13 Human health

The health risk assessment has considered the risks associated with construction and operation of the Stage 1 development on the health of the community. The assessment focuses on the chronic health risks associated with changes to air quality, noise, and surface and groundwater through a comparison with existing conditions. These issues were identified as the most likely pathways of potential impact to community health from the Stage 1 development. Other perceived and non-chronic health effects, such as anxiety associated with the airport, are considered as part of the social impact assessment in Chapter 23.

The air quality health risk assessment evaluated the predicted health risks associated with the emission of particulate matter, nitrogen dioxide, sulfur dioxide, air toxics (benzene, toluene, xylenes and formaldehydes), diesel, and ozone. The noise health risk assessment considered both aircraft overflight and ground-based operations sources. The water quality health risk assessment considered water contaminants to surface water and groundwater including petroleum hydrocarbons, heavy metals, polyaromatic hydrocarbons, chlorinated hydrocarbons and perflourinated compounds. In all cases, the relevant EIS technical studies were drawn upon to provide the exposure and impact level data used in the risk assessment. Criteria used for the health risk assessment included the National Environmental Protection Measure (NEPM), as well as national and international guideslines from the National Health and Medical Research Council, NSW Health and the World Health Organization (WHO).

During construction, health risks are generally predicted to be low and within acceptable limits. Emission of particulates would be less than the NEPM criteria for both PM_{10} and $PM_{2.5}$. Construction noise levels would be confined mostly to the airport site and risks to local water quality are typical of most major construction projects. Standard precautionary measures are considered to be appropriate to address these issues. Due to the relatively short period over which construction will take place, it is unlikely that any of the potential health risks will be realised.

The air quality health risk assessment identified that the predicted health risks from the Stage 1 operations would generally be within or at the upper bound of national and international standards of acceptability, with the exception of NO_2. As noted in the air quality assessment in Chapter 12, a significantly large contributor to air quality impacts, and therefore health risks, are background emissions from urban development and road vehicles external to the airport site. Overall, air quality impacts are predicted to increase the risk of mortality, hospital admissions and emergency department attendances. However, these risks are very small when compared to health impacts from existing air pollution in Sydney.

Overall, the risk posed by noise to the health of exposed communities is generally low and within acceptable limits. The results of the noise health risk assessment indicate that noise from aircraft overflight and ground-based operations may lead to a small increase in sleep disturbance for communities around the airport site. The noise health risk assessment also found that there is no predicted risk for increases in cardiovascular disease and the risk to learning and cognitive development in children is largely within acceptable limits. During Stage 1 operations, Luddenham is predicted to experience the highest risks associated with noise due to its proximity to the airport site.

The water quality health risk assessment found that potential impacts to Sydney's drinking water supplies, in reservoirs at Warragamba and Prospect, is unlikely due to their distance from the airport site and low predicted levels of particulates at these locations. Similarly, the health risk assessment did not find evidence to suggest that private rainwater tanks would be adversely affected by airport operations. Comprehensive surface and groundwater baseline data will be collected throughout construction and operation of the Stage 1 development to better inform the future assessment of potential water contamination.

Having regard to the identified risks outlined above, and that for some pollutants there is no defined 'safe' level below which exposure will not result in adverse health effects, the health risk assessment includes reference to mitigation and management measures in other chapters in the EIS which will reduce the health risks of the proposed airport. It is expected that following implementation of these measures, the identified health risks of the Stage 1 development will be reduced.

It is acknowledged that just over half of the representative communities analysed in the health risk assessment had a SEIFA index (socio-economic index for areas) less than the Sydney average. This indicates that populations in these localities may be vulnerable to the effects of air, noise and water pollution from the proposed airport.

13.1 Introduction

This chapter considers the risks associated with the construction and operation of the Stage 1 development on the health of the community. It draws on the specialist health risk assessment (see Appendix G (Volume 4)) undertaken during the preparation of the EIS which considered the risks associated with noise, air and surface/ground water emissions from the proposed airport.

The health risk assessment considers the baseline health profile of the region and identifies key health risks from the construction and operation of the Stage 1 development. The implementation of mitigation measures associated with noise, air quality and water quality described in the relevant chapters of this EIS would reduce the predicted risks.

13.2 Methodology

The health risk assessment was undertaken in accordance with the Australian Government Guidelines for Health Risk Assessment (enHealth 2012), the National Health and Medical Research Council Approach to Hazard Assessment for Air Quality (NHMRC 2006), WHO Guidelines for Community Noise (WHO 2000), the WHO Night Noise Guidelines for Europe (WHO 2009) and the WHO Guidelines for Drinking Water Quality (2011).

The health risk assessment uses information about pollutants to estimate a theoretical level of risk for people who might be exposed to defined pollutant levels. Health statistics for Sydney have been used as a baseline in the assessment, with information on the health risks of pollutants being drawn from scientific studies. Data on existing pollutant levels come from ambient monitoring stations in Western Sydney operated by the NSW Office of Environment and Heritage and the NSW Environment Protection Authority.

The risk assessment process comprises five stages: issue identification, hazard (or toxicity) assessment, exposure assessment, risk characterisation and uncertainty assessment. Through the issues identification stage, it was determined that the primary pathways by which the proposed airport could pose a risk to human health were exposure to air pollutants, noise, and surface water pollutants and groundwater pollutants.

The health risk assessment is based upon the findings of the local air quality, regional air quality, aircraft overflight noise, ground-based noise and water quality technical studies undertaken as part of the preparation of the EIS. The potential health effects of airport operations have been considered in the assessment, as well as the health impacts associated with emissions from background sources associated with road traffic and urbanisation in the broader region. The potential health risk from construction activities has also been assessed.

The results of the risk assessment are typically presented in terms of the number of ‘attributable cases’ relevant to each aspect considered. For example, health risk assessments for pollutants draw on population studies typically undertaken across an entire society or a specified section of society. Accordingly, references to the number of hospital admissions for respiratory disease are intended to identify a change in the number of hospital admissions across a specified population resulting from exposure to the pollutant compared to the baseline level.

13.2.1 Air quality

13.2.1.1 Pollutants

The health effects resulting from exposure to particulate matter of 10 micrometres or less (PM_{10}), particulate matter of 2.5 micrometres or less ($PM_{2.5}$), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO) have been assessed in this health risk assessment. These pollutants have been considered for the potential for any increases in mortality, hospital admissions for respiratory and cardiovascular disease, and emergency department visits for asthma in children, that may be attributable to emissions from the proposed airport.

Baseline health statistics for Sydney have been used in the assessment and the risk has been assessed for localities within five kilometres of the airport boundary. The localities include Bringelly, Luddenham, Greendale, Kemps Creek, Mulgoa, Wallacia, Badgerys Creek, Rossmore and Mount Vernon.

13.2.1.2 Ozone

The regional air quality assessment follows the NSW EPA guidelines and identifies peak ozone periods with potential exceedances of air quality standards. The assessment has considered the potential risk that ozone may have on mortality and emergency department visits for asthma in children that may be attributable to emissions from the proposed airport.

The assessment is based on a small sample of days when exceedances of the standards are predicted and when there is a good correlation between the model outputs and existing monitoring data obtained from NSW EPA monitoring stations. Given there is only a limited ozone prediction dataset available, a full risk characterisation is not possible. The approach adopted focuses on the potential increase in risk due to changes in ozone only on the days where exceedances are predicted. However, this is considered to be a reasonable approach because the likelihood of health impacts arising in circumstances where there are no or very few relevant exceedances of ozone is very small.

13.2.1.3 Air toxics

A number of air toxics will be emitted during airport operations. Air dispersion modelling has been conducted for benzene, toluene, xylenes and formaldehyde. The most significant potential health risk is cancer from exposure to benzene. The predicted data for benzene has been used in the health risk assessment for Stage 1 operations.

To enable the potential increased risk of cancer arising from the airport operations to be evaluated, annual average concentrations of benzene have been modelled. The maximum concentration predicted at any location was 0.1 $\mu g/m^3$. This value has been used to calculate the maximum cancer risk from benzene in the surrounding area.

13.2.1.4 Diesel

Diesel emissions associated with the proposed airport would arise from machinery used during construction activities as well as truck movements to, from and on the site. Diesel emissions would also be generated through the use of diesel powered equipment onsite during operations.

In recent years there has been increased community concern about the health effects of diesel. Exposure to diesel exhaust can have immediate health effects. Diesel exhaust can irritate the eyes, nose, throat and lungs, and it can cause coughs, headaches, light headedness and nausea. In studies with human volunteers, exposure to diesel exhaust particles at certain intensities made people with allergies more susceptible to the materials to which they are allergic, such as dust and pollen. Exposure to diesel exhaust at certain intensities also causes inflammation in the lungs, which may aggravate chronic respiratory symptoms and increase the frequency or intensity of asthma attacks. Diesel exhaust and many individual substances contained in it (including arsenic, benzene, formaldehyde and nickel) have the potential to contribute to mutations in cells that can lead to cancer.

