VOLUME 4

Appendix H
Hazard and risk

DUE DILIGENCE ENGINEERS

GHD

WESTERN SYDNEY AIRPORT EIS HAZARD AND RISK REVIEW

AUGUST 2016

DOCUMENT CONTROL

This document has been prepared to the particular instructions of our client or responsible R2A director. It should only be used for the purpose for which it has been commissioned.

Risk is peculiar to time, place and circumstance. So unless specifically indicated to the contrary, this report only applies to the particular situation or scenario that is the subject of this commission.

PROJECT DETAILS

Client:	GHD
Project Name:	Western Sydney Airport EIS Hazard and Risk Review
Client Reference:	RFQTS 2014/7540 WSA
R2A Reference:	213-11

REVISION SCHEDULE

VERSION	DATE	DESCRIPTION	PREPARED BY:	REVIEWED BY:	ISSUE AUTH BY:
0.9	18/6/15	Draft report	GF/RR	JA/SR	
0.95	24/6/15	2nd draft	RR	GF	
0.96	13/7/15	Client feedback	RR	GF	
1.0	4/8/15	First release	GF	RR	
2.0	8/9/15	2nd release following advice from AGS	GF	RR	RR
2.1	18/04/16	Section 1.1 modified at request of WSU	GF	RR	RR
2.2	24/08/16	Section 1.1 update	RR	TP	RR

DISTRIBUTION

	DISTRIBUTION	NUMBER	COMMENTS
i	Client	1	Greg Marshall
Ii	R2A	1	Client File
	Total	2	

TABLE OF CONTENTS

EXECUTIVE SUMMARY

R2A has been commissioned by GHD to complete a Hazard and Risk review for the Western Sydney Airport Environmental Impact Statement (EIS). The EIS is being undertaken in accordance with the requirements of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and the guidelines issued for the EIS (Reference: EPBC 2014/7391).

A precautionary based approach to the risk assessment was adopted which is consistent with the provisions of both the Commonwealth *Work Health and Safety Act 2011* and the NSW *Work Health and Safety Act 2011.* The approach included a desktop review with input from various project stakeholders regarding the key construction and operational safety risks for the nominal design years 2030 (single runway) and 2063 (two runways).

Regarding potential aircraft safety issues associated with the proposed Stage 1 (single runway) development, the indicative flight paths prepared by Airservices Australia mostly eliminate interactions with existing air traffic in the Sydney basin and also avoid existing major infrastructure including Defence Establishment Orchard Hills, Warragamba Dam and Prospect Reservoir. No unmanageable airspace safety issues were identified by the study for the proposed Stage 1 airport development.

The subsequent development of final flight paths and procedures for the proposed Western Sydney Airport (WSA) and related airspace design would occur under the existing airspace management arrangements established by Airservices Australia with approvals from the Civil Aviation Safety Authority (CASA). Those processes include a significant focus on safety and risk management as well as other issues.

The development of the second (southern) runway around 2050 may require significantly greater airspace planning and design due to the complexity of managing aircraft movements at the proposed Western Sydney Airport, Sydney (Kingsford Smith) Airport and other airports in the Sydney basin. To facilitate the expected level of future demand, and based on current air safety controls and technology, a reconfiguration of the Sydney basin airspace may be necessary.

The delivery and storage of fuel is also an important issue which will require further consideration and design. It is expected that the proposed airport would be initially serviced by B-double fuel tanker trucks. In 2030, the forecast fuel demand would require the mobilisation of approximately 43 B-doubles of fuel per day. If a dedicated fuel supply pipeline was not provided, the number of truck movements would need to increase in line with the growth in air traffic. The transport of fuel by trucks presents a potential safety hazard for other road users and adjacent facilities.

A potential worst case fuel storage fire has been modelled at the airport site. Depending on the expected adjacent land use further precautions for off-site facilities may be required with the presently planned 80m buffer. Both fuel supply and fuel storage issues should be further investigated during detailed design to incorporate appropriate hazard elimination and reduction measures.

A number of the issues identified through this risk assessment relate to the construction phase of the proposed Stage 1 airport development. Separate desktop risk assessments were conducted for bushfire, flooding and contaminated land. Risks identified in relation to these matters, are proposed to be managed through the preparation and implementation of issue-specific management plans. Other potential construction issues include storage and management of fuels, chemicals and any combustible gases. In these cases, adoption of industry standard practices would largely manage the risk they pose to users and the environment.

Details regarding the specific risks and precautions are contained in Section 5.

1. INTRODUCTION AND BACKGROUND

1.1 WESTERN SYDNEY AIRPORT PROPOSAL

Planning investigations to identify a site for a second Sydney airport first commenced in 1946, with a number of comprehensive studies—including two previous environmental impact statements for a site at Badgerys Creek—having been completed over the last 30 years.

More recently, the Joint Study on Aviation Capacity in the Sydney Region (Department of Infrastructure and Transport, 2012) and A Study of Wilton and RAAF Base Richmond for civil aviation operations (Department of Infrastructure and Transport, 2013) led to the Australian Government announcement on 15 April 2014 that Badgerys Creek will be the site of a new airport for Western Sydney. The airport is proposed to be developed on approximately 1,780 hectares of land acquired by the Commonwealth in the 1980s and 1990s. Airport operations are expected to commence in the mid-2020s.

The proposed airport would provide both domestic and international services, with development staged in response to demand. The initial development of the proposed airport (referred to as the Stage 1 development) would include a single, 3,700 metre runway coupled with landside and airside facilities such as passenger terminals, cargo and maintenance areas, car parks and navigational instrumentation capable of facilitating the safe and efficient movement of approximately 10 million passengers per year as well as freight operations. To maximise the potential of the site, the airport is proposed to operate on a 24 hour basis. Consistent with the practice at all federally leased airports, non-aeronautical commercial uses could be permitted on the airport site subject to relevant approvals.

While the proposed Stage 1 development does not currently include a rail service, planning for the proposed airport preserves flexibility for several possible rail alignments including a potential express service. A joint scoping study is being undertaken with the NSW Government to determine rail needs for Western Sydney and the airport. A potential final rail alignment will be determined through the joint scoping study with the New South Wales Government, with any significant enabling work required during Stage 1 expected to be subject to a separate approval and environmental assessment process.

As demand increases, additional aviation infrastructure and aviation support precincts are expected to be developed until the first runway reaches capacity at around 37 million passenger movements. At this time, expected to be around 2050, a second parallel runway is expected to be required. In the long term, approximately 40 years after operations commence, the airport development is expected to fully occupy the airport site, with additional passenger and transport facilities for around 82 million passenger movements per year.

On 23 December 2014, the Australian Government Minister for the Environment determined that the construction and operation of the airport would require assessment in accordance with the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act). Guidelines for the content of an environmental impact statement (EIS) were issued in January 2015.

Approval for the construction and operation of the proposed airport will be controlled by the Airports Act 1996 (Cth) (Airports Act). The Airports Act provides for the preparation of an Airport Plan, which will serve as the authorisation for the development of the proposed airport.

The Australian Government Department of Infrastructure and Regional Development is undertaking detailed planning and investigations for the proposed airport, including the development of an Airport Plan. A draft Airport Plan was exhibited for public comment with the draft EIS late in 2015.

Following receipt of public comments, a revised draft Airport Plan has been developed. The revised draft Airport Plan is the primary source of reference for, and companion document to, the EIS. The revised draft Airport Plan identifies a staged development of the proposed airport. It provides details of the initial development being authorised, as well as a long-term vision of the airport's development over a number of stages. This enables preliminary consideration of the implications of long term airport operations. Any airport development beyond Stage 1, including the construction of additional terminal areas or supporting infrastructure to expand the capacity of the airport using the first runway or construction of a second runway, would be managed in accordance with the existing process in the Airports Act. This includes a requirement that, for major airport developments (defined in the Airports Act), a major development plan be approved by the Australian Government Minister for Infrastructure and Regional Development following a referral under the EPBC Act.

The Airport Plan will be required to include any conditions notified by the Environment Minister following this EIS. Any subsequent approvals for future stages of the development will form part of the airport lessee company's responsibilities in accordance with the relevant legislation.

1.2 EXISTING SITE CONTEXT

The airport site is situated about 56 kilometres south-west of the Sydney CBD and about 50 kilometres west of Sydney (Kingsford Smith) Airport (KSA). The site terrain comprises low lying hills with several watercourses and farm dams. The major land uses currently comprise low density rural residential and agricultural land uses. The site is bounded by Elizabeth Drive to the north, Willowdene Avenue to the south-west, the village of Luddenham and Adams Road to the west and Badgerys Creek to the south-east. The Northern Road currently passes through the site but would be diverted prior to construction commencing.

In terms of existing major infrastructure, the area surrounding the airport site includes the Defence Establishment Orchard Hills approximately six kilometres to the north, Warragamba Dam approximately 10 kilometres to the west, and Prospect Reservoir approximately 14 kilometres to the north-west. Existing residential areas fringing the site include the villages of Luddenham, Greendale, Bringelly and Badgerys Creek.

Two major future developments will abut the airport site subject to rezoning and based on regional plans undertaken by the NSW Department of Planning and Environment. The South West Priority Growth Area is located directly to the south-east and east of the airport site. The area is approximately 17,000 hectares in size and, on current forecasts, is expected to provide 110,000 new dwellings. The potential extension of the South West Rail Link corridor from Leppington, which may include an extension to, or through, the airport site and extend further north, is likely to pass through the Growth Area.

The NSW Government has also established the Western Sydney Employment Area (WSEA) to provide businesses in Western Sydney with land for industry and employment generating uses, including transport and logistics, warehousing and commercial office space. In January 2015, the WSEA was extended to include land adjacent to the airport site (known as the Broader WSEA).

1.3 OBJECTIVE OF THIS REVIEW

R2A has been commissioned by GHD to complete a Hazard and Risk (safety) review for the Western Sydney Airport (WSA) Environmental Impact Statement (EIS). The EIS is being undertaken in accordance with the requirements of the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. In relation to hazards and risks, the guidelines issued for the EIS (Reference: EPBC 2014/7391) require consideration of (Section 5 (g)):

- bird or bat airstrike
- creation of any risks or hazards to people or property that may be associated with any component of the action (i.e. the construction and operation of the airport).

This review identifies, assesses and documents these risks and other issues using a precautionary based approach that leverages the knowledge of key regulators and stakeholders (refer Section 4).

This review provides an assessment of the following key reference points for the proposed airport:

- the Stage 1 airport development, which has an estimated construction time frame of 2016-2024 and an operational reference date of 2030 (when it is anticipated that the proposed airport will handle approximately 10 million passengers per year); and
- a long term development, which involves two parallel runways, using an operational reference date of 2063 (when it is anticipated that the proposed airport would handle approximately 82 million passengers per year).

