Australian Government

Department of Infrastructure, Transport, Regional Development, Communications and the Arts

Western Sydney International (Nancy-Bird Walton) Airport – Airspace and flight path design

Draft Environmental Impact Statement

Technical paper 12: Human health

September 2023

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Terms and abbreviations

Term/abbreviation	Definition
µg	Mass in micrograms
µg/m³	Micrograms per cubic metre
AEDT	Aviation Environmental Design Tool (US FAA)
A weighted decibels (dB(A))	The A weighting is a frequency filter applied to measured noise levels to represent how the human ear hears sounds. Adjustments are applied between 10 Hz and 20 kHz. When an overall sound level is A-weighted it is expressed in units of dB(A) or dBA
Acute or short-term exposure	Contact with a substance that occurs only once or for a short period of time, typically an hour or less, but may be up to 14 days
Absorption	The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs
Adverse health effect	A change in body function or cell structure that might lead to disease or health problems
Anthropogenic	Human sourced
ATC	Air traffic control
ANZECC	Australia and New Zealand Environment and Conservation Council
ATM	Air traffic movement
ATSDR	Agency for Toxic Substances and Disease Register
Background level	An average or expected amount of a substance or material in a specific environment, or typical amounts of substances that occur naturally in an environment
Biodegradation	Decomposition or breakdown of a substance through the action of micro-organisms (such as bacteria or fungi) or other natural physical processes (such as sunlight)
Body burden	The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly
BOM	Bureau of Meteorology
CALD	Cultural and linguistic diversity
Carcinogen	A substance that causes cancer
Chronic or long-term exposure	Contact with a substance that occurs repeatedly over a long time, with the USEPA indicating defining this as exposures that occur for more than approximately 10% of a lifetime. Exposures that occur for less than 10% of a lifespan are considered sub-chronic
Co-exposure	Exposure to more than one pollutant or stressor (such as noise) by a population

Term/abbreviation	Definition
Combined	In the context of the health impact assessment, combined refers to the sum of exposures from different project impacts: such as impacts on health from emissions to air from the tunnel ventilation facilities plus impacts on health from changes in air impacts from surface roads; or impacts on health from changes in air quality plus impacts on health from changes in noise
Cumulative	Total exposure, used in the health impact assessment to refer to exposures that include the background plus project, or to multiple different sources from the project
CALPUFF	A multi-layer, multi-species, non-steady state Gaussian puff dispersion model that is able to simulate the effects of time- and space-varying meteorological conditions on pollutant transport
CO	Carbon monoxide
COPD	Chronic Obstructive Pulmonary Disease
CMAQ	Community Multiscale Air Quality Model
Cth	Commonwealth
Decibel (dB)	A logarithmic scale is used to describe the level of sound, referenced to a standard level. It is widely accepted that a 3 dB change in traffic noise levels (of the same character) is barely, if at all detectable; whereas a change of 5 dB is clearly noticeable. A 10 dB increase is typically considered to sound twice as loud (noting a change of -10 dB would typically sound half as loud)
Detection limit	The lowest concentration of a chemical that can reliably be distinguished from a zero concentration
Dispersion modelling	Modelling by computer to mathematically simulate the effect on plume dispersion under varying atmospheric conditions; used to calculate spatial and temporal fields of concentrations and particle deposition due to emissions from various source types
Dose	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligrams (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An 'exposure dose' is how much of a substance is encountered in the environment. An 'absorbed dose' is the amount of a substance that actually gets into the body through the eyes, skin, stomach, intestines, or lungs
DPE	Department of Planning and Environment
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EPA	Environment Protection Authority (EPA – New South Wales)
EPBC Act	Environment Protection and Biodiversity Conservation (1999) – Cth

Term/abbreviation	Definition
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term (acute exposure), of intermediate duration, or long-term (chronic exposure)
Exposure assessment	The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with
Exposure pathway	The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed) to it. An exposure pathway has 5 parts: a source of contamination (such as chemical leakage into the subsurface); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receiver population (people potentially or actually exposed). When all 5 parts are present, the exposure pathway is termed a completed exposure pathway
FAA	Federal Aviation Administration (US)
First Nations	Aboriginal and Torres Strait Islander People
Guideline value	A guideline value is a concentration in soil, sediment, water, biota or air (established by relevant regulatory authorities such as the NSW Department of Environment and Conservation (DEC), or institutions such as the National Health and Medical Research Council (NHMRC) Australia and New Zealand Environment and Conservation Council (ANZECC) and World Health Organisation (WHO)). The guideline value is used to identify conditions below which no adverse effects, nuisance or indirect health effects are expected. The derivation of a guideline value utilises relevant studies on animals or humans and relevant factors to account for inter- and intra-species variations and uncertainty factors. Separate guidelines may be identified for protection of human health, or the environment. Dependent on the source, guidelines have different names, such as investigation level, trigger value, ambient guideline etc
GMR	(Sydney) Greater Metropolitan Region
IARC	International Agency for Research on Cancer
ICAO	International Civil Aviation Organization
Inhalation	The act of breathing. A hazardous substance can enter the body this way
Intermediate exposure duration	Contact with a substance that occurs for more than 14 days and less than a year
Incremental impact	The impact due to an emission source (or group of sources) in isolation, i.e., without including background levels
km/h	Kilometres per hour
KSA	Kingsford Smith Airport (Sydney)
LGA	Local Government Area
LTO (cycle)	Landing take-off (phases of flight up to 3,000 feet)
L_{10}	The sound pressure level exceeded for 10% of the measurement period. The A-weighted form is denoted 'L_{A10}'

Term/abbreviation	Definition
$L_{A10(18h)}$	The $L_{A10(18\text{-hour})}$ noise level refers to the noise level exceeded for 10 per cent of the time during an 18-hour period (from 6 am to midnight). This noise descriptor is calculated using the arithmetic average of the L_{A10} noise levels for each hour from 6 am to midnight
L_{den}	The average noise level over the day, evening and night (i.e. a 24-hour period)
L_{eq}	Equivalent continuous sound level. The constant sound level which, when occurring over the same period of time, would result in the receptor experiencing the same amount of sound energy. The A-weighted form is denoted 'L_{Aeq}'
L_{night}	The average noise level over the night-time period, typically between 11 pm or midnight and 6 am
LOAEL	Lowest-observed-adverse-effect-level – The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals
m	Metre
m^3	Volume in cubic metres
mg/m^3	Milligrams per cubic metre
Metabolism	The conversion or breakdown of a substance from one form to another by a living organism
Morbidity	A diseased condition or state or the incidence or prevalence of disease in a population
Mortality	Death, which may occur as a result of a range of reasons or diseases
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NO_2	Nitrogen dioxide
NO_X	Oxides of nitrogen, including NO and NO_2
NOS	National Operating Standard (Airservices)
NOAEL	No-observed-adverse-effect-level – The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals

Term/abbreviation	Definition
Not measurable	The term “no measurable” or “not measurable” is used in this health impact assessment when referring to changes in air quality, noise or health outcomes in a population. For air quality and noise, a change that would be not be measurable is one where the estimated change in the concentration of the pollutant in ambient air, or noise, is so small that it could not be measured – i.e. within the error of the analytical method/measurement equipment. For health outcomes, it refers to exposures that are below a threshold so there are no health effects, or to changes in the number of people that may be affected (i.e. increase or decrease in deaths or hospitalisations) that is within the error/variability of the statistical measures (i.e. is not measurable)
NSW	New South Wales
O_3	Ozone
O-D	Origin and destination (flight route)
OEHHA	Office of Environmental Health Hazard Assessment, California Environment Protection Agency (Cal EPA)
PAAM	Plan for Aviation Airspace Management (the Project)
PM_{10}	Particulate matter less than 10 µm in aerodynamic equivalent diameter
$PM_{2.5}$	Particulate matter less than 2.5 µm in aerodynamic equivalent diameter
POEO Act	Protection of the Environment and Operations Act (1997 – Cth)
Point of exposure	The place where someone comes into contact with a substance present in the environment
Population	A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age)
ppm	Parts per million
RAAF	Royal Australian Air Force
Receiver population	People who could come into contact with hazardous substances
Risk	The probability that something would cause injury or harm
Route of exposure	The way people come into contact with a hazardous substance. The 3 routes of exposure are breathing (inhalation), eating or drinking (ingestion), or contact with the skin (dermal contact)
RRO	Reciprocal runway operations
Sensitive receptor	A location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area
SIA	Social Impact Analysis
SID	Standard instrument departure
SO_2	Sulfur dioxide
SO_3	Sulfur trioxide

Term/abbreviation	Definition
STAR	Standard instrument arrival
TCEQ	Texas Commission on Environmental Quality
Toxicity	The degree of danger posed by a substance to human, animal or plant life
Toxicity data	Characterisation or quantitative value estimated (by recognised authorities) for each individual chemical for relevant exposure pathway (inhalation, oral or dermal), with special emphasis on dose-response characteristics. The data is based on available toxicity studies relevant to humans and/or animals and relevant safety factors
Toxicological profile	An assessment that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed
Toxicology	The study of the harmful effects of substances on humans or animals
TRV	Toxicity reference value
THC	Total hydrocarbons
US	United States
US EPA	United States Environmental Protection Agency
Uncertainty factor	Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure would cause harm to people (also sometimes called a safety or assessment factor)
VOC	Volatile organic compounds
WHO	World Health Organization
WRF	Weather Research and Forecasting
WSA	Western Sydney Airport Company Limited
WSI	Western Sydney International (Nancy-Bird Walton) Airport

Executive summary

Introduction

This technical paper investigates the potential impacts on human health that may arise because of the Western Sydney International (Nancy-Bird Walton) Airport (WSI) airspace and flight path design (the project) at a local and regional scale.

The airfield, terminal, surface transport and landside infrastructure of WSI is greenfield development (and are not the subject of this EIS), the airspace is not "greenfield" and needs to account for the existing flight paths within the Sydney Basin airspace. This focus of the project is the design of flight paths, airspace changes, air traffic control procedures and noise abatement procedures for the Stage 1 Development of WSI, a single runway system for eventual use by civil commercial passenger and freight aircraft to and from the runways. The airspace and flight path design considers the safety of air navigation, efficiency, capacity to meet projected demand and minimising adverse effects on the environment from WSI aircraft operations.

The WSI Environmental Impact Statement (EIS) 2016 quantified the potential impacts on human health associated with the Stage 1 Development and included all land-based sources as well as all aircraft emissions. The aircraft emissions were based on the anticipated air traffic movement schedules, expected aircraft fleet and air emission estimate data available at the time of the assessment.

The proposed airspace and flight path design developed as part of this project is based on more contemporary aircraft fleet and associated air emissions.

Existing environment

Assessment of potential impacts on community health has focused on a local study area that comprises suburbs and localities (SALs) located close to and surrounding WSI. The local study area comprises SALs within western and southwestern Sydney. A larger, regional study area comprising the local government areas surrounding WSI has also been evaluated, where relevant to the impacts being considered.

The population in the local study area comprises a multicultural population with generally low levels of unemployment and high levels of economic resources compared with Greater Sydney and NSW. In relation to behaviours that can affect community health, the population is generally similar to NSW however in some areas the rates of smoking are higher, the consumption of fruit and vegetables is lower, the level of physical activity is lower and there are higher rates of overweight and obesity.

The baseline health of the population in the local study area is also generally similar to NSW, however there are some areas with higher rates of respiratory and cardiovascular disease (as mortality and hospitalisations), particularly for older people. The prevalence and management of asthma in adults and children is variable in the population.

Data relevant to the local and regional study areas suggest that the population may have some level of increased vulnerability to impacts derived from the project. The potential vulnerability of the population to project related impacts is addressed through the use of guidelines that are protective of all members of the community, including sensitive individuals such as young children and older people, and calculations of health impacts that utilise population specific data on baseline health.

Assessment methodology

The assessment of potential impacts of the project on community health has been undertaken on the basis of Australian guidance provided by enHealth (enHealth 2012, 2017) and the National Environment Protection Council (NEPC 2021). Other key guidance from international organisations such as the World Health Organization (WHO) and United States Environment Protection Agency (USEPA) have also been used.

The assessment has specifically address potential impacts on community health as a result of changes in air quality, from aircraft emissions, and aircraft noise from the operation of the flight paths. This assessment has also reviewed impacts relating to safety and other risks associated with the operation of aircraft at WSI.

Potential impacts in the community has relied on the assessment of changes in air quality and noise presented in other technical papers, specifically Technical paper 1: Aircraft noise (Technical paper 1) and Technical paper 2: Air quality (Technical paper 2). These technical papers provide estimates of pollutant concentrations or noise levels at various locations in the local study area, which are considered representative of community exposures. This assessment has considered health impacts that have been identified as causally related to these exposures, and adopted guidelines and exposure-response relationships that enable an assessment of potential health impacts, for key health effects, in the community.

Main findings

Based on the assessment undertaken, with consideration of the population located in the community surrounding WSI and the uncertainties identified, the following is concluded in relation to potential impacts on community health:

Air quality

The assessment undertaken has not identified any risk issues of concern in relation to impacts on community health in the local study area as a result of exposure to pollutants derived from aircraft emissions. More specifically the assessment has identified the following:

- impacts on community health as a result of exposure to fine particulates (as $PM_{2.5}$) are low
- impacts on community health as a result of exposure to nitrogen dioxide are considered to be low. While there may be the potential for elevated exposures to occur close to the WSI, however further review of these impacts indicates that the potential impact on respiratory health is considered to be low. It is noted that the areas where elevated exposures are identified are expected to be rezoned such that residential use is no longer relevant
- impacts on community health as a result of exposure to carbon monoxide are low, and essentially negligible
- impacts on community health as a result of exposure to sulfur dioxide are low, and essentially negligible
- impacts on community health as a result of exposure to individual volatile organic compounds derived from aircraft emissions are low, and essentially negligible
- emissions to air derived from the operation of aircraft would have a negligible impact on water quality in Prospect Reservoir or rainwater tanks in the community. Potential impacts on these water supplies would be so low they would not be measured.

In addition to the above, no risk issues of concern in relation to community health has been identified in relation to changes in regional air quality.

Noise

This assessment has addressed potential impacts on community health associated with aircraft noise derived from the operation of the project.

The assessment has identified that there is the potential for noise from the project to result in significant increases in sleep disturbance, noise annoyance (and therefore complaints) and, to a lesser extent, cognitive impairment for children (as learning delays). These impacts have been identified at a number of locations located close to the runway as well as beneath the approaches and take off routes away from the runway.

Most of the impacts on community health that are considered to be significant are located within the existing or predicted ANEC 20 contours where existing and potentially future land use planning controls are in place to prevent future noise sensitive development, which includes new residential development, and construction of new childcare centres and schools. By 2055 there are some additional locations, outside of the modelled ANEC 20 contours where impacts on community health may be of significance. Changes in noise as a result of operations between 2033 and 2055 would be expected to be gradual, and hence the significance of the impacts identified may be influenced by community adjustment to the presence of aircraft noise in the environment. These changes, however, may remain of significance to some members of the community.

For existing residential properties located in the existing ANEC 20 contours, there is the potential for the community in these areas to experience increased and significant levels of annoyance and sleep disturbance.

There are a range of measures outlined to address noise impacts, which include land use planning controls, NIPA (once developed) and community engagement. These measures should be implemented to minimise the potential impacts on community health as a result of aircraft noise.

Hazards and risk

A range of hazards and risks have been identified that relate to the operation of aircraft in the airspace above and around WSI and within the Sydney area. A range of mitigation measures have been identified to manage these hazards and risks, consistent with the way such risks are managed for all aircraft and airports. Where these are implemented, risks to community safety and health would be considered low and acceptable.

Chapter 1 Introduction

This chapter provides an overview of the proposed airspace and flight path design for the Western Sydney International (Nancy-Bird Walton) Airport (WSI). This includes the background to WSI and its accompanying airspace and flight path design (the project) which impacts on the existing Sydney Basin airspace. It describes the key features and objectives of the project and identifies the purpose and structure of this this technical paper.

1.1 Western Sydney International (Nancy-Bird Walton) Airport

1.1.1 Background

In 2016, the then Australian Minister for Urban Infrastructure approved development for a new airport for Western Sydney, now known as the Western Sydney International (Nancy-Bird Walton) Airport (WSI), under the *Airports Act 1996* (Commonwealth). The site of the new airport (the Airport Site) covers approximately 1,780 hectares (ha) at Badgerys Creek, as shown in Figure 1.1. The Airport Site is located within the Liverpool local government area (LGA).

Following the finalisation of the *Western Sydney Airport – Environmental Impact Statement* (2016 EIS), the Western Sydney Airport – Airport Plan (Airport Plan) was approved in December 2016. The Airport Plan authorised the construction and operation of the Stage 1 Development. It also set the requirements for the further development and assessment of the preliminary airspace design for WSI. The Australian Government has committed to developing and delivering WSI by the end of 2026.