13.2.2 Noise

Health risks associated with aircraft overflight noise and airport ground-based noise were predicted for three health outcomes:

- sleep disturbance (measured as awakenings);
- myocardial infarction (heart attacks); and
- impacts on learning and cognitive development in children.

Other impacts associated with noise, such as annoyance and impacts on lifestyle and social amenity are assessed in the social impact assessment (see Chapter 23).

The health risk assessment includes consideration of noise exposure from aircraft overflights as well as airport ground-based sources. Residential areas and schools were identified as sensitive noise receivers in the EIS (see Appendix E (Volume 4)) and are listed in Table 13–1 and shown in Figure 13–1. Although the schools have been identified primarily for assessment of the potential impacts on children’s learning and cognitive development, they are also located in residential areas. Accordingly, the noise levels predicted at these locations would be representative of the exposure to noise for the local community, and have also been used in the assessment of sleep disturbance.

Table 13–1 Representative sensitive noise receivers

Residential areas	
Bringelly	Greendale
Kemps Creek	Silverdale
Erskine Park	Horsley Park
Rossmore	Rooty Hill
St Marys	Prospect
Schools	
Warragamba Preschool	Bringelly Public School
Emmaus Catholic College (Kemps Creek)	Mount Druitt Public School
Horsley Park Public School	St Marys South Public School
Luddenham Public School	Colyton High School
Bennett Road Public School (Colyton)	Banks Public School (St Clair)
St Clair High School	Plumpton High School
Blackwell Public School (St Clair)	

Following the enHealth Health Effects of Environmental Noise other than Hearing Loss (2004) WHO guidelines (2009; 1999), the assessment of the potential impacts of aircraft noise considers the following noise metrics:

- L_{Aeq}: a measure of noise which represents the equivalent-continuous noise level averaged over a specified period;
- $L_{Aeq,11pm\text{-}7am}$ or $L_{night,outside}$: the equivalent-continuous noise level between 11.00 pm and 7:00 am. This metric is used to describe night time noise exposure and assess chronic health impacts associated with noise exposure;
- $L_{Aeq,9am\text{-}3pm}$: the equivalent-continuous noise level between 9.00 am and 3.00 pm. This metric is used to assess the impact of noise on school students and teachers; and
- L_{Amax}: a measure of the maximum noise level during a specified period. This metric is used to assess night time noise impacts from aircraft overflights.

The WHO Night Noise Guidelines for Europe (2009), summarised in Table 13–2, identify the relationship between different night noise levels and health effects. These guidelines were used to inform the assessment of health risks.

Table 13–2 WHO Guidelines (2009) – Effects of different levels of night noise on population health

Average night noise level over a year L_{night} outside	Health effects observed in the population
Up to 30 dB	Although individual sensitivities and circumstances may differ, up to this level no substantial biological effects are observed. A level of 30 dB L_{night} outside is equivalent to the no observed effects level (NOEL) for night noise.
30 to 40 dB	A number of effects on sleep are observed in this range such as body movements, awakening, self-reported sleep disturbance and arousals. The intensity of the effects depends on the nature of the source and the number of events. Vulnerable groups (for example children, the chronically ill and the elderly) are more susceptible. However, even in the worst case, the effects are modest. A level of 40 dB L_{night} outside is equivalent to the lowest observed adverse effects level (LOAEL) for night noise.
40 to 55 dB	Adverse health effects are observed among the exposed population. Many people have to adapt their lives to cope with noise at night. Vulnerable groups are more severely affected.
Above 55 dB	The situation is considered increasingly dangerous for public health. Adverse health effects occur frequently, a sizeable portion of the population is highly annoyed and sleep-disturbed. There is evidence that the risk of cardiovascular disease increases.

As outlined in Table 13–2, below the level of 30 dB $L_{night,outside}$, no effects on sleep are observed except for a slight increase in the frequency of body movements during sleep due to night noise. There is insufficient evidence that the biological effects observed below 40 dB $L_{night,outside}$ are harmful to health (WHO, 2009). The WHO recommends that for the prevention of subclinical adverse health effects associated with night noise, the population should not be exposed to night noise levels greater than 40 dB $L_{night,outside}$. An interim target of 55 dB was recommended by the WHO in situations where the night noise guideline was not feasible in the short term.

Two approaches have been taken to assess sleep disturbance. The first is to estimate the number of electroencephalography (EEG) awakenings that may be associated with noise and the second is to assess full awakenings. An EEG awakening is not a fully awakened state but is a measure of disturbed sleep. The dose-response curves shown in the European Environment Agency (EEA) Good Practice Guide on Noise Exposure and Potential Health Effects (EEA, 2010) have been used to estimate the number of EEG awakenings due to both aircraft and ground operational sources.

In relation to noise impacts on learning and cognitive development in children, the hazard quotient approach has been used to assess the potential impacts. This involves dividing the predicted levels for daytime noise by the noise guidelines levels to generate a hazard quotient. The relevant noise guidelines used are based on the WHO Guidelines for Community Noise (WHO 2000), summarised in Table 13–3, which establishes a noise guideline of 55 dB for outside noise and 35 dB for inside noise in school environments.

Table 13–3 WHO Guidelines (2000) – Community noise guidelines for school environments

School Environment	Critical Health Effects	L_{Aeq} (dBA)	Time base (hours)
School class rooms and preschools indoors	Speech intelligibility, disturbance of information extraction, message communication	35	During class
School playground, outdoors	Annoyance (external source)	55	During play

If the hazard quotient is less than 1, then no adverse health effects are expected as a result of exposure to the hazard. If the hazard quotient is greater than 1, then adverse health effects are possible. It should be noted that a hazard quotient exceeding 1 does not necessarily mean that adverse effects will occur.

Using the findings from the noise impact assessments, the health risk assessment used these metrics and guidelines to identify the potential for annoyance, sleep disturbance, increased likelihood of cardiovascular disease, and impacts on children's learning and cognitive development. Predicted noise levels were calculated at an external point of the building. Noise levels within a building would be significantly lower, depending on the building fabric and whether windows and doors are opened. To assess inside noise impacts on learning and cognitive development in children, the predicted outside noise levels were reduced by 10 dB, consistent with the aircraft overflight noise report (see Appendix E1 (Volume 4)).

Further information about the methodology used in the health risk assessment can be found in Appendix G (Volume 4). The predicted noise levels were calculated at specific locations (see Figure 13–1), using assumptions and procedures that are described in detail in the noise assessment reports in Appendix E (Volume 4).

13.2.3 Ground and surface water

Groundwater data from samples collected in 1995 and 1998 were compared to groundwater investigation levels from relevant guideline sources. A qualitative evaluation of the risk potential to identified waterbodies under current conditions at the site and in surrounding areas has been conducted.

The ANZECC (2000) guidelines set out key indicators which can be used to measure whether there is a potential risk to each environmental value. Indicators have been selected based on the appropriate level of protection for the waterways at and surrounding the site. These indicators provide a risk-based approach to assessing the potential for impacts to environmental values.

13.3 Existing environment

13.3.1 Airport site

The airport site covers an area of approximately 1,780 hectares located at Badgerys Creek in Western Sydney. The site is located approximately 50 kilometres west of Sydney's central business district and 15 to 20 kilometres from major population centres such as Liverpool, Fairfield, Campbelltown and Penrith.

The Northern Road transects the western end of the airport site and Elizabeth Drive borders the site to the north. Badgerys Creek flows in a north-easterly direction and forms the south-eastern boundary of the airport site. The airport site is located on undulating topography that has been extensively cleared with the exception of stands of remnant vegetation located predominantly along Badgerys Creek and the south-western portion of the site.

Figure 13–1 shows the sensitive receivers selected for the purposes of the health risk assessment.