1.4 STRUCTURE OF THIS REPORT

The remainder of this report is structured as follows:

- Section 2 – introduces the philosophy of the precautionary approach to risk assessment.
- Section 3 – outlines the key existing legislation and guidelines relevant to airspace protection, airport operation and transport of dangerous goods.
- Section 4 – presents the methodology adopted for the study
- Section 5 – documents the findings of the risk review
- Section 6 – summarises the key precautions and mitigation measures resulting from the risk review.

1.5 REVIEW LIMITATIONS

This review is being completed at an early stage in the concept development of the proposed new airport to ensure that any overarching safety issues are identified prior to construction and operation. It is based on information available at the time of writing this report. A list of referenced documents is contained in Section 7 *References*.

WHS legislation will apply to the future design, construction and operation of the airport. All safety risks will need to be assessed prior to work commencing by any person who will be conducting a business or undertaking (PCBU) as part of the proposed airport in line with their duty as a PCBU under WHS legislation.

However, it is not possible at this preliminary design stage to identify what businesses or undertakings will be conducted or the persons who will be conducting those businesses or undertakings. This means that it is not possible to demonstrate safety due diligence consistent with the provisions of the WHS legislation at this time.

Accordingly the hazards and risk review process has been limited to:

- A high-level outline of the type and nature of the hazards and risks that may be expected to arise as a result of the construction and anticipated operations of the proposed airport, and
- Identification of possible practicable precautions that could be provided based on the understanding that the relevant PCBUs will complete a full SFAIRP determination in due course.

Further design definition and subsequent safety reviews will be required as the airport concept is developed and prior to the airport commencing operation.

The review primarily focuses on the proposed Stage 1 (single runway) operations.

2. UNDERSTANDING THE PRECAUTIONARY APPROACH TO RISK MANAGEMENT

2.1 LEGISLATIVE CONTEXT

The primary legislation with regards to safety for both the Commonwealth and NSW is the *Work Health and Safety Act 2011* (Cth) (Cth WHS Act) and the *Work Health and Safety Act 2011* (NSW) (NSW WHS Act) respectively. These acts require that persons conducting a business or undertaking should eliminate risks, so far as is reasonably practicable (SFAIRP), and if this is not possible, reduce risks so far as is reasonably practicable. Persons conducting a business or undertaking (PCBUs) have an obligation to ensure that they comply with their duties and obligations.

The enactment of the WHS acts in 2011 has brought with it a change in philosophy for the identification and management of safety risks compared to previous practice. While this study is not being conducted to comply with WHS legislation (refer Section 1.5), the concepts of risk management in the WHS legislation have been considered in undertaking this risk assessment and as far as possible, this new approach has been adopted for this study.

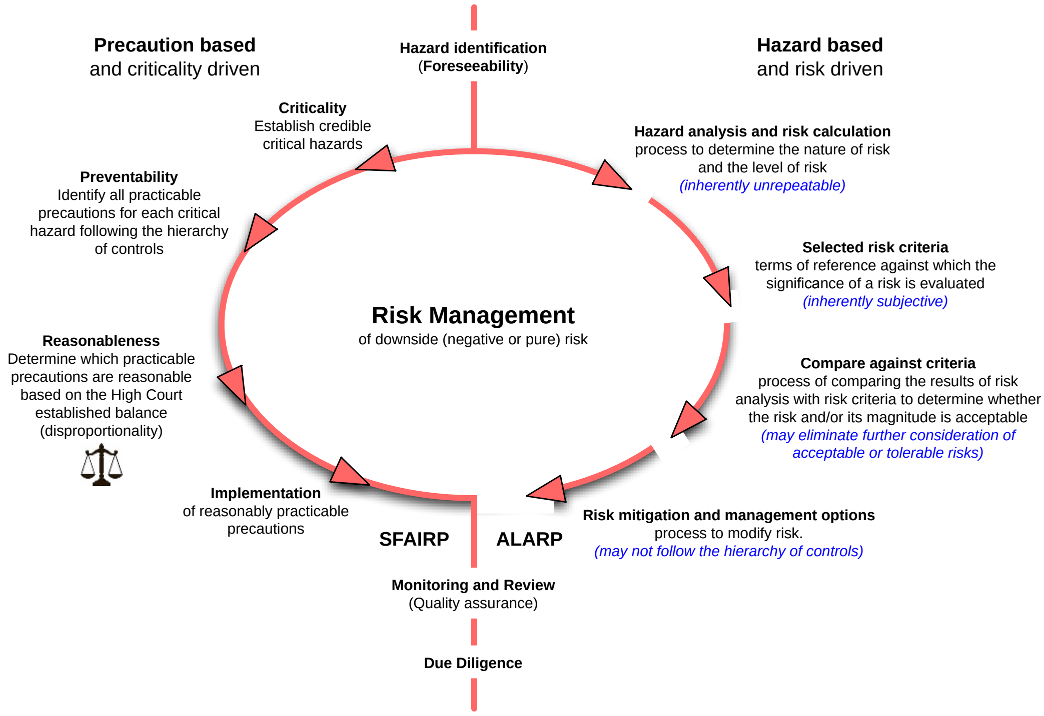
2.2 HAZARD VS PRECAUTIONARY BASED RISK APPROACHES

Two primary paradigms of safety risk management, hazard and precautionary based approaches, have co-existed over the last few decades.

The hazard-based risk management approach requires that hazards be identified, and the risk (likelihood and consequence) associated with them be determined and then compared to acceptable or tolerable risk criteria. If the criteria are not satisfied, then risk treatments are applied until the criteria are satisfied.

The precautionary-based risk management approach aims to identify practical options that are available to address identified safety issues and then tests to see which options are reasonable in the circumstances and ought to be done, especially recognised good practices.

Both approaches aim for the same result. If all reasonable practicable precautions are in place for all hazards, then the risk associated with those hazards is as low as reasonably practicable. This is shown in the diagram below which summarises the key steps of the two approaches.



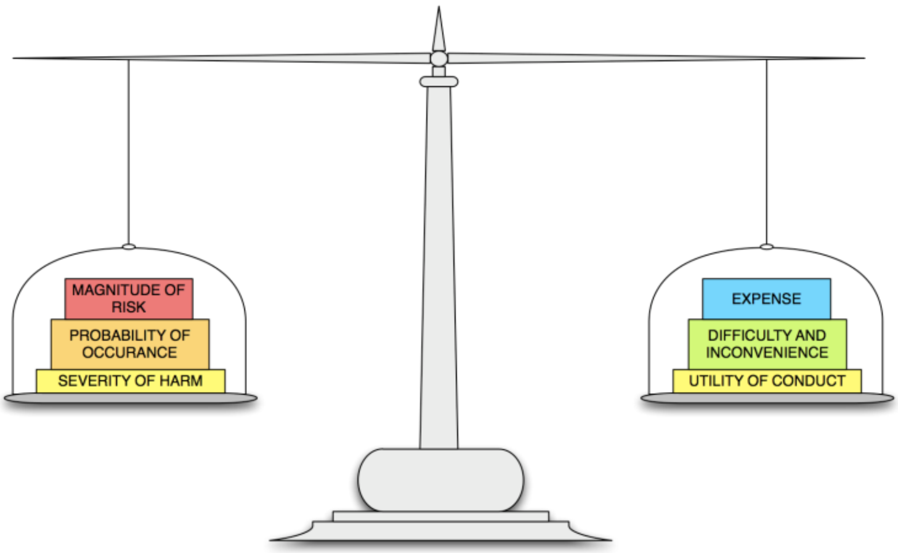
Precaution vs hazard based approaches to risk management[1]

The left hand side of the loop in the diagram above describes the precaution based (or precautionary) approach adopted for this study which results in risk being eliminated or reduced *so far as is reasonably practicable* (SFAIRP) such as described in the WHS legislation. Its purpose is to demonstrate that all reasonable practicable precautions are in place by firstly identifying the practicable precautions and then testing these precautions for reasonableness in the circumstances. The diagram below, adapted from Sappideen and Stillman[2] (1995) illustrates the concept of reasonableness:

---

1 Adapted from Robinson Richard M, Gaye E Francis et al (2015). *Engineering Due Diligence* (10th Edition). R2A Pty Ltd. Page 169.

2 Carolyn Sappideen & R H Stillman (1995). *Liability for electrical accidents: risk, negligence and tort*. Engineers Australia Pty Limited, Crows Nest, Sydney. Page 22.



This is based on a judgement of Justice Sir Anthony Mason of the High Court of Australia[3]:

The perception of a reasonable man's response calls for a consideration of the magnitude of the risk and the degree of probability of its occurrence, along with the expense, difficulty and inconvenience of taking alleviating action and any other conflicting responsibilities which the defendant may have.

As Work Safe Australia notes[4], this is an objective test.

There are two elements to what is 'reasonably practicable'. A duty-holder must first consider what can be done - that is, what is possible in the circumstances for ensuring health and safety. They must then consider whether it is reasonable, in the circumstances to do all that is possible.

This means that what can be done should be done unless it is reasonable in the circumstances for the duty-holder to do something less.

Reasonableness is tested by the PCBU in due course by the designer, owner and operator of the proposed airport.

---

3 *Wyong Shire Council vs Shirt* (1980) 146 CLR 40.

4 From http://www.safeworkaustralia.gov.au/sites/SWA/about/Publications/Documents/607/Interpretive%20guideline%20-%20reasonably%20practicable.pdf viewed 24 July 2013

By contrast, the hazard based approach shown in the loop on the right hand side, aims to demonstrate that risk is *as low as reasonably practicable* or ALARP. There are difficulties with each step of this approach as noted in blue in the diagram. That is:

- hazard analysis and risk calculations are inherently unrepeatable. Risk calculations and characterisations to enable a comparison with risk criteria are always imperfect especially with regard to the estimation of risk associated with human failings and the reliability of management systems.
- risk criteria are subjective. The inconsistency in individual and societal risk criteria between industries is inherently problematic.
- if the risk associated with a hazard is below acceptable thresholds, there is a tendency to say that nothing further needs to be done. However in Turner v. The State of South Australia, Chief Justice Gibbs of the High Court of Australia noted that[5]:

  Where it is possible to guard against a foreseeable risk, which, though perhaps not great, nevertheless cannot be called remote or fanciful, by adopting a means, which involves little difficulty or expense, the failure to adopt such means will in general be negligent.

  That is, it does not matter how low the risk estimate is, if more can be done for very little effort, then the failure to do so will be negligent, in the event of an incident.
- there may be a tendency to implement a precaution that reaches the target risk threshold without formally considering the hierarchy of safety controls.

The purpose of the shift in approaches is to ensure that all reasonable practicable precautions are in place (that is, so that risks are eliminated or minimised so far as is reasonably practicable or SFAIRP), rather than to achieve a target level of risk or safety, which is a typical result of the hazard based approach.