The 2016 approval provided for the on-ground development of Stage 1 Development of WSI (a single runway and terminal facility capable of initially handling up to 10 million passengers per year) utilising indicative ‘proof of concept’ flight paths. These flight paths, presented in the 2016 EIS demonstrated that WSI could operate safely and efficiently in the Sydney Basin. WSI will be a 24-hour international airport and will:

- cater for ongoing growth in demand for air travel, particularly in the rapidly expanding Western Sydney region, as well as providing additional aviation capacity in the Sydney region more broadly
- provide a more accessible and convenient international and domestic airport facility for the large and growing population of Western Sydney
- provide long term economic and employment opportunities in the surrounding area
- accelerate the development of critical infrastructure and urban development.

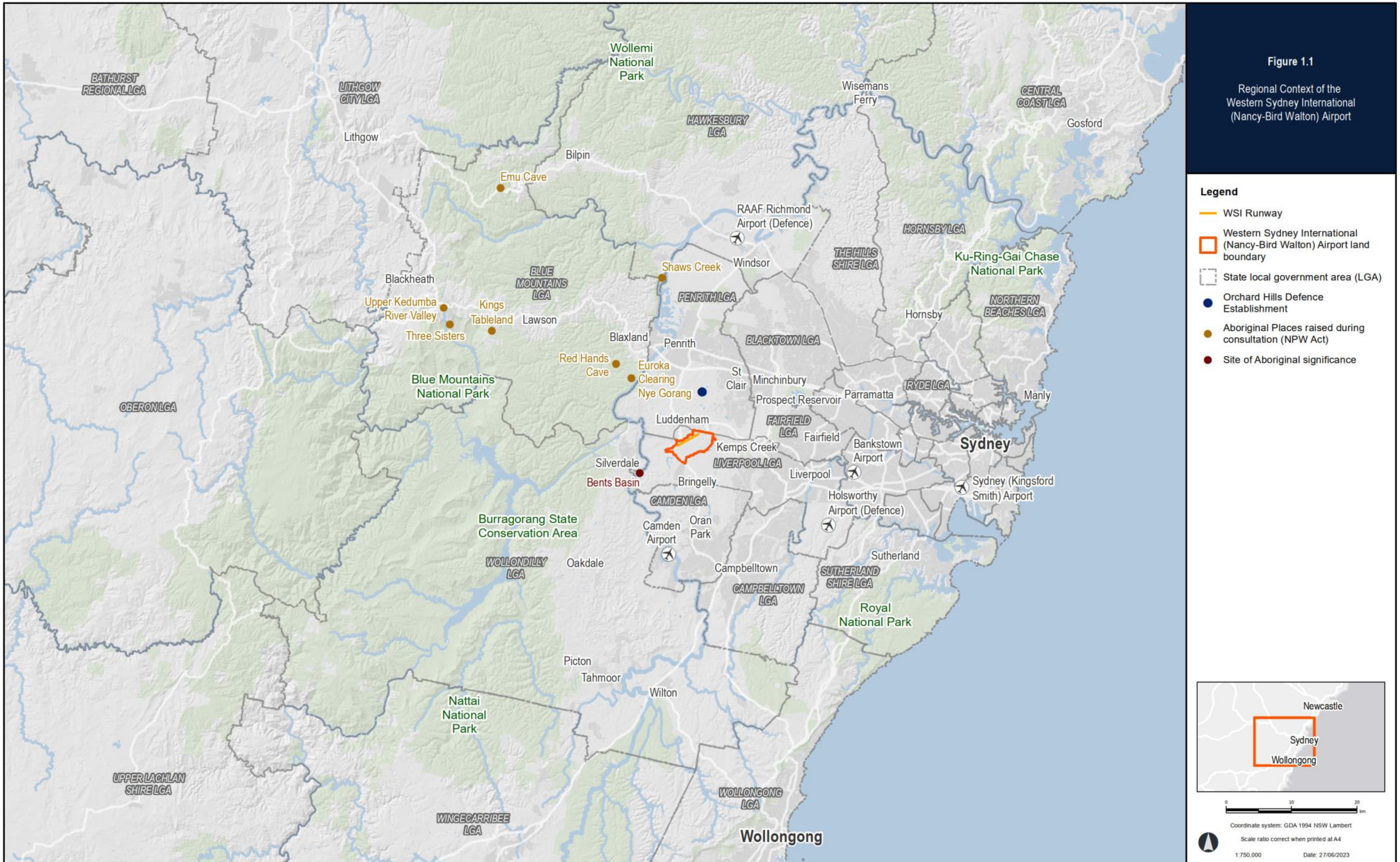
The Australian Government has committed to developing and delivering WSI by the end of 2026.

The design and assessment process for the next phase of the airspace design (referred to as the preliminary airspace design) was set by Condition 16 of the Airport Plan. This included the future airspace design principles and the establishment of an Expert Steering Group. Key to these design principles was the need to minimise the impact on the community and other airspace users while maximising safety, efficiency and capacity of WSI and the Sydney Basin airspace. The airspace design must also meet the requirements of Airservices Australia and civil aviation safety regulatory standards.

Led by the Australian Government Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA), the Expert Steering Group has developed the preliminary flight paths and airspace arrangements for WSI (the project). The preliminary airspace design is the subject of the Draft EIS and this assessment on the impacts to human health.

Figure 1.1

Regional Context of the Western Sydney International (Nancy-Bird Walton) Airport



Data sources: - DITRDC, DCS, Geoscience Australia
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Airbus,USGS,NGA,NASA,CGIAR,NCEAS,NLS,OS,NMA,Geodatastyrelsen,GSA,GSI and the GIS User Community

1.1.2 The Airport

1.1.2.1 Stage 1 Development

The Stage 1 Development of WSI has been approved and is limited to single runway operations. It will handle up to 10 million annual passengers and around 81,000 air traffic movements per year by 2033 including freight operations (a movement being a single aircraft arrival or departure). Single runway operations are expected to reach capacity at around 37 million annual passengers and around 226,000 air traffic movements per year in 2055.

The approval provides for the construction of the aerodrome (including the single runway), terminal and landside layout and facilities, and ground infrastructure such as the instrument landing systems and high intensity approach lighting arrays. Construction of the Stage 1 Development commenced in 2018. Figure 1.2 shows location of the single runway within the Airport Site.

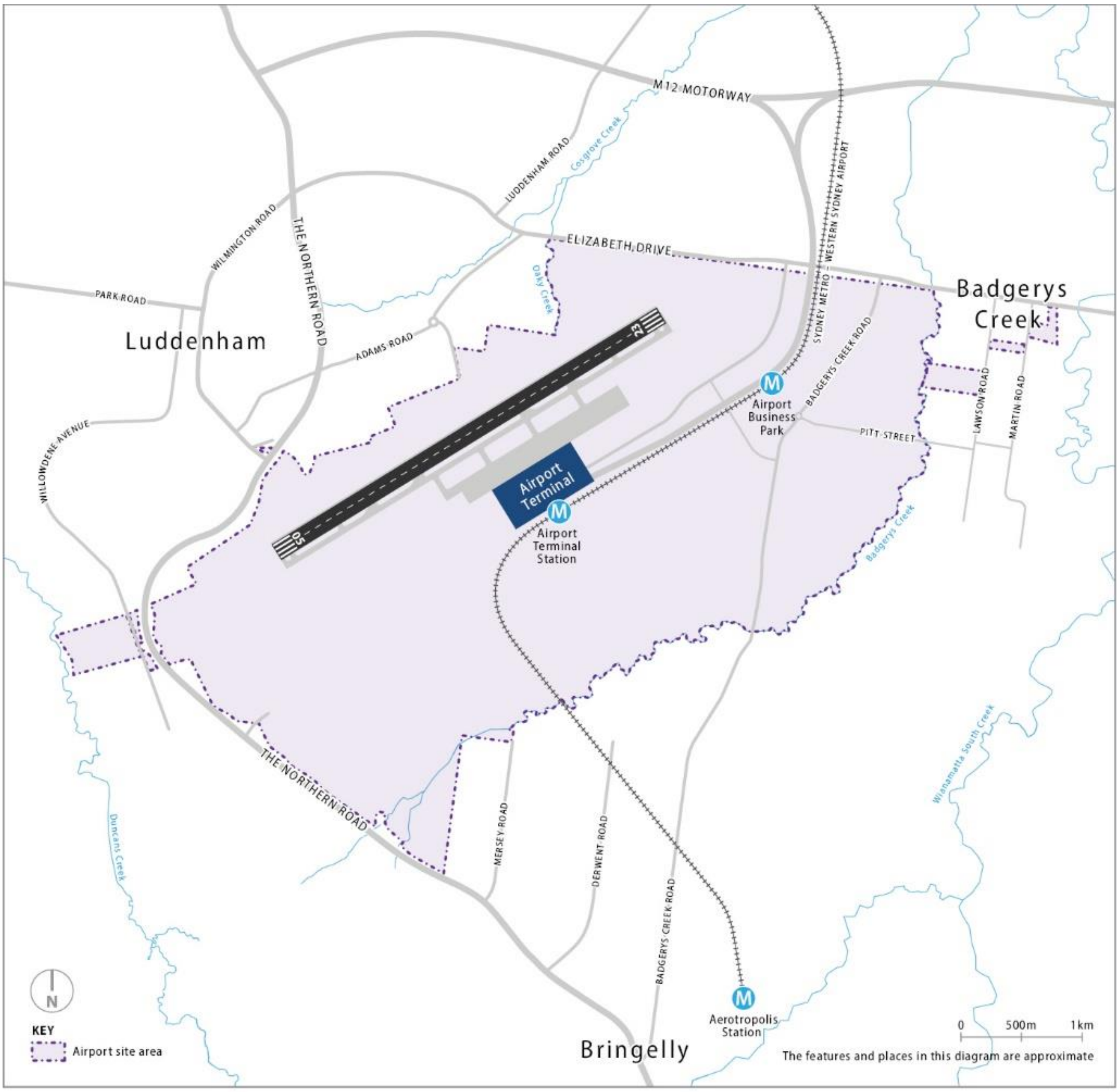


Figure 1.2 Western Sydney International Stage 1 Development

1.2 The project

The project consists of the development and implementation of proposed flight paths and a new controlled airspace volume for single runway operations at WSI. The project also includes the associated air traffic control and noise abatement procedures for eventual use by civil, commercial passenger and freight aircraft. The airspace and flight paths would be managed by the Air Navigation Services Provider (ANSP), Airservices Australia.

The project involves flight paths for all-weather operations on Runway 05 and Runway 23 during the day (5:30 am to 11 pm) and night (11 pm to 5:30 am), as well as head-to-head Reciprocal Runway Operations (RRO) during night-time periods (when meteorological conditions and low flight demand permit) to minimise the number of residences subjected to potential noise disturbance.

The flight paths differ during the day and night. Flight paths at night differ to take advantage of the additional airspace capacity offered when the curfew for Sydney (Kingsford Smith) Airport is in force. The proposed flight paths are depicted in Figure 1.3 to Figure 1.7.

The project does not include any physical infrastructure or construction work.

1.2.1 Objectives of the project

The overall objectives for WSI are to:

- improve access to aviation services for Western Sydney
- resolve the long-term aviation capacity constraints in the Sydney Basin
- maximise the economic benefit for Australia by maximising the value of the Airport as a national asset
- optimise the benefit of WSI for employment and investment in Western Sydney
- deliver sound financial, environmental and social outcomes for the Australian community.

The project will assist in achieving these overall objectives as it would enable single runway operations to commence at WSI through the introduction of new flight paths and a new controlled airspace volume.

The Western Sydney Airport Plan sets out 12 airspace design principles that the design process is required to follow. The principles were informed by and reflect community and industry feedback on the 2016 EIS. The principles seek to maximise safety, efficiency and capacity, while minimising impacts on the community and the environment. For further information on the airspace design principles refer to Chapter 6 (Project development and alternatives) in the Draft EIS.

1.3 Purpose of this technical paper

This technical paper has been prepared to inform the Draft EIS for the project and to document the process and outcomes of the assessment of potential human health impacts that may occur during operation of the project.

It provides a technical assessment of the potential human health impacts associated with the WSI's airspace and flight path design. Specifically, impacts of changes in air quality, noise, hazards and risk on the health of the community at a local and regional scale. The assessment of health impacts considers both positive (benefits) and negative (impacts) that may occur during the pre-operational and operational phases of the project.

This assessment is closely linked with the Air Quality Impact Assessment (AQIA), Noise Impact Assessment (NIA), Hazards and Risk and Social Impact Assessment (SIA) reports, with this assessment providing specific focus and detail relevant to the assessment of impacts on community health.

The report has identified and considered impacts on a local and regional scale. The local assessment is focussed on health impacts to communities located near WSI, whereas the regional assessment covers a much larger area.

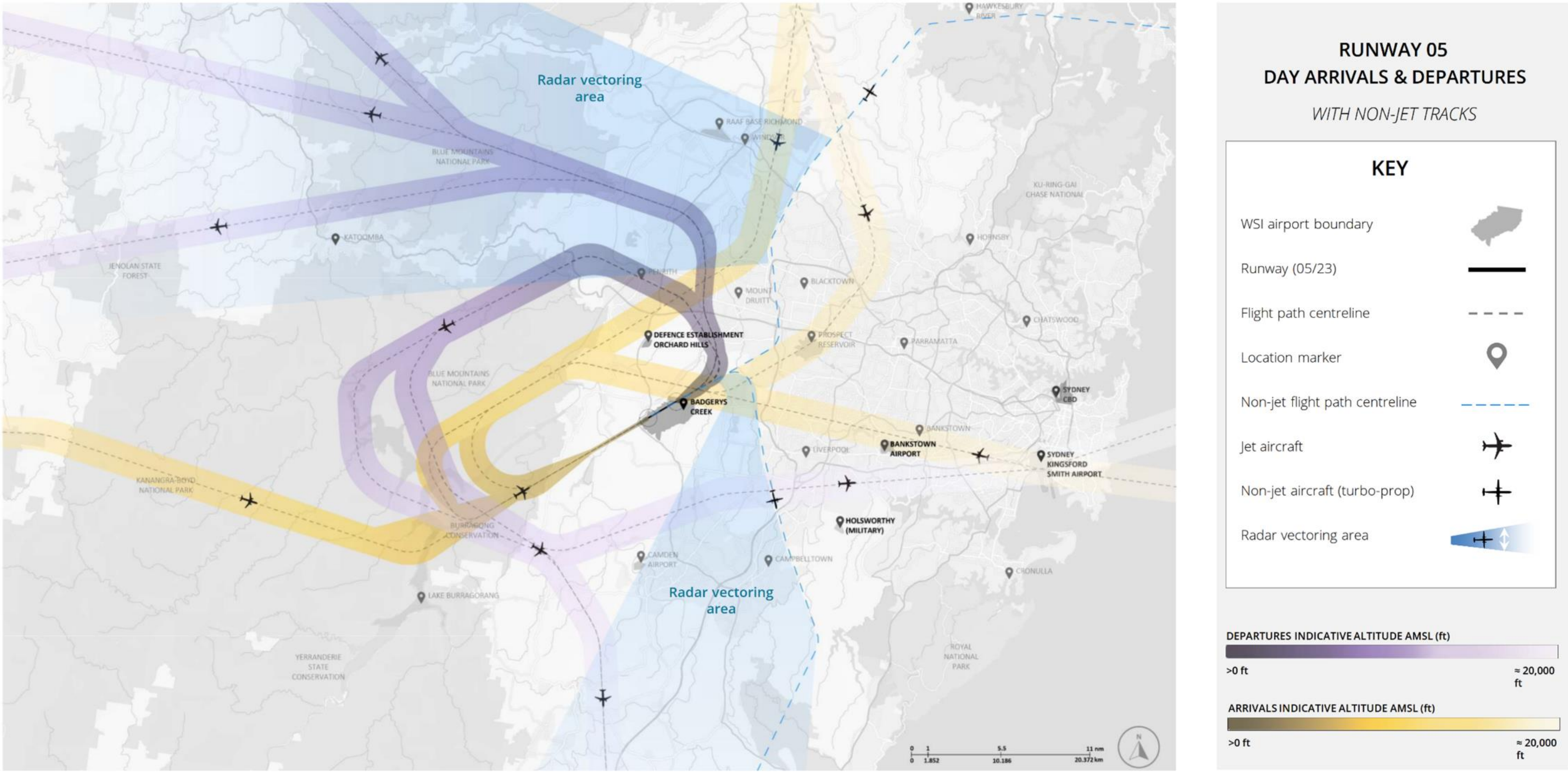


Figure 1.3 Proposed flight paths for Runway 05 (day)