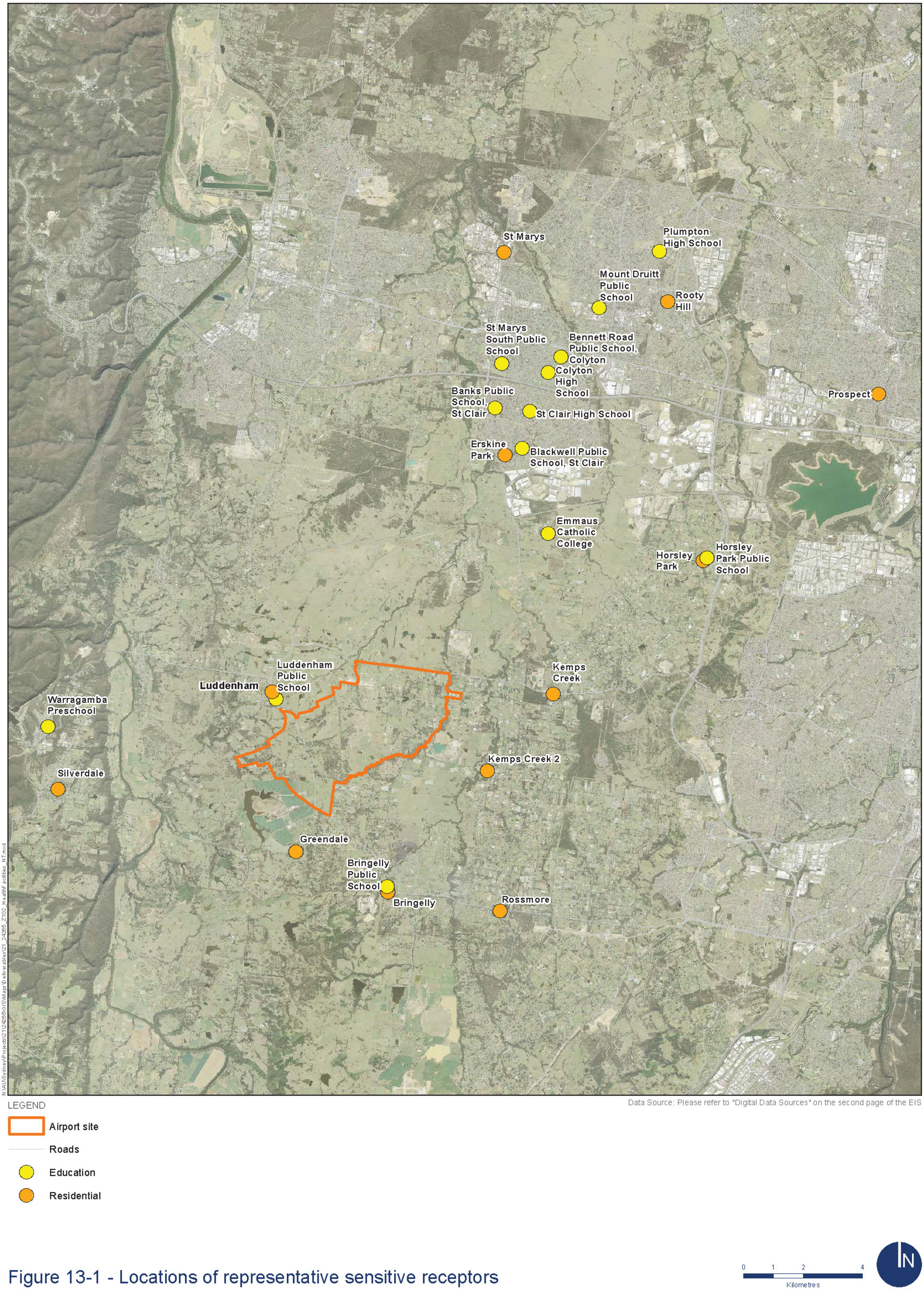


Figure 13-1 - Locations of representative sensitive receptors

13.3.2 Demography

The airport site is located within the Liverpool local government area (LGA). The Liverpool LGA is bounded by Fairfield, Penrith, Camden, Wollondilly and Canterbury-Bankstown LGAs (see Figure 13–2).

Population statistics for the 2011 Census have been obtained from the Australian Bureau of Statistics for each of the localities surrounding the airport which have been considered in the health risk assessment. These statistics are shown in Table 13–2, with the localities sorted in order of increasing population size. It is noted that the stated population of Badgerys Creek would have included tenants on the airport site, however as the majority of these tenants have relocated, the current population would be much lower.

The South West Sydney Local Health District forecasts in its Liverpool Community Health Profile (2014) that the population of Liverpool LGA will increase significantly from 188,088 people in 2011 to 288,959 in 2031. The highest rate of growth is anticipated in the age cohort 45-69.

13.3.3 Socio-economic status

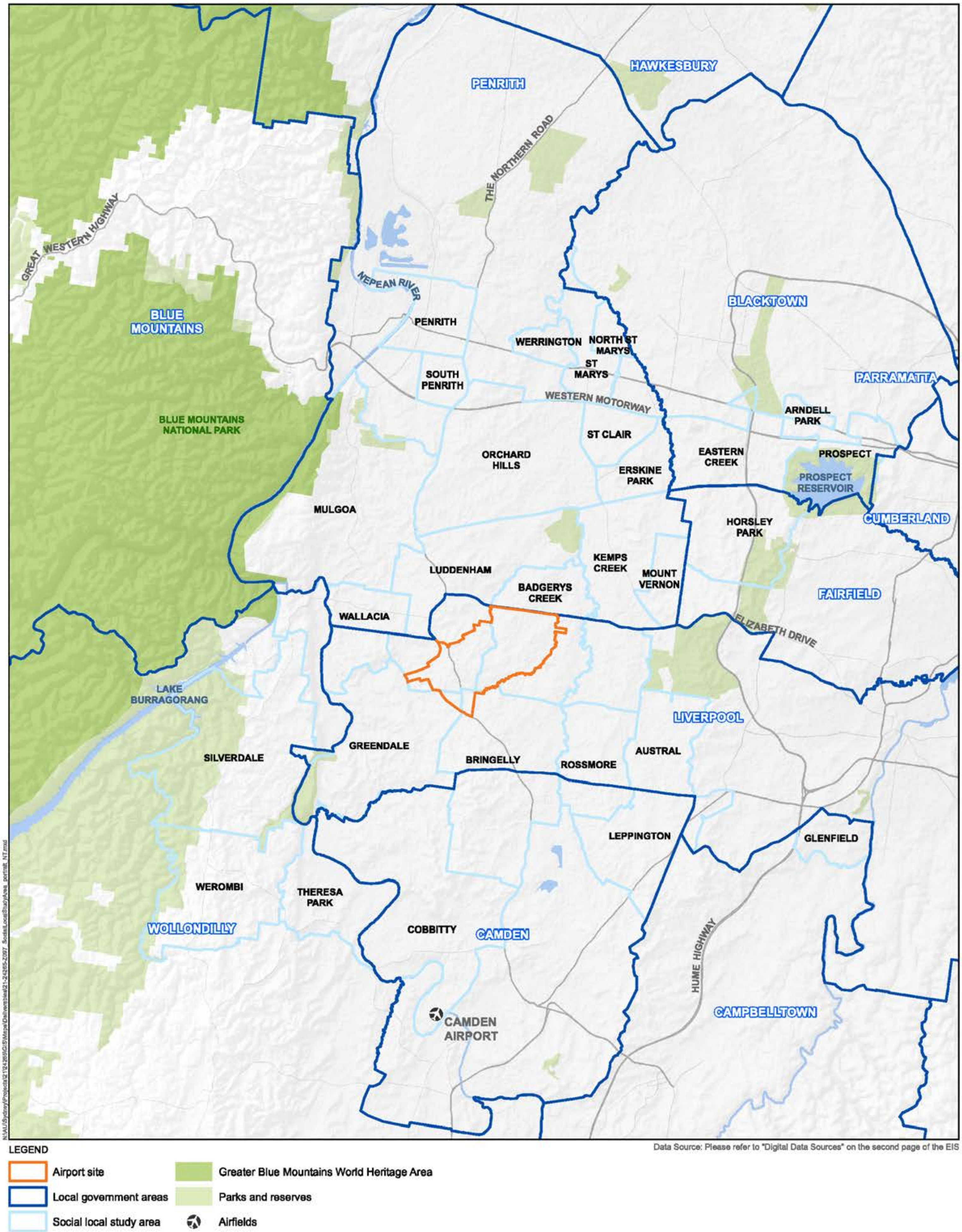
Consistent with assumptions found generally in epidemiological studies, people who are of a low socioeconomic status are identified as a vulnerable group for the effects of air, noise and water pollution for the purposes of a health risk assessment. This is largely due to the fact that people within these groups usually have a poorer health status, may have limited access to medical care, and may live in more affordable areas which generally experience higher rates of pollution (e.g. near major roads or industry).

The health risk assessment adopts the Socioeconomic Indexes for Areas (SEIFA) as a measure of relative social disadvantage. This measure takes into account 20 variables (including income levels, educational attainment, unemployment and vocational skills).

SEIFA scores in Table 13–4 indicate that there are areas within the vicinity of the proposed airport with a lower socioeconomic status than the Australian average (SEIFA score of 1,000) or Sydney as a whole (SEIFA score of 1,025). The localities of Badgerys Creek, St Marys, Mount Druitt, Rooty Hill, Colyton and Warragamba all have low SEIFA scores indicating that the populations in these localities may be vulnerable to the effects of air, noise and water pollution from the proposed airport.

