wide range of potential outcomes of an accident from the more common scenarios (relatively few fatalities) to less common scenarios (larger numbers of fatalities).

Societal risks have been determined by reference to the following parameters:

- the likelihood of a crash at any given location relative to the runway and associated flight paths
- the area impacted on the ground in the event of a crash for each different aircraft type
- the density of occupancy at any given location subject to crash risk.

This modelling approach provides estimates for the frequency (f) of scenarios causing a wide range of numbers of fatalities (n) up to a maximum number associated with an impact of the largest aircraft type into the area of highest population density. These estimates are then used to derive estimates for different societal risk measures for comparison with appropriate acceptability criteria. Usual practice is to present societal risk estimates graphically in terms of an ‘FN curve’, which summaries the full range of potential outcomes by means of a plot on a logarithmic scale of the number of fatalities against the event frequencies for all foreseeable scenarios.

The criteria available to assess the significance of societal risk are broadly similar to one another in that:

- risk is considered increasingly significant at any given frequency with the increasing number of fatalities associated with it, and
- risk giving rise to any given number of fatalities is considered increasingly significant with the increasing frequency of the event.

However, the criteria are not consistent in how the level of concern (or aversion) about a risk with the increase in the number of fatalities is considered. Some criteria adopt no specific aversion, whereas some apply differing levels of increasing aversion to multiple fatality events.

Given the uncertainty in determining the significance of societal risk, this assessment has made reference to 3 criteria identified by the following jurisdictions:

- the UK, which does not add additional importance to events giving rise to higher number of fatalities. The UK has adopted the view that any differential risk aversion must be done explicitly and that there is already an element of high fatality aversion inherent in its FN criterion
- Australia, within Safe Work Australia (SWA) and NSW guidelines. The SWA guideline includes a substantial aversion to risks giving rise to higher numbers of fatalities within its FN criterion, whereas NSW guidance adopts some aversion within its FN criterion.

Reference has also been made to the following:

- A ‘scaled risk integral’ which has been adopted by the Republic of Ireland for hazardous land use planning and is not expressed in an FN curve. This represents the sum over all scenarios of the accident frequency multiplied by the number of fatalities. A value of 2,000 is considered broadly acceptable and a value of 500,000 is considered significant. This guidance identified that it should only be used for initial assessments of societal risk given the debate on scale aversion, and that the FN curve remains a more robust approach.
- The expectation value, which represents the average number of fatalities per annum associated with a hazardous event and can be used as an alternative societal risk criterion which is neutral to high fatality risk aversion. Events leading to one fatality at a frequency of 1 in 10,000 years is the upper limit of negligible risk. The limit for 10 fatality events is 1 in 100,000 years.

The crash risk frequency and area impacted have been determined using the available empirical models. The density of occupancy has been estimated by reference to the available census data.

Further detail on the methodology and a detailed discussion of the criteria applied in this assessment is provided in Section 3.1.3 of Technical paper 4.

13.3.2.3 Wildlife strike risk assessment

On-airport risks

Risks due to wildlife strike from wildlife within the Airport Site are reported as a Species Risk Index. This index considers the likelihood (based on population size, position on the Airport Site, time spent in the air and the ability of the species to avoid collision) and consequence (fauna size (mass) and flock size). Based on these factors, the Species Risk Index rating ranges from very low to very high.

The assessment provides for a systematic approach to identify and treat wildlife related risks at an airport. The assessment also assists in identifying high risk species to allow for suitable management practices to be targeted in areas where the maximum reduction in risk may be achieved while conserving native wildlife populations.

To inform the assessment, surveys were completed across July, August, September and October 2022 at the Airport Site. Further detail on the methodology and risk assessment method is provided in Chapter 3 and Appendix D of Technical paper 5.

Off-airport risks

Airspace risk level posed by wildlife within the Airport Site or in the vicinity of WSI has been determined with an assessment of:

- species risk, which considers the probability (based on the population size, location, time spent in the air and the species ability to avoid collision) and the consequence to the aircraft (based on the size of the animal and flock size). This assists in the identification and treatment of wildlife related risks at WSI
- off-airport risk, which considers sites located off-site that could contribute to aviation strike risk at WSI. This considers the likelihood of a species being present, the attractiveness of a location for wildlife (specifically food, shelter and water resources), proximity to WSI and flight paths, as well as the connectivity of other relevant wildlife attracting sites.

Further detail on the methodology and risk assessment method is provided in Chapter 3 and Appendix D of Technical paper 5.

To inform the assessment, surveys were completed:

- across July, August, September and October 2022 at the 76 wildlife-attracting sites within 13 km of the Airport Site
- on 4 occasions at the 8 Flying-fox camps located within 30 km of the Airport Site. These surveys were augmented by surveys completed by Avisure or others at the camp sites over 2018 to 2022.

Not all off-airport sites were surveyed in each survey round due to land access constraints. Further detail on the survey methods are provided in Appendix B of Technical paper 5.

13.3.2.4 Assessment of other hazards

Risks associated with the other identified hazards have been characterised by reference to operational experience, provided through the Australian Transport Safety Bureau (ATSB) accident and incident database and wider international experience. This includes use of the US National Transportation Safety Board (NTSB) dataset to characterise each identified hazard in terms of frequency and severity.

The potential impacts have then been assessed by reference to the environments along the flight paths to provide a basis for evaluating the scale of the anticipated risks.

13.3.2.5 Assumptions and limitations

The aircraft crash hazard assessment is based on an empirical model developed by reference to recent historical accident data. It provides generic insight into:

- the likelihood of aircraft crashes
- the likely locations of events in relation to flight paths
- the impact consequences on the ground.

Future risks associated with operations at WSI are estimated on forecasts for future operations, in terms of:

- the numbers of aircraft movements following the available departure and approach paths
- the aircraft types involved.

There will inevitably be limitations to the reliability of any quantitative risk model based on this empirical approach, due to inherent modelling uncertainties and uncertainties in the forecasts for future operations.

Careful consideration has been given to the possible limitations of the modelling approach used, as described in Appendix A of Technical paper 4. This modelling approach is consistent with current best practice and provides a sound basis for assessing the implications for public safety of WSI's airspace and flight path design.

With respect to the wildlife strike risk assessment, the risk is dynamic and is likely to change in response to landscape changes as WSI is developed and as land use surrounding the Airport Site undergoes significant change.

The assessment of other hazards is similarly based on empirical evidence from operational experience and is subject to similar limitations and assumptions.

13.3.3 Dependencies and interactions with other study areas

This assessment interacts with other study areas, including:

- aircraft noise: flight path design has sought to minimise noise impacts on people, in part through avoiding overflight of areas that would give rise to impacts on larger number of individuals
- biodiversity: wildlife strike risk management involves a balance between aeronautical safety and biodiversity objectives.

Further detail on the interactions is found in Section 3.2 of the Technical paper 4.

13.4 Existing environment

As outlined in Section 4.1 of the EIS, the Sydney Basin airspace encompasses an extensive network of flight paths associated with existing airports, Defence facilities, flying training, recreational aviation activities (gliders, ballooning and parachuting), emergency aviation activities (for example, medical or bushfire), helicopter activity and transiting flights. A number of restricted areas and danger areas are also present in the Sydney Basin airspace where flying is restricted.