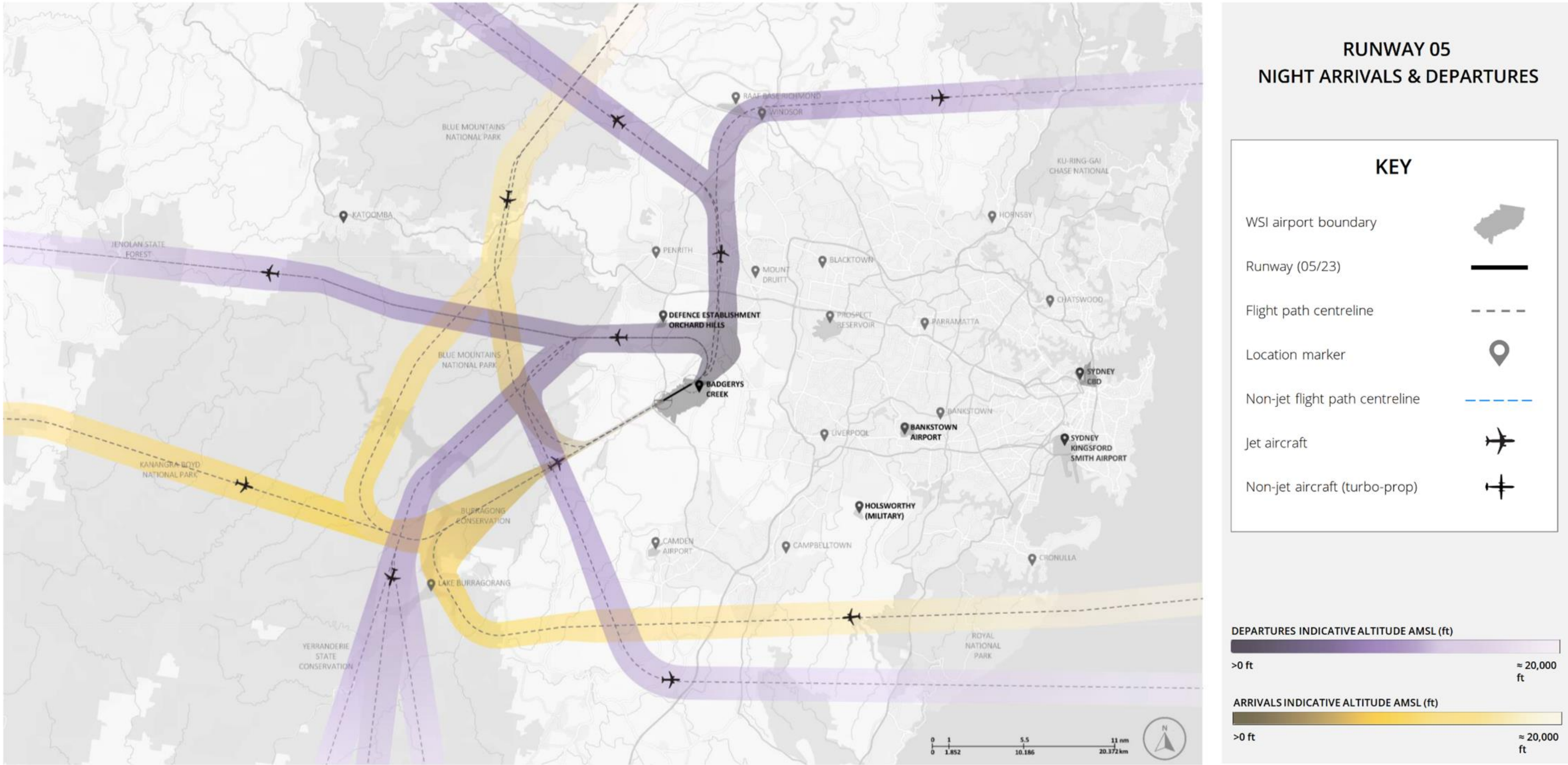


Figure 1.4 Proposed flight paths for Runway 05 (night)

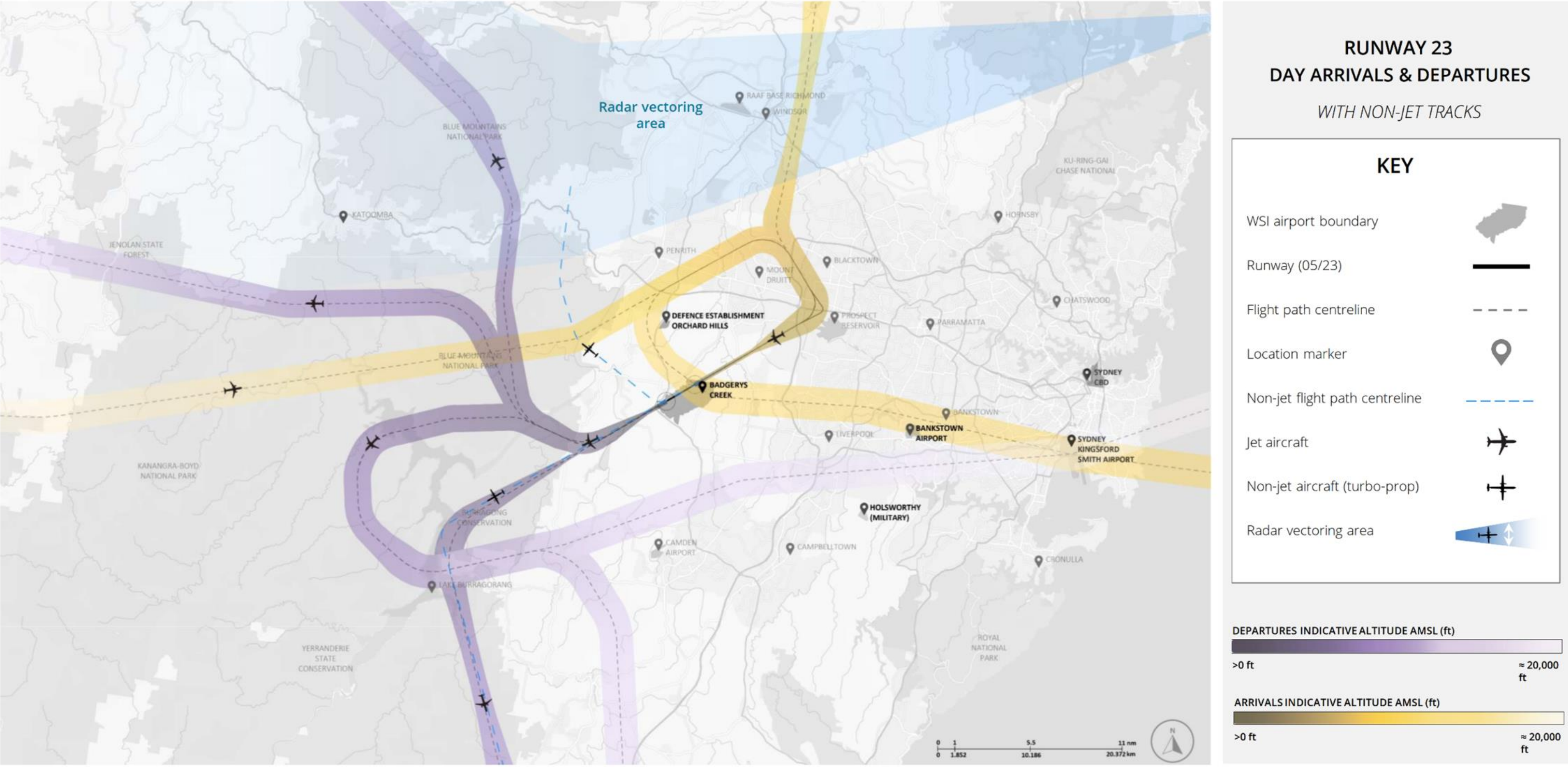


Figure 1.5 **Proposed flight paths for Runway 23 (day)**

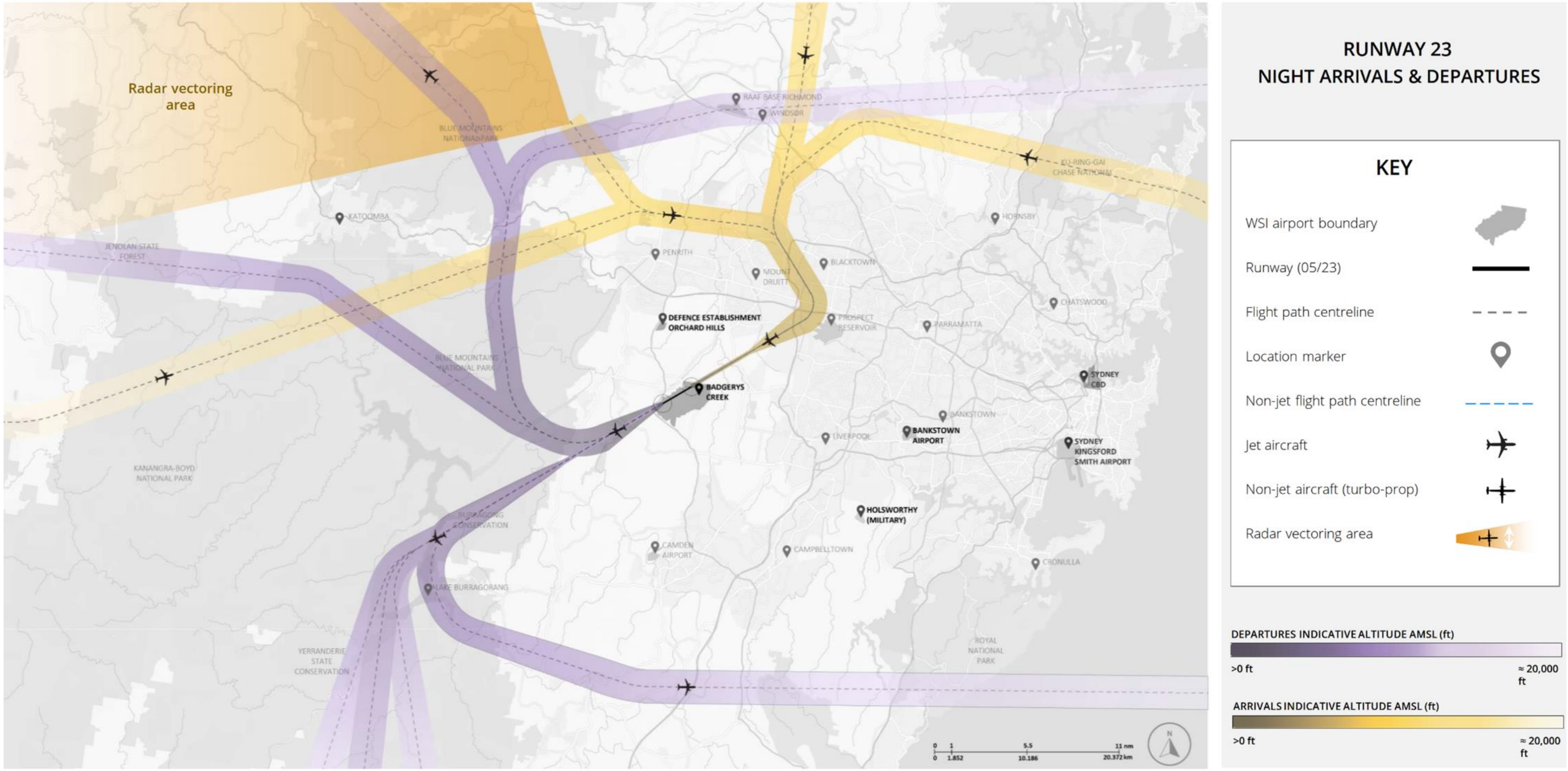


Figure 1.6 Proposed flight paths for Runway 23 (night)

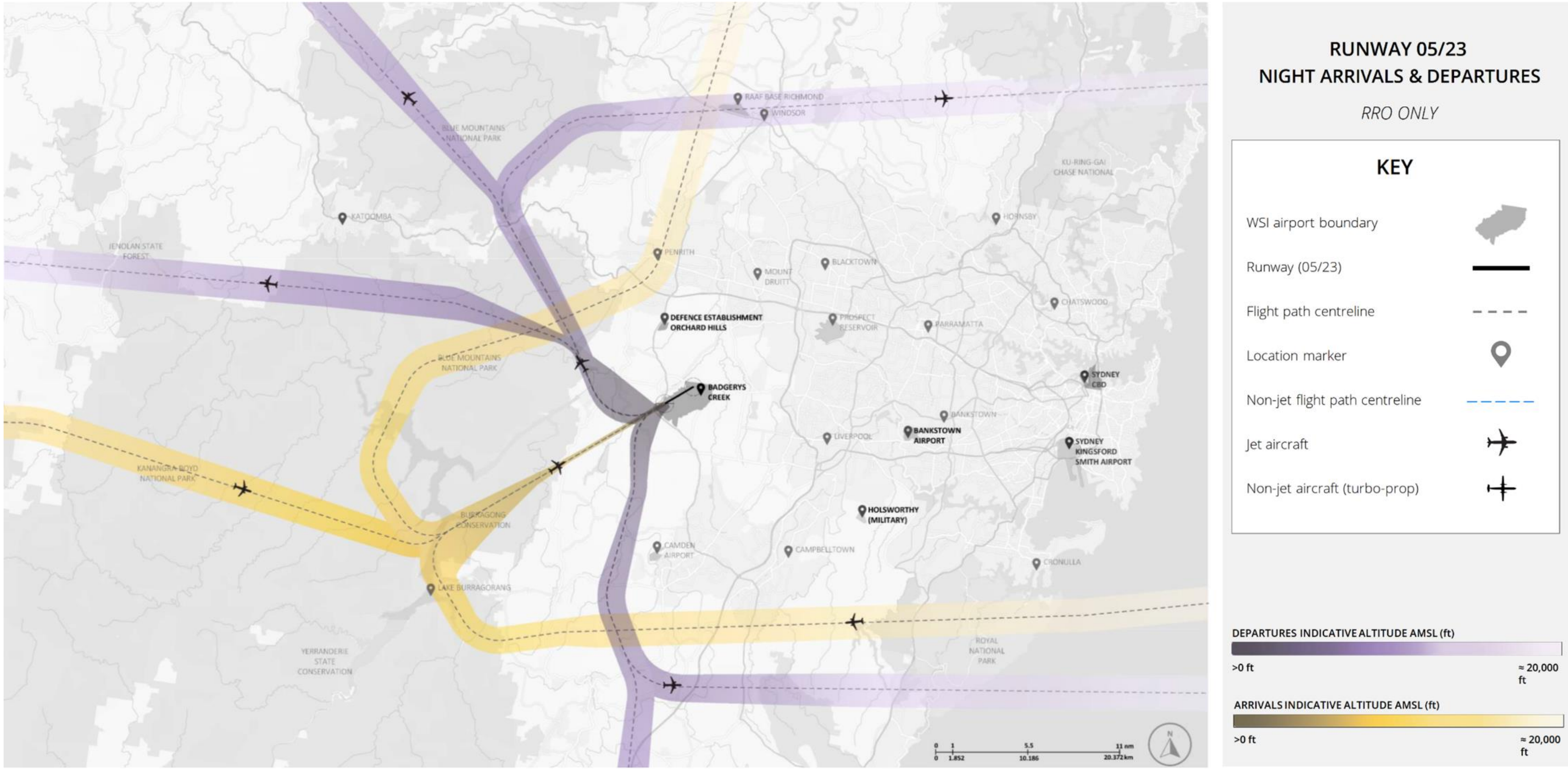


**Figure 1.7	Proposed flight paths for Runway 05/23 (night)**

1.3.1 Assessment requirements

The project was referred to the Minister for the Environment and Water in 2021 (EPBC 2022/9143) in accordance with Section 161 of the EPBC Act and Condition 16 of the Airport Plan. In response, the delegate for the Minister for the Environment and Water determined that an EIS would be required and issued the EIS Guidelines on 26 April 2022.

This technical paper has been prepared to address the requirements related to human health outlined in Table 1.1.

Table 1.1 Guidelines for the EIS – Human health

Matters of interest	Assessment requirement	Aspects relevant to this assessment, and where addressed in this report
7.4 People and communities	7.4.1 Detailed assessment of impacts that the proposed project may facilitate on people and communities. Including, but not limited to, assessment of impacts from noise, change in land use and an assessment of any identified risks to people and communities associated with the proposed project. This should be based on relevant metrics such as the Australian Noise Exposure Concept (ANEC), Australian Noise Exposure Forecast (ANEF) if available, the Number Above 'N' measure, and the maximum noise level (L_{Amax}) single event noise measure. Identify whether land uses that are noise sensitive could be affected, directly and indirectly, by the Project including identification and analysis of impacts to: • health and wellbeing • changes to land use and affordability • lifestyle and culture • social and economic factors. Discuss recent and proposed changes in planning, such as the aerotropolis precinct, and how these changes will alter the likely impacts to people and communities. Where land use is likely to intensify, assess any foreseeable impacts to new residents and visitors to the region.	The HHIA addresses impacts to people and communities specific to community health. More specifically, the assessment relating to impacts of aircraft noise on health, including land use planning aspects are discussed in Chapter 6.