---

5 Turner v. The State of South Australia (1982) High Court of Australia before Gibbs CJ, Murphy, Brennan, Deane and Dawson JJ).

3 RELEVANT LEGISLATION AND GUIDELINES

In addition to the WHS legislation previously outlined in Section 2.1, other legislation relevant to the management of risks and hazards for the proposed airport is summarised below.

3.1 AVIATION LEGISLATION AND GUIDELINES

Prior to the proposed WSA becoming a certified aerodrome under the Civil Aviation Safety Regulations (CASRs), the airport developer will need to satisfy the Civil Aviation Safety Authority (CASA) that appropriate measures including operating procedures, adequate infrastructure and personnel are in place to ensure the safe operation of aircraft.

A key element of this will be the future formal airspace design process which is expected to occur closer to the commencement of operations at the proposed airport. This is discussed elsewhere in the EIS.

The design, construction and operation of the proposed Western Sydney Airport will be informed and regulated by the extensive safety, security and other regulatory requirements which apply to the operation of all airports in Australia. In particular, the operation of the proposed airport will be regulated in accordance with the civil aviation safety requirements and WSA will only commence operations once the airport operator has obtained an aerodrome certificate from CASA under Part 139 of the *Civil Aviation Safety Regulations 1988*. The National Airports Safeguarding Framework will also apply as discussed in Section 3.1.4.

Once certified, aircraft operations around the proposed WSA will be controlled by a range of aviation-specific Commonwealth Acts and Regulations. The following outlines the Commonwealth regulatory controls that affect airports and air traffic operation:

- *Civil Aviation Act 1988;*
- Civil Aviation Regulations 1988;
- Civil Aviation Safety Regulations 1998;
- *Air Navigation Act 1920;*
- *Airports Act 1996;*
- Airports (Protection of Airspace) Regulations 1996;
- Air Navigation Regulations 1947;
- Airport (Building Control) Regulations 1996;
- Airport (Environment Protection) Regulations 1997;
- Airports Regulations 1997;
- Airports (Control of On-Airports Activities) Regulations 1997;
- Airports (Ownership and Interests in Shares) Regulations 1996;
- *Aviation Transport Security Act 2004;* and
- Aviation Transport Security Regulations 2005.

The Civil Aviation Safety Authority (CASA) has the primary responsibility to conduct the safety regulation of civil air operations in Australia. The Civil Aviation Regulations 1988 and the Civil Aviation Safety Regulations 1998 (CASRs) provide the general regulatory controls for the safety of air navigation. The CASRs empower CASA to issue Manuals of Standards (MOS) which support CASRs by providing detailed technical material. The following are relevant to the proposed Western Sydney Airport:

- Manual of Standards Part 139 - Aerodromes
- Manual of Standards Part 139H - Standards Applicable to the Provision of Aerodrome Rescue and Fire Fighting Services
- Manual of Standards Part 172 - Air Traffic Services
- Manual of Standards Part 171 - Aeronautical Telecommunication and Radio Navigation Services
- Manual of Standards Part 173 - Standards Applicable to Instrument Flight Procedure Design

3.1.1 AIRSPACE PROTECTION

The airspace at and around airports is protected under Part 12 of the *Airports Act 1996* and the Airports (Protection of Airspace) Regulations 1996 (APARs). The protected airspace is defined using international standards and is the space above two sets of invisible surfaces above the ground around an airport, namely the:

- Obstacle Limitation Surface (OLS); and
- Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS) surfaces.

The OLS is intended to provide protection for aircraft flying into or out of the airport when the pilot is flying by sight. The PANS-OPS surfaces are intended to safeguard an aircraft from collision with obstacles when the aircraft's flight is guided solely by instruments which is the case for large RPTs.

The *Airports Act 1996* defines any activity resulting in an intrusion into an airport's prescribed airspace to be a 'controlled activity', and requires that controlled activities cannot be carried out without approval. The APARs provide for the Australian Government Department of Infrastructure and Regional Development (DIRD) or the airport operator to assess and approve applications to carry out controlled activities, and to impose conditions on approval. A controlled activity which results in an intrusion into the airspace above the OLS may be permitted if assessed as acceptable by CASA. CASA may require the approved obstacle to be marked and/or lit.

However, intrusions into the airspace above a PANS-OPS surface are not permitted as these have a direct impact on the safety of aircraft flying an instrument approach or departure procedure. Buildings and other structures are considered to be controlled activities within the meaning of the *Airports Act 1996* and the APARs and are dealt with accordingly.

3.1.2 NAVIGATION SYSTEMS AND AIR TRAFFIC MANAGEMENT

A variety of satellite and ground-based navigational aids would be used to provide appropriate levels of safety for aircraft approaches and departures in reduced visibility conditions. The required accuracy, operation and availability of these facilities are strictly controlled under the CASRs. All aircraft operating at WSA in reduced visibility conditions would need to be suitably equipped to use the available navigational aids. Radar services would assist air traffic control to fulfil its responsibilities to manage air traffic in the controlled airspace surrounding the proposed airport under the CASRs.

3.1.3 DEVELOPMENT IN THE VICINITY OF AIRPORTS

The assessment of proposed developments in the vicinity of the airport site is primarily the responsibility of State and local government. Aviation airspace is protected through a formal declaration under Part 12 of the *Airports Act 1996* and the Airports (Protection of Airspace) Regulations 1996 (APARs). The declaration usually comprises an OLS and/or PANS-OPS design. Once the airspace is declared for the proposed Western Sydney Airport, surrounding councils would be be notified and OLS and/or PANS-OPS requirements would be incorporated into local planning instruments.

Any development with the potential to exceed these surfaces must be referred to the airport operator and the Department of Infrastructure and Regional Development for review prior to development proceeding. The OLS applies to both building obstacles (e.g. antennae, masts or tall buildings) as well as hot or high velocity air emissions (such as smoke stacks or vents) which may cause a potential hazard to aircraft. In addition, civil aviation regulations also require approval from CASA for the installation of lighting which might cause a distraction, glare or confusion of pilots.

3.1.4 THE NATIONAL AIRPORTS SAFEGUARDING FRAMEWORK

The National Airports Safeguarding Framework (NASF) is a national land use planning framework, agreed to by Commonwealth, State and Territory Ministers in 2012. The NASF recognises that responsibility for land use planning rests with State and local governments, but that a national approach can assist in improving planning outcomes on and near airports and flight paths. The framework aims to:

- improve community amenity by minimising aircraft noise-sensitive developments near airports including through the use of additional noise metrics and improved noise-disclosure mechanisms; and

- improve safety outcomes by ensuring aviation safety requirements are recognised in land use planning decisions through guidelines being adopted by jurisdictions on various safety-related issues.

The NASF comprises seven key planning principles:

- Principle 1: The safety, efficiency and operational integrity of airports should be protected by all governments, recognising their economic, defence and social significance;
- Principle 2: Airports, governments and local communities should share responsibility to ensure that airport planning is integrated with local and regional planning;
- Principle 3: Governments at all levels should align land use planning and building requirements in the vicinity of airports;
- Principle 4: Land use planning processes should balance and protect both airport and aviation operations as well as community safety and amenity expectations;
- Principle 5: Governments will protect operational airspace around airports in the interests of both aviation and community safety;
- Principle 6: Strategic and statutory planning frameworks should address aircraft noise by applying a comprehensive suite of noise measures; and
- Principle 7: Airports should work with governments to provide comprehensive and understandable information to local communities on their operations concerning noise impacts and airspace requirements.

The NASF guidelines provide comprehensive information and recommendations relating to six airport safeguarding matters. The NASF guidelines are:

- Guideline A: Measures for Managing Impacts of Aircraft Noise;
- Guideline B: Managing the Risk of Building Generated Windshear and Turbulence at Airports;
- Guideline C: Managing the Risk of Wildlife Strikes in the Vicinity of Airports;
- Guideline D: Managing the Risk of Wind Turbine Farms as Physical Obstacles to Air Navigation;
- Guideline E: Managing the Risk of Distractions to Pilots from Lighting in the Vicinity of Airports; and
- Guideline F: Managing the Risk of Intrusions into the Protected Airspace of Airports.

Additional guidelines for the protection of Public Safety Zones and Communication, Navigation and Surveillance infrastructure are proposed to be developed by National Airports Safeguarding Advisory Group in the near future.

3.2 DANGEROUS GOODS LEGISLATION & GUIDELINES

There is other specific legislation related to Dangerous Goods. For the storage and handling of dangerous goods (which includes jet fuel), the responsible authority in NSW is WorkCover (under the provisions of the NSW WHS Act). The authority with regard to the transport of dangerous goods is the NSW Environment Protection Authority (EPA) under the provisions of the *Dangerous Goods (Road and Rail Transport) Act 2008* (NSW)**.** The authorising agency for a fuel pipeline is the NSW Department of Trade and Investment (Resources and Energy) under the provisions of the *Pipelines Act 1967* (NSW).

The NSW Department of Planning and Environment (DP&E) also provides guidelines for the planning and development of hazardous industry in NSW which applies to NSW land. This risk study also includes reference to potential incidents which may occur on areas around the airport site (off-site areas) on NSW land. Relevant guidelines include the NSW Hazardous Industry Planning and Advisory Paper (HIPAP) Guideline series:

- HIPAP 4 – Risk Criteria for Land Use Safety Planning (January 2011); and
- HIPAP 10 – Land Use Safety Planning (January 2011)

HIPAP Guideline 4[6] notes that two aspects of off-site risk to 3rd parties need to be considered:

- *individual risk, which considers the acceptability of a particular level of risk to an exposed individual; and*
- *societal risk, which takes into account society's aversion to accidents which can result in multiple fatalities.*

While it is useful to have objective, quantitative risk criteria, qualitative principles are equally important. These include:

- *all 'avoidable' risks should be avoided;*
- *particular attention needs to be given to eliminating or reducing major hazards, irrespective of whether numerical criteria are met; and*
- *as far as possible, the consequences of significant events should be kept within facility boundaries.*

These regulations were published prior to the commencement of the NSW WHS Act in 2012. As can be seen above, the first part of HIPAP 4 uses a hazard based approach, whereas the latter part considers the precautionary approach. Until such time as the regulations are updated, both approaches continue to apply in NSW.

[6] Department of Planning (NSW) 2011. *HIPAP 4: Risk Criteria for Land Use Safety Planning*

4. METHODOLOGY

The hazard and risk review was undertaken as a desktop study with input from various project stakeholders regarding the key safety issues and possible precautions as well as the hazard and risk study methodology. The following organisations were involved in the consultation process.

- Department of Infrastructure and Regional Development
- Australian Government Solicitor
- Civil Aviation Safety Authority
- Airservices Australia
- NSW Department of Planning and Environment
- Australian Federal Police
- NSW Rural Fire Services
- GHD

The issues and precautionary options identified in the various meetings were considered as part of the risk review.