13.3.4 Health baseline

A baseline health status of the Liverpool LGA was prepared by the South West Sydney Local Health District as part of their 2014 Community Health Profile (see Table 13–3). This table summarises the key indicators for hospitalisations and mortality in the Liverpool LGA, compared to the average for NSW over the same period. Whilst Liverpool experiences a relatively higher number of coronary heart disease, diabetes, and fall related hospitalisations, it is generally comparable to the NSW health profile, having regard to the full range of measured health indicators for the population.



Data Source: Please refer to "Digital Data Sources" on the second page of the EIS

Figure 13-2 - Airport site and social local study area

Table 13–4 Demographic profile of localities surrounding the airport site (ABS 2011)

Locality	Approximate distance to the airport (km)	Total population	Proportion of population older than 65 years of age (%)	Proportion of population younger than 15 years of age (%)	SEIFA index
Australia (average)	-	-	14	19	1,000
Sydney (average)	-	-	13	19	1,025
Greendale	8	352	11	22	986
Badgerys Creek*	3	455*	12	20	913
Mt Vernon	8	1,036	11	20	1,102
Warragamba	11	1,236	12	22	914
Luddenham	3	1,496	12	22	1,034
Wallacia	8	1,700	10	21	1,032
Mulgoa	8.5	1,792	12	20	1,065
Horsley Park	13	1,936	16	18	1,007
Kemps Creek	6	2,309	15	19	993
Bringelly	6	2,387	10	21	1,036
Rossmore	8	2,412	13	22	997
Silverdale	11	3,439	7	24	1,077
Prospect	21	4,621	9	21	1,031
Erskine Park	11.5	6,668	4	23	1,041
Colyton	13	7,993	11	22	930
Plumpton	18.5	8,244	6	25	999
St Marys	14	10,961	14	21	881
Mt Druitt	16	15,764	8	26	895
Rooty Hill	17	13,377	12	22	970
St Clair	12	19,837	6	21	1,013

*The population of Badgerys Creek includes tenants on the proposed airport site; however, at the time the airport becomes operational, these tenants will no longer be occupying the site and therefore the population would be expected to be much lower.

Table 13–5 Liverpool LGA baseline health status

Indicator	Liverpool LGA	Proportion of NSW average (%)
Hospitalisations		
Hospitalisations (2009/10 to 2010/11) per year	58,010	99.9
Potentially preventable hospitalisations per year (2010/11 to 2011/12)	3,850	95.4
Alcohol attributable hospitalisations per year (2010/11 to 2011/12)	934	81.8
Smoking attributable hospitalisations per year (2010/11 to 2011/12)	905	100.5
High body mass index attributable hospitalisations per year (2010/11 to 2011/12)	719	101
Coronary heart disease hospitalisations per year (2009/10 to 2010/11)	821	91.2
Chronic obstructive pulmonary disease hospitalisations (persons aged over 65) per year (2009/10 to 2010/11)	262	112.9
Diabetes hospitalisations per year (2009/10 to 2010/11)	515	132.1
Fall-related injury overnight hospitalisations (persons aged 65 years and over) per year (2010/2011 to 2011/12)	572	116.9
Stroke hospitalisations per year (2010/11 to 2011/12)	196	97.6
Deaths		
Potentially avoidable deaths (persons aged under 75 years) per year (2006 to 2007)	211	99.5
Potentially avoidable deaths from preventable causes (persons aged under 75 years) (2006 to 2007)	122	96.6
Potentially avoidable deaths from causes amenable to health care (persons aged under 75 years) per year (2006 to 2007)	84	97.8
High body mass index attributable deaths (2006 to 2007)	46	91.1
Alcohol attributable deaths per year (2006 to 2007)	23	94.6
Smoking attributable deaths per year (2006 to 2007)	79	99.2

Over the period 2005 to 2007, Liverpool LGA had a higher mortality ratio of 107.3 (NSW baselined at 100). The life expectancy for both males (79.5) and females (83.4) was less than the NSW averages (males 79.6 and females 84.3).

According to the Liverpool Community Health Profile (SWSLHD), the asthma prevalence rate in people over 16 years of age in the area is 6.3 per cent. This is lower than the NSW average for the same age group.

In 2006, a Parliamentary Inquiry into the health impacts of air pollution in the Sydney basin found that despite evidence that air pollution had improved over the last 30 years, these improvements were offset by Sydney's growing population, particularly in the south-west and western areas of Sydney. An increasing reliance on private motor vehicles, made worse by inadequate public transport was noted as a major challenge. Evidence provided by NSW Health at that time estimated that in Sydney there was between 600 and 1,400 deaths per year due to air pollution in the Sydney basin.

13.3.5 Air quality

Air quality monitoring data collected between 2005 and 2014 from the NSW Office of Environment and Heritage monitoring stations in Bringelly, Macarthur/Campbelltown West, Liverpool and Richmond was used to describe the existing air quality in Badgerys Creek. A detailed outline of the available air quality data is provided in Appendix F1 (Volume 4). Generally, air quality for the local area is good, with the exception of isolated high pollution days or extreme events such as dust storms and bushfires. Uncontrolled combustion events such as bushfires will influence regional measurements of PM_{10}, $PM_{2.5}$ and to a lesser extent, NO_X.

13.3.6 Groundwater

Groundwater at the airport site is generally poor quality with limited beneficial use or environmental value. The aquifers at the airport site include:

- an unconfined aquifer in the shallow alluvium of the main watercourses at the airport site;
- an intermittent aquifer in weathered clays overlying the Bringelly Shale;
- a confined aquifer within the Bringelly Shale; and
- a confined aquifer within the Hawkesbury Sandstone.

Groundwater within the alluvium has been measured at depths between 0.7 and 4.7 metres. Within the Bringelly Shale, groundwater has been measured at depths between 3.0 and 11.7 metres, and at depths between 2.4 and 4 metres in the overlying weathered material (PPK 1997; Coffey & Partners 1991). Groundwater within the Hawkesbury Sandstone is significantly deeper because the aquifer is 100 metres below ground level.

Groundwater quality data indicates elevated concentrations of lead, zinc, copper, nitrogen and phosphorous above the values in the ANZECC freshwater guidelines. Nitrate and sulphate exceeded guideline values at some locations. Groundwater was found to be saline with an average electrical conductivity equalling 21,474 µS/cm and exceeding the 2,200 µS/cm guideline (PPK 1997), indicating a low beneficial reuse potential.

The shallower alluvial aquifer at the airport site is understood to discharge at Badgerys Creek, Cosgroves Creek and Duncans Creek. However, surface discharges from the Bringelly Shale aquifer and overlying weathered material are likely to be limited by low connectivity and hydraulic conductivity. Groundwater salinity is an order of magnitude higher on average than surface water salinity at the airport site, which is further evidence of the limited groundwater discharge.

A number of surface water dams are present across the site. These features are expected to have been developed initially to capture surface water runoff and are therefore primarily reliant on surface water inputs rather than groundwater. The low permeability clays in which these dams have been developed would limit the connection with surrounding groundwater.

A total of 42 groundwater bores are registered in the vicinity of the airport site. The groundwater bores are recorded as being constructed to significant depths and are understood to generally target the Hawkesbury Sandstone aquifer, which is known to be of higher beneficial use value. It is likely that the Hawkesbury Sandstone is preferentially targeted because of the relatively poor quality of Bringelly Shale groundwater.

13.3.7 Surface water

Two main catchments drain the site: the South Creek Catchment and the Nepean River Catchment. There are several waterways that are within, or in the vicinity of, the airport site:

- Duncans Creek is located to the south-west of the site and drains to the Nepean River west of the airport site;
- Oaky Creek flows through the central and northern area of the airport site and then drains to Cosgroves Creek;
- Cosgroves Creek flows along to the north-west and north of the airport site, before draining into South Creek to the north-east of the site;
- Badgerys Creek flows along the southern and south-eastern boundary of the airport site and then drains to South Creek to the north-east of the airport site; and
- Thompsons Creek is located to the south-east of the airport site and drains to South Creek to the south-east of the airport site.

Each of the above listed waterways has a number of small tributaries which drain the airport site and areas in the vicinity. Many of the creeks which drain the airport site and surrounding area may not flow continuously. During dry periods, only intermittent pools of water may remain along the creek beds.

Warragamba Dam is located approximately 11 kilometres west of the airport site and is one of Sydney's major drinking water supply dams. Prospect Reservoir is located approximately 16 kilometres north-east of the site. Prospect Reservoir is a potable water supply which is used during periods of high demand. The airport site is not located within the catchment area for either the dam or the reservoir. There are also numerous farm storage dams on and surrounding the airport site, as well as rain water tanks on properties around the site used for potable water.