<table>
<thead>
<tr><th>Matters of interest</th><th>Assessment requirement</th><th>Aspects relevant to this assessment, and where addressed in this report</th></tr>
</thead>
<tbody>
<tr><td>13 Economic and Social Matters</td><td>The economic and social impacts of the project, both positive and negative, must be analysed. Matters of interest may include:
details of any public consultation activities undertaken and their outcomes
projected economic costs and benefits of the project, including the basis for their estimation through cost/ benefit analysis or similar studies
employment opportunities expected to be generated by the project
human health impacts arising from the Project, with reference to the findings of impact assessments including those relating to noise, air quality, and social/ community issues. Give consideration to the demographic characteristics of the sub-region such as the prevalence of existing medical conditions and capacity of health services
impacts on potential Native Title claimants
impacts on regional and local communities including impacts on demographic characteristics due to redevelopment or changes in land values
economic and social impacts should be considered at the local, regional and national levels.</td><td>This assessment addresses human health impacts arising from the project – with input from other relevant technical studies.

The assessment addresses impacts on regional and local communities including consideration to demographic characteristics and the existing health of the community.

Key characteristics of the existing community are presented in Chapter 4, with impacts on community health as a result of changes in air quality and noise presented in Chapter 5 and Chapter 6. Impacts on community health as a result of other hazards and risks associated with the operation of the flight paths are presented in Chapter 7.</td></tr>
</tbody>
</table>

Chapter 2 Legislation and strategic context

This chapter provides an overview of the relevant legislation, national and international policies and guidelines relevant to the project and considered in this technical paper.

The methodology adopted for the conduct of the health impact assessment is in accordance with national and international guidance that is endorsed/accepted by Australian health and environmental authorities, and includes:

- Health Impact Assessment Guidelines. Published by the Environmental Health Committee (enHealth), which is a subcommittee of the Australian Health Protection Committee (AHPC) (enHealth 2017)
- Environmental Health Risk Assessment: Guidelines for assessing human health risks from environmental hazards, 2012 (enHealth 2012)
- National Environmental Protection (Ambient Air Quality) Measure 2021 (NEPC 2021)
- Schedule B8 Guideline on Community Engagement and Risk Communication, National Environment Protection (Assessment of Site Contamination) Measure, 1999 (National Environment Protection Council (NEPC 1999 amended 2013a))
- State Environmental Planning Policy (SEPP) (Resilience and Hazards) 2021 (NSW Government 2021)
- National Environmental Protection (Air Toxics) Measure, Impact Statement for the National Environment Protection (Air Toxics) Measure, 2003 (NEPC 2003)
- Harris, P., Harris-Roxas, B., Harris, E. & Kemp, L., Health Impact Assessment: A Practical Guide, Centre for Health Equity Training, Research and Evaluation (CHETRE). Part of the UNSW Research Centre for Primary Health Care and Equity. University of NSW, Sydney (Harris et al. 2007).

In addition, there are a range of more specific guidance relevant to the assessment of health impacts from changes in air quality and noise, in particular, that are available from Australian and key international organisations or reviews. These include the following:

- National Environment Protection Council (NEPC) reviews on the health effects of air pollution ((Burgers & Walsh 2002; NEPC 1998, 2002, 2003, 2009, 2010, 2014, 2019b, 2019a))
- World Health Organization (WHO) reviews on the health effects of air pollution (Ostro 2004; WHO 2003, 2006b, 2006a, 2013a, 2021)
- USEPA reviews on the health effects of nitrogen dioxide and particulates (USEPA 2005a, 2009, 2010, 2012, 2016b, 2018a, 2019, 2020, 2022a)
- Guidance on the assessment of environmental noise (enHealth 2018; I-INCE 2011; WHO 2011a, 2018).

Chapter 3 Methodology

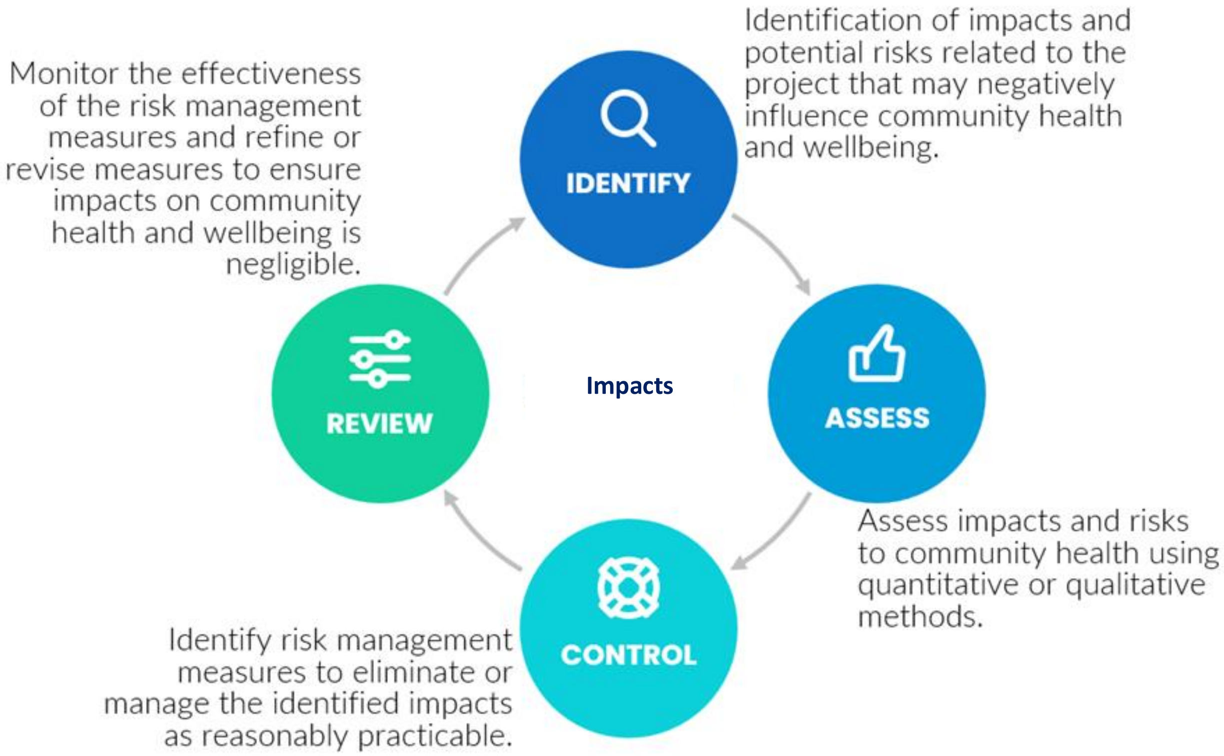
This chapter provides an overview of the methodology for the human health assessment, including the approach to assessment, dependencies with other studies and any limitations and assumptions.

3.1 Impact assessment approach

A human health impact assessment is a systematic tool used to review key aspects of a specific project that may affect the health and wellbeing of a community. The human health impact assessment for the project has been undertaken as a desktop assessment. The term desktop assessment is used to describe that the assessment has not involved the collection of any additional data over and above that provided from project-specific EIS technical specialists, community consultations, and statistics on the existing population. Rather, the assessment has been conducted using existing information with additional detail obtained via literature review only.

Broadly, the methodology and legislative requirements to assess health impacts/risks follow a standard risk assessment and management-type approach, shown in Figure 3.1.

3.2 General approach to assessing health impacts



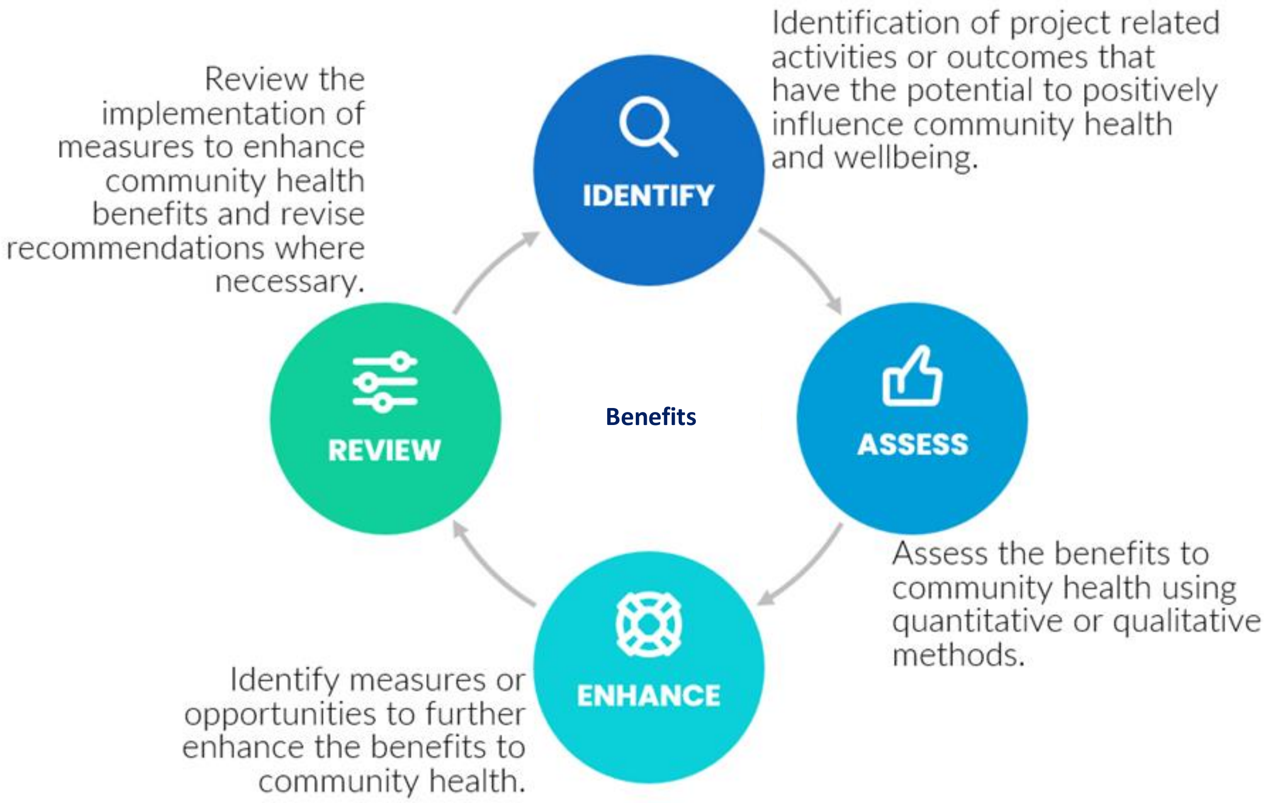


Figure 3.1 Approach to assessing human health impacts and benefits

This assessment of impacts on human health has been undertaken in accordance with the guidelines outlined in Chapter 2. This has involved quantitative and qualitative evaluations, drawn from other technical studies.

3.3 Defining risk

Risk assessment is used extensively in Australia and overseas to assist in decision making on the acceptability of the risks associated with the presence of contaminants or stressors in the environment and assessment of potential risks to the public. Risk is commonly defined as the chance of injury, damage, or loss. Therefore, to put oneself or the environment 'at risk' means to participate, either voluntarily or involuntarily, in an activity or activities that could lead to injury, damage, or loss.

Voluntary risks are those associated with activities that we decide to undertake (or not undertake) such as driving a vehicle, riding a motorcycle and smoking cigarettes. Involuntary risks are those associated with activities that may happen to us without our prior consent or forewarning. Acts of nature such as being struck by lightning, fires, floods and tornados, and exposures to environmental contaminants are examples of involuntary risks.

Risks to the public and the environment are determined by direct observation or by applying mathematical models and a series of assumptions to infer risk. No matter how risks are defined or quantified, they are usually expressed as a probability of adverse effects associated with a particular activity. Risk is typically expressed as a likelihood of occurrence and/or consequence (such as negligible, low or significant) or quantified as a fraction of, or relative to, an acceptable risk number.

Risks or impacts from a range of facilities (e.g., industrial or infrastructure) or activities (such as vehicle or aircraft movements) are usually assessed through qualitative and/or quantitative risk assessment techniques. In general, risk or impact assessments seek to identify all relevant hazards; assess or quantify their likelihood of occurrence and the consequences associated with these events occurring; and provision of an estimate of the risk levels for people who could be exposed.

3.4 Dependencies and interactions with other technical papers

This report relies on or is informed by the technical reports identified in Table 3.1. The health impact assessment has drawn on information provided in these reports and, in some areas, provides a summary of key (and relevant) aspects. All details relevant to the underlying assumptions, methodology and interpretation of impacts relevant to these specialist areas are presented in the individual reports. Where more detail than provided in the health impact assessment is required, the relevant technical report should be reviewed.

Table 3.1 Dependencies and interactions with other Technical Papers

Technical Paper	Relevance
Technical paper 1: Aircraft noise (Technical paper 1)	Provides details on the methodology and results of the modelling of aircraft noise impacts associated with the project. Modelled noise impacts relevant to the assessment of impacts on community health have been used in this assessment, as detailed in Chapter 6.
Technical paper 2: Air quality (Technical paper 2)	Provides details on the methodology and results of the modelling of air quality impacts associated with the project. Modelled impacts or changes in air quality as a result of aircraft emissions have been used in this assessment, as detailed in Chapter 5.
Technical paper 4: Hazard and risk (Technical paper 4)	The detailed assessment of hazards and risks relevant to the operation of the airspace have been reviewed and considered in relation to potential impacts on community health, as detailed in Chapter 7.
Technical paper 10: Social (Technical paper 10)	Provides additional detail and information relevant to understanding the characteristics of the community surrounding the project, with information incorporated into Chapter 4.

3.5 Health impact assessment approach

Broadly, the available guidance for the assessment of health impacts or risks, follow a standard risk assessment or risk management-type approach. This requires the identification of risk issues of concern, assessment of the potential significance of community exposures, or the benefits of the project on health outcomes, identification of measures to manage impacts or enhance benefits and review risks and benefits with the implementation of these measures.

The human health impact assessment assesses the benefits and/or impacts to the local community and users of the project.

The conduct of the human health impact assessment considers a wide range of factors with the potential to affect human health, both direct and indirect factors that affect community health and wellbeing.

To inform the assessment of potential health impacts, information on the community or population in areas surrounding the project is relevant. Information on the existing includes:

- **the community profile**, which comprises information on the population that may be impacted by the project, specifically the demographics, lifestyle factors and baseline health, and the social environment that have the potential to determine the vulnerability of various aspects of the community to impacts from the project. This information is presented in Chapter 4
- **existing conditions of key environments** in which the community reside that affect and are of importance for the human health impact assessment, including existing air quality and noise. Where relevant the existing conditions for these areas are summarised in the relevant sections of this report.

Figure 3.2 provides an overview of the key aspects that are considered in the assessment of impacts on community health.

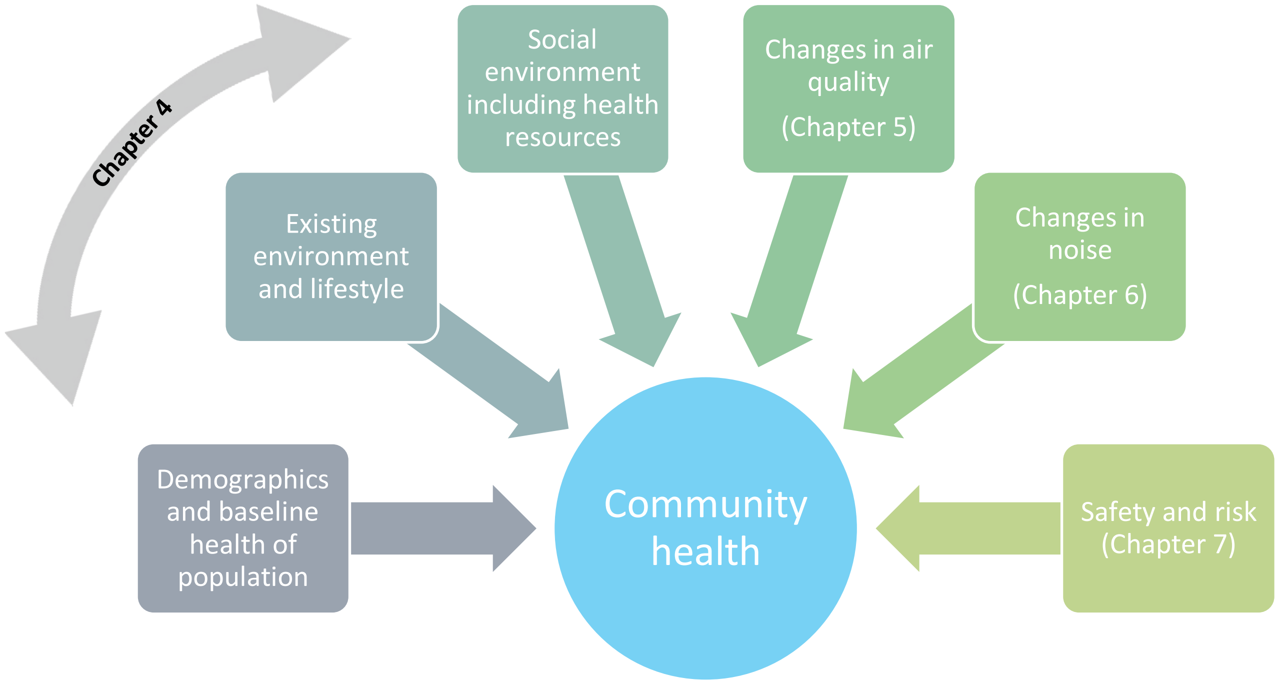


Figure 3.2 Key aspects relevant to the conduct of the health impact assessment (HIA)

3.6 Characterising health impacts

The assessment of health impacts involves the use of a combination of quantitative and qualitative approaches.