In addition, a number of EIS background documents were provided as part of the hazard and risk review. The two most relevant documents are the *Western Sydney Airport Referral of proposed action* (DIRD 2014) and the *1997-1999 Draft Environmental Impact Statement*, especially *Technical Paper 10 - Hazards and Risks* (PPK 1997-1999). These were primarily used for background context and as a consistency check to ensure no important safety issue or hazard was overlooked.

In addition, a number of project reports were provided by GHD including:

- Western Sydney Airport: Preliminary Airspace Management Analysis (Airservices Australia 2015)
- Western Sydney Airport Climatological Review (Bureau of Meteorology 2015a)
- Western Sydney Airport Usability Report – meteorological impacts (Bureau of Meteorology 2015b)
- Western Sydney Airport indicative airport layouts

Reports referenced in this report are listed in Section 7.

Owing to the fact that no airport or procedures specific to the airport site currently exist and given the limited nature of the airport design documentation, the necessary focus of this report is the proposed Stage 1 airport development.

5. HAZARD AND RISK REVIEW

5.1 OVERVIEW

The following table summarises the key exposed groups and the risks and hazards to which they would potentially be exposed to from the proposed Western Sydney Airport. This table was developed in consultation with the key stakeholders identified in Section 4. The table provides a summary of the worst-case consequences of each credible threat. It does not consider the likelihood of the event occurring. This is consistent with the precautionary approach.

		Construction crews	Airport Airspace	Airport			Offsite	
	Critical Exposed Groups > Credible Threats		Air crew and passengers	Public at airport	Airport staff and workers including contractors	Airport emergency services	Public outside airport	Offsite emergency services
1.0	Air operations							
1.1	Aircraft fire (inflight)	-	xxx	-	-	-	xxx	-
1.2	Bird or bat strike	-	xxx	-	-	-	xxx	-
1.3	Drones and model a/c strike (RPAVs)	-	xxx	xxx	xxx	xx	xxx	-
1.5	Fuel exhaustion	-	xxx	xxx	xxx	xx	xxx	-
1.6	High structure/terrain strike	-	xxx	-	-	-	-	-
1.7	Mechanical failure	-	xxx	xxx	xxx	xx	xxx	-
1.8	Mid-air collision (other a/c)	-	xxx	-	-	-	xxx	-
1.9	Pilot error (multiple runways)	-	xxx	xxx	xxx	xx	xxx	-
1.10	Runway collision	-	xxx	xxx	xxx	xx	-	xx
1.11	Special military and emergency sevices ops incl bushfire ops in Blue Mountains (RFS)	-	xxx	-	-	-	-	-
1.12	Stack discharge	-	xxx	-	-	-	xxx	-
2.0	Adverse meteorology							
2.1	Aircraft icing (freezing fog)	-	xxx	xxx	xxx	xx	xxx	xx
2.2	Cross wind (especially gusts)	-	xxx	xxx	xxx	xx	-	xx
2.3	Cyclone/tornado	xx	xxx	xxx	xxx	xx	-	xx
2.4	Fog (visibility)	-	xxx	xxx	xxx	xx	-	xx
2.5	Lightning (thunderstorm)	xx	xxx	-	-	xx	-	xx
2.6	Windshear (esp threshold)	-	xxx	-	-	xx	-	xx
3.0	Fire & Explosion (on site)							
3.1	Aircraft fire (on ground)	-	xxx	-	xxx	xx	-	xx
3.2	Building fire	xx	xxx	xxx	xxx	xx	-	xx
3.3	Fuelling fire (esp > 35 deg ambient)	-	xxx	-	xxx	xx	-	xx
3.4	Grass fire (on site)	xx	xxx	-	xxx	xx	xx	xx
3.5	Storage fire & explosion (Jet A-1)	xx	-	-	xxx	xxx	xx	xxx
4.0	Contaminated sites	xx	-	x	x	x	-	x
5.0	Terrorism	xxx	xxx	xxx	xxx	xxx	xxx	xxx
6.0	Bushfire / Smoke (offsite)	xx	xxx	-	-	xx	xxx	xx
7.0	Transport of dangerous goods (Jet A1)	-	-	-	-	xx	xxx	xx
8.0	Flood / inundation	xx	xxx	xx	xx	xx	-	-
9.0	Aircrashes into major (offsite) infrastructure	-	-	-	-	-	xxx	xx
10.0	Railway incidents	-	-	xxx	xxx	xx	xxx	xx

High Level Threat and Safety Vulnerability Table

xxx Multiple fatalities possible

xx Single fatality possible

The table above presents a high level summary of the key safety risks posed by the proposed airport as agreed with the project stakeholders. Based on the precautionary approach, if all these hazards are eliminated, so far as is reasonably practicable (SFAIRP), and if this is not possible, reduced SFAIRP by the appropriate persons conducting a business or undertaking (PCBUs) through the ongoing design, construction and regulatory processes, then the proposed airport will be considered to be safe.

The following sections outline the precautions that should be considered for the proposed airport because of the nature of the safety threat associated with expected operations. PCBUs will be required to assess the reasonableness of these in due course as designers, owners and operators.

Some of the credible critical safety threats identified do not require particular precautionary consideration as the design and operation of the proposed airport could have no material control over these risks. The operator of the proposed airport would have no control over either the risk arising, nor of any measures which could mitigate the risk. These are generic issues associated with the operation of any major airport and current industry (airport and airline) operational procedures and regulatory requirements would be applied to resolve the issues as appropriate. These include:

- aircraft fire (inflight);
- fuel exhaustion;
- mechanical failure;
- pilot error (multiple runways) (not an issue with one runway); and
- collision because of intersecting runways (not an issue with the proposed airport as no cross runways proposed).

Consequently, these have not been considered further in this report.

Related issues in the above table such as grassfire and bushfire have been also merged together in the following sections as precautionary effort is similar.

5.2 AIRCRAFT ACCIDENTS

To gain an appreciation of midair collision risk, a review of past accidents was completed, supported by an internet search for authoritative accident summaries, including the Australian Transport Safety (ATSB)[7], the International Civil Aviation Organization (ICAO) and Boeing.

7 Australian Transport Safety Bureau (2014). *Aviation Occurrence Statistics 2004 to 2013*. Report AR-2014-084.

Australia has a good aviation safety record comparable to other developed countries such as the USA, Canada and the United Kingdom. There have been no high capacity (above 38 seats) regular passenger transport (RPT) fatal accidents in Australia since at least 1968[8].

Aviation occurrence statistics are updated and published annually by the ATSB. Responsible persons as defined in Part 2.5 of the Transport Safety Investigation Regulations 2003 provide occurrence data to the ATSB. Statistics collected by the ATSB indicate that the number of reported safety incidents in Australia has risen significantly over the past decade. In 2013, there were 23 serious incidents, 1 serious injury accident and 1 total accident among 3.3 million departures for high capacity RPT aircraft similar to those expected to use WSA.

The 23 aircraft involved in serious incidents in 2013 was the highest number for this operation type in more than 10 years. The most common occurrences reported were wildlife strikes, weather affecting aircraft, and aircraft system problems. Most accidents and serious incidents involved reduced aircraft separation, engine malfunction, or runway excursions.

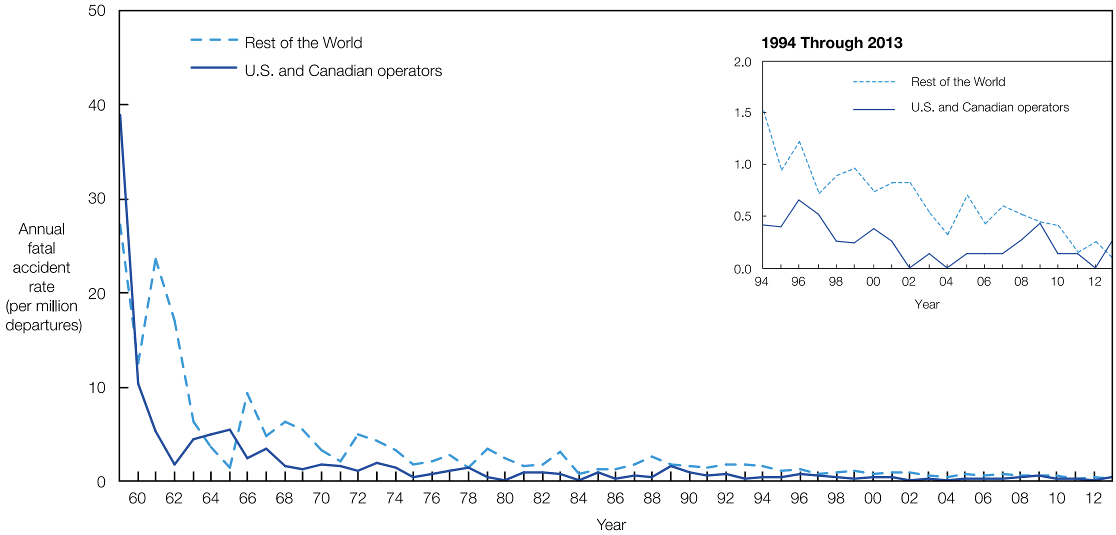
In addition, the Civil Aviation Safety Authority (CASA) recently completed an aeronautical study of the airspace arrangements in the Sydney Basin within 45 nautical miles (NM) of Sydney Kingsford Smith Airport (Sydney). One of the findings of the report was that the Sydney Basin has shown a decreasing rate of total airspace related incidents over the past six years. Most incidents related to airspace involved operational non-compliance or navigation problems resulting in airspace infringements by VFR aircraft and did not result in significant safety hazards. This supports the overall findings of the ATSB review.

The diagram from Boeing below shows the overall global and North American improvement in accident rates from 1959 through 2013[9]. Airplanes manufactured in the Commonwealth of Independent States (CIS) or the former Union of Soviet Socialist Republics (USSR) are excluded because of the lack of operational data. Commercial airplanes operated in military service are also excluded. 'Accidents' do not include experimental test flights or hostile action including sabotage, hijacking, terrorism or military actions.

---

[8] Australian Government (2011) *Australia's State Aviation Safety Program* plus R2A's review of accidents from 2010 to the present.