Most of the land immediately surrounding WSI currently comprises low density rural residential and agricultural land uses. There are a few residential areas adjacent to The Northern Road and Park Road intersection and further south of The Northern Road. The primary sensitive receivers for consideration in the aircraft crash hazard assessment fall within the following categories:

- areas of development along flight paths where people live, work or otherwise congregate that may be impacted by aircraft crash
- critical built infrastructure such as transport links
- major hazard industrial facilities, for example nuclear facilities and chemical processing and storage facilities at which an aircraft crash may lead to serious knock-on consequences
- water supplies that may be contaminated, either by a crash or by fuel jettisoning in an emergency
- any other facilities or environmental assets of notable value that may be harmed by the identified hazard scenarios.

Fauna in the region is supported by remnant and disturbed native vegetation, as well as resources provided by agricultural and urban development. Based on current land uses, 76 sites that attract or potentially attract wildlife (if left unmanaged) were identified within the Airport Site or within 13 km of Runway 05/23. This includes artificial and natural waterbodies (including basins), waste resource recovery facilities and landfills, recreational sites and reserves, the Luddenham Showground, golf courses and water reservoirs (such as the Warragamba Dam), as well as commercial and agricultural operations (such as landscaping supplies and horticultural operations). The Lake Gillawarna Ibis colony is located around 23 km from Runway 05/23.

Eight Flying-Fox camps are located within 30 km of Runway 05/23. Monitoring completed by Avisure over 2022 found that 6 of the 8 Flying-fox camps (as of October 2022) were active with populations ranging from 15 to around 15,000 individuals. No individuals were recorded at the Emu Plains or Wetherill Park camps.

13.5 Assessment of impacts

13.5.1 Airspace conflicts and system operability

Safe and efficient airspace design is underpinned by technical standards developed by the international aviation community. A well-defined safeguarding process ensures that safe and efficient operations can be maintained and will not be compromised by future developments, as set out in NASF guidance. It is further supported by risk assessment and the 'as low as reasonably practicable' principle. This approach was followed during the design of the project and its interfaces with the existing airspace uses. The eventual outcome is an overall airspace system that:

- is safe by design within the various constraints inherent in it
- minimises airspace conflicts
- maximises system inter-operability.

The project is expected to be safe by design, achieves the 'as low as reasonably practicable' principle and achieves an acceptable level of safety, due to the following key features in the design process outlined in Chapter 6 (Project development and alternatives):

- the project has been designed within a safety regulatory and management framework in which the safety of air navigation is regarded as the most important consideration and where management systems are in place to ensure that such a commitment is met
- the airspace and flight path design is underpinned by defined goals established at the outset that all risks will be managed to be as low as reasonably practicable and that any residual risk will be acceptable
- the airspace and flight path design is further underpinned by 2 design principles supporting inherent safety: systemic separation of aircraft and air traffic controller workload minimisation
- the identification and evaluation of options for airspace and flight path design, and the selection of the preferred concept option has followed a rigorous process which can be expected to deliver an optimum solution within the inherent constraints of the existing operational requirements that is safer by design
- the subsequent development of the preliminary airspace design from the selected concept option follows established industry practice and has delivered a more detailed operational specification that can be expected to deliver an eventual outcome meeting the identified objectives, minimising airspace conflicts and maximising system operability.

The consideration of airspace conflicts and other threats to operational safety is a complex and ongoing process. As outlined in Section 6.4 (Future phases) of the EIS, the consideration of safety will continue as the project advances to detailed design and implementation. This includes safety and hazard assessments to ensure that risks have been identified and managed to the lowest practicable level.

13.5.2 Aircraft crash incidents

While aviation regulations and the requirements that guide airspace and flight path design are intended to primarily provide for the safety of aircraft and their occupants, it also supports the safety of those living and working in the vicinity of an airport by ensuring that aircraft crashes are very rare events.

The assessment considers the risk posed to the health and safety of persons living and working in the vicinity of an airport whose presence is not associated with the activities of WSI. For example, aircraft workers and passengers are not considered in the assessment. While aircraft crashes are uncommon, the majority occur along flight paths and close to the runway ends where the crash risk is more concentrated. The consequence of an aircraft crash incident on the ground would include property damage, injuries and fatalities.

13.5.2.1 Individual risk

The assessment of individual risk in the 2033 and 2055 assessment years at the ends of Runway 05/23 found that:

- the 1 in 10,000 per annum contours are contained entirely within the Airport Site for both assessment years and are located at both ends of Runway 05/23
- the 1 in 100,000 per annum contours in 2033 at the south-west runway end is fully contained within the Airport Site. The majority of the 1 in 100,000 per annum contour at the north-east runway end is also contained within the Airport Site. Around 20 per cent of the area (1.64 hectares (ha)) is located outside the Airport Site (beyond Elizabeth Drive)
- the majority of the 1 in 100,000 per annum contours are contained in the Airport Site in 2055. Around 37 per cent (23.06 ha) is located outside the Airport Site
- the 1 in 1,000,000 per annum contours for the 2033 and 2055 assessment years extend beyond the Airport Site at both runway ends, with a greater extent of areas outside the Airport Site occurring in 2055. The shape of this risk contour is also influenced by turns on some departure flights.

The individual risk contours are shown in Figure 13.2 (2033) and Figure 13.3 (2055).

The extent to which the operations at WSI would represent a real threat to people and other facilities on the ground is dependent on the extent to which developments are located within them. A limited number of people and dwellings occur within the individual risk contours that extend beyond the Airport Site (refer to Table 13.2).

Table 13.2 Summary of the number of dwellings and persons estimated within individual risk contours

Assessment year	Dwellings	Persons
2033		
1 in 100,000 per annum	0	0
1 in 1,000,000 per annum	6	22
2055		
1 in 100,000 per annum	2	5
1 in 1,000,000 per annum	30	108

Figure 13.2

2033 risk contours

Legend

- WSI Runway
- Western Sydney International (Nancy-Bird Walton) Airport land boundary
- Aboriginal Places raised during consultation (NPW Act)
- Site of Aboriginal

Risk contours

- 1 in 10,000 per annum
- 1 in 100,000 per annum
- 1 in 1,000,000 per annum

0 1 2 km

Coordinate system: GDA 1994 NSW Lambert

Scale ratio correct when printed at A4

1:100,000 Date: 27/06/2023

Data sources: - DITRDC, DCS, Nearmap, Geoscience Australia
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

Figure 13.3

2055 risk contours

Legend

- WSI Runway
- Western Sydney International (Nancy-Bird Walton) Airport land boundary
- Aboriginal Places raised during consultation (NPW Act)
- Site of Aboriginal significance

Risk contours

- 1 in 10,000 per annum
- 1 in 100,000 per annum
- 1 in 1,000,000 per annum

0 1 2 km

Coordinate system: GDA 1994 NSW Lambert

Scale ratio correct when printed at A4

1:100,000 Date: 27/06/2023

Data sources: - DITRDC, DCS, Nearmap, Geoscience Australia
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

Based on the criteria provided in Table 13.1, the risks for the:

- 2033 assessment year are classified as 'slight effects', which corresponds with low numbers (up to a few tens) of people exposed to an individual fatality risk between 1 in 1,000,000 per annum and 1 in 100,000 per annum
- 2055 assessment year is classified as 'moderate effects', towards the lower end of the classification. This corresponds with low numbers (up to a few tens) of people exposed to an individual risk above 1 in 100,000 per annum or high numbers (hundreds to thousands) exposed to an individual risk between 1 in 1,000,000 per annum and 1 in 100,000 per annum.

Except for 2 dwellings in the 2055 assessment year, the risk impacts are consistent with the NASF Guideline I public safety area criterion of an individual risk of 1 in 100,000 per annum.