Where a quantitative assessment is undertaken, the following terminology has been used in this assessment:

- No health impacts of concern or negligible – this means that all exposure levels or concentrations quantified are below guidelines that are protective of all adverse health effects in the community or are so low that they are effectively considered to be indistinguishable from zero.
- Low – exposure levels or concentrations quantified are equal to guidelines that are protective of all adverse health effects in the community or at a level that may result in some amenity impacts but no health impacts (e.g., visible dust deposition).

Where exposure levels or concentrations are not described as above, they are considered to be elevated and potentially unacceptable.

Where a qualitative assessment is undertaken, the following terminology has been used in this assessment:

- No health impacts of concern or negligible – impacts evaluated or considered would not result in a health effect that would be different to the variability typically experienced within normal urban or suburban environments.
- Low – impacts evaluated or considered may be noticeable or result in a short-term increase in stress and anxiety, however the level of impact can be managed through normal daily coping mechanisms just as are common when there is a change in our normal environment, e.g., new building works occurs nearby or a common travel route change.

Where impacts have the potential to result in the development of or exacerbation of disease or result in levels of stress and anxiety that cannot be managed through normal daily coping mechanisms, they are considered to be elevated and potentially unacceptable.

3.7 Features of the health impact assessment

The health impact assessment has been carried out in accordance with international best practice and general principles and methodology accepted in Australia by groups/organisations such as National Health and Medical Research Committee (NHMRC), NEPC and enHealth. There are certain features of risk assessment methodology that are fundamental to the assessment of the outputs and to drawing conclusions on the significance of the results. These are summarised below:

- A health impact assessment is a systematic tool used to review key aspects of a specific project that may affect the health of the local community. The assessment includes both qualitative and quantitative assessment methods.
- The assessment has relied on assessments completed in other technical reports, specifically in relation to air quality, noise, hazard and risk.
- A risk assessment is a systematic tool that addresses potential exposure pathways based on an understanding of the nature and extent of the impact assessed and the uses of the local and regional areas by the community. The risk assessment is based on an estimation of maximum, or worst case, impacts (air quality and/or noise) in the local community and hence is expected to overestimate the actual risks.
- Conclusions can only be drawn with respect to project related impacts as outlined in the respective technical reports.
- Available statistics in relation to the existing health status of the existing community are presented. However, the health impact assessment does not provide an evaluation of the overall health status of the community or any individuals. Rather, it is a logical process of calculating and comparing potential exposure concentrations (acute and chronic) in surrounding areas (associated with the project) with regulatory and published acceptable air pollutant concentrations that any person may be exposed to over a lifetime without unacceptable risk to their health. It can also involve calculating an incremental impact that can be evaluated in terms of an acceptable level of risk.
- The health impact assessment reflects the current state of knowledge regarding the potential health effects of identified chemicals and pollutants for this project. This knowledge base may change as more insight into biological processes is gained, further studies are undertaken, and more detailed and critical review of information is conducted.

Chapter 4 Existing conditions

This chapter describes the existing conditions and features of the study area to provide a baseline against which the project's impacts can be assessed. This includes information on the population profile, access to health and community services and existing and population health.

4.1 Study area

The Western Sydney International Airport is located approximately 15 kilometres south-southeast of Penrith and approximately 20 kilometres east of Liverpool. As this assessment addresses impacts relating to the airspace, the community that may be impacted comprises a larger area around the airport.

The study area applicable to the assessment of health impacts needs to align with the study areas identified and evaluated in relation to changes in air quality, noise, hazard and risk and social impacts. More specifically the study area considered in the assessment of health impacts is consistent with the social impact assessment, which has divided the study area into a local area and regional area, with the State of NSW and the Greater Sydney area adopted as points of comparison.

The local study area showcases the communities most likely to be most affected by impacts of the project, including changes to noise, air quality and visual impacts. The regional study area showcases the communities that would possibly be affected by visual and noise impacts of the project.

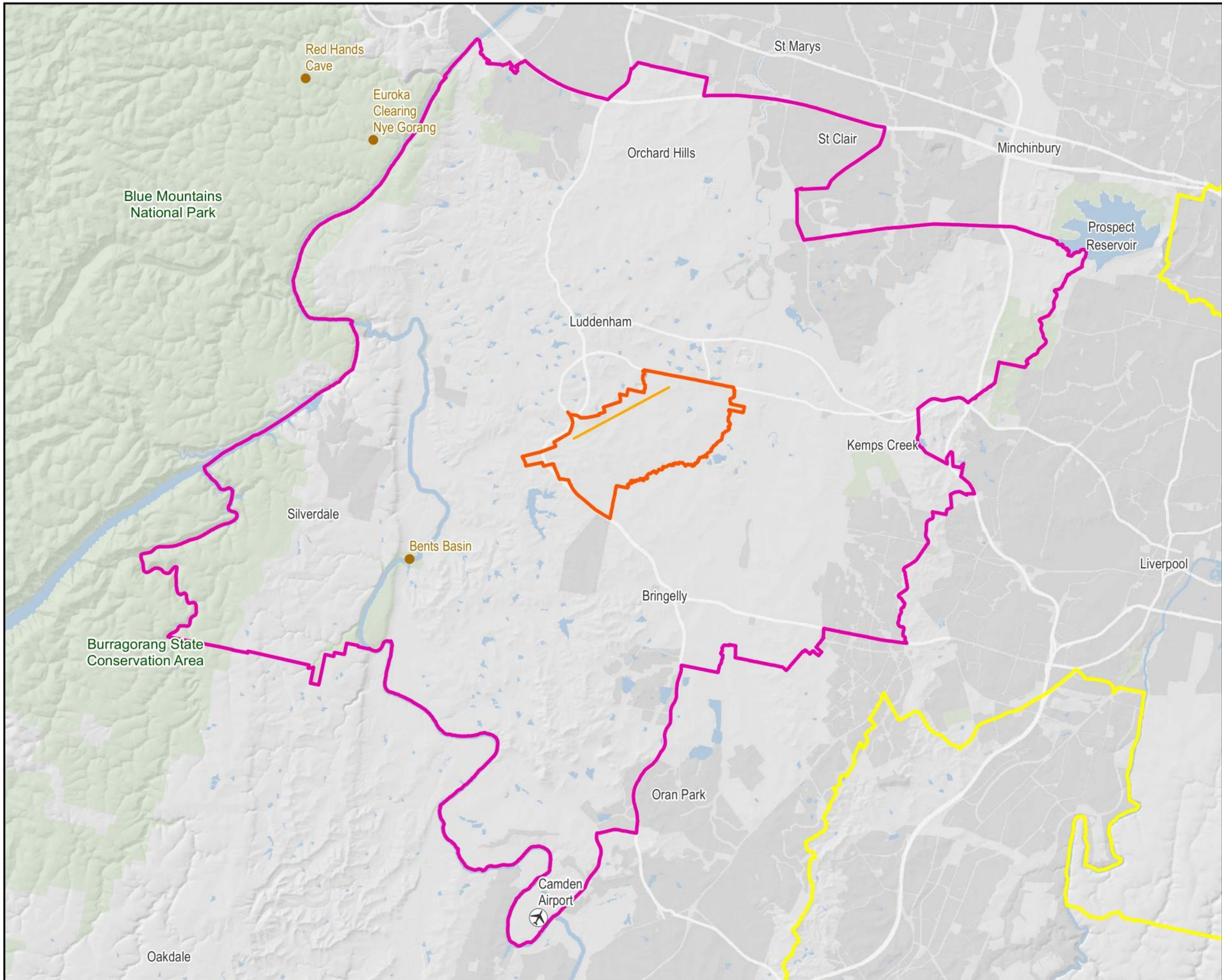
Noise impacts are identified as per noise metrics applied within Technical paper 1. Key noise metrics addressed include the following (also refer to Chapter 6):

1. The ANEC, which has been adopted by land use planning around airports and describes the cumulative aircraft noise for an 'annual average day'. This does not illustrate the day-to-day variation in noise exposure and reflects a hypothetical future airport usage pattern.
2. 'N-above contours' of N60 (24-hour), N60 (Night-time) and N70 (24-hours). These describe aircraft noise impacts by the number of noise events that exceed a certain noise level. N-above contours provide cumulative-event descriptor which provide as assessment of the sustained exposure to aircraft noise. For the assessment, the following metrics have been used:
   - N70 (24-hour) contours, which represents 10 aircraft noise events with L_{Amax} that exceed 70 dB(A) over a 24-hour period. N70 is typically used to assess day-time noise impacts. An outside noise event of 70 dB(A) (such as aircraft flyover) can lead to in an indoor sound level of 60 dB(A) when windows are opened (enough to disturb conversation)
   - N60 (24-hour) contours, which represent 10 aircraft noise events with L_{Amax} that exceed 60 dB(A) over a 24-hour period
   - N60 (night-time) contours, which represent 2 aircraft noise events with L_{Amax} that exceed 60 dB(A) over the night time period (defined as 11 pm to 5:30 am). An outside noise event of L_{Amax} that exceeds 60 dB(A) results in an indoor maximum sound level of 50 dB(A) with windows open, or 40 dB(A) with windows closed. A 50 dB(A) maximum noise level is considered close to the point at which someone sleeping may wake up.

Based on the above the local study area has been defined to include Australian Bureau of Statistics (ABS) Suburb and Localities (SALs) within 10 km from the centre of the runway, as shown in Figure 4.1. This represents residential communities that are within the ANEC and noise contours (N60 and N70) as well as locations potentially affected by visual impacts and changes in air quality.

Figure 4.1

Local study area



Legend

- WSI Runway
- Western Sydney International (Nancy-Bird Walton) Airport land boundary
- Regional study area
- Local study area
- Aboriginal Gazetted Places

Coordinate system: GDA 1994 NSW Lambert

Scale ratio correct when printed at A4

1:175,000 Date: 10/05/2023

Data sources: - DITRDC, DCS, Geoscience Australia
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Airbus,USGS,NGA,NASA,CGIAR,NCEAS,NLS,OS,NMA,Geodatastyrelsen,GSA,GSI and the GIS User Community

The following SALs are included in the local study area:

- Austal
- Badgerys Creek
- Bringelly
- Cobbitty
- Cecil Park
- Horsley Park
- Glenmore Park
- Greendale
- Kemps Creek
- Luddenham
- Mulgoa
- Mount Vernon
- Orchard Hills
- St Clair
- Rossmore
- Silverdale
- Wallacia
- Warragamba.

The regional study area is shown on Figure 4.2 and includes Local Government Areas (LGAs) in which residential areas are intersected by noise contours (N60 and N70).

The following LGAs are included in the regional study area:

- Blacktown
- Blue Mountains
- Camden
- Fairfield
- Hawkesbury
- Liverpool
- Penrith
- Wollondilly.

In addition to these statistical population areas, the regional study area sits within the South Western Sydney, Western Sydney and Nepean Blue Mountains Local Health Districts (LHD).

Data relevant to characterising the existing health of the community within the study area comes a number of different sources, resulting in data applicable to different sizes of populations. Much of the key health related data is not available for small populations such as the SALs, as listed for the local study area. Hence data for larger population groups are assumed to be applicable to the smaller sub-populations.

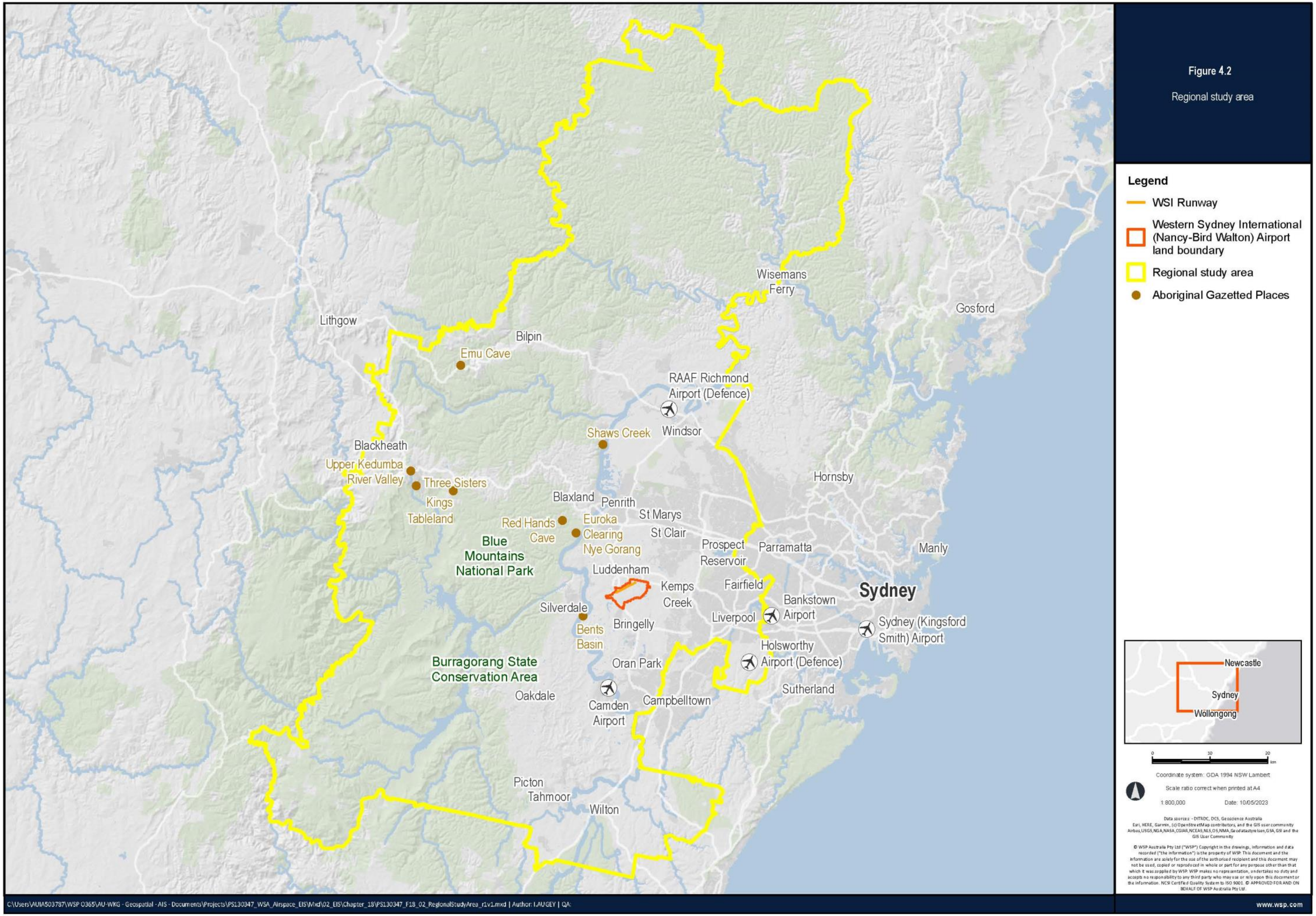


Figure 4.2
Regional study area

4.2 Sensitive receptors

Within the study area, the air quality and aircraft noise impact assessments have identified and evaluated impacts at specific residential and community locations, termed receptors, where sensitive members of the community are more likely to be present. In terms of evaluating health impacts sensitive groups include infants and young children, the elderly and individuals who are unwell or with health conditions. Hence residential homes, childcare centres, schools, hospitals and aged care facilities are considered to be sensitive receptor locations. Other sensitive receptor locations may include recreational areas and religious premises.