Surface water quality sampling has been undertaken for the EIS and is outlined in Appendix L2 (Volume 4). The results indicate that the nutrient loads are generally well above both the Airports (Environment Protection) Regulations 1997 (AEPR) accepted limits and the default values in the Australian and New Zealand Environment Conservation Council (ANZECC) guidelines. Turbidity and total suspended solids were found to be within acceptable levels, while dissolved oxygen levels were found to be relatively low. The data also indicate that conductivity levels were high, and above those for typical lowland rivers. Some exceedances of chromium, copper and zinc were also detected. The results are generally consistent with prior sampling conducted in 1997 and more recently in 2014, and demonstrates the limited change to land uses in the intervening period.

The water quality sampling results indicate that both the airport and downstream catchments are fairly degraded, particularly in terms of nutrients. The existing water quality does not typically satisfy the AEPR limits or default ANZECC guideline criteria for the protection of aquatic ecosystems, primary and secondary contact recreation, as well as irrigation water use for food and non-food crops.

13.4 Assessment of impacts during operation

13.4.1 Particulate matter

The local air quality assessment found that Stage 1 operations would result in the emission of particulate matter (PM_{10} and $PM_{2.5}$). Background emissions from road vehicles using roads external to the airport site would account for approximately 92 per cent of total PM_{10} emissions and approximately 90 per cent of total $PM_{2.5}$ emissions. Activities on the airport site itself would amount to approximately 7 per cent of total PM_{10} emissions and approximately 10 per cent of total $PM_{2.5}$ emissions, with the remaining balance coming from road traffic accessing the airport site. The main source of PM_{10} and $PM_{2.5}$ onsite would be aircraft engines, followed by the operation of auxiliary power units (APUs) and ground support equipment (GSE).

Annual average and 24-hour emissions for particulate matter have been modelled as part of the local air quality assessment. The average 24-hour NEPM Ambient Air Quality (NEPM-AAQ) standard for PM_{10} and $PM_{2.5}$ are 50 $\mu g/m^3$ and 25 $\mu g/m^3$ respectively and all predictions of emissions from the Stage 1 development are below these levels. A revised NEPM-AAQ standard will reduce the acceptable levels for 24-hour $PM_{2.5}$ to 20 $\mu g/m^3$ however all predictions for $PM_{2.5}$ emissions are also below this standard. The highest predicted 24-hour average PM_{10} and $PM_{2.5}$ concentrations are predicted at Badgerys Creek, Bringelly and Rossmore.

The health effects of particle matter linked to ambient exposures have been well studied and reviewed by international agencies. An overview of the literature related to the health effects of particulate matter is provided in Appendix G (Volume 4). Most information comes from population-based epidemiological studies that find increases in mortality, increases in hospital admissions and emergency room attendances, and exacerbation of asthma associated with daily changes in ambient particle levels. In recent years, there has been an increasing focus on the association between exposure to particles and cardiovascular outcomes. In addition to studies on the various size metrics for particles, recent research has also investigated the role of particle composition in the observed health effects.

The predicted number of attributable cases due to PM_{10} during operations is low. The highest risk is for all-cause mortality from long term exposures with between four additional deaths per 1,000 years and six additional deaths per 100 years attributable to PM_{10}. The highest risk is predicted for Bringelly and Rossmore with an additional six deaths per 100 years predicted. All other risks are lower than that predicted for these outcomes.

Similar to PM_{10}, the numbers of cases attributable to $PM_{2.5}$ are low. The highest risk is for all-cause mortality and cardiopulmonary mortality from long term exposures with between two additional deaths per 1,000 years and six additional deaths per 100 years. The highest risks are predicted for Bringelly and Rossmore. All other risks are lower than that predicted for these outcomes.

13.4.2 Nitrogen dioxide

The local air quality assessment found that Stage 1 operations would result in the emission of nitrogen oxides (NO_x), which includes nitrogen dioxide (NO_2). Background emissions from road vehicles using the external road infrastructure would account for approximately 68 per cent of total NO_x emissions. Activities on the airport site itself would amount to approximately 31 per cent of total NO_x emissions, with the remaining balance coming from road traffic accessing the airport site. The majority of NO_x emissions generated onsite would come from aircraft engines, with some emissions generated from the operation of APUs and GSE.

Although the predicted NO_x levels meet the NEPM-AAQ standards, it is recognised that there is no threshold for these pollutants below which adverse health effects are not observed. This means that even meeting the air quality standards means that there remains a level of risk associated with exposure.

The daily maximum 1-hour nitrogen dioxide concentrations at residential receivers are predicted to be low. The local air quality assessment identified that for all relevant averaging periods, the nitrogen dioxide levels due to airport operations are below the current NEPM-AAQ standards. The levels predicted at all residential locations are similar, with slightly higher levels at Greendale.

An overview of the literature related to the health effects of NO_2 is provided in Appendix G (Volume 4). Recent studies of both long term and short-term exposure to NO_2 have concluded that short-term exposure to NO_2 is associated with increases in mortality, hospital admissions and respiratory symptoms. Studies of the long term effects of exposure to NO_2 have also shown associations with both mortality and morbidity outcomes. The effects that have been observed for both long term and short-term exposure are occurring below current WHO air quality guidelines for NO_2 which are lower than the current NEPM standards. The most recent studies have provided evidence that NO_2 has an independent effect from other pollutants. Epidemiological studies of the long term effects of NO_2 exposure on mortality (both respiratory and cardiovascular causes) and with children's respiratory symptoms and lung function also support the conclusion that NO_2 has an independent effect on health.

Based on the modelling data, the highest risk is for long term mortality in people over 30 years of age with between nine additional deaths every 100 years and 1.1 additional deaths every year. This risk relates to the combined emissions from the airport as well as traffic on roads outside the airport site. The highest risks are predicted to occur at Bringelly, Kemps Creek and Rossmore, reflecting the predicted concentration of emissions from background sources external to the airport site.

To enable an assessment of the risk posed by NO_2 emissions from airport operations in isolation of external background emissions, additional modelling was conducted in the absence of traffic on roads outside the airport site. Without traffic emissions, there was a significant reduction in the health risk predicted. When looking at airport operations only, the highest risk associated with NO_2 was for all-cause mortality in people over 30 years of age with a maximum of four additional deaths every 10 years. In this case, the highest risks are predicted to occur in Luddenham, Kemps Creek, Mulgoa and Wallacia.

A recent review of the *Fuel Quality Act 2000* estimated that in Sydney in 2015, NO_2 was responsible for 330 additional deaths per year and an additional 336 and 371 hospital admissions for respiratory disease and cardiovascular disease respectively in people over 65 years of age. The risk predicted for Stage 1 operations is very small within this context.

It should be noted that the health risk assessment predictions also do not take into account the implementation of any mitigation measures proposed in the EIS to reduce nitrous oxide emissions. The implementation of the mitigation measures identified in Chapter 12 will be implanted to reduce community exposure to NO_2 and reduce the predicted health risks associated with NO_2 emissions.

13.4.3 Sulfur dioxide

The local air quality assessment found that Stage 1 operations would result in the emission of sulfur dioxides (SO_2). Activities on the airport site are predicted to account for approximately 88 per cent of total SO_2 emissions. Background emissions from road traffic using the external road system would amount to approximately 12 per cent of total SO_2 emissions. The majority of SO_2 emissions generated onsite would come from aircraft engines, with some emissions generated from the operation of APUs and GSE.

Air dispersion modelling conducted for the local air quality assessment has predicted maximum 1-hour, 24-hour average and annual average sulfur dioxide concentrations for a range of receivers in the vicinity of the airport site. The daily 24-hour sulfur dioxide concentrations at the most affected receivers show that all levels are only a few percent of the current NEPM-AAQ standard of 80 ppb. The levels are highest at receivers in Badgerys Creek, Greendale and Mount Vernon.

The health effects of SO_2 linked to ambient exposures have been well studied and reviewed by international agencies. An overview of the literature related to the health effects of SO_2 is provided in Appendix G (Volume 4). A large number of population-based epidemiological studies have reported a link between short term SO_2 exposure and daily mortality and respiratory and cardiovascular effects. Adverse effects, such as sneezing or shortness of breath occur within the first few minutes after inhalation. The effects are greater when the person is exercising, and are most pronounced in people with asthma and other respiratory conditions and particularly in exercising asthmatics. A large body of epidemiological studies generally report consistent and robust associations between ambient SO_2 concentrations and emergency department visits and hospitalisations for all respiratory causes, particularly among children and older adults (65+ years), and for asthma and chronic obstructive pulmonary disease.

The health risk from exposure to sulfur dioxide from the Stage 1 operations is predicted to be very low. The highest risk is for hospital admissions from respiratory causes for people aged over 65 years, with between seven additional admissions per 1,000 years and seven additional admissions per 100 years. All other risks associated with sulfur dioxide exposure are lower than this. The highest risks are predicted to occur in Luddenham, Mulgoa and Wallacia.