13.5.2.2 Societal risk

The societal risk impacts have been determined by consideration of the full range of accident scenarios involving aircraft of different sizes from the fleet mix anticipated in 2033 and 2055 and impacts in different locations with different densities of occupation. The FN curve method summarises the full range of potential outcomes, by means of a plot on a logarithmic scale of the number of fatalities against the event frequencies for all foreseeable scenarios. This is shown in Figure 13.4. The available criteria typically identify levels of societal risk defined in terms of the FN curve measure below which risks can generally be considered negligible, generally acceptable and not of any regulatory concern. Similarly, the criteria identify risks levels that may be considered of substantial regulatory concern and perhaps intolerable. The primary focus of safety regulation is on ensuring that risks between these 2 limits, identified in FN curve terms as the 'as low as reasonably practicable' region, are appropriately managed so as to meet the 'as low as reasonably practicable' requirement. A summary of the societal risk assessment estimates for 2033 and 2055 is further described in Table 13.3.

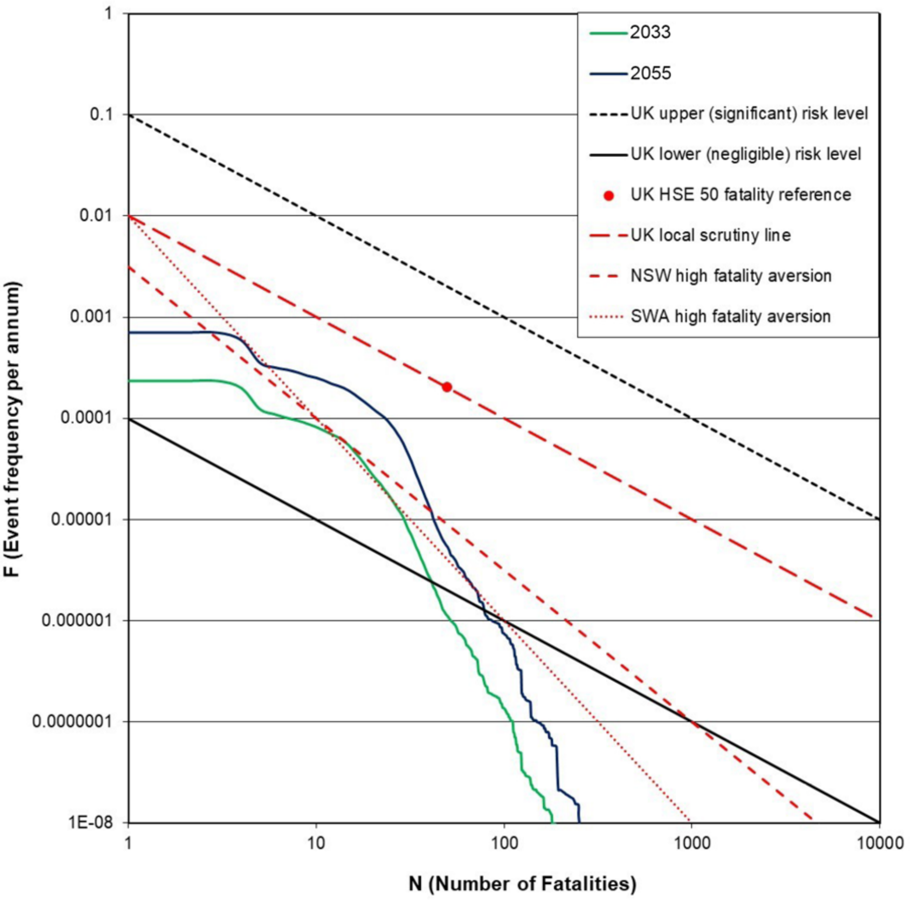


Figure 13.4 Societal risk FN curve for 2033 and 2055 assessment years

Table 13.3 Summary of societal risk assessment estimates for 2033 and 2055

Risk measure	2033	2055
Crashes involving one or more fatalities	0.000236 per annum, or 1 in 4,245 years	0.000706 per annum, or 1 in 1,416 years
Average number of fatalities per crash[1]	9.6	10.7
Expectation value	0.00227 per annum, or 1 in 441 years	0.00755 per annum, or 1 in 132 years
Scaled risk integral value	6,770	24,244

1. As outlined in Section 13.3.2.2, the assessment of societal risk considers the risk posed to the health and safety of persons living and working in the vicinity of an airport, and does not account for aircraft passengers or workers at WSI.

The assessment found that:

- on average, crashes involving one or more fatalities can be expected to occur at a frequency of 1 in 4,245 years and 1 in 1,416 years in 2033 and 2055, respectively
- the average number of fatalities estimated for the full range of scenarios involving crashes of different sized aircraft into the range of population densities encountered along flight paths is around 9.6 and 10.7 for 2033 and 2055, respectively. Incidents resulting in fatalities of 100 or more third parties, which would occur as a result of a larger aircraft crashing into a more densely populated area, are expected to be very uncommon with estimated rates of 1 in 7.3 million years and 1 in 1.3 million years for 2033 and 2055, respectively
- for the 2033 assessment year (refer to Figure 13.4), the total societal risk would:
  - be above the UK criterion level for negligible risk, but well below the UK criterion for significant risk
  - meet the more stringent criteria for additional aversion to high fatality incidents as identified in Australian guidance (NSW and SWA)
- for the 2055 assessment year (refer to Figure 13.4), the societal risks would be broadly similar to the 2033 scenario but somewhat greater, reflecting the increased number of aircraft movements. Specifically that societal risk would:
  - exceed the UK criterion level for negligible risk, but would be well below the UK criterion for significant risk
  - exceed the more stringent criteria for additional aversion to high fatality incidents as identified in Australian guidance (NSW and SWA) for incidents that result in 5 to 50 fatalities. For a higher number of third-party fatalities (in the order of 100 or more), the risk for the project in 2055 is below the Australian guidance criteria (NSW and SWA).

The FN curves for both the 2033 and 2055 assessment years are within the middle to lower risk part of the 'as low as reasonably practicable' region. These risks are considered acceptable, provided no further practicable means for mitigating these residual risks are available. In this regard, based on the runway location, airspace design requirements and the relative location of developed areas within the Sydney Basin, the flight path design has minimised these risks, as far as is practicable.

While the more stringent additional aversion to high fatality incidents criterion would be exceeded in the 2055 assessment year, the comparison to the scaled risk integral (as defined in Republic of Ireland guidance to account for high fatality risk aversion) indicates a relatively moderate societal risk and that this would be below the significant risk threshold of 500,000. This is generally consistent with the conclusions when considering the UK criteria, in that the risks would not be considered entirely negligible but would be below the upper limit in which risks might be considered unacceptable.

Further consideration has been given to the NSW and Australian guidance criteria, noting that the average number of third-party fatalities is estimated at 10. This is substantially below the average number of passenger and crew fatalities that could be expected based on the typical numbers onboard an aircraft. As such, the Australian guidance criteria are not particularly representative of societal risks that are accepted and do not warrant application in this case to assess high fatality risk aversion. Third-party risks at similar levels, if not higher, would be expected at other airports serving comparable numbers of movements.

Expectation values, representing the number of fatalities on average in a year to be expected from the range of identified crash scenarios in terms of the number of fatalities (n) and event frequencies (F), are shown in Table 13.3. This measure provides a relatively simple means of combining the 2 elements of societal risk into one number for comparison with other risks. The estimated fatality rates of 1 in 441 years (2033) and 1 in 132 years (2055) represent relatively low risks, however the expectation value is not employed formally as a basis for defining any risk acceptability criteria.