Figure 4.3 presents the location of the key residential and community receptors considered in the assessment of local air quality impacts, and in the assessment of noise impacts (noting the noise assessment included a number of other locations within the regional study area). It is noted that there are millions of residents in the Sydney Basin however, the selected receptors that have been assessed in this report represent the potentially affected locations, and less impacts are likely in other locations.

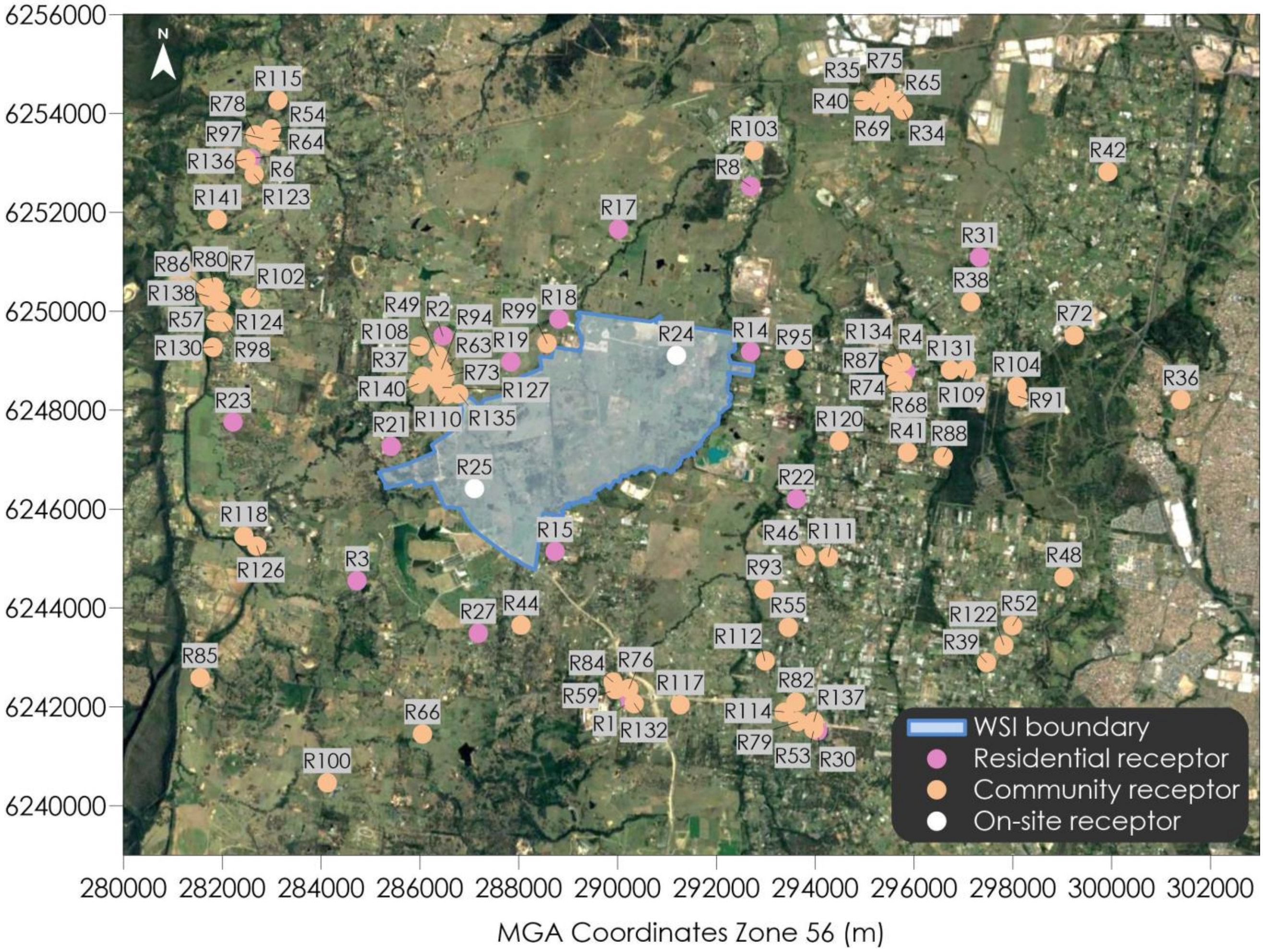


Figure 4.3 Location of sensitive receptors assessed

4.3 Population profile

4.3.1 General

In relation to the assessment of potential health impacts, it is important to understand the demographics of the population in the study area to determine if the population has the potential to be more or less vulnerable to environmental stressors relevant to the project. The statistics relevant to be considered relate to the age distribution of the population, housing, unemployment rate, level of socioeconomic disadvantage and availability of economic resources. In addition, the characteristics of the population in relation to cultural and linguistic diversity (CALD) is also relevant.

Statistics relevant to the study area have been obtained from the ABS and are summarised in the tables below.

4.3.2 Demographics

Table 4.1 presents a summary of the age distribution and median age of the populations in the regional and local study areas, with comparison against the data for NSW. The data is derived from the 2021 ABS census and focuses on the proportion of the population that comprises young children, older children, adults of working age and older individuals. Areas where there is a higher proportion of young children (aged 0 to 4 years) or older individuals (aged 60 years and over), compared with Greater Sydney and NSW, have been highlighted with blue shading. Areas with a lower proportion of individuals in these age groups, compared with Greater Sydney or NSW, are shaded in green.

Table 4.2 presents a summary of the household composition, the proportion of dwellings that comprise social housing as well as the proportion of the population considered to be under rental or mortgage stress. Populations that have a higher proportion of social housing or are considered to be under rental or mortgage stress are highlighted in blue. It is noted that in relation to rental stress, most populations evaluated, including the larger populations of Greater Sydney and NSW, are considered to be under rental stress.

In terms of the key statistics presented for the local and regional study areas, there are some populations that have a higher proportion of young children or older individuals, that also include a higher proportion of social housing and/or are under rental or mortgage stress. These areas include Blacktown, Camden, Liverpool and Penrith LGAs; and Austral, Badgerys Creek, Bringelly, Cecil Park, Glenmore Park, Horsley Park, Kemps Creek, Orchard Hills, Rossmore, Silverdale and Warragamba SALs. These populations may be more vulnerable to environmental stressors.

Conversely, there are also some populations in the study areas that may be less vulnerable, where there is a smaller proportion of the population that comprises young children or older individuals and there are lower levels of rental and/or mortgage stress. These areas include Mount Vernon and Luddenham.

It is also noted that the projected population growth for all LGAs, with the exception of Blue Mountains LGA, is more than 15% (ranging from 18.9% to 67.4%) between 2021 and 2024.

Table 4.1 Population demographics

Location	Total number of people	Age group (% of total population)						Median age
		0–4 years	5–17 years	18–64 years	65 years and over	1-14 years	30 years and over	
Blacktown LGA	396776	7.5	18.9	62.5	11.0	21.3	57.5	34
Blue Mountains LGA	78121	5.0	16.3	56.3	22.4	16.6	68.2	45
Camden LGA	119325	9.4	19.7	61.0	9.9	23.3	55.4	33
Fairfield LGA	208475	5.2	16.8	61.2	16.8	16.9	61.4	39
Hawkesbury LGA	67207	6.2	16.9	60.4	16.6	17.9	61.5	39
Liverpool LGA	233446	7.1	19.1	62.2	11.6	20.7	56.9	34
Penrith LGA	217664	7.2	17.1	62.1	13.0	19.8	58.4	35
Wollondilly LGA	53961	7.0	19.0	58.8	15.2	20.4	59.7	37
Austral SAL	6847	10.8	17.8	61.3	9.7	22.8	53.9	31
Badgerys Creek SAL	168	7.1	15.5	48.2	24.4	16.7	61.9	40
Bringelly SAL	2433	3.8	16.8	60.4	18.9	15.3	63.0	42
Cobbitty SAL	4206	8.5	17.4	58.6	15.4	20.1	58.1	35
Cecil Park SAL	815	4.7	14.6	58.4	20.1	13.6	61.8	43
Glenmore Park SAL	25021	7.6	21.0	62.7	8.8	22.3	55.8	34
Greendale SAL	314	6.4	16.2	58.0	17.8	17.2	61.8	42
Horsley Park SAL	1790	4.9	14.7	57.8	21.1	15.4	63.0	45
Kemps Creek SAL	2121	3.8	15.8	58.9	21.2	15.2	64.5	44
Luddenham SAL	1927	5.5	20.7	61.9	11.7	20.8	57.1	37
Mulgoa SAL	2044	5.4	18.8	58.5	17.5	18.4	62.3	41
Mount Vernon SAL	1235	4.4	19.3	60.6	15.3	17.1	58.9	40
Orchard Hills SAL	1798	3.4	14.1	62.2	20.5	13.3	65.0	47
Rossmore SAL	2241	5.0	18.4	57.3	19.2	16.9	60.4	40
St Clair SAL	19942	6.8	18.1	62.5	12.7	19.6	59.7	36
Silverdale SAL	4543	8.1	19.8	61.9	10.7	21.2	57.4	35
Wallacia SAL	1711	6.7	17.5	58.0	17.4	19.2	61.1	38
Warragamba SAL	1202	8.4	14.6	64.5	11.7	18.1	58.7	34
Greater Sydney	5231147	6.0	15.9	63.0	15.2	17.2	61.9	37
NSW	8072163	5.8	15.9	60.7	17.6	17.1	63.1	39

Source: ABS 2021

Note: populations with a higher percentage (more than 1% higher than Greater Sydney or NSW) of young children or older individuals highlighted in blue shading; and populations with a lower percentage (more than 1% lower than Greater Sydney or NSW) of young children or older individuals in green shading.

Table 4.2 Population housing characteristics

Location	Characteristics (% of dwellings)			Housing affordability stress* – rental (%)	Housing affordability stress* – mortgage (%)
	Occupied private dwellings	Family households	Social housing		
Blacktown LGA	95.0	81.5	5.9	31.1	18.0
Blue Mountains LGA	89.5	70.9	1.7	44.7	13.3
Camden LGA	96.4	84.5	1.3	32.4	18.3
Fairfield LGA	94.6	80.2	7.3	48.5	25.4
Hawkesbury LGA	94.2	76.1	3.2	38.1	17.3
Liverpool LGA	93.8	80.9	6.1	41.2	23.0
Penrith LGA	94.9	75.6	3.9	34.8	16.8
Wollondilly LGA	95.1	81.8	1.0	37.7	17.0
Austral SAL	93.4	85.9	0.2	42.2	28.5
Badgerys Creek SAL	86.4	83.7	0.0	36.8	37.5
Bringelly SAL	93.1	81.6	0.0	39.7	19.8
Cobbitty SAL	96.4	84.2	0.3	26.8	18.4
Cecil Park SAL	94.8	89.8	0.0	28.1	26.3
Glenmore Park SAL	97.3	86.9	0.9	27.4	14.5
Greendale SAL	92.2	96.2	0.0	34.8	0.0
Horsley Park SAL	90.7	82.9	0.0	35.2	28.6
Kemps Creek SAL	93.7	81.1	0.6	37.1	20.7
Luddenham SAL	93.8	89.5	0.0	27.5	22.2
Mulgoa SAL	95.1	85.6	0.0	31.2	18.9
Mount Vernon SAL	97.2	92.1	0.0	29.4	26.2
Orchard Hills SAL	94.4	85.1	0.0	33.3	19.6
Rossmore SAL	90.9	82.6	0.0	40.9	22.8
St Clair SAL	97.3	84.1	0.8	32.0	18.1
Silverdale SAL	96.8	90.1	0.0	36.4	17.5
Wallacia SAL	95.9	76.4	0.0	36.0	20.5
Warragamba SAL	92.6	98.9	0.0	37.9	20.6
Greater Sydney	91.7	72.6	4.8**	35.3	19.8
NSW	90.6	71.2	3.6	35.5	17.3

Source: ABS 2021

Notes: * Affordability stress defined as rental or mortgage repayments greater than or equal to 30% of household income; populations with a higher proportion (more than 1% higher than Greater Sydney or NSW) of social housing or under rental or mortgage stress highlighted in blue

** Rate for regional study area

4.3.3 Culture

The cultural mix within the local and regional study areas is important to understand.

For First Nations people there is a higher burden of disease compared with the rest of the population. More specifically the following is important for these individuals (NSW Health 2017):

- First Nations people experience a higher prevalence of most chronic diseases, and chronic disease risk factors compared with non-First Nations people, and at younger ages
- cardiovascular disease is the main cause of death for First Nations people in NSW
- diabetes is a major contributor to the disparity in health between First Nations and non-First Nations people
- First Nations people have a higher prevalence of renal disease when compared to non-First Nations people
- First Nations people experience higher levels of psychological distress compared to non-First Nations people
- barriers to accessing health care contribute to the poor health status of First Nations people.

The population located within the study areas are within the Deerubbin, Tharawal, and Gandangara Local Aboriginal Land Councils (LALC)[1] area on Dharug Country.

In addition, as there are a number of people from some culturally and linguistically diverse (CALD) backgrounds where NSW Health has identified higher rates of disease and health risk factors (NSW Health 2019). More specifically this relates to the following populations:

- higher levels of smoking: Iraq and Lebanon
- higher rates of overweight and obesity: Lebanon, Italy, Iraq
- higher rates of inadequate exercise: Lebanon, Italy, Vietnam and Iraq
- higher rates of diabetes or high blood glucose: Italy, Lebanon, Vietnam and United Kingdom
- higher rates of hospitalisations for coronary heart disease, diabetes, dialysis and heart failure: Malta, Greece, Lebanon, Samoa, Turkey, Croatia, Cook Islands, Tonga, Italy, Egypt, Fiji, Macedonia.

Migration and settlement can adversely affect the physical and mental health of both individuals and communities and hence population with higher rates of migration may be more susceptible to poorer health outcomes. In addition, populations with a higher proportion of individuals from CALD backgrounds can be affected by poor access to health services and a lack of appropriate information on healthcare, as a result of a range of factors (NSW Health 2019).

Table 4.3 presents a summary of the proportion of the population that identify as First Nations people, were born overseas and the top 3 countries of birth. Populations with higher (compared with Greater Sydney and NSW) levels of First Nations people, people born overseas and from background with identified higher levels of health disease factors are highlighted in blue shading.

Based on the available data, the populations in Hawkesbury and Penrith LGAs, and the SALs of Silverdale and Warragamba have a higher proportion of First Nations people. Populations in Blacktown, Fairfield and Liverpool LGAs and the SALs of Austral and Badgerys Creek have a higher proportion of people born overseas. Further much of the study area includes people born in countries with the potential for higher rates of health related factors or a higher burden of disease (in particular cardiovascular and diabetes).

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1 NSWALC 2023, Land Council Map

Table 4.3 Summary of cultural aspects

Location	% population that identify as First Nations people	% born overseas	Top 3 countries of birth		
Blacktown LGA	3.0	49.6%	India (11.9%)	Philippines (6.4%)	New Zealand (2.1%)
Blue Mountains LGA	2.7	20.8%	England (5.5%)	New Zealand (1.5%)	Germany (0.7%)
Camden LGA	3.2	25.9	India (2.4%)	England (2.3%)	New Zealand (1.5%)
Fairfield LGA	0.7	61.4	Vietnam (16.3%)	Iraq (12%)	Cambodia (3.6%)
Hawkesbury LGA	4.8	17.7	England (3.2%)	New Zealand (1.2%)	India (0.8%)
Liverpool LGA	1.6	48.8	Iraq (6.1%)	Vietnam (3.6%)	Fiji (3.0%)
Penrith LGA	5.0	28.7	India (3.1%)	England (2.5%)	Philippines (2.3)
Wollondilly LGA	4.4	15.8	England (3.3%)	New Zealand (1.0%)	Scotland (0.5%)
Austral SAL	1.4	49.7	Iraq (5.6%)	Nepal (4.3%)	India (4.0%)
Badgerys Creek SAL	0.0	48.8	China (13.1%)	Italy (4.8%)	Malta (4.8%)
Bringelly SAL	2.3	29.0	Italy (2.3%)	Malta (2.3%)	Lebanon (1.6%)
Cobbitty SAL	3.4	20.7	England (3.4%)	New Zealand (1.1%)	Philippines (0.8%)
Cecil Park SAL	0.0	39.9	Italy (6.9%)	Iraq (3.6%)	Iran (3.1%)
Glenmore Park SAL	3.7	22.9	India (3.6%)	England (2.9%)	Philippines (1.9%)
Greendale SAL	3.2	30.9	China (7.6%)	Malta (3.5%)	Italy (2.5%)
Horsley Park SAL	1.8	35.0	Italy (7.7%)	Malta (5.1%)	Iraq (3.0%)
Kemps Creek SAL	2.5	36.9	Italy (5.8%)	Iraq (2.6%)	China (2.6%)
Luddenham SAL	2.3	19.8	Italy (2.1%)	Malta (1.5%)	England (1.2%)
Mulgoa SAL	2.1	18.4	England (2.4%)	Malta (1.7%)	Germany (1.3%)
Mount Vernon SAL	1.9	28.3	Iraq (6.2%)	Italy (4.1%)	Croatia (2.0%)
Orchard Hills SAL	2.9	25.8	Malta (4.0%)	England (2.5%)	Italy (2.3%)
Rossmore SAL	2.1	34.3	Lebanon (5.4%)	Italy (3.6%)	China (3.1%)
St Clair SAL	3.8	31.3	Philippines (3.5%)	New Zealand (2.6%)	India (2.6%)
Silverdale SAL	4.6	13.1	England (2.2%)	Malta (0.9%)	New Zealand (0.7%)
Wallacia SAL	3.9	18.1	England (2.6%)	New Zealand (1.3%)	China (1.1%)
Warragamba SAL	7.9	13.1	England (2.1%)	New Zealand (1.9%)	Cambodia (0.7%)
Greater Sydney	1.7	43.2	China (4.6%)	India (3.6%)	England (2.9%)
NSW	3.4	34.6	China (3.1%)	England (2.9%)	India (2.6%)

Source: ABS 2021

Note: populations with a higher proportion (more than 1% higher than Greater Sydney or NSW) of First Nations population, born overseas or people from backgrounds with higher rates of health factors or disease burden shaded in blue.