[9] Boeing Commercial Services (August 2014). *Statistical Summary of Commercial Jet Airplane Operations I 1959 – 2013.*



Fatal Accidents 1959 through 2013

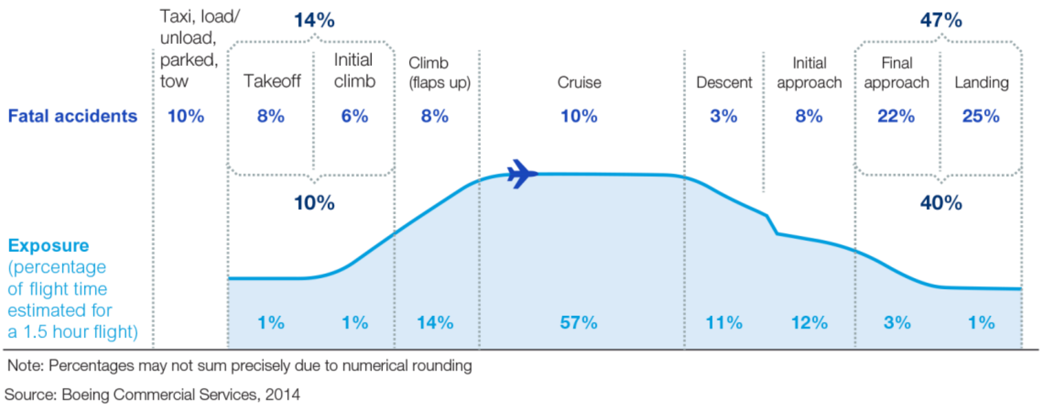
Of note is that whilst Boeing reports 5 major accidents worldwide in 2013, resulting in the deaths of 62 crew and passengers, no deaths to external parties either on the ground or on other aircraft are recorded. This is based on 25 million departures that year.

ICAO[10] reports an improving accident rate (for all RPT aircraft including those below 38 seats) worldwide in 2014 as shown below.

Global Accident Rate (accidents per million departures)

The Boeing report also notes that 47% of fatal accidents occur on final approach and landing as shown below.

10 ICAO (2014). *Safety Report.*



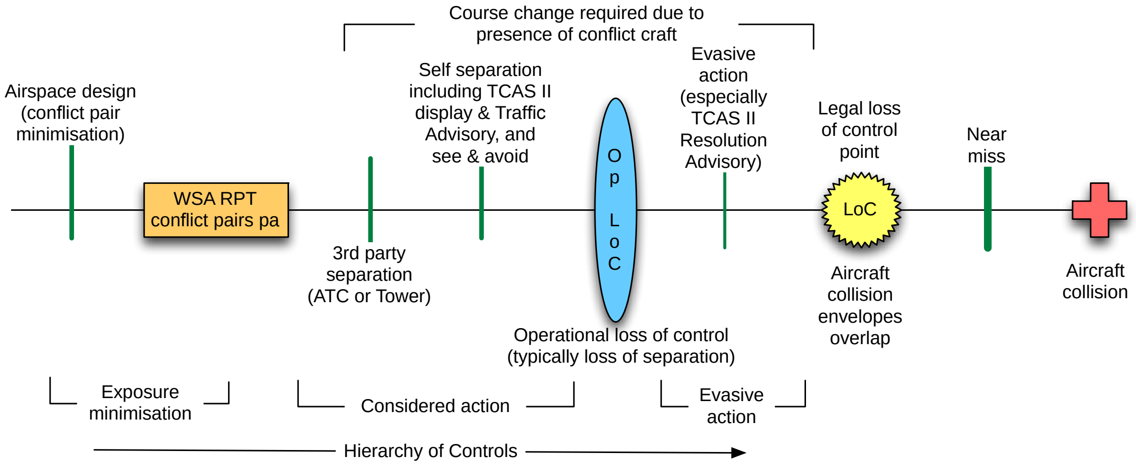
Fatal Accidents and Onboard Fatalities by Phase of Flight (adapted from Boeing)

Worldwide Commercial Jet Fleet 2004 through 2013

In assessing the potential for aircraft accidents at the proposed airport, consideration was given to the surrounding airspace in the Sydney basin and the sources of potential conflict aircraft. The primary potential conflict aircraft to RPT traffic at the proposed airport are those engaged in general aviation and military activities at surrounding airports as summarised below:

- 'lost' students, especially in marginal visual flight rule (VFR) conditions, from various general aviation flying schools in the Sydney Basin including Camden and Bankstown. This includes both VFR and instrument flight rules (IFR) students;
- off-course charter IFR traffic from general aviation airports including Bankstown and Camden;
- unexpected or unknown military movements, particularly from Holsworthy (Military) Airport and RAAF Base Richmond;
- operations at Sydney Airport (only relevant to potential future two runway operations at the proposed Western Sydney Airport post 2050);
- unexpected aircraft from small airfields like Wedderburn and Kennetts Strip and closed facilities like Schofields, particularly for ultralights, remotely piloted aircraft (RPAs), including model aircraft;
- glider operations;
- off-course aviators following the western Sydney VFR route via Richmond airspace which can be used by any aircraft including those to and from Camden; and
- other RPT aircraft operating at the proposed airport particularly under emergency procedural conditions including forced go-rounds and breakouts.

In order to assess the proposed controls to manage these potential airspace conflicts, Airservices Australia's indicative airspace management concept was conceptually tested using the threat barrier diagram shown below.



Single Line Collision Threat Barrier Diagram

The hierarchy of controls is expressed from left to right, with conflict pair[11] minimisation (that is, the elimination option) the first and necessary precautionary test following the hierarchy of controls.

The Stage 1 (northern) runway airspace concept is comparatively straight forward with the airspace designed to minimise conflict pairs. Satellite based navigation and landing aid with ground based augmentation system (GBAS) similar to that recently provided at KSA would also be provided. The proposed WSA Class C air traffic control tower (to 2500ft) would provide third party aircraft separation advice to aircraft. A primary radar feed from KSA for WSA is also expected with common ATC control. This would provide a backup radar system to WSA air traffic control.

The indicative design of the WSA airspace includes adoption of a point merge system which was first introduced in Norway in 2011. The point merge system has since been implemented elsewhere in Europe as well as in Asian cities such as Seoul and Kuala Lumpur. One of the cited benefits of this new concept is safety improvements through a reduction of tactical vectoring, increased situational awareness by pilots and a lower workload for air traffic controller staff.

[11] A conflict pair refers to an event in which two or more aircraft experience a loss of minimum separation. This does not in itself suggest that the aircraft are at any risk of collision.

A formal flight path design process is expected to occur closer to the time operations commence at WSA. Optimal flight path design using improved navigation technologies such as a point merge system should ensure that potential conflicts, even in emergency go-round scenarios are reduced.

During the detailed design of airspace, a number of additional precautions[12] to manage aircraft collisions would be considered as part of the standard airspace design process. These include:

- upgrading the airspace of all airports in the Sydney Basin to Class C and Class E after hours (meaning radio and transponders for all aircraft movements for all VFR aircraft including gliders and ultralights). There is a continuing enhancement of navigation and transponder equipment occurring. For example, Global Navigation System Satellite System navigation and Automatic Dependent Surveillance – Broadcast transponder technology is being rolled out for all IFR aircraft[13];
- redesign VFR corridors to and from Bankstown Airport to encourage a greater use of GPS navigation;
- redesign the western VFR routes via Richmond airspace; and
- ATC confirmation response to all calls including VFR calls.

During the detailed design process and beyond, the above options need to be tested for reasonableness by the relevant PCBU to determine which precautions would be implemented to demonstrate SFAIRP.

In order to investigate the potential level of off-site risk posed by an aircraft accident, in accordance with NSW DP&E requirements, the following preliminary analysis has been completed using the Boeing statistics of five major accidents in 25 million departures (that is a likelihood of 2×10^{-7} (or 0.0000002) per departure), as well as having regard to the expected aircraft movement types at the proposed airport[14]. The major accident rates for the proposed Stage 1 development and the long term development scenarios are presented in the table below.

---

[12] Legally, precautions act before the loss of control point, mitigations afterwards. In aircraft collision terms, there few mitigations, it is almost all precautions.

[13] See Airservices Australia (undated). *Fact Sheet – Regulation Reform: Performance based navigation: GNSS and ADS-B equipment mandates.*

[14] DIRD (June 2015). Airport Plan Version 2.1 Western Sydney Airport.

Airport development scenario	Total annual air traffic movements (passenger & freight)	Departures (per year) (half movements)	Likelihood of major accident per departure	Major accidents per year	Years between major accidents	Years between major accidents on final approach or runway
Stage 1 (c. 2030)	63,000	31,500	0.0000002	0.0063	159	317
Long term (c. 2063)	370,000	185,000	0.0000002	0.037	27	54

WSA major accident rate projection

(assuming no improvement in safety from 2013)

Assuming no improvement in aircraft safety from the 2013 statistics, in 2030, the expected fatal accident rate for aircraft operating from the proposed airport would be around 1 in 300 years on final approach and/or landing based on statistics from Boeing which indicate about 50% of accidents occur during these stages, and around 1 in 300 years for all other phases of flight.

However, these results have limited meaning, as aviation technology (aircraft, navigation aids, avionics etc.) is most likely to substantially improve over time, and population densities around the proposed airport will change. For example, ASD-B (automatic dependent surveillance-broadcast) for all IFR aircraft[15] is presently being rolled out in the Sydney basin, and KSA is the first airport in the Southern hemisphere and fifth in the world to certify a satellite-based navigation and landing aid, with a ground based augmentation system (GBAS) recently going into service in May 2015[16]. This replicates and will eventually supplant the six existing ILS services at KSA. This is typical of the continuing developments in commercial aviation.

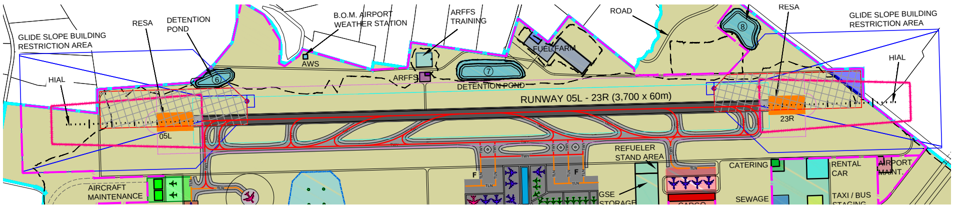
It is presently proposed that the WSA would also adopt GBAS and that other superior technology will emerge over time. The likelihood of future accidents that might result in aircraft accidents having off-site impacts is expected to continue to decrease with the adoption of such systems.

---

[15] Civil Aviation Safety Authority (undated). *Fact Sheet – Regulation Reform: Performance based navigation: GNSS and ADS-B equipment mandates.*

[16] See http://www.flightsafetyaustralia.com/2014/07/satellite-ground-station-opens-at-sydney-airport/ viewed 12jun15.

The likelihood of an off-site impact as a result of an aircraft accident is further reduced by the proposed 1,000m public safety zone (PSZ) at either end of the runway as shown in the indicative airport layout below (area bound by pink borders at each runway end). The Australian Airports Association[17] refers to ICAO reports that most aircraft crashes occur within 1,000 m of landing and 500 m of takeoff. No building or occupied structure is expected in this area.