13.5.2.3 Risks to critical infrastructure

A list of infrastructure has been identified for assessment:

- transport links that cross the extended centreline of the runway or are in the more immediate vicinity of flight paths, such as Elizabeth Drive, the A9, M7, M4 and Nepean River Bridge crossing
- Defence Establishment Orchard Hills, which serves as a munitions store
- major hospitals
- reservoir facilities, from the perspective of structural integrity and contamination risk to water supplies in the event of a crash or by fuel jettisoning in an emergency
- fire initiation risk, in particular in relation to the GBMA.

The areas in the vicinity of WSI subject to relatively high risk are located along flight paths towards the runway ends. The individual risk contours provide a guide to the areas that are subject to more elevated levels of risk and those areas where risks at any individual site can normally be considered to be negligible and acceptable. No infrastructure that might be considered particularly sensitive or critical is located within the area of elevated risk delineated by the 1 in 1,000,000 per annum individual risk contour for 2055.

Transport links

Elizabeth Drive and the A9 pass through the area covered by the 1 in 100,000 per annum contour for the 2055 assessment year at each runway end. Given that an individual motorist or road user is not expected to spend a significant amount of time within the area of elevated risk, no individual is subject to an individual risk above the negligible level of 1 in 1,000,000 per annum. It is nevertheless recognised in NASF Guideline I that many people may be using a transport link at any given time and should be assessed in terms of the density of people using them that might be exposed to the risk.

Three transport routes have been quantitatively assessed (Table 13.4). Other transport routes at similar distances or further away from flight paths would have comparable levels of risk or lower (such as the Nepean River Bridge). These risks were estimated by reference to the crash risks that are predicted across the carriageways out to distances of several kilometres either side of the runway extended centreline. Risks would reduce along these transport links as the distance to the centreline increases.

Table 13.4 Transport link impact risk

Transport link	2033	2055
Elizabeth Drive	4.28×10^{-5} per annum, or 1 in 23,367 years	1.23×10^{-4} per annum, or 1 in 8,137 years
A9	5.36×10^{-5} per annum, or 1 in 18,641 years	1.54×10^{-4} per annum, or 1 in 6,495 years
M7	3.37×10^{-6} per annum, or 1 in 296,742 years	9.14×10^{-6} per annum, or 1 in 109,396 years

The potential impact consequences include fatalities to road users and infrastructure damage. The area affected in the event of an aircraft crash is estimated to be in the order of 0.5 to 0.6 ha in 2033 and 2055, respectively (equivalent to a circle of 40 metre radius).

The number of fatalities for typical densities of use of road links can be expected to be in the order of tens or fewer, on the assumption that several vehicles with several occupants are impacted. This value is generally consistent with the average number of fatalities identified for impacts in residential areas in the societal risk assessment. The overall risk is not particularly significant when assessed against the available societal risk criteria.

The disruption of roads can be expected to be limited (such as repairs over a short period during which alternative routes from the wider network provide mitigation). Longer term disruption could include damage to bridge structures at motorway interchanges. There is limited scope for such events, given the proximity of motorway interchanges to flight paths.

Defence Establishment Orchard Hills

Some Runway 05 departure routes pass close by the Defence Establishment Orchard Hills site, which has been assessed given its munitions storage function. Crash risks across the site are estimated to be 1 in 100,000 years in 2033 and 1 in 43,000 years in 2055. However, much of the site is open space and the risk of impact with site infrastructure would be lower than these estimates. The risks of an impact with a munitions storage building are estimated to be 1 in 2,000,000 years in 2033 and 1 in 835,000 years in 2055.

Crashes can normally be expected to affect a single building only or in the case of impacts of larger aircraft 2 buildings. Protocols for munitions storage at the site will limit the knock-on impacts to other storage buildings in the event of an explosion at one building. The consequences of an impact are expected to be those resulting directly from an impact only.

Major hospitals

Three major hospitals are located in the general vicinity of WSI (Penrith, Liverpool and Westmead hospitals). They represent relatively large potential exposure areas for an aircraft crash (of between around 15 to 25 ha, compared with the estimated crash impact area of 0.5 to 0.6 ha). A crash can therefore be expected to affect only a small proportion of these sites, estimated to be around 2 per cent to 4 per cent.

The highest overall site crash risk probabilities are estimated for Penrith Hospital, which is closer to higher levels of flight activity. Crash risks at Penrith Hospital are estimated to be 1 in 19 million years in 2033 and 1 in 7 million years in 2055. Flight activity near Liverpool and Westmead Hospitals is much lower and lower crash risks have been estimated.

Given the densities of occupation of these sites, high levels of fatalities may potentially arise in the event of an aircraft impact. However, the scale of the fatalities is unlikely to exceed the upper levels that have been estimated according to the societal risk assessment. Taking account of the low event frequencies, the risk associated with these scenarios are low and acceptable when assessed against the available societal risk criteria.

Warragamba Dam and Prospect Reservoir

A limited number of Runway 23 departures pass close to the Warragamba Dam barrage. The probability of an impact directly on the barrage of the Warragamba Dam is estimated to be 1 in 40 million years in 2033 and 1 in 13 million in 2055. A substantially larger area of water at Lake Burragorang is exposed to a crash risk. The frequency of impacts in the lake are estimated to be 1 in 240,000 years in 2033 and 1 in 87,000 years in 2055.

While the contamination of the water is a possibility in the event of a crash, it is expected that significant adverse impacts would not necessarily occur in all instances. The capacity of Lake Burragorang is 3 million tonnes. Fuel spillages may have limited impacts on water quality given the dilution involved.

Prospect Reservoir lies relatively close to (but not directly beneath) the Runway 23 approach path. The event frequencies for Prospect Reservoir are similar to those estimated for Warragamba Dam and Lake Burragorang.

Blue Mountains and other fire initiation risks

Given the fuel load on aircraft, particularly during and shortly after take-off, fuel fires are a potential concern in the event of a crash. Commonly encountered fire impacts following impacts are taken into account in the consequence model used for the assessment of fatality risks. The potential for wider knock-on bushfires in the event of a post-impact fire also merits attention. Jet aviation fuel is of relatively low volatility and requires a fairly powerful ignition source for fire initiation which may be present in some impacts. Analysis of historical incidents indicated around 50 per cent of crashes involve post-impact fire.

The estimated crash rate during take-off and landing for 2055 operations is estimated to be around 1 in 50 years. The corresponding post-impact fire rate is therefore estimated to be around 1 in 100 years. This rate applies in the more immediate vicinity of the runway and covers the majority of the crash events. An additional but relatively small risk applies along airways, beyond the immediate runway, and has been estimated using the available airways model (as described in Appendix C of Technical paper 4). Given its importance, specific attention has been given to the crash risk in the GBMA.

Operation of flight paths over the GBMA is found to present a low risk of introducing fire through aircraft accidents. This is based on an estimate for the crash rate from aircraft during flight over the GBMA ranging between approximately 1 in 1,700 to 1 in 2,400 years in 2055 (as set out in Appendix C of Technical paper 4), and a post-impact fire rate of around half that value (1 in 3,400 to 1 in 4,800 years in 2055). The range in the crash rate risk reflects the likely distribution of traffic movements using the flight paths over the GBMA. This estimate covers all events throughout the year, including events outside the season of primary bushfire risk. Compared with the current fire initiation rates from other causes, this risk can be seen to be very small.