4.3.4 Socio-economic advantage and disadvantage

Factors such as socio-economic disadvantage, the availability of economic resources and availability of education and employment are important factors in relation to community health and wellbeing.

The ABS Socio-Economic Index for Areas (SEIFA) assesses the economic and social conditions of households within an area. SEIFA consists of 4 indexes measuring relative advantage and disadvantage: Index of Relative Socio-economic Disadvantage (IRSD); Index of Relative Socio-economic Advantage and Disadvantage (IRSAD); Index of Economic Resources (IER); and Index of Education and Occupation (IEO).

Table 4.4 presents a summary of 3 indexed, IRSD, IER and IEO for the local and regional study areas ranking in the lowest 10% of areas are deemed most disadvantaged and the highest 10% the least disadvantaged.

In addition, Table 4.4 also includes current information relating to the rate of unemployment in the study area (data for June quarter 2022). It is noted that current unemployment data is not available for individual suburbs, hence data for the statistical area SA2 has been adopted for each of the suburbs located in these areas. Unemployment is a key determinant in evaluating community health and wellbeing and is linked with socio economic disadvantage and the availability of resources.

The available data indicates that Fairfield LGA is considered more significantly disadvantaged in terms of socio-economic disadvantage or availability of economic resources and availability of education and occupation resources, and also has a higher rate of unemployment. Populations in the SALs of Badgerys Creek, Greendale, Rossmore and Warragamba are also considered more disadvantaged (in the lower 20 percentile) with Warragamba SAL also the most disadvantaged in terms of availability of education and occupation resources. The populations in Blue Mountains, Camden and Hawkesbury LGAs and the SALs of Cobbitty, Luddenham, Mulgoa, Mount Vernon and Silverdale are considered the least disadvantaged. Much of the population in the study area are in locations with lower rates of unemployment, with only populations in the Fairfield and Liverpool LGAs reporting higher rates of unemployment.

Table 4.4 SEIFA percentile rankings and unemployment rate within NSW

Location	Percentile ranking within NSW			Unemployment rate Dec 22
	IRSD	IER	IEO	
Blacktown LGA	59	81	73	4.1%
Blue Mountains LGA	85	86	84	2.4%
Camden LGA	83	98	77	2.0%
Fairfield LGA	1	9	25	8.3%
Hawkesbury LGA	80	90	64	3.5%
Liverpool LGA	16	64	67	5.4%
Penrith LGA	64	79	53	3.6%
Wollondilly LGA	82	97	60	2.1%
Austral SAL	46	69	59	3.9%
Badgerys Creek SAL	18	51	63	--
Bringelly SAL	49	73	24	--
Cobbitty SAL	80	94	67	2.2%
Cecil Park SAL	59	92	50	2.4%
Glenmore Park SAL	76	87	58	1.4%
Greendale SAL	14	38	19	3.9%
Horsley Park SAL	51	80	41	2.2%
Kemps Creek SAL	23	43	28	2.2%
Luddenham SAL	84	100	56	1.1%
Mulgoa SAL	84	97	55	1.1%
Mount Vernon SAL	84	98	57	2.8%
Orchard Hills SAL	59	86	38	1.1%
Rossmore SAL	20	43	33	--
St Clair SAL	39	53	21	2.8%
Silverdale SAL	82	98	31	2.1%
Wallacia SAL	42	75	27	1.4%
Warragamba SAL	20	25	5	2.1%
Greater Sydney	--	--	--	**3.5%**
NSW	--	--	--	**3.5%**

Source: ABS 2021, SEIFA, and Australian Government Small Area Labour Markets (unemployment data for December Quarter 2022)

Notes: Lowest percentiles for each index are highlighted blue and reflect populations that are more disadvantaged (lower 10 percentile) or have a higher rate of unemployment (more than 1% higher than Greater Sydney or NSW), while highest percentiles for each index are highlighted green and reflect populations that are the least disadvantaged (top 10 percentile or 90th percentile and higher) or have a lower rate of unemployment (more than 1% lower than Greater Sydney or NSW).

4.4 Access to health and community services

The study area sits within the Sydney urban area and hence includes a number of health and community services. Where services are not located within the study area, such a specialist medical services, these are available in the Sydney area, noting that access may require some travel within the larger urban area.

There are no hospitals in the local study area, however, there is a total of 26 medical centres with the highest number of centres being located in St Clair, Glenmore Park and Austral. The Western Sydney Aerotropolis considers provision of health services, including a hospital.

There are twelve hospitals in the regional study area that service the communities within, as listed below:

- Blacktown Hospital
- Nepean Hospital
- Somerset Private Hospital
- Liverpool Hospital
- Camden Hospital
- Blue Mountains District ANZAC Memorial Hospital
- Mount Druitt Hospital
- Nepean Private Hospital
- Springwood Hospital
- Sydney Southwest Private Hospital
- Minchinbury Community Hospital
- Hawkesbury District Health Service.

There are 19 residential aged care centres located in the regional study area, 9 of which are located in the local study aera. There are 12 community centres located in the local study area.

Populations in Fairfield LGA; and Badgerys Creek, Kemps Creek, Rossmore, Horsley Park and Orchard Hills SALs have a higher proportion of individuals with need for assistance in relation to self-care, mobility and communication due to long-term health conditions.

4.5 Existing population health

4.5.1 General

The assessment presented in this report has focused changes in air quality and noise as a result of the project, on community health. For the key air pollutants considered (derived from aircraft emissions) and noise sources (aircraft), there are numerous other sources in urban areas that include these emissions. This includes emissions from other combustion sources such as vehicles, wood-fired heating, domestic cooking and industrial emissions, with noise being present from a range of sources, including existing aircraft movements, road and rail traffic.

These sources are important to note, when evaluating potential health impacts within a community. However, when considering the health of a local community there are many factors to consider. The health of the community is influenced by a complex range of interacting factors including age, socio-economic status, social networks, behaviours, beliefs and lifestyle, life experiences, country of origin, genetic predisposition and access to health and social care. While it is possible to review existing health statistics for the study area and compare them to the Greater Sydney area and NSW, it is not possible or appropriate to be able to identify a causal source, particularly individual or localised sources.

Information relevant to the health of populations in NSW is available from NSW Health for populations grouped by local health districts. Most of the health indicators presented in this report are not available for each of the smaller suburbs/statistical areas surrounding the site. Health indicators are only available from these larger areas that incorporate the study area.

There are few health statistics that are reported for the local government areas relevant to this project. The health statistics for these larger areas (and in some cases data for the Greater Sydney area) are assumed to be representative of the smaller population located within these areas.

4.5.2 Health related behaviours

Information in relation to health related behaviours (that are linked to poorer health status and chronic disease including cardiovascular and respiratory diseases, cancer, and other conditions that account for much of the burden of morbidity and mortality in later life) is available for the larger populations within the local health districts in Sydney and NSW. These health related behaviours include those where the behaviour/factor may adversely affect health (e.g. alcohol drinking, smoking, being overweight/obese and inadequate physical activity) and others where the behaviour/factor may positively affect (enhance) health (e.g. adequate fruit and vegetable consumption).

The study population is largely located within the South Western Sydney LHD, Western Sydney LHD and the Nepean Blue Mountains LHD. The incidence of these health-related behaviours in these districts, compared with other local health districts in NSW, and the state of NSW (based on NSW Health data from 2020 and 2021) is illustrated in Figure 4.4.

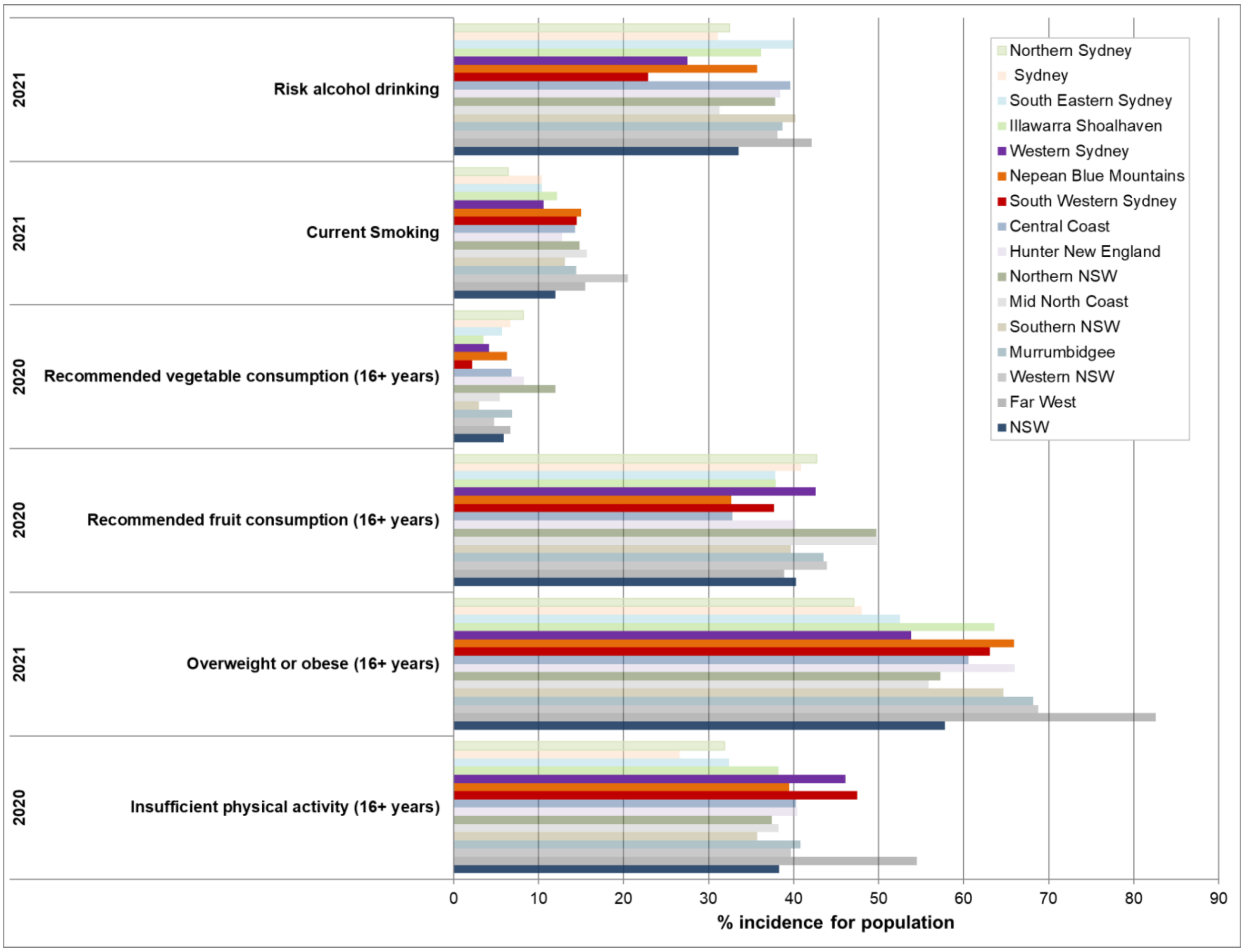

Figure 4.4 Summary of incidence of health-related behaviours (Source: HealthStats NSW, 2023)

Note: The local study area is located in the South Western Sydney (red bars) with the regional study area also incorporating the Western Sydney (purple bars) and Nepean Blue Mountains (orange bars) LHDs. Data for NSW is presented in the dark blue bars at the bottom of each group.

Review of this data indicates the population in the study area has (in comparison to the NSW population):

- a lower rate of risky alcohol consumption, particularly in South Western Sydney and Western Sydney
- similar to higher rates of smoking
- similar to lower rates of adequate consumption of vegetables
- populations in South Western Sydney and Nepean Blue Mountains have lower rates of adequate fruit consumption, however populations in Western Sydney have a higher rate
- populations in South Western Sydney and Nepean Blue Mountains have a higher proportion of people overweight or obese, while the proportion of lower in Western Sydney
- similar to higher levels in inadequate physical activity.

4.5.3 Baseline health

Baseline health data is available in relation to a range of key health indicators relevant to the assessment of impacts evaluated in this assessment. The data relates to mortality and hospitalisation rates for key health outcomes relating to respiratory disease and cardiovascular disease.

Figure 4.5 presents a comparison of the rates of the key mortality indicators based on data from 2018 to 2021 (depending on the available data) for all causes, potentially avoidable, cardiovascular disease, respiratory disease (all causes) and chronic obstructive pulmonary disease (COPD), reported in the relevant Local Health Districts, with comparison to other NSW local health districts (in urban and regional areas) as well as NSW as a whole.

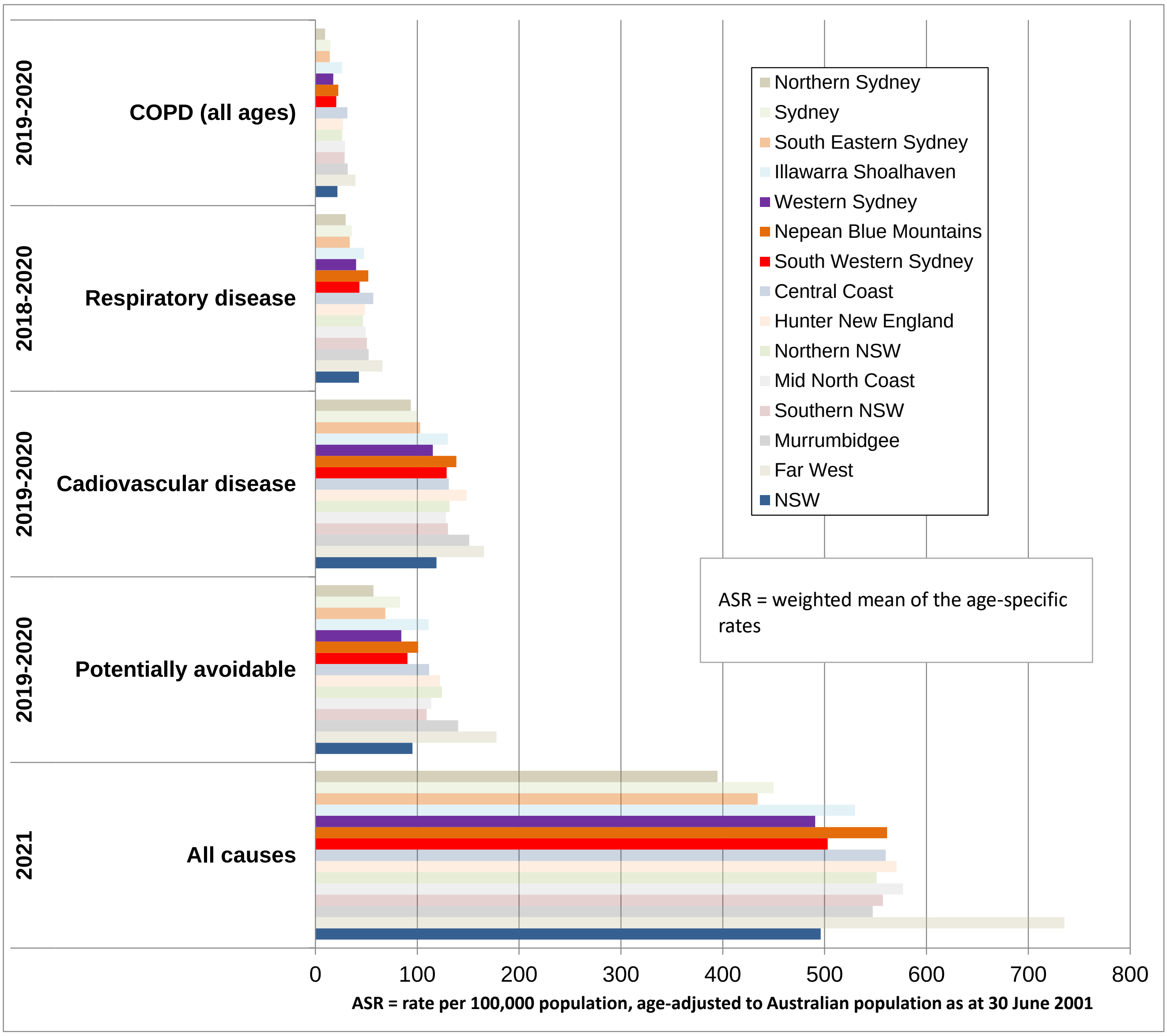

Figure 4.5 Summary of mortality data (Source: HealthStats NSW 2023)

Note: The local study area is located in the South Western Sydney (red bars) with the regional study area also including Western Sydney (purple bars) and Nepean Blue Mountains (orange bars) LHDs. Data for NSW is presented in the dark blue bars at the bottom of each group.