13.4.4 Carbon monoxide

The local air quality assessment found that Stage 1 operations would result in the emission of carbon monoxide (CO). Background emissions from road vehicles using the external road infrastructure would account for approximately 88 per cent of total CO emissions. Activities on the airport site itself would amount to approximately 12 per cent of total CO emissions, with the remaining balance coming from road traffic accessing the airport site. The main source of CO onsite would be aircraft engines, followed by the operation of GSE and vehicles using parking facilities.

The local air quality assessment assessed daily 8-hour maximum CO levels for the worst affected locations in the vicinity of the airport site. The data indicates that the predicted CO levels are higher at Kemps Creek, Bringelly, Rossmore and Badgerys Creek, however all predicted concentrations are well below the NEPM-AAQ standard of 9 ppm.

Carbon monoxide is a toxic gas and, given exposure to sufficient concentrations, may result in cardiovascular morbidity. The health effects of CO are based on the ability of carbon monoxide to remove haemoglobin from the blood forming carboxyhaemoglobin. An overview of the literature related to the health effects of CO is provided in Appendix G (Volume 4). Epidemiological studies of emergency department visits and hospital admissions for ischaemic heart disease report consistent positive associations for an increase in cardiovascular-related mortality. New toxicological evidence suggests that other mechanisms involving altered cellular signalling may play a role in cardiovascular disease outcomes following CO exposure.

The health risk assessment modelling results indicate that the predicted health effects associated with CO emissions from operation of the Stage 1 development are very low. The highest risk is for hospital admissions for cardiovascular disease in people 65 years of age and older with a maximum of an additional four hospital admissions in 1,000 years. This risk is negligible.

13.4.5 Air toxics (benzene)

A number of air toxics including benzene, toluene, xylenes and formaldehyde would be emitted from airport operations and were modelled as part of the local air quality assessment. The most significant potential health risk of these is cancer from exposure to benzene.

For the Stage 1 development, the local air quality assessment estimated that airport operations would contribute approximately 30 per cent of the total air toxics with approximately 70 per cent from vehicles on external roads. Stationary sources and fuel tanks onsite are considered to be the major contributors associated with the airport operations.

The local air quality assessment identified that the annual average concentration of benzene would be an order of magnitude lower than the monitoring investigation level in the Air Toxics NEPM (NEPM-AT) of 0.3 ppb.

Human exposure to benzene has been associated with a range of acute and long term adverse health effects and diseases, including cancer and aplastic anaemia. Acute (short-term) inhalation exposure of humans to benzene may cause drowsiness, dizziness, headaches, as well as eye, skin, and respiratory tract irritation, and, at high levels, unconsciousness. Chronic (long term) inhalation exposure has caused various disorders in the blood, including reduced numbers of red blood cells and aplastic anaemia. An overview of the literature related to the health effects of benzene is provided in Appendix G (Volume 4).

The maximum predicted cancer risk was estimated using a unit risk factor adopted by the California Environmental Protection Agency Office of Environmental Health Hazard Assessment. The modelled maximum annual average concentration was 0.1 $\mu g/m^3$, resulting in an increase in cancer risk of 2.9×10^{-6} (2.9 in a million).

It is generally accepted by national and international regulatory agencies that an increase in risk between 1 x 10^{-6} (one in a million) and 1 x 10^{-5} (one in 100,000) is considered to be a low risk and therefore acceptable. The maximum predicted increase in cancer risk from exposure to benzene associated with operation of the Stage 1 development is within this range and is therefore considered to be acceptable.

13.4.6 Diesel particulates

The local air quality assessment estimated diesel emissions likely to be generated as a result of the proposed airport. Diesel emissions associated with the proposed airport would arise from truck movements and diesel-powered equipment used during operation. The local air quality assessment modelled diesel emissions for the Stage 1 development. The annual average concentrations range from 0.07 to 0.3 µg/m^3.

In recent years, there has been increased community concern about the health effects of diesel emissions. Exposure to diesel exhaust can irritate the eyes, nose, throat and lungs, and it can cause coughs, headaches, light headedness and nausea. In studies with human volunteers, diesel exhaust particles made people with allergies more susceptible to the materials to which they are allergic, such as dust and pollen. Exposure to diesel exhaust also causes inflammation in the lungs, which may aggravate chronic respiratory symptoms and increase the frequency or intensity of asthma attacks. Diesel exhaust and many individual substances contained in it (including arsenic, benzene, formaldehyde and nickel) have the potential to contribute to mutations in cells that can lead to cancer. WHO have classified diesel particles and diesel exhaust as a known human carcinogen. An overview of the literature related to the health effects of diesel is provided in Appendix G (Volume 4).

The unit risk factor from the California Environmental Protection Agency Office of Environmental Health Hazard Assessment has been used in the assessment of the increase in cancer risk associated with diesel particles from the construction and future operations of the airport. The unit risk factor for diesel particles is 3 x 10^{-4} (3 in 10,000) per 1 µg/m^3 increase in diesel particles.

The maximum predicted increase in cancer risk attributable to diesel particles is 2 x 10^{-4} (2 in 10,000) and ranges from 9 x 10^{-5} (9 in 100,000) to 2 x 10^{-4} (2 in 10,000). These risk levels fall at the upper bound of the range generally considered accepted by national and international regulatory agencies. For values between 1 x 10^{-5} (1 in 100,000) and 1 x 10^{-4} (1 in 10,000), mitigation measures should be considered to reduce the risk.

The highest risk level is predicted at the Badgerys Creek location that is within the airport site itself. It is therefore more representative of the exposure of airport workers than the general public. However, other offsite locations at Mulgoa and Wallacia are also at the upper bound of acceptable levels. Modelling conducted for the local air quality assessment that has been used in the health risk assessment has not assumed any improvements to diesel emissions that may occur through changes to motor vehicle regulations or through changes to fuel quality standards over time. Along with the mitigation measures in Chapter 12, such improvements would lead to reductions in diesel particles and a lowering of the risk to exposed communities.

13.4.7 Ozone

The regional air quality assessment provided an assessment of ozone impacts associated with the proposed airport. It found that the operation of the Stage 1 development would lead to the formation of ozone. Increases in ozone from the proposed airport are predicted to occur downwind of the airport site which, on most days, is to the south and south-west. Decreases in daily maximum ozone occur only in the vicinity of the airport site and are attributable to ozone suppression by nitrous oxide emissions from activities on the airport site. The operation of the Stage 1 development would not result in an increase in the peak predicted 1-hour ozone concentrations. This is because the predicted ozone concentrations from the proposed airport occur in different locations to where ozone peaks currently occur.

The regional air quality assessment has found that peak ozone concentrations in 2030 would be above the NEPM-AAQ criterion of 100 ppb for all but one day of the analysis. These exceedances would occur regardless of the airport development and reflect the contribution of background emission activity to ozone concentrations.

Ozone is a secondary pollutant and is formed from precursors such as oxides of nitrogen and volatile organic compounds. Ozone levels are influenced by meteorology and seasonality (i.e. warmer seasons, cloudless skies, stable atmosphere) and bushfires.

The main health effects associated with exposure to ozone are associated with the respiratory tract. Studies have shown that long term exposure to ozone has an impact on people with existing disease, in particular people with chronic obstructive pulmonary disease, diabetes, congestive heart failure and myocardial infarction. Long term exposure to ozone has also been associated with an increase in asthma incidence, asthma severity, hospital care for asthma and lung function growth. Short-term effects associated with daily maximum one-hour and eight-hour ozone concentrations include all cause, cardiovascular and respiratory mortality as well as cardiovascular and respiratory hospital admissions. An overview of the literature related to the health effects of ozone is provided in Appendix G (Volume 4).

The increase in risk from ozone concentrations associated with the Stage 1 development ranges from the lowest risk of 5×10^{-6} (0.5 in 100,000) for respiratory mortality to the highest risk of 4.5×10^{-5} (4.5 in 100,000) for emergency department attendances for asthma in children. Given the nature of ozone formulation, these risks are for the Western Sydney region as a whole and are not broken down to the community level.

There is general agreement by international agencies including the WHO and the US EPA that acceptable risk levels fall between 1×10^{-6} (one in a million) and 1×10^{-5} (one in 100,000). The predicted health risk for emergency department attendances for asthma in children is marginally outside these limits. Noting that international agencies usually consider 1×10^{-4} (1 in 10,000) as the level of risk that is considered as unacceptable, the predicted risk for ozone from Stage 1 operations is considered manageable.

In relation to this finding, it is noted that the regional air quality assessment of ozone relies on a conservative modelling methodology selecting a ‘snapshot’ of days when ozone formation is likely to occur rather than a more comprehensive (annual) dataset which would normally be used to complete a quantitative health risk assessment. The actual occurrence of ozone in these concentrations would also not necessarily result at the airport site itself and the concentrations would vary day to day due to factors such as wind speed and direction as well as other factors.