13.5.3 Fuel jettisoning

Fuel jettisoning (or fuel dumping) would be carried out in accordance with the AIP ENR. Fuel jettisoning is a rare occurrence in Australia and only occurs after authorisation from air traffic control. There are very limited occurrences of impacts ground level. Fuel jettisoned at a sufficient altitude would volatise (change from liquid to vapour) as it falls and is completely dispersed as vapour before any liquid reaches ground level. If possible, except in the case of emergencies, fuel jettisoning will be conducted at an altitude of at least 6,000 ft (approximately 1.8 km) above ground level to ensure total dissipation into the atmosphere prior to contacting the ground (as per the AIP ENR).

A total of 145 events (occurrences where an aircraft jettisons or burns off fuel in order to reduce its landing weight to an acceptable limit) in Australian airspace have been recorded in the ATSB National Aviation Occurrence Database between 2003 and 2022. While this database documents accidents and incidents that have been reported to the ATSB since 1 July 2003, systematic reporting and recording of these events did not begin until 2010 and only one recorded incident is from before 2010. For this assessment, the period between 2010 to 2022 has been considered where 144 incidents were reported.

The review of available data indicates that:

- based on the aircraft type or on the information provided, 43 per cent of the occurrences are understood to have involved fuel jettisoning. The occurrences were mostly relatively minor incidents, although there is limited information in the database and only around 78 per cent of the entries identified whether fuel burn off or jettisoning occurred
- the majority of the fuel jettisoning or fuel burn off events occurred shortly after take-off or during the climb (around 77 per cent of occurrences) and one occurred during landing. All other occurrences were enroute incidents.

A review of available ATSB safety investigations on fuel jettisoning incidents or related incidents (noting that only a portion of incidents are investigated) found that:

- 6 incidents of fuel jettisoning occurred over the sea and at altitudes of 7,000 feet (ft) or more. One of the 6 cases involved a deliberate flight path diversion
- one incident occurred during take-off which required the aircraft to return to the departure airport. In this incident, the aircraft remained under 2,000 ft and fuel was not jettisoned as an overweight landing was executed.

The general conclusions to be drawn from the review of incidents identified in the ATSB National Aviation Occurrence Database is that fuel jettisoning can be carried out safely and without any impacts at ground level when appropriate procedures are followed. This is supported by a review of the wider international data.

Further detail is provided in Section 8.1.1 of Technical paper 4.

With respect to potential risks to land in the vicinity of WSI, fuel jettisoning events associated with failures during take-off and climbing phases of flight is of primary relevance. Of the 144 incidents between 2010 and 2022, 43 per cent involved fuel jettisoning and 77 per cent occurring on take-off, representing around 48 fuel jettisoning incidents following take-off.

Based on the operational statistics presented in Appendix A of Technical paper 4, a total of 9,281,707 commercial air transport take-off operations are estimated to have taken place over the period 2010 to 2022 from which an incident rate of 5.17×10^{-6} per take-off movement is estimated. When considering the annual aircraft movements at WSI in 2055 (around 226,000 aircraft movements), this rate translates to slightly less than one fuel jettisoning event per annum.

There are limited occurrences only of impacts at ground level associated with fuel jettisoning in the wider international incident record, confirming that this is a very small risk. The likelihood of a fuel jettisoning event that results in ground level impacts is expected to be less than the likelihood of an aircraft crash during take-off or landing at WSI.

In terms of the potential risks to sensitive receiving environments (e.g., water supplies), analysis indicates that fuel jettisoning represents less of a threat than a direct aircraft crash impact. As a fuel jettisoning incident that results in ground level impacts in the vicinity of WSI is estimated to be extremely remote, events with tangible impacts on potentially sensitive receiving environments would be even less likely and therefore would be exceedingly remote.

Overall, fuel jettisoning is a relatively uncommon non-standard operational requirement that would not have ground level impacts if carried out in accordance with appropriate procedures. There would be no significant adverse impact from fuel jettisoning associated with the project. While it cannot be guaranteed that such impacts could never occur, the historical record indicates that any such incident would be a very remote event.

13.5.4 Objects from falling aircraft

A total of 189 occurrences of objects falling from aircraft involving commercial air transport movements between 2003 and 2022 have been identified from a search of the ATSB National Aviation Occurrence Database. Across all phases of flight, 115 occurrences were associated with commercial air transport movements that may be considered representative of future operations at WSI. Approximately 50 per cent of these occurrences took place in the general vicinity of airports during take-off, initial climb, approach and landing. With consideration to the number of flights over that period of time, it is estimated that this type of incident during these phases of flight occurs around 1 in 300,000 flights (1 in 600,000 take-off and landing movements). On that basis, it is estimated that such incidents would be 1 in 3 year events for the level of activity forecast in 2055.

Two of the identified occurrences affecting fixed wing commercial air transport movements are identified as serious incidents and the remainder are identified as incidents. No injuries are reported to have occurred in any of these occurrences and those classified as serious incidents were evidently given that classification due to the potential threat to aircraft safety associated with the loss of the falling object rather than any identified threat to third parties. A wide variety of objects were involved in these reported occurrences, including maintenance inspection panels (as a relatively common item), baggage from aircraft holds following cargo door failure events, and various smaller items such as windscreen wipers and VHF antennas. While small, falling objects may lead to a significant injury to an individual on the ground.

The consequence of an impact would be substantially smaller than the consequence of an aircraft impact, but the frequency of such an event is greater. The frequency of an aircraft crash is around 1 in 50 years compared to a risk of 1 in 3 years for an object falling from aircraft in 2055. However, the risk of an object falling from aircraft is small compared to the risks of an aircraft crash when considering the consequence and frequency of such an event. As outlined in Section 8.2 of Technical paper 4, the impact area associated with the largest object would not be greater than 1 m^2 or around 6,000 times smaller than the average aircraft crash areas in 2055. Considering the different scale in consequence and rate of incidence, the risk associated with an object falling from aircraft is estimated to be more than 300 times smaller than the risk associated with an aircraft crash.

Given that the risks associated with aircraft crashes have been shown to be low and acceptable, it is concluded that the lesser risks associated with objects falling from aircraft are low and acceptable. Further detail is provided in Section 8.2 of Technical paper 4.

13.5.5 Wake vortex impacts

In generating the lift forces necessary to allow an aircraft to fly, its wings generate movements in the volume of air through which the aircraft passes. The most significant of these are spiralling movements of air flowing from each wingtip leading to a pair of wake vortices that trail behind the aircraft and tend to descend as they rotate. Vortices are an unavoidable consequence of aerodynamic lift and are generated by all aircraft in all phases of flight. Vortices generally dissipate without causing any physical impacts. However, when aircraft are relatively close to the ground during landing (i.e., shortly before touchdown), vortices sometimes reach the ground and have sufficient power to cause building damage. The strongest vortices are generated by heavy aircraft flying at low speed, during approach.

Vortex damage incidents typically involve the disturbance of tiles or slates on the roofs of traditionally constructed houses. Vortex damage is more frequently encountered at busier airports serving larger wide-bodied jets where housing is located close to the flight paths and runway ends.

The likelihood of vortex damage is dependent upon several different factors:

- the size of the aircraft operating at WSI
- the distance between the approach path and buildings along it (vertical and lateral)
- weather conditions at the time of the operation
- the susceptibility of a building to damage (based on its construction).

The statistics for London Heathrow Airport (Heathrow Airport) provide a reasonable basis for assessing the potential for wake vortex impacts at WSI as there is a broad similarity of the fleet mixes anticipated at WSI and those operating at Heathrow Airport. However, it is acknowledged that the possible differences in meteorological conditions may influence the relative rates and location of occurrence.