Public Safety Zones[18] Runway 05L & 23R

(shown as the truncated red trapezoids adjoining the runway ends)

The actual shape and size (primarily the length) of the PSZ required for a particular airport varies according to a large number of factors. This includes:

- the crash frequency per departure (which is aircraft size/type dependent and seems to be steadily improving with time, and appears to be lower in Australia than other places);
- the STARs (standard terminal arrival routes) and standard instrument departures (SIDs) flight paths;
- the number and aircraft mix of departures and arrivals;
- a historical spatial crash location distribution model which generally assumes crashes will be closer to runways and dissipate away from flight paths (which can also be aircraft type dependent); and
- an estimation of the size of the area affected by the crash (bigger aircraft with larger fuel loads have bigger damage areas although this is also related to shallow or vertical impacts). Fuel loads are also usually greater on takeoff for larger aircraft on long haul routes.

These factors have been used to calculate PSZs for many UK airports. Results vary although generally a 1km zone includes the 10^{-4} pa individual risk contour[19] which is considered by the Health and Safety Executive in the UK as the limit of tolerable risk to a member of the public. In terms of the NSW HIPAP 4

---

17 Australian Airports Association (Oct 2014). *Airport Practice Note 5*. Page 7

18 DIRD (June 2015). Master Plan Layout. Concept 11C. Phase 1 – Year 2030, Scenario 2A.

19 Department of Transport (1/120) Farnborough Airport Public Safety Zones (PSZs) and NATS (May 2004) A Second Runway for Gatwick Appendix A27 Public Safety Zones. Version 1.0 Final

Guideline, no development should occur within 10^{-4} pa individual risk contour[20]. The risk calculation has not been completed at this stage, but given that the PSZ at either end of the runway extends beyond the airport site boundary, additional airport design control measures may need to be provided in order to meet NSW DP&E off-site risk criteria. This would be reviewed during detailed design and any necessary controls implemented.

Aircraft crashes into major infrastructure were also cited by DP&E as an issue for investigation. The indicative Stage 1 flight paths avoid Defence Establishment Orchard Hills and the Warragamba Dam. The indicative flight paths also keep aircraft clear of other critical infrastructure like Prospect Reservoir. All aircraft are expected to be provided with precision based GPS navigation by the time the proposed airport commences operation in the mid-2020s ensuring the exact location of all aircraft is known at any time.

An obstruction charting survey is underway to identify any high structures and terrain. The Airservices Australia report recommendation was to remove obstacles if possible. Where obstacle removal is not feasible, air traffic operational rules would be established to avoid obstacles. The report also recommended that a risk assessment would be required prior to commencement of parallel runway operations to provide guidance on whether independent simultaneous ILS/ microwave landing system (MLS) operations to parallel runways should be approved.

Consideration of these recommendations would be part of the formal flight path design process that is expected to occur closer to the time operations commence at WSA. Optimal flight path design using improved navigation technologies should ensure that potential conflicts with critical infrastructure and other obstacles are reduced.

The report also indicates that, when parallel runway operations are in use in the long term, the (emergency) Breakout Areas provided for conflict resolution for departing aircraft from the proposed airport would be in conflict with Defence Establishment Orchard Hills when it is active for military operations. This issue would require further consideration during airspace design prior to the second runway commencing operations, which is anticipated to occur around 2050.

The following sections further consider the precautionary options associated with particular air operation threats.

20 NSW Department of Planning (2011). HIPAP 4. Risk Criteria for Land Use Safety Planning.

5.2.1 BIRD AND BAT STRIKE

A preliminary bird and bat strike risk assessment by Avisure[21] identifies the type, number and flocking characteristics of species in the vicinity of the proposed airport.

Construction of the proposed airport would in itself reduce the habitat of various species at the airport site, particularly in the long term as clearing of the remainder of the vegetation on the airport site would be undertaken. Other precautions to reduce the attractiveness of the site to birds would also be implemented during the construction and operational phases of the proposed development, including draining or covering dams to discourage wader birds and ensuring landscape and grassed areas at the airport are not conducive to particular species.

Avisure concludes that the proposed airport, being inland from the coast, is dissimilar to other existing airports including KSA where this risk is overall much higher. It concludes that the likelihood of bird strikes by large flocking birds is considered very low and that the most probable consequence of bird and bat strike is damage to aeroplanes (particularly engines) and inconvenience to the travelling public. Notwithstanding, further seasonal surveys of bird behaviour should be undertaken and the ongoing design reviewed to ensure birds and bats are not encouraged onto the airport and surrounds.

There is also a range of regulatory guidelines and controls which address this risk at airports including CASA and ICAO operational regulations and procedures as well as the *National Airports Safeguarding Framework Guideline C - Managing the risk of wildlife strikes in the vicinity of airports* and the CASA Advisory Circular AC 139-26(0) Wildlife hazard management at aerodromes.

5.2.2 REMOTELY PILOTED AIRCRAFT

Remotely piloted aircraft (RPAs) (which includes drones, model aircraft and unmanned aerial vehicles) are considered to be a generic but increasing hazard for all airport airspaces and is a focus for CASA[22], Airservices Australia and other authorities.

It is expected that the operator of the proposed airport would implement the recognised good practice precautions used at similar airports like KSA, which is keeping abreast of RPA developments, reporting RPA incidents and facilitating relevant RPA publicity.

---

[21] Avisure May 2015. *Preliminary Bird and Bat Strike Risk Assessment*. Draft.

[22] See for example, CASA's website: *CASA and remotely piloted aircraft*. http://www.casa.gov.au/scripts/nc.dll?WCMS:STANDARD::pc=PC_100376 viewed 23jun15.

Australia was the first country in the world to regulate remotely piloted aircraft, with the first operational regulation for unmanned aircraft in 2002 ([CASR]). CASA is currently reviewing Part 101 of the *Civil Aviation Safety Regulation 1998* regarding unmanned aircraft to address their increasing use.

5.2.3 HIGH STRUCTURE / TERRAIN STRIKE

Airspace obstructions are a primary threat at any airport. It is anticipated that clearance criteria described in existing regulations[23] would be applied as outlined in Section 3.1.1. Obstacle Limitation Surfaces (OLS) and Procedures for Air Navigation Services – Aircraft Operations (PANS-OPS) would also be prescribed. An obstruction charting survey is underway to identify any such structures. Treatment options include relocation of obstructions or if this is not practicable in the circumstances, identifying and appropriately managing those high structures during detailed airspace design activities.

Existing height restriction planning rules for new structures would need to be confirmed as appropriate to accommodate possible future flight paths.

As outlined in Section 3.1.1, once the WSA airspace is declared, Councils would be informed and relevant planning instruments updated to include definition of these areas and any new developments which may impact on the airspace would be referred to the airport operator for comment.

5.2.4 SPECIAL MILITARY AND EMERGENCY SERVICES OPERATIONS

In an emergency, other aircraft may require use of the airspace, especially NSW Rural Fire Service (RFS) bushfire operations in the Blue Mountains to the west of the proposed airport. Other emergency operations can include military, security, police, ambulance and RFS aircraft from Richmond, Holsworthy, Bankstown and Camden. This creates potential for mid air collisions.

Such emergency aircraft would be expected to have priority over RPT traffic. Western Sydney Airport ATC would facilitate these operations and communicate with pilots any changes to procedures required in the event of these operations occurring.

---

[23] *Airports (Protection of Airspace) Regulations 1996* (Cth).

5.2.5 STACK DISCHARGE

Stack discharge refers to emissions to air that might affect aircraft flight. Gas efflux from industrial chimneys with an average vertical velocity exceeding 4.3 m per second at the OLS or 110 m above ground level is a controlled activity under the *Airports (Protection of Airspace) Regulations 1996* (Cth).

With regards to the proposed Western Sydney Airport, a survey should be completed to identify any current or proposed future emissions and the results integrated into the refinement of proposed flight paths.

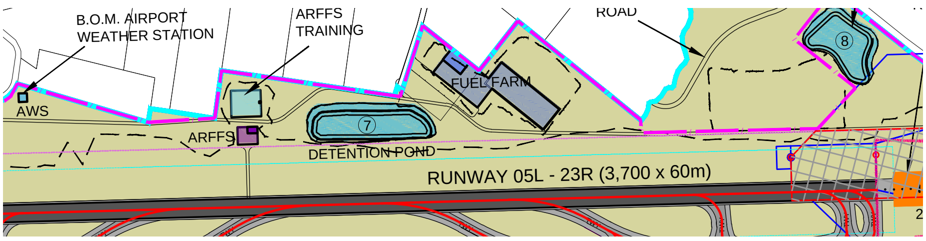
5.3 FIRE AND EXPLOSION

The following sections investigate fire and explosion potentials on the proposed airport site and the possible on and off site consequence.

5.3.1 FUEL STORAGE FIRE AND EXPLOSION

A key issue at this early design stage relates to the bulk storage of jet fuel and the ability to contain the risks presented by storage within the on-site facility. No bulk storage of avgas or diesel for aircraft use is proposed. Small quantities of other fuels would be available for airport surface vehicles, but this would be addressed in the detailed design phase.

The indicative airport layout and draft Airport Plan provides for a fuel farm with storage of 3-days average demand[24]. The proposed Stage 1 (single runway) development commences with up to 10 ML storage whilst long term airport development (two runways) sees onsite storage increase to 66 ML. The proposed fuel farm location is shown below.

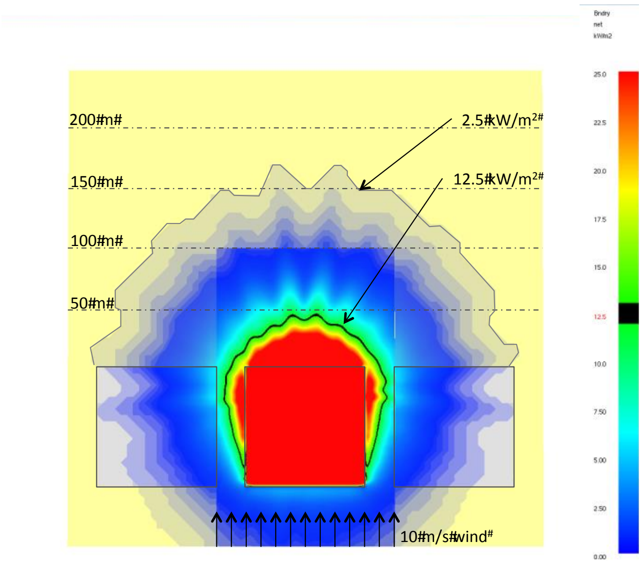


Fuel Farm Location - Stage 1 (2030)

24 DIRD (June 2015). Airport Plan, Western Sydney Airport. Draft.

Stage 1 operations provide for an indicative build of up to four tanks in 100 m x 100 m square bunds, with 25 metres between bunds. Standard industry precautions for a fuel tank farm would be assumed to be present, namely tank foam injection and water spray thermal exposure protection consistent with Australian Standard 1940-2004 *The storage and handling of flammable and combustible liquids*. Two days on site storage of water for fires is planned. The distance from the edge of the bund to the nearest airport site boundary is approximately 80 m.