As noted previously, these risks from ozone include the risks associated with background emissions from other sources. Given the relatively limited impact of the Stage 1 development on ozone concentrations when compared to existing and future background emissions, the ability for a future airport lessee company to reduce ozone impacts and health risks at the regional scale will be very limited.

13.4.8 Aircraft overflight noise

The assessment of health risks associated with aircraft overflight noise from Stage 1 operations are based on the findings of the noise exposure modelling presented in Chapter 10 of this EIS. The predicted risks associated with overflight noise consider the differences associated with potential operating strategies at the proposed airport (i.e. Prefer 05, Prefer 23) and the use of operating modes such as head-to-head. Further information on operating modes and operating strategies can be found in Chapter 10.

For night time aircraft noise during Stage 1 operations, the results indicate that only Luddenham is predicted to experience noise levels above the WHO 40 dB $L_{night,outside}$ criterion for all potential airport operating strategies modelled. All other areas assessed would be below this criterion, which is the level of lowest observed adverse effects to public health. The highest daytime noise levels of between 44-46 dB are also predicted at Luddenham. The noise levels at all other locations are predicted to be below 40 dB. The full table of results are outlined in Appendix G (Volume 4).

13.4.8.1 Sleep disturbance

The health risk assessment found that aircraft overflights associated with the operation of the Stage 1 development would not significantly increase the risk of sleep disturbance. The predicted number of additional EEG awakenings was between zero and 40 per person per year, depending on the community and the operating strategy in use. $L_{night,outside}$ noise results indicate that the Prefer 05 operating strategy results in more EEG awakenings across more localities than the Prefer 23 strategy. Use of the head-to-head mode at night—involving all landings and departures to the south-west of the airport site—could reduce the number of EEG awakenings in some instances compared to both the Prefer 05 strategy and the Prefer 23 strategy.

The area with the highest number of additional EEG awakenings per person per year is Luddenham, which is predicted to experience 40 additional EEG awakenings per person per year no matter which operating strategy is selected. Due to Luddenham’s proximity to the airport site, the use of the head-to-head operating mode does not reduce the potential incidence of EEG awakenings as it does at other localities, such as Erskine Park and Kemps Creek, where a similar impact is predicted from the Prefer 05 and Prefer 23 operating strategy, respectively. The full table of results for additional EEG awakenings is provided in Appendix G (Volume 4).

For context, individuals typically exhibit about 24 EEG awakenings per eight hours of sleep (European Environment Agency 2010). The number of additional EEG awakenings per person per year due to aircraft overflight noise is predicted to be between zero and 40 per person per year and would therefore represent an increase of approximately zero to 0.5 per cent over a year. This shows that the predicted number of additional EEG awakenings from aircraft overflight noise during Stage 1 operations would be very low.

Sleep disturbance impacts were also quantified as the increased risk of full awakenings. The health risk assessment found that the number of additional full awakenings would be significantly lower than the predicted number of additional EEG awakenings. The number of additional full awakenings due to aircraft overflight noise is predicted to be between zero and five additional full awakenings per person per year, depending on the community and the operating strategy used. Similar to the analysis of EEG awakenings, the highest risk of additional full awakenings is predicted for Luddenham, which would experience an additional three full awakenings per person per year under the Prefer 05 and Prefer 23 operating strategies and an additional five full awakenings per person per year if the head-to-head operating mode was used at night. The full table of results for additional full awakenings is provided in Appendix G (Volume 4).

13.4.8.2 Cardiovascular effects

The WHO has identified that the noise level for potential increases for myocardial infarction (heart attacks) is 55 dB $L_{night,outside}$. For all receivers assessed for overflight noise impacts, the $L_{night,outside}$ predicted levels are below 55 dB. This was observed for all operating strategies assessed. On the basis of these results, it can be concluded that aircraft noise would not lead to any increased risk in myocardial infarction in communities in the vicinity of the airport site.

13.4.8.3 Learning and cognitive development in children

The health risk assessment determined that hazard quotients for outdoor noise levels were all less than one, indicating that the risk from aircraft overflight noise during Stage 1 operations for each of the proposed operating strategies generally does not pose an unacceptable risk. For indoor noise levels, hazard quotients were also less than one, except at Luddenham, where the WHO 35 dB L_{Aeq} criterion was exceeded by 1 dB at Luddenham Primary School. This does not mean that there will be an impact on children's learning and cognitive development but that there is an increased risk, albeit very low. The full table of results for hazard quotients for outdoor and indoor noise is provided in Appendix G (Volume 4).

13.4.9 Ground-based operations noise

Ground-based operations noise is predicted to have a greater (health) impact than aircraft overflight noise and has the most impact at localities closest to the proposed airport, in particular at Luddenham.

Modelling indicates that only Luddenham would experience noise levels above the WHO 40 dB $L_{night,outside}$ criterion—with a predicted noise level of 47 dB—from ground-based operations noise during operation of the Stage 1 development. All other areas assessed would be below the WHO criterion, which is the level of lowest observed adverse effects to public health.

Luddenham is predicted to also experience the highest daytime noise levels of 50 dB $L_{Aeq,9am\text{-}3pm}$. Greendale would experience a relatively high daytime noise level of 42 dB $L_{Aeq,9am\text{-}3pm}$. These results are below the WHO guideline value of 55 dB $L_{Aeq,9am\text{-}3pm}$. The daytime noise levels at all other locations are predicted to be below 40 dB $L_{Aeq,9am\text{-}3pm}$. The full table of results are outlined in Appendix G (Volume 4).

13.4.9.1 Sleep disturbance

The effects of ground based operations noise are predicted to lead to an additional 0 to 75 EEG awakenings per year per person, depending on the location. Due to their proximity to the airport site, Luddenham and Greendale are predicted to be the most affected locations. Luddenham is predicted to experience an additional 75 EEG awakenings per person per year, Greendale is predicted to experience an additional 37 EEG awakenings and Kemps Creek would experience an additional 20 EEG awakenings per person per year. The full table of results for EEG awakenings is provided in Appendix G (Volume 4).

Based on the fact that individuals typically exhibit about 24 EEG awakenings per eight hours of sleep (European Environment Agency 2010), the additional EEG awakenings associated with ground-based operations noise would represent a relatively modest increase of between 0 and 0.9 per cent per year.

In relation to full awakenings, ground-based operations noise is predicted to result in a relatively small impact. Luddenham is predicted to experience an additional four full awakenings per person per year and Greendale is predicted to experience an additional two full awakenings per person per year. All other locations are predicted to experience no increase in full awakenings due to ground based operations noise. The complete results for full awakenings is provided in Appendix G (Volume 4).

13.4.9.2 Cardiovascular effects

The WHO has identified that the noise level for potential increases for myocardial infarction (heart attacks) is 55 dB $L_{night,outside}$. Similar to aircraft overflight noise, for all receivers assessed, the $L_{night,outside}$ predicted levels for ground based operations noise were below 55 dB. On the basis of these results, it can be concluded that ground-based operations noise would not lead to any increased risk for myocardial infarction in communities in the vicinity of the airport site.

13.4.9.3 Learning and cognitive development in children

In terms of children’s learning and cognitive development, the health risk assessment predicts that hazard quotients for outdoor noise levels will be less than one, which generally indicates that the risk from ground-based operations noise does not pose an unacceptable risk. For indoor noise levels, hazard quotients were also less than one, except at Luddenham where it was 1.1. This is because ground-based operations noise at Luddenham is predicted to exceed the WHO 35 dB $L_{Aeq,9am\text{-}3pm}$ criteria for indoor noise by 5 dB, which represents a significant increase in noise levels. This does not mean that there will be an impact on children’s learning and cognitive development but that there is an increased risk. The full table of results for hazard quotients for outdoor and indoor noise is provided in Appendix G (Volume 4).

13.4.10 Surface and groundwater

A number of activities undertaken during the operation of the proposed airport have the potential to result in the contamination of ground and surface water. These activities include chemical and fuel storage, equipment operation, equipment maintenance and firefighting. Potential contaminants include petroleum hydrocarbons, heavy metals, polyaromatic hydrocarbons, perflourinated compounds and chlorinated hydrocarbons.

Aqueous film-forming foams (AFFF) have historically been used for firefighting purposes at airports, at fuel depots, hangars and for aviation rescue and fire-fighting (for both operational and training purposes). AFFF products historically used on airport sites contain perfluorinated or polyfluorinated compounds, or fluorosurfactants (PFCs). Depending on the type of AFFF used, the principal PFC constituents could have included perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) and fluorotelomers such as 6:2 fluorotelomer sulfonate (6:2FtS) and 8:2 fluorotelomer sulfonate (8:2FtS). AFFF has not been used for aviation rescue and fire-fighting by Airservices Australia since 2010, but continues to be used around fuel depots and hangars at many airports (GHD 2016b).