A review of vortex strike records for Heathrow Airport indicates an annual average of around 102 verified strikes between 2006 and 2010. Annual aircraft movements during that period were around 470,000. Given the prevailing westerly wind conditions, most approach operations at Heathrow Airport (typically 75–80 per cent) take place over predominantly urban development. A relatively high probability of wake vortex events at Heathrow Airport is therefore expected. The records also indicate that most events are contained within 4 km from the end of the runway (runway threshold) in a funnel of around 14 degrees extending either side of the approach path. Observations from Heathrow Airport and the number of annual movements at WSI in 2055 suggest that around 50 wake vortex events that have the potential to cause roof damage could occur annually, if the vortices occur at a building that is susceptible to damage. Based on observations at Heathrow Airport, it is expected that most of these events would be contained within an area that extends from the runway threshold for around 4 km in a funnel shape of around 14 degrees either side of the approach path (refer to Figure 13.5).

There is a limited number of buildings located in the area where possible wake vortex damage from WSI operations could occur. From the available satellite images only one building with a tiled roof was identified that may be susceptible to wake vortex damage. This building is located towards the periphery of the area subject to potential wake vortex damage, therefore the probability of impact is expected to be low.

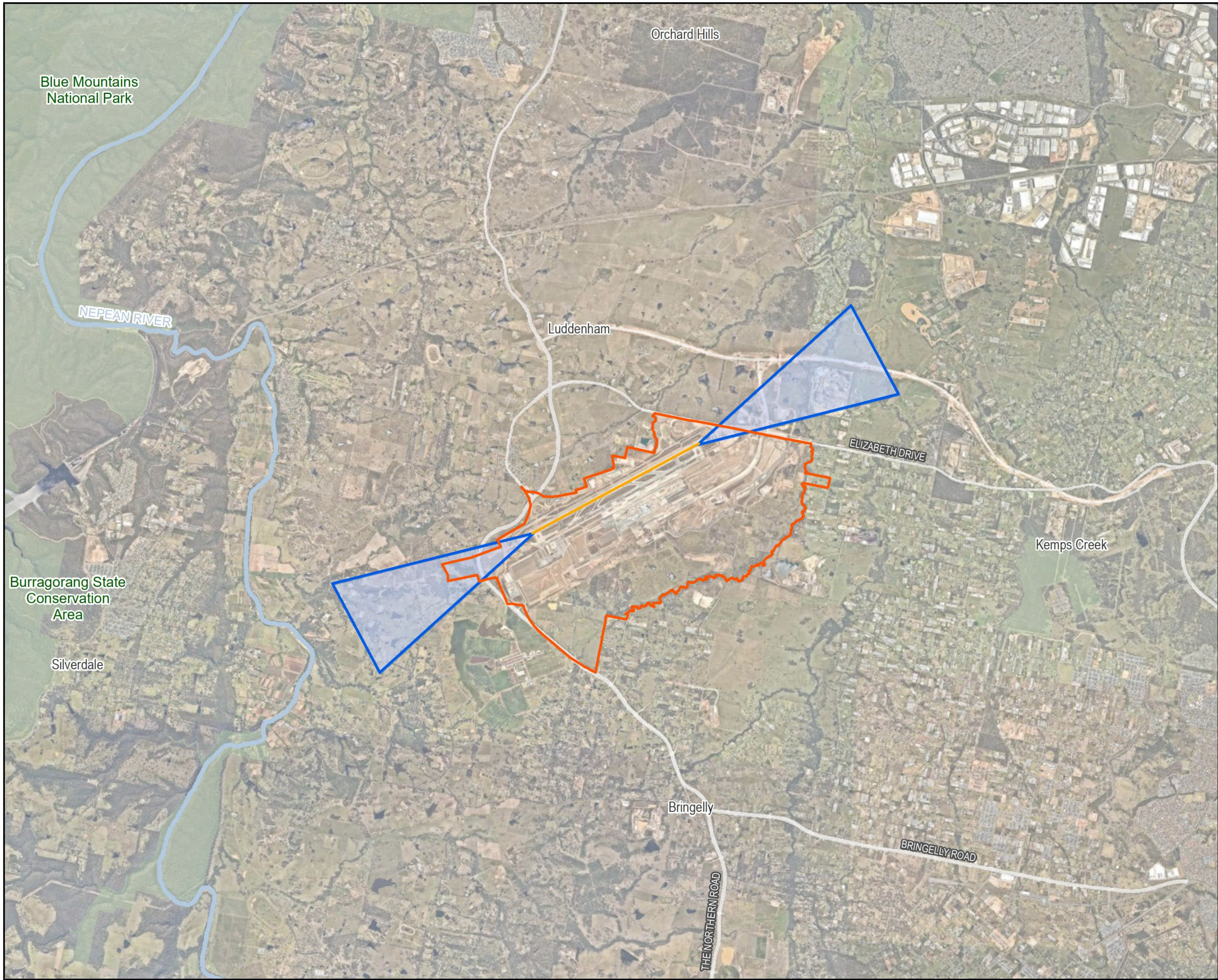
Overall, there is a low risk of wake vortex damage associated with the project due to:

- the limited number of buildings located in areas where wake vortex damage is identified as a possibility
- the type of roof construction adopted for most of the buildings
- the low probability of impacts in the area where potentially susceptible roofs are located.

In the unlikely event of damage occurring, this can be effectively addressed by the compensation scheme operated by Airservices Australia in accordance with the *Air Services Regulation 1995* (Cth).

Figure 13.5

Areas subject to potential wake vortex damage



Legend

- WSI Runway
- Western Sydney International (Nancy-Bird Walton) Airport land boundary
- Wake vortex

0 1 2 km

Coordinate system: GDA 1994 NSW Lambert

Scale ratio correct when printed at A4

1:100,000 Date: 21/04/2023

Data sources: - DITRDC, DCS, Nearmap, Geoscience Australia
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community

NASF principles and guidelines *Guideline B: Managing the Risk of Building Generated Windshear and Turbulence at Airports* (NASF Guideline B) refers to wake vortex as a component of overall turbulence impacts and provides some high-level guidance for building design to minimise future impacts, in the event new development is proposed in the identified wake vortex area. At WSI, there are no off-airport planning controls that relate specifically to the management of risk to buildings due to wake vortex associated with the Western Parkland City SEPP. However, in regard to most land uses, other planning controls are already in place which would serve to reduce development within the wake vortex area and minimise impacts to buildings from turbulence. This includes the Obstacle Limitation Surface, Public Safety Areas and the ANEC contours which restrict certain land use types within the ANEC 20 and above contours (refer to Technical paper 6 (Land use and planning) (Technical paper 6)). These are all in proximity to the wake vortex area identified for WSI and would to some extent address the associated impacts.

13.5.6 Meteorological hazards

The extent to which potential adverse meteorological conditions may represent hazards to aircraft operations at WSI and lead to real risks to operational safety has been assessed by reference to the ATSB National Aviation Occurrence Database and site-specific assessment of local conditions at WSI provided by the Western Sydney Airport Usability Report (Bureau of Meteorology, 2015).

Around 5,097 weather-related occurrences since 2003 have been identified in the ATSB database, with turbulence and windshear accounting for around 68 per cent of occurrences, and lighting strike accounting for 25 per cent. The majority of these occurrences were classified as incidents, 49 as serious incidents and 28 as accidents, 2 of which resulted in fatalities. Both accidents that resulted in fatalities involved relatively small piston-engine powered aircraft operating charter passenger flights.