In order to investigate the potential level of off-site risk posed by the fuel facility, in accordance with NSW DP&E requirements, a worst case design fire scenario was assessed comprising a full bund fire (100 m x 100 m) with a 20 kt wind blowing towards the edge of the airport site. The following figure shows the results of the fire simulation conducted using the National Institute of Standards and Technology's Fire Dynamics Simulator[25] for a design kerosene fire with a 20 kt (10 m/s) wind.



Plan View 100 m x 100 m Kerosene Fire with 20 kt wind

The effects of varying levels of heat radiation as provided in HIPAP 4 and depicted in the above figure, are shown below.

[25] National Institute of Standards and Technology. Fire Dynamics Simulator (FDS) is a computational fluid dynamics (CFD) model of fire-driven fluid flow. The software solves numerically a form of the Navier-Stokes equations appropriate for low-speed, thermally-driven flow, with an emphasis on smoke and heat transport from fires.

Table 6: Consequences of Heat Radiation

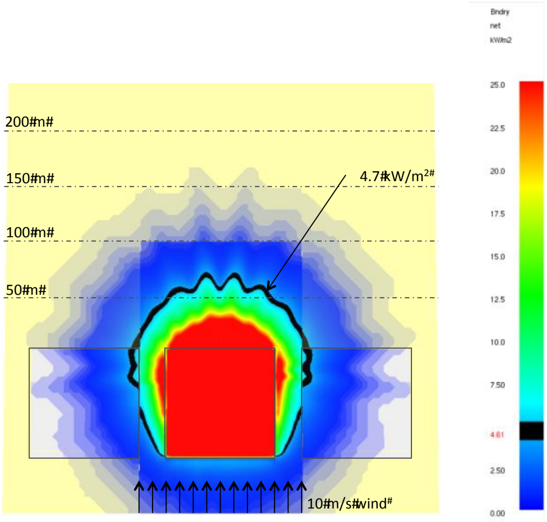
Heat Radiation (kW/m^2)	Effect
1 .2	Received from the sun at noon in summer
2.1	Minimum to cause pain after 1 minute
4.7	Will cause pain in 1 5-20 seconds and injury after 30 seconds' exposure (at least second degree burns will occur)
12.6	• Significant chance of fatality for extended exposure. High chance of injury • Causes the temperature of wood to rise to a point where it can be ignited by a naked flame after long exposure • Thin steel with insulation on the side away from the fire may reach a thermal stress level high enough to cause structural failure
23	• Likely fatality for extended exposure and chance of fatality for instantaneous exposure • Spontaneous ignition of wood after long exposure • Unprotected steel will reach thermal stress temperatures which can cause failure • Pressure vessel needs to be relieved or failure would occur
35	• Cellulosic material will pilot ignite within one minute's exposure • Significant chance of fatality for people exposed instantaneously

In terms of good practice fire engineering, all buildings should be outside of the cellulosic pilot ignition heat flux (12.6 kW/m^2) contour. The preliminary modelling shows that a minimum 50 m buffer from the tank farm to all airport site boundaries is required to achieve this. This would be achieved by the current 80 m buffer.

Buildings outside the pain threshold criteria (2.1 kW/m^2) do not typically require special fire protection. Off-site facilities between the 12.6kW/m^2 and 2.1 kW/m^2 thresholds require consideration of alternate measures including appropriate land use zoning and building construction.

Further, HIPAP 10[26] indicates that incident heat flux radiation at residential and sensitive use areas (such as those adjacent to the proposed WSA) should not exceed 4.7 kW/m^2 at a frequency of more than 50 chances in a million per year.

[26] NSW Department of Planning 2011. *HIPAP 10: Land Use Safety Planning*. p 33.



Plan View 100 m x 100 m Kerosene Fire with 20 kt wind (4.7kW/m^2 contour)

Based on the above figure, a level of 4.7 kW/m^2 is reached approximately 80 m from the edge of the bund. This is on the site boundary. Further risk calculations may be required to determine the frequency of such an event in order to meet NSW DP&E off-site risk criteria. Additional control measures may need to be considered including land use zoning and building construction.

Other fires associated with tanker truck discharge would also be possible, but are likely to be smaller. Standard fuel and fire-fighting runoff containment is assumed in all cases. An Airservices Australia ARFFS station is proposed for single runway operations with an additional station being provided for the second runway.

5.3.2 FUELLING FIRE

It is planned that all jet fuelling operations would be provided by hydrants delivered through underground pipes from the airport fuel farm. Standard industry precautions for aircraft fuelling at major airports would be implemented including:

- provision of appropriate clearances for refuelling aircraft and ground fuelling equipment in relation to buildings and other aircraft;
- appropriate passenger boarding and disembarking procedures during refuelling operations;
- earth bonding; and
- designating refuelling areas as non-smoking areas.

Airport tanker operations are expected to be minimal as general aviation operations are not proposed.

5.3.3 AIRCRAFT FIRE (ON THE GROUND)

Fire-fighting facilities similar to other major airports would be provided. This includes the provision of an Airservices Australia's Airport Rescue Fire Fighting Service (ARFFS) station for each runway. A mutual aid agreement with the New South Wales Rural Fire Service (NSW RFS) is also expected to be in place before airport operations commence.

5.3.4 BUILDING FIRE

Fire detection, suppression and response systems would be incorporated into buildings in accordance with relevant regulations and consistent with other major airports. The specific features of fire detection and suppression systems would be determined during the detailed design phase.

5.4 ADVERSE METEOROLOGY

In 2014 the Bureau of Meteorology was engaged by the Australian Government Department of Infrastructure and Regional Development (DIRD) to provide a preliminary report[27] on the meteorological parameters affecting the usability of the Badgerys Creek site for the development of the Western Sydney Airport (WSA).

With respect to the planned nomination of runways at Badgerys creek, it is expected that the current runway configuration proposed will be usable approximately 99.5% of the time based on crosswinds alone. Other weather phenomena such as fog, low cloud and low visibility conditions may lower the usability of the airport; however mitigation is obtainable through navigational systems and aids.

The report outlined the following precautionary options to address these issues:

i. Clearance of vegetation to the west and south-west of the airport site should be avoided as reducing drag may cause increases in wind speeds from downslope winds.

ii. Orientation of buildings containing large surface areas should avoid the direction of strongest wind (westerly sector) as much as possible to avoid creating turbulent effects.

iii. The effect of high temperatures may need to be considered during the construction of jet fuel facilities at the proposed airport.

[27] Bureau of Meteorology (April 2015). *Western Sydney Airport Usability Report – Meteorological impacts.*

iv. De-icing equipment may need to be considered in order to optimise operations at WSA during periods of low temperature.

v. Changes in land surface coverage would need to be accounted for in hydrological studies to ensure appropriate control measures and engineering can mitigate surface runoff.

vi. Automatic instrumentation for cloud and visibility (including fog) should be installed for the collection of climatological information and for the production of forecasting products in future.

vii. Appropriate low visibility (including fog) landing equipment, such as runway visual range (RVR) needs to be considered in order to optimise operations at the proposed airport.

viii. A Doppler LIDAR system at Badgerys Creek can provide the necessary information for observing wind movement in the lower atmosphere including detection of wind shear and rotors. The Doppler LIDAR system is costly and a cost-benefit analysis would be recommended.

ix. The Bureau of Meteorology would implement an Automated Thunderstorm Alert Service (ATSAS) at the proposed airport to improve the accuracy of thunderstorm forecasting for the airport whilst increasing the operational safety of ground staff and aircraft.

Provided appropriate airport operating parameters were established (for example, for crosswinds and visibility etc.), and complied with, there would be no particular or unique safety concerns associated with the Western Sydney Airport site in relation to adverse meteorology.

5.5 OTHER ISSUES

5.5.1 TERRORISM

At this conceptual stage, no issues or precautions above those in use at KSA or other similar international facilities are envisaged for the proposed airport.

The airport is expected to be designated as a category 1 airport under the *Aviation Transport Security Act 2004* and this would dictate detailed security planning for the infrastructure and operational requirements which would take place during detailed design.

5.5.2 BUSHFIRE / SMOKE (OFFSITE)

A bushfire risk assessment was conducted by GHD as part of the design process for the proposed airport[28]. The airport site is located in a landscape that contains vegetation that may represent a bushfire risk to users of the airport, on-site workers and the general community.

A history of bushfires[29] in NSW as provided by the RFS suggests that bushfire is an issue of concern. The airport site is located within the northern portion of the Macarthur Bushfire Fire Management Centre area where an average of 417 bushfires are recorded annually, of which around five develop into major fires (Macarthur BFMC, 2012).

Construction and operation of the proposed airport would have the potential to provide a source of ignition, which under adverse winds could allow a fire to escape off-site. As such fires could develop quickly in this landscape and where suppression resources are remote from the site, site specific mitigation measures are the primary means to reduce the risk.

A clear mown area around the inside of the airport fence line is anticipated once the proposed Stage 1 airport is complete. DIRD are currently preparing an updated Bushfire Management Plan in consultation with the NSW RFS for current site management purposes. This would be augmented with the Emergency Response Plan to be developed by the airport lessee company as part of the requirements for obtaining the aerodrome certificate.

Risks during construction could include ignition sources such as welding and angle grinding, sparks from machinery operating in rocky environments, combustion of vegetation heaps and vegetation contact with power lines.

Risks to airport assets which adjoin vegetated areas (e.g. at the airport site perimeter) may be reduced through the creation and maintenance of asset protection zones, use of appropriate construction materials and appropriate operational preparedness actions.

The Bushfire Management Plan would contain procedures which document how on site personnel should respond in the event of a bushfire occurring within or threatening the site.

---

[28] Western Sydney Airport EIS – Bushfire Risk Assessment, July 2015

[29] NSW Rural Fire Service (2015). *History of Fires in NSW.*

5.5.3 FLOODING

An assessment of the potential for flooding of the site was conducted by GHD[30]. A summary of the report *Draft proposed Western Sydney Airport Environmental Impact Statement, Surface Water and Geomorphology Assessment,* July 2015 is as follows.

The indicative concept design for the proposed airport has included a water management system for the site.

The airport infrastructure is located outside the 100 year ARI flood extent of Badgerys Creek, Duncans Creek and Oaky Creek. The existing creeks on the airport site would be removed and replaced with an extensive stormwater drainage network including a series of detention basins which would be created during the construction stage and remain in use during airport operation.