13.4.10.1 Surface water

The indicative flight paths for the proposed Stage 1 development are located above the catchment areas for Warragamba Dam and Prospect Reservoir. In addition, through consultations there have been concerns raised by parts of the community about the potential for aircraft emissions to impact on the quality of tank water in the area close to the airport site.

A qualitative evaluation was conducted to understand the potential for these activities, and activities at the airport site, to impact on surface water bodies in and around the airport site. The following operational activities were considered for their potential to impact on surface water:

- the accidental spill of stored chemicals or fuels from vehicles, which may be released to nearby surface water environments;
- the release of stored groundwater, which has not been adequately characterised with regard to contamination concentrations, to surface water bodies;
- the deposit of aircraft emissions to nearby surface water bodies which may result in increased contaminant loading to waterways; and
- the very rare event of aircraft fuel jettisoning during emergency incidents as aircraft approach the airport site.

Based on available information, there is considered to be a low risk for operation of the proposed airport to impact on the environmental values of surface water.

In relation to accidental spills and stored groundwater, the health risk assessment found that there was a very low risk of airport operations impacting on nearby surface water bodies. In addition, the mitigation measures outlined in Chapter 17 and Chapter 18 would be implemented to reduce the potential for surface water risks.

For aircraft emissions, there are currently no data available which can be used to assess whether emissions from aircraft operations would result in increased loading of contaminants to surface waters. However, air dispersion modelling was conducted as part of the air quality assessment (see Chapter 12) to predict ground level concentrations of volatile organic compounds (VOCs) and PM_{10} in areas close to the airport site. The maximum predicted concentration of benzene within five kilometres of the airport site is 0.1 $\mu g/m^3$ and diesel particles 0.8 $\mu g/m^3$. These concentrations are very low and would not impact on the quality of tank water.

As discussed in Chapter 7 (Volume 1), fuel jettisoning for commercial aircraft is very rare (in 2014 only 0.001 per cent of all civilian aircraft movements in Australia) and only occurs during emergency circumstances where an unscheduled landing is required. Based on the information presented in Chapter 7 (Volume 1), it is considered unlikely that the jettisoning of fuel will result in impacts to surface water bodies surrounding the proposed airport site.

13.4.10.2 Groundwater

Based on available information relating to the types of activities which will be conducted during construction and operation of the airport, there is considered to be minor potential for risks to the environmental values of groundwater in the alluvial and Bringelly Shale aquifers.

Groundwater bores are recorded as being constructed to significant depths and are understood to target the underlying Hawkesbury Sandstone aquifer.

The management and mitigation measures identified in Chapter 18 would be implemented to reduce the potential for these risks to occur. It is noted however that the potential for exposure to groundwater contaminants by offsite users of extracted groundwater is minimal as bores draw from the Hawkesbury Sandstone aquifer.

13.5 Assessment of impacts during construction

The health risk assessment assessed the impacts on community health associated with the construction of the Stage 1 development. This was done by quantifying the increased risk of health outcomes for communities around the airport site as a result of impacts on air quality (through particulate matter) and impacts on surface and groundwater quality. Health risks from construction noise have not been assessed as it is a short-term activity and the levels of exposure are lower than those for aircraft overflight and ground-based operations noise.

It should be noted that the construction of Stage 1 development would occur for a period of less than 10 years. Therefore, the predicted risk levels associated with the construction phase are unlikely to be realised as they are predicted to occur over much longer timeframes (100 to 10,000 years).

13.5.1 Particulates

The local air quality assessment modelled the emission of particulate matters (PM_{10} and $PM_{2.5}$) associated with construction of the Stage 1 development. The main sources of emissions during main construction works are bulk earthworks, the construction of aviation infrastructure, the operation of machinery and trucks, and the operation of the concrete batching plant. Details of the modelling and sources considered are provided in the local air quality assessment (see Chapter 12).

13.5.1.1 PM_{10}

The local air quality assessment predicts that 24 hour average PM_{10} levels from bulk earthworks would be well below the current NEPM-AAQ standard of 50 µg/m^3 at all residential locations assessed. The highest concentrations are predicted on the airport site.

The health risk assessment found that the highest predicted risk attributable to PM_{10} during bulk earthworks is for all-cause mortality from long term (annual) exposures with between one additional death per 1,000 years and one additional death per 100 years. The highest risk would be for Luddenham. All other risks would be lower than that predicted for long term mortality.

Similar to bulk earthworks, the predicted PM_{10} concentrations during the construction of aviation infrastructure works are higher than those during bulk earthworks but still below the NEPM-AAQ standard. The highest concentration is predicted on the airport site.

The highest predicted risks attributable to PM_{10} during construction of aviation infrastructure are for all-cause mortality from long term exposures with between two additional deaths per 1,000 years and one additional death per 100 years. The highest impacts are predicted at Luddenham, Bringelly, Kemps Creek and Badgerys Creek.

13.5.1.2 $PM_{2.5}$

The local air quality assessment predicted $PM_{2.5}$ concentrations for bulk earthworks and found them to be low and below the NEPM-AAQ advisory reporting standard of 25 µg/m^3. The highest concentrations are predicted for Greendale and Badgerys Creek.

The health risk assessment predicted the highest risk attributable to $PM_{2.5}$ during bulk earthworks is for all-cause mortality and cardiopulmonary mortality from long term exposures with between seven additional deaths per 10,000 years and four additional deaths per 1,000 years. The highest risks are predicted at Bringelly and Luddenham.

The predicted $PM_{2.5}$ concentrations during construction of aviation infrastructure are higher than those predicted for bulk earthworks but still in compliance with the NEPM-AAQ advisory reporting standard of 25 µg/m^3. The highest concentrations are predicted for Badgerys Creek, Greendale and Rossmore.

The highest predicted risks attributable to $PM_{2.5}$ during main construction works are for all-cause mortality and cardiopulmonary mortality from long term (annual) exposures with between three additional deaths per 1,000 years and two additional deaths per 100 years. All other risks are lower than that predicted for these outcomes. The highest risks are predicted to occur at Bringelly and Luddenham.

13.5.2 Local surface waters

The following activities during construction of the proposed airport have the potential to result in impacts on surface water bodies:

- earthmoving activities and/or vegetation clearance resulting in potentially increased sediment loading in surface run-off;
- accidental spills of fuels or chemicals from construction vehicles which may discharge into surface water environments; and
- discharge of collected groundwater to surface water bodies which may contain potential contaminants that have not been adequately assessed prior to discharge.

These risks are typical of most major construction projects and standard precautionary measures are considered to be appropriate to address these issues. The recommended monitoring, management and mitigation measures identified in Chapter 18 are expected to reduce the potential for these risks to be realised during airport construction.

13.5.3 Sydney's drinking water catchment

Construction of the proposed airport is not located within the catchments for Warragamba Dam or Prospect Reservoir. However, there is potential that airborne particles from construction may be deposited within these two waterbodies through dispersion of airborne dust, potentially affecting water quality.

Warragamba Dam is approximately 11 kilometres from the airport site. Dispersion modelling forecasts an annual average deposition rate of 0.02 $\mu g/m^3$ at Warragamba due to airport construction. This is unlikely to result in a significant risk to water quality. Prospect Reservoir is located further away, approximately 18 kilometres from the airport site. Airborne particle deposition is therefore also unlikely to be a significant risk for this site, given the separation distance.

Dust suppression mitigation measures outlined for air quality in Chapter 12 would further reduce the risk of these impacts.

13.6 Mitigation and management measures

Potential impacts to human health associated with the construction and operation of the Stage 1 development would be directly related to potential noise, air quality and water quality impacts that are described in the relevant sections of this EIS. The mitigation measures described to manage potential issues associated with these other disciplines would be expected to reduce the potential impacts on community health. These mitigation measures are described in Chapters 10, 11, 12, 17 and 18.

13.7 Conclusion

The health risk assessment considers the likely health impacts of construction and operation of the Stage 1 development. The assessment considers the predicted risk associated with the proposed airport on community health from the most likely contaminant exposure pathways: air quality, noise and surface and groundwater.

Generally, the assessment found that the predicted health risk associated with the Stage 1 development would be low and in line with national and international standards of acceptability. The implementation of proposed mitigation measures associated with noise, air quality and surface and groundwater described in the relevant chapters of this EIS would reduce the predicted community health risks

The modelling used in the various inputs to the health risk assessment have been developed on a conservative basis, meaning that the health risks predicted represented conservative estimates of the predicted impact on human health. Environmental impacts, and by extension health risks, will continue to be regulated under the legislative framework in which the airport development would be developed, including the Airports Act, the formal future process for defining aircraft flight paths and the Environmental Management Framework outlined in Chapter 28 (Volume 2b).