Of the 28 occurrences identified as accidents, 12 involved turbofan powered aircraft or turboprop powered aircraft. 10 of these 12 occurrences were classified in the turbulence, windshear and microburst category.

Weather related occurrences were reported across the full range of phases of flight. Around 20 per cent were in the cruise phase and 80 per cent spread across take-off, initial climb, climb, descent, approach and landing.

Weather related factors have potentially significant implications for the safety and efficiency of aircraft operations. The most significant factor was identified as turbulence and windshear. However, the severity of the consequence is normally relatively limited.

The types of turbofan and turboprop aircraft that would operate at WSI are normally expected to be resilient to turbulence and windshear. The historical records indicate that the consequences of such encounters are typically limited to injuries to low numbers of aircraft occupants not using seat belts. Nevertheless, it is evident from the wider international dataset that such weather phenomena may lead to aircraft crashes when they are encountered relatively close to the ground, near airports.

Weather phenomena that may adversely affect operations at WSI have been considered in detail in the Western Sydney Airport Usability Report (Bureau of Meteorology, 2015). Meteorological characteristics considered in the usability report include wind, temperature, rainfall, fog and low cloud, turbulence and thunderstorms. The report focuses on the operational implications of meteorological conditions at WSI, based on recent historical weather records and concludes:

- the runway configuration would be usable approximately 99.5 per cent of the time based on crosswinds alone
- other weather phenomena, such as fog, low cloud and low visibility conditions, may lower the usability of WSI but that these impacts could be mitigated through navigational systems and aids
- WSI would be less susceptible to turbulence and wind shear than Sydney (Kingsford Smith) Airport and identifies no particular concerns about these weather phenomena
- the proximity (around 20 km) of the Airport Site to the Great Dividing Range (Blue Mountains) means that a short lead time for thunderstorm aerodrome warnings would be available and recommended that an Automated Thunderstorm Alert Service (ATSAS) is implemented at WSI to improve the accuracy of thunderstorm forecasting.

The potential for adverse meteorological conditions, in particular turbulence, wind shear and thunderstorm activity, is evident. The available historical evidence indicates that the risk of these types of occurrences leading to a real threat to aircraft safety is limited. Compared with other airports which operate with an acceptable level of safety, there are no exceptional meteorological conditions at WSI that might lead to significant risks to operational safety.

Measures to identify and avoid adverse weather conditions are applied generally in the air transport industry to limit the risk to aircraft safety. Airservices Australia works with the Bureau of Meteorology to advise pilots of hazards as appropriate, such as haze or smoke caused by bushfires or controlled burning. Where smoke does reduce visibility at an airport, usual procedures for flying in low-visibility conditions would apply. The implementation of an ATSAS at WSI would help mitigate the identified site-specific susceptibility to potential thunderstorm activity.

While these measures are primarily directed towards the provision of aircraft safety, they would support the achievement of acceptable levels of safety for third parties in the vicinity of WSI. The generic aircraft crash risk model that has been used to determine the level of risks to third parties takes account of a wide range of causal factors, including weather-related accident scenarios. No specific weather related risks to aircraft operations at WSI were identified that would suggest that the risk estimates provided by the available generic model do not adequately represent the risk to third parties in the vicinity of WSI.

Climate related risks to aviation associated with WSI flight paths are discussed in Chapter 3 of Technical paper 3 (Greenhouse gas) (Technical paper 3). Higher temperatures and more severe heat waves are climate related risks for WSI (refer to Table 3.1 of Technical paper 3), however the assessment did not find evidence to demonstrate that increased temperatures associated with climate change would have a material impact on the rate of operational failures as a result of adoption of the flight paths. Previous international operational experience covers a wide range of temperatures, including those expected to be at WSI under anticipated climate change scenarios, and operational practices are in place to ensure safe operations under those conditions.

13.5.7 Wildlife hazards

Wildlife strikes with aircraft can present a significant risk to aircraft safety. Consequences can be very serious, resulting in human fatalities and loss of aircraft. They can also result in significant costs due to the repair of damaged aircraft or operating costs due to downtime. Strike risk depends on the probability of colliding with wildlife and the consequence to the aircraft if collision occurs. The probability is determined by a number of factors including the number of wildlife and aircraft operating in the same airspace, the airspeed, and altitude. The consequence of a strike is influenced by the number and size of the animals struck, the combined closing speed, the phase of flight and the part of the aircraft hit.

Wildlife strikes rarely have catastrophic outcomes for aircraft in Australia. The ATSB received 22,526 wildlife related occurrences for civil aircraft operations between 2003 and 2022. Of these occurrences that involved wildlife strike, one of these occurrences was classified as an accident (due to the scale of aircraft damage) and 2 were classified as serious incidents which resulted in minor damage. These were a result of kangaroo or bird strike during aircraft landing. None resulted in human fatalities or injury.

Most of the reported incidents involved bird strikes and resulted in minor or no aircraft damage and no injuries.
Bird strike hazards that have potential implications for third party safety are concentrated at and in the immediate vicinity of an airport with 75 per cent of incidents occurring during take-off or landing and 22.5 per cent during the initial climb and approach.

In civil aviation, around 93 per cent of strikes occur at or below 3,500 ft (Dolbeer, 2011). As such, the primary concern for wildlife strikes occurs along the approach and departure paths at or below this altitude. While strikes above 3,500 ft can occur with thermal soaring species, such as the Australia Pelican and Wedge-tailed Eagle, the frequency of high-altitude strikes is comparatively low.

Managing wildlife hazards on airports is regulated by Civil Aviation Safety Regulations (CASR) (1998) Part 139 (Aerodromes) Manual of Standards (MOS) as defined by the *Civil Aviation Act 1998*. A number of other State, national and international legislation, regulations, policies and guidance documents also guide the management of wildlife hazards on- and off-airports. This includes the various ICAO documents, the *NASF Guideline C: Managing the Risk of Wildlife Strikes in the Vicinity of Airports*, the Western Parkland City SEPP, and the Western Sydney Aerotropolis Development Control Plan (DCP).

As such, safeguarding WSI against wildlife hazards requires a multi-stakeholder approach. WSA Co will prepare, in accordance with civil aviation regulations, a wildlife management program that focuses on the Airport Site, however land users and relevant consent authorities within the vicinity of WSI must adhere to the safeguarding principles set out in the Western Parkland City SEPP and Western Sydney Aerotropolis DCP.

Based on the available survey data of the Airport Site, one species (the Eastern Grey Kangaroo) was identified as a very high species risk. The risk posed by this species would be minimal once WSI is fully contained by perimeter fencing and the existing population is removed. Eight avian and terrestrial fauna species were identified as a high species risk (Straw-necked Ibis, Australian White Ibis, European Brown Hare, Red Fox, Wood Duck, Pacific Black Duck, Little Black Cormorant and Chestnut Teal).

Birds flying over the runway and not using the airside area accounted for almost half of the in-air observations, and the Australian White Ibis accounted for 62 per cent of these observations. The Australian White Ibis was also the most observed species during on-airport surveys. This was attributed to active breeding colonies and access to resources in the vicinity of WSI. Australian White Ibis populations close to other Australian airports have created significant strike risks and have resulted in some serious strike events.

Based on the species recorded, habitat values and location of off-airport habitat relative to Runway 05/23, 6 of the 76 potential habitat sites within 13 km of Runway 05/23 were rated as having a very high land use risk (Duncan Creek) or high land use risk (ponds near Elizabeth Drive and Wolstenholme Avenue, Kemps Creek Resource Recovery Park, Western Sydney Parklands and the Lake Gillawarna Ibis Colony).