The indicative airport concept layout has considered the *Stormwater Drainage Design Manual* (former Department of Construction, Roads and Aerodrome Branch 1978) which identifies Average Recurrence Interval (ARI) standards for Aerodromes and is consistent with current industry practice. The guideline states minimum flood immunity requirements for airport infrastructure as shown below. Consideration has also been given to Australian Rainfall and Runoff (Engineers Australia, 1987) recommendations including the need to make appropriate allowances in the design for blockage of stormwater structures.

Aerodrome Area	Criterion	Storm Frequency (ARI, years)
Pavements		
Runways	No Ponding	50
Taxiways	No Ponding	50
Apron Other paved areas	No Ponding No Ponding within 30 m of buildings	10 50
Grassed Areas		
Runway Strip	Ponding within 75 m of runway centreline not to exceed 12 hours	5
Taxiway Strip and Apron Flanks	Ponding within 15 m of pavement edge not to exceed 12 hours	5

Typical Annual Recurrence Intervals for Aerodromes

[30] Draft proposed Western Sydney Airport Environmental Impact Statement, Surface Water and Geomorphology Assessment, July 2015

The table shows that, for key infrastructure such as runways and taxiways, flood immunity would be at least a 50-year ARI event, with additional restrictions on the duration for which any water can pond nearby.

During construction, the effects of changes to the site topography would be mitigated by the use of a network of flood detention basins. A detailed surface water management plan would be developed to manage the impacts of flooding on site during the construction period.

Assessment by GHD as part of the EIS concluded that there was a need to further develop the water management system during detailed design to be more effective at mimicking natural flows across a range of storm durations and magnitudes. The GHD assessment found that further consideration should also be given to providing a basin or other form of water detention on a tributary of Duncans Creek prior to discharge from the site.

5.5.4 CONTAMINATED LAND

No particular operational safety concerns are expected from contamination at this time. This will primarily be an issue for construction. A preliminary contamination assessment identifies that the site is currently occupied by a mixture of rural residential, agricultural and light commercial properties. Waste dumping, stockpiling of soils and the potential for asbestos was identified at many of the properties.

The assessment recommended that the following actions be completed:

- preparation and implementation of an asbestos and lead based paint management plan to prevent contamination during demolition of existing buildings including procedures for clearance of building footprints following demolition;
- intrusive contamination investigation (soil and/or groundwater sampling) as part of an early works package to assess the requirement for site remediation and/or management of contamination to prepare the site for bulk earthworks. Intrusive investigation should also include classification of waste soils (in accordance with EPA *Waste Classification Guidelines* (2014) which would require management during early works;
- preparation of a detailed remediation action plan to facilitate coordinated remediation and management of contamination during early works with consideration of the program and scope of bulk earthworks and airport development;
- remediation and validation of identified contamination to prepare the site for bulk earthworks; and
- preparation of an Unexpected Findings Protocol pertaining to contamination which would be implemented during bulk earthworks and construction of the proposed airport.

5.5.5 RAILWAY INCIDENTS

The proposed Western Sydney Airport is expected to be serviced by a rail in the future. To avoid critical airport infrastructure, the onsite portion of the rail line is expected to be predominantly underground. Underground trains and stations require particular safety matters to be addressed during design and operation and fall within the jurisdiction of the Transport for New South Wales, Office of the National Rail Safety Regulator and the NSW Independent Transport Safety Regulator. The regulatory requirements would be considered during the design of the proposed underground rail corridor.

6. FINDINGS AND CONCLUSIONS

Section 5 provides the results of a review of the key safety risks posed by the proposed airport as identified by key project stakeholders. It discusses either specific measures or outcomes which are required to further analyse the potential risks and/or resolve the identified issues. A number of these require further definition through the detailed design or related processes and a number of these studies are currently underway or will need to be undertaken in the future to achieve airport approvals.

The Stage 1 (single runway) development indicative flight paths prepared by Airservices Australia mostly eliminate interactions with existing air traffic in the Sydney basin and also avoid existing major infrastructure including Defence Establishment Orchard Hills, Warragamba Dam and Prospect Reservoir. At this stage, no unmanageable airspace safety issues have been identified for the proposed Stage 1 airport development.

A formal flight path design process would occur under the existing airspace management arrangements established by Airservices Australia with approvals from the Civil Aviation Safety Authority (CASA) closer to the time operations commence at WSA. Optimal flight path design using improved navigation technologies should ensure that potential aircraft conflicts, even in emergency go-round scenarios are reduced. Conflicts with critical infrastructure and other obstacles would also be considered during this process.

The proposed 1000 m public safety zones (PSZs) at either end of the Stage 1 runway exceeds the airport site boundary. Further risk analysis to determine individual risk levels at the airport site boundary may be required in order to meet NSW DP&E off-site risk criteria. This would be reviewed during detailed design and any necessary controls implemented.

The delivery and storage of fuel is also an important issue which will require further consideration and design. The worst case design fuel storage fire has been modelled at the airport site and indicates that in order to meet NSW DP&E off-site risk criteria, additional control measures may need to be provided. This should be further investigated during detailed design.

The other key safety risks have adequate and effective precautions available not dissimilar to other operating airports in Australia and overseas.

If all these hazards are eliminated, so far as is reasonably practicable (SFAIRP), and if this is not possible, reduced so far as is reasonably practicable by the appropriate persons conducting a business or undertaking (PCBUs) through the ongoing design, construction and regulatory processes, then the proposed airport would be considered to be safe.

Considering a possible long term airport development around 2063, it is assumed that all design issues and risk studies identified as being required for the proposed Stage 1 operation in Section 5 have been undertaken and completed. Further development of the airport however would entail similar design and operations procedures to be addressed for any additional infrastructure in accordance with all relevant industry legislation and standards and where appropriate, adaption of existing processes and procedures to the new operations area. Additionally, the aerodrome manual would need to be updated.

The development of the second (southern) runway around 2063 may require greater airspace planning and design due to the expected growth in aircraft movements and the complexity of managing aircraft movements at a number of airports in the Sydney basin including the proposed Western Sydney Airport and, Sydney (Kingsford Smith) Airport. At the time of this study, to facilitate the expected level of future demand, and based on current air safety controls and technology, a reconfiguration of the Sydney basin airspace may be necessary. However, the action that needs to be taken cannot be ascertained this far in advance and may change in response to for example, land use changes, operating practices and new technologies introduced in the intervening period.

7. REFERENCES

Airservices Australia (10 April 2015) *Western Sydney Airport Preliminary Airspace Management Analysis*. Final Report.

Airservices Australia (July). *Smartpath.*

Airservices Australia (undated). *Fact Sheet – Regulation Reform: Performance based navigation: GNSS and ADS-B equipment mandates.*

Australian Government (2011) *Australia's State Aviation Safety Program*

Australian Airports Association (Oct 2014). *Airport Practice Note 5*.

Avisure 2015. *Preliminary Bird and Bat Strike Risk Assessment*. Draft May 2015

Boeing Commercial Services (August 2014). *Statistical Summary of Commercial Jet Airplane Operations I 1959 – 2013.*

Bureau of Meteorology 2015a. *Western Sydney Airport Climatological Review.*

Bureau of Meteorology 2015b. *Western Sydney Airport Usability Meteorological Impacts*

Civil Aviation Safety Authority (March 2015). *Sydney Basin Aeronautical Study*. Draft.

DIRD (June 2015). Airport Plan, Western Sydney Airport. Draft.

Department of Transport (March 2010). *Control of Development in Public Safety Zones*

Department of Transport (1/210) *Farnborough Airport Public Safety Zones (PSZs)*

Evans, Andrew (c 1997). *Third Party Risk and Airport Public Safety Zones*. Private communication.

GHD (June 2015). Proposed WSA Preliminary Contamination Assessment

GHD (July 2015). Draft proposed Western Sydney Airport Environmental Impact Statement, Surface Water and Geomorphology Assessment

GHD (July 2015). Western Sydney Airport EIS – Bushfire Risk Assessment

ICAO (2014). *Safety Report*

NATS (May 2014). *A Second Runway for Gatwick Appendix A27 Public Safety Zones*. Version 1.0 Final

National Transportation Safety Board TSB/AAR-10/03 PB2010-910403 Notation 8082A Adopted May 4, 2010.

NSW Department of Planning (2011). *HIPAP 4: Risk Criteria for Land Use Safety Planning*

NSW Department of Planning *(2011). HIPAP 10: Land Use Safety Planning*

NSW Rural Fire Service (2015). *History of Fires in NSW.*

PPK Environment and Infrastructure 1997, *Draft Environmental Impact Statement: Second Sydney Airport Proposal*, PPK House, Concord West.

Robinson, Richard M and Gaye Francis (2015). *Engineering Due Diligence* (10th edition). R2A Pty Ltd. Melbourne.

GLOSSARY AND ABBREVIATIONS

AAA	Australian Airport Association
ASD-B	Automatic dependent surveillance-broadcast
AFRRS	Airport Rescue Fire Fighting Service (Airservices Australia)
AFP	Australian Federal Police
ATC	Air Traffic Control
BoM	Bureau of Meteorology
CAA	Civil Aviation Authority, New Zealand
CASA	Civil Aviation Safety Authority
Cth	Commonwealth
DIRD	Department of Infrastructure and Regional Development
DP&E	NSW Department of Planning and Environment
EIS	environmental impact statement
EPA	NSW Environment Protection Authority
FDS	fire dynamics simulator
GA	general aviation
GNSS	global navigation satellite system
GPS	global positioning system (USA)
HIPAP	NSW Hazardous Industry Planning Advisory Paper
ICAO	International Civil Aviation Organisation
IFR	instrument flight rules
ILS	instrument landing system
Individual risk	The frequency at which an individual may be expected to sustain a given level of harm from the realisation of specified hazards (Institution of Chemical Engineers (2005) *Nomenclature for Hazard and Risk Assessment in the Process Industries)*.
KSA	Sydney Kingsford Smith Airport
NDB	non directional beacon
NSW	New South Wales
OAR	Office of Airspace Regulation (CASA)
OLS	obstacle limitation surfaces
PANS-OPS	Procedures for Air Navigation Services – Aircraft Operations
PCBU	person conducting a business or undertaking
PSZ	public safety zone
PBN	performance based navigation
R2A	R2A Due Diligence Engineers
RFS	Rural Fire Service, New South Wales
RPA	remotely piloted aircraft
RPT	regular passenger transport
SID	standard instrument departure
Societal Risk	The relationship between frequency and the number of people suffering from a specific level of harm in a given population from the realisation of specified hazards. (Institution of Chemical Engineers (2005) *Nomenclature for Hazard and Risk Assessment in the Process Industries)*.
STAR	standard terminal arrival route
TCAS	traffic collision avoidance system
VFR	visual flight rules
VOR	VHF omnidirectional radio range
WHS	Work health and safety
WSA	Western Sydney Airport

www.r2a.com.au

Level 1, 55 Hardware Lane
Melbourne, VIC, 3000 Australia
1300 772 333