Bats (recorded as fruit bat, bat and Flying-fox) were the most reported species group struck at Australian airports between 2008 and 2017 (1,240 strikes) and over 10 per cent of these strikes resulted in damage to aircraft (ATSB, 2019). The primary conflict with aircraft with Flying-foxes would occur when they infringe on the airspace when travelling to or from foraging and roosting sites. Ninety-six per cent of Flying-fox collisions with aircraft occur at or below 1,000 ft above ground level (AGL), with the majority below 500 ft (Parsons et al., 2008) which indicates that areas within flight paths and at airports have the greatest strike risk from Flying-foxes. The conflict with WSI aircraft would depend on the altitude of the Flying-fox and aircraft. However, Flying-fox strikes are likely once WSI is operational given the high number of Flying-fox camps in the vicinity of WSI. To practically minimise the likelihood of collision, further understanding of foraging patterns is required in order to notify air traffic control if collision probability is high.

While wildlife presents a potential significant threat to aircraft safety, it can be effectively managed so that, for the most part, wildlife-related occurrences primarily give rise to financial costs to the commercial civil aviation industry (in respect to repair of damaged engines and airframes) rather than significant safety risks. Acceptable wildlife strike risk mitigation for WSI is achievable with the implementation of a rigorous and integrated wildlife management program that recognises site-specific characteristics alongside the effective implementation of safeguarding principles on land within 13 km of Runway 05/23. Any contribution to third party risks resulting from wildlife hazards can be expected to be small with the implementation of these measures. The likelihood of a wildlife strike leading to a ground impact in the vicinity of WSI would be negligible, compared with the overall crash probability which is itself very small. In the unlikely event of a wildlife strike compromising aircraft safety to the extent that a ground impact were to occur, the most likely locations affected will be within or close to the runway where harm to third parties would not arise.

Species recorded during the surveys are also indicative of the suite of species likely to occur at WSI and surrounds once WSI is operational. Changes to the landscape, including the objective of increasing tree canopy cover by 40 per cent in the Western Sydney Aerotropolis, means that it is difficult to accurately quantify how wildlife populations would respond. Ongoing monitoring would be critical to identify trends and ensure the early detection of wildlife issues. This is discussed further in Section 13.6.

13.6 Mitigation and management

13.6.1 Existing management

Strategic planning in the vicinity of WSI has considered and incorporated the operational needs of WSI into land use planning in accordance with guidance provided in the NASF. This has been ongoing for over a decade in conjunction with planning for WSI and is well established in existing planning instruments. The NSW Department of Planning and Environment's *Aviation Safeguarding Guidelines – Western Sydney Aerotropolis and surrounding areas* were also developed with input from DITRDCA and seek to ensure planning authorities consider WSI operations when undertaking land use planning for the Aerotropolis and surrounding areas of influence. Current planning provisions for land associated with the Aerotropolis has been developed in conjunction with the NASF specifically to support the operation of WSI and limit potential restrictions on surrounding land uses (and therefore risks to third parties or surrounding development).

With respect to aircraft wake vortex impacts, in the unlikely event of building damage occurring, mitigation is available through the compensation scheme operated by Airservices Australia which provides for repairs under the *Air Services Regulations 1995* (Cth).

13.6.2 Project specific mitigation measures

Consideration has been given to management and mitigation measures for the following hazards:

- airspace conflicts
- residual off-airport aircraft crash risks to third parties and critical infrastructure
- aircraft fuel jettisoning
- local meteorological hazards
- local bird and bat strike hazards.

Risk mitigation is provided by a wide variety of general measures adopted across the aviation industry that will apply to operations at WSI. WSI specific recommendations for mitigation have been identified, and are summarised in Table 13.5 and supported by the proposed monitoring program in Table 13.6.

Table 13.5 Proposed mitigation measures – aircraft hazard and risk

ID No.	Issue	Mitigation measure	Owner	Timing
HR1	Airspace conflicts	Airservices Australia will continue to address hazard identification and risk mitigation during the remainder of the design process and prioritise on-going safety performance monitoring.	Airservices Australia	**Pre-operation** (Detailed design, 2024–2026)
HR2	Contingency planning	WSA Co will implement contingency planning to respond to the impacts of crash events as per Part 139 Aerodromes Manual of Standards 2019.	WSA Co	**Operation** (Implementation, 2026–ongoing)
HR3	Aircraft fuel jettisoning	Airservices Australia will apply existing procedures to deal with aircraft fuel jettisoning occurrences as per AIP ENR.	Airservices Australia	**Operation** (Implementation, 2026–ongoing)
HR4	Local meteorological hazards	Automated Thunderstorm Alert Service (ATSAS) will be implemented by the Bureau of Meteorology (BoM) to provide improved thunderstorm forecasting. Implementation of a Doppler LIDAR, if required, will support the identification of turbulence and wind shear (subject to the conclusions of an appropriate cost-benefit study).	WSA Co (in coordination with BoM)	**Operation** (Implementation, 2026–ongoing)
HR5	Wildlife strike	WSA Co will monitor and control the presence of birds and other wildlife on or in the vicinity of WSI in accordance with Civil Aviation Safety Regulations (CASR) Part 139 MOS requirements and National Airports Safeguarding Framework (NASF) Guideline C (See Table 24.2).	WSA Co	**Operation** (Implementation, 2026–ongoing)
HR6	Wildlife strike	WSA Co will liaise with planning authorities on matters related to the development of, or modifications to, off-airport land uses that have the potential to attract hazardous numbers or types of wildlife.	WSA Co	**Pre-operation** (Detailed design, 2024–2026) and **Operation** (Implementation, 2026–ongoing)
HR7	Wildlife strike	WSA Co will establish a WSI Wildlife Hazard Management Committee (WHMC) that will likely comprise Western Sydney local government representatives, NSW Department of Planning and Environment and other relevant aviation stakeholders.	WSA Co	**Operation** (within 6 months of Implementation, 2026–ongoing)

ID No.	Issue	Mitigation measure	Owner	Timing
HR8	Wildlife strike	The WHMC will contribute to the preparation of regional species management programs (including Australian White Ibis) as required. Regional species management plans will build on any existing management programs (e.g. the Canterbury-Bankstown Council Australian White Ibis Management Program). The regional programs will aim to: • reduce species impacts on aviation and the community in general • provide advice to landowners on how they can contribute to species management programs on non-council land • establish measurable targets for species management • maintain the long-term sustainability of the local species populations.	WSA Co	**Operation** (Implementation, 2026–ongoing)

Table 13.6 Proposed monitoring program – aircraft hazard and risk

ID No.	Issue	Monitoring measure	Owner	Timing
M2	Wildlife strike	A bird and bat strike monitoring program will be conducted to monitor for the presence of wildlife on the WSI site and in vicinity of WSI. The monitoring program will: • identify wildlife hazards which must be assessed to reduce potential risk to aircraft operations • be conducted in accordance with relevant Commonwealth and State guidelines and standards including any recovery plans for threatened species • carried out under the direction of a suitably qualified person • be carried out in liaison with local government in relation to plans for proposed developments within 13 km of WSI that are likely to increase bird and bat strike • identify locations where reasonable and feasible mitigation measures to manage wildlife strike risk are required • be reviewed annually to determine its effectiveness.	WSA Co	**Operation** (Implementation, 2026–ongoing)