Figure 4.6 presents a comparison of the rates of the hospitalisations for key health effects based on data from 2019–2021 for cardiovascular disease, respiratory disease, asthma (5 to 34 years) and COPD (65+ years) reported in the Nepean Blue Mountains Local Health District, with comparison to other NSW local health districts (in urban and regional areas) as well as NSW as a whole.

It is noted that the data reported in these figures are based on statistics that are publicly available from NSW Health. Therefore, some of the statistics for mortality and hospitalisations relate to slightly different health endpoints and/or different age groups. The statistics are included for general comparison and discussion.

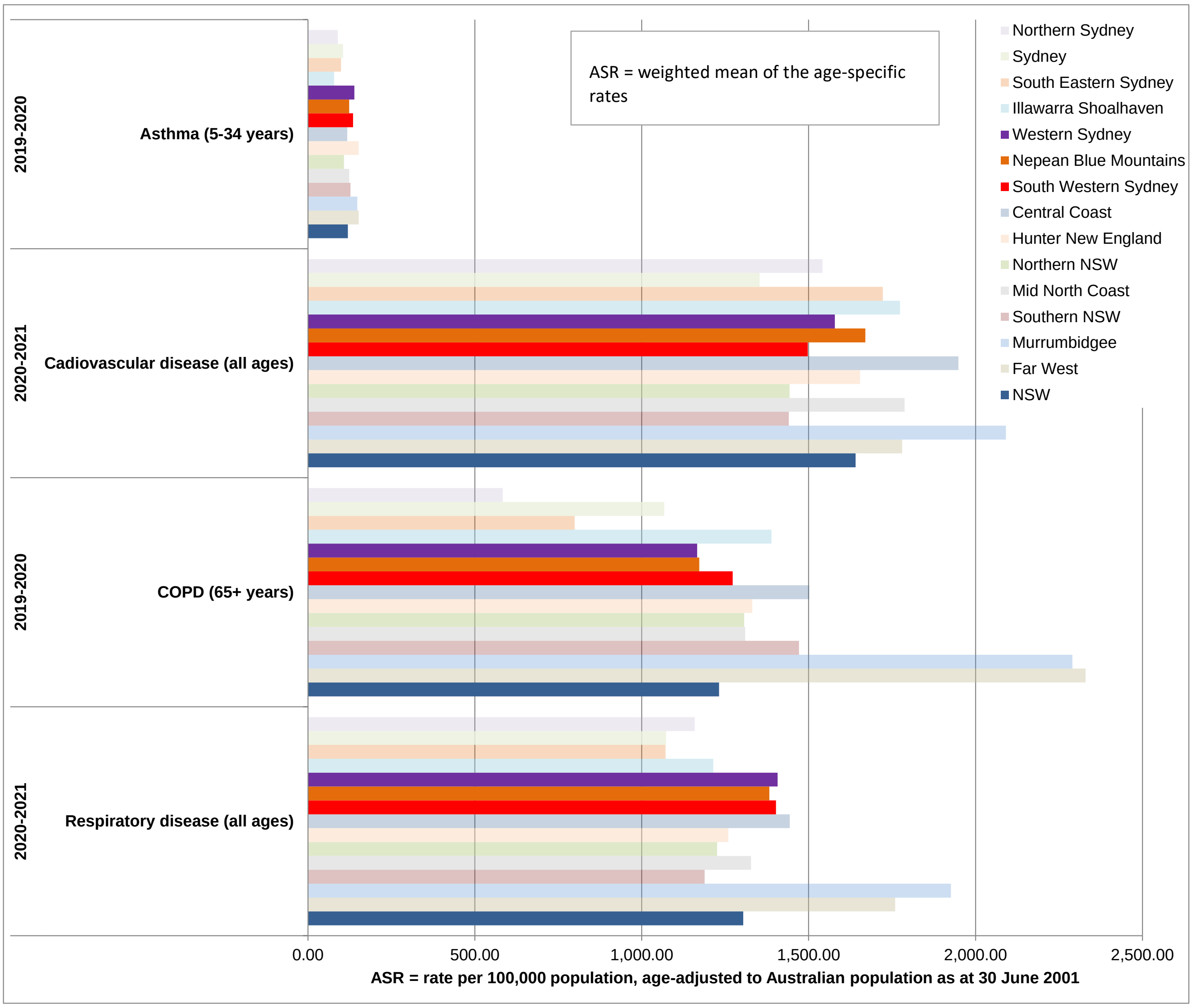

Figure 4.6 Summary of hospitalisation data (Source: HealthStats NSW 2023)

Note: The local study area is located in the South Western Sydney (red bars) with the regional study area also including Western Sydney (purple bars) and Nepean Blue Mountains (orange bars) LHDs. Data for NSW is presented in the dark blue bars at the bottom of each group.

Review of the figures presented above indicate the following (in comparison to NSW):

- The rate of mortality in the study area is generally similar to that of NSW. Higher rates of mortality from cardiovascular disease has been reported in South Western Sydney LHD, and higher rates of mortality including respiratory and cardiovascular causes presented in the Nepean Blue Mountains LHD.
- The rate of hospitalisations in the study area is generally similar to that of NSW for respiratory and cardiovascular disease, however the rate of respiratory hospitalisations is higher in the South Western Sydney and Nepean Blue Mountains LHDs.

Table 4.5 presents more specific baseline health data available for the population in the study area. This data focuses on indicators of cardiovascular and respiratory health, including asthma, and other indicators relevant to the assessment of wellbeing or mental health.

Table 4.5 Summary of key health indicators

Health indicator	Rate per 100,000 population (unless otherwise indicated)											
	LGAs								LHDs			NSW
	Penrith	Blacktown	Fairfield	Hawkesbury	Liverpool#	Camden	Wollondilly	Blue Mountains	South Western Sydney#	Western Sydney	Nepean Blue Mountains	
Mortality												
All causes – all ages for 2021 (LGA data from ABS, LHDs from NSW Health)	590	550	510	510	500	560	500	500	503.0	641.6	561.4	ABS: 510 All LHDs: 496.2
All causes - >65 years (2015-2019***)	4131.6	3777.8	3362.7	3925.3	3509.9	4050.2	3580.3	3655.4	3571.5	3410.7	3935.8	3503.8
Cardiovascular – all ages (2019–2020)	140.3	140.0	129.9	135.4	122.1	146.1	126.2	126.7	128.8	115.3	138.4	118.9
Respiratory – all ages (2018-2020)	--	--	--	--	--	--	--	--	43.3	40.0	51.9	42.8
Hospitalisations												
Coronary heart disease (2020-2021)	--	--	--	--	--	--	--	--	415.8	486.0	529.7	482.9
COPD All ages (2019–2020)	--	--	--	--	--	--	--	--	197.0	195.8	205.3	204.9
COPD >65 years (2018–2019 for LGAs** otherwise 2019–2020)	--	--	--	--	--	--	--	--	1272.6	1166.1	1172.5	1231.4

Health indicator	Rate per 100,000 population (unless otherwise indicated)											
	LGAs								LHDs			NSW
	Penrith	Blacktown	Fairfield	Hawkesbury	Liverpool#	Camden	Wollondilly	Blue Mountains	South Western Sydney#	Western Sydney	Nepean Blue Mountains	
Cardiovascular disease hospitalisations												
All ages (2019–2021 for LGAs otherwise 2020–2021)	1724.6	1824.5	1317.9	1763.8	1466.2	1749.1	1667.1	1549.8	1497.3	1578.7	1669.9	1640.9
>65 years (2018–2019)***	6980.1	7629.4	6792.8	6410.1	6829.0	6779.6	6731.9	6002.6	6816	6279	6571	6405.7
Respiratory disease hospitalisations												
All ages (2020–2021)	--	--	--	--	--	--	--	--	1401.9	1407.2	1382.2	1303.9
>65 years (2018–2019)***	4773.6	5288.4	4646.9	3744.5	4955.0	5209.2	4981.9	3250.9	4665	4020	4221	4069.2
Asthma												
Asthma hospitalisations (ages 5–34 years) (2018-2020 for LGAs, 2019–2020 for LHDs)	161.4	151.8	141.1	115.2	191.2	102.8	96.2	137.7	135.1	139.0	123.0	2018-2020: 131.7 2019-2020: 119.2
Asthma emergency department hospitalisations (all ages, unless specified) (2020–2021)	--	--	--	--	--	--	--	--	134.6	108.6	176.8	200.1
Asthma prescriptions (ages 3–19 years) 2013–2014**	32899	36086	51259	24857	39181	25973	27268	30903	--	--	--	31527

Health indicator	Rate per 100,000 population (unless otherwise indicated)											
	LGAs								LHDs			NSW
	Penrith	Blacktown	Fairfield	Hawkesbury	Liverpool#	Camden	Wollondilly	Blue Mountains	South Western Sydney#	Western Sydney	Nepean Blue Mountains	
Asthma prevalence (current) for children: LGAs aged 1–14 years (2021)***; LHDs aged 2–15 years (2017–2019)	7.6%	6.2%	5.4%	7%	5.4%	6.3%	7.5%	7.2%	8.7%	6.8%	12.2%	6.6% (2021)** 11.8% (2017–2019)
Current asthma for ages 16 and over (2019)	--	--	--	--	--	--	--	--	8.9%	8.7%	12.7%	10.5%
Mental health												
Number of prescriptions for antidepressants (2019–2020) – rate per 1,000 population*	1548.0	1180.9	993.0	1639.4	997.2	1311.1	1521.8	1990.7	1162.1	1003.4	1653.6	1456.8
Mental health emergency department admissions – all ages (2020–2021)	--	--	--	--	--	--	--	--	1199.0	985.1	1261.1	1495.3
Very high level of psychological distress (2019–2021)	--	--	--	--	--	--	--	--	6.0%	6.7%	8.1%	5.5%
High level of psychological distress in secondary school students (2017)	--	--	--	--	--	--	--	--	14.5%	13.5%	13.5%	14.0%

Source: NSW Health Stats unless otherwise indicated

Notes:

Indicators that are significantly higher than for NSW are highlighted blue and reflect populations that may be more vulnerable, while indicators that are significantly lower than for NSW are highlighted green and reflect populations that may be less vulnerable

Data from Liverpool LGA and South Western Sydney LHD adopted as representative of the population in the local study area

* Data from the Australian Institute of Health and Welfare on mental health prescriptions.

** Data from the Australian Atlas of Healthcare Variation (Australian Commission on Safety and Quality in Health Care)

*** Data from the Social Health Atlas of Australia, Child and Youth Social Health Atlas of Australia and the Social Health Atlas of Older People in Australia, https://phidu.torrens.edu.au/

Review of Table 4.5 indicates the following (in comparison with data for NSW):

- Most of the population in the study area has a higher rate of mortality as all cause, cardiovascular and respiratory, noting the rates are lower in the Western Sydney LHD.
- Rates of hospitalisations for respiratory disease are generally higher in the study area, including for older people (65 years and older).
- Rates of hospitalisations for cardiovascular disease are variable in the study population with some areas reporting higher rates (Penrith, Blacktown and Camden LGAs) and others reporting lower rates (Fairfield Liverpool and Blue Mountains LGAs). The rates reported for older people is higher for most of the study area.
- The prevalence of asthma in children in the study area is variable, being higher in the Penrith, Wollondilly and Blue Mountains LGAs, but lower in the Fairfield and Liverpool LGAs and the South Western Sydney and western Sydney LHDs.
- The rate of asthma in adults is similar to NSW, except in the Nepean Blue Mountains LHD which has a higher rate.
- In terms of hospitalisations the available data suggests there is a lower rate of emergency department admissions for asthma for all ages, however for people aged 5–34 years the rate of hospitalisation is higher in the South Western Sydney and Western Sydney LHDs.
- Asthma prescriptions for children are generally similar to NSW, noting a higher rate of prescriptions in Fairfield and Liverpool LGAs, and a lower rate of prescriptions in Camden and Wollondilly LGAs.
- The study area generally has a similar or lower rate of prescriptions for antidepressants, with the exception of the Blue Mountains LGA and Nepean Blue Mountains LHD. The number of mental health emergency admissions is lower in the study area.
- The proportion of the population with high or very high levels of psychological distress is similar to NSW, with the exception of a higher rate of very high levels for all ages noted in the Nepean Blue Mountains LHD.

4.6 Summary of existing community health

Overall, the population in the local study area is located in western and southwestern Sydney and comprises a multicultural population with generally low levels of unemployment and high levels of economic resources compared with Greater Sydney and NSW. In relation to behaviours that can affect health, the population is generally similar to NSW however in some areas the rates of smoking are higher, the consumption of fruit and vegetables is lower, the level of physical activity is lower and there are higher rates of overweight and obesity.

The baseline health of the population in the local study area is also generally similar to NSW, however there are some areas with higher rates of respiratory and cardiovascular disease (as mortality and hospitalisations), particularly for older people. The prevalence and management of asthma in adults and children is variable in the population.

This data suggests that the population may have some level of increased vulnerability to impacts derived from the project. The potential vulnerability of the population to project related impacts is addressed through the use of guidelines that are protective of all members of the community, including sensitive individuals, and calculations of health impacts that utilise population specific data on baseline health.

Chapter 5 Assessment of health impacts: changes in air quality

5.1 Introduction

This section specifically addresses potential impacts on community health as a result of changes in air quality from the operation of aircraft within the air space. The assessment of changes in air quality has focused on pollutants derived from aircraft emissions and relied on the modelling of these emissions in the Technical paper 2, from aircraft operating at or close to the airport, including taxi, take-off, landing and operations below 1000 ft, that may impact on air quality for receptors located in the local study area. Assessing potential impacts on community health has been undertaken on the basis of the guidelines detailed in Chapter 3. Figure 5.1 provides an overview of the approach adopted in this assessment.

Issue Identification (Chapter 5.2)	•Provides an overview of existing air quality in the study area •Idnetifies the key pollutants and scenarios that require consideration in this assessment
Hazard assessment (Chapter 5.3)	•Identifies the hazards and health endpoints that need to be addressed for the key pollutants evaluated •Identifies the guidelines or dose-response relationships to be used in the assessment of health risks
Exposure assessment (Chapter 5.4)	•Identifies the community potentially exposed to pollutants derived from aircraft emissions •Identifies the way in which exposure may occur, such as inhalation or ingestion •Use outputs from the air modelling to quantify concentration of pollutants where exposure can occur
Risk characterisation or impact assessment (Chapter 5.5)	•Combines the exposure and hazard assessment •Provides an assessment of potential impacts on community health •Considers the uncertainties associated with the risk characterisation in making conclusions

Figure 5.1 Approach to the assessment of health impacts from changes in air quality

5.2 Issue identification

5.2.1 Existing air quality in local study area

Technical paper 2 provides a review of the existing air quality relevant to local and regional study areas. The main sources of air pollutants in these study aeras include industrial and commercial operations and local anthropogenic activities such as wood heaters and vehicle exhaust. Air quality monitoring data from the NSW Department of Planning and Environment (DPE) at Bringelly, St Marys and Camden (located within the regional study area) indicate the following:

- Annual average PM_{10} concentrations are below the NSW EPA air criteria of 25 µg/m³. The 24-hour average concentrations are more variable with concentrations exceeding the NSW EPA air criteria of 50 µg/m³, mainly as a result of regional dust events and bushfires that affect a wide area.
- Annual average $PM_{2.5}$ concentrations are typically below the NSW EPA air criteria of 8 µg/m³ with the exception of data from 2019 (all locations) and Bringelly in 2020. These exceedances relate to bushfire events, woodsmoke from domestic wood heaters and vehicle exhaust. The 24-hour average concentrations are typically below the NSW EPA criteria of 25 µg/m³, however there are some exceedances as a result of regional bushfires, hazard reduction burns and dust storms that affect a wide area.
- Annual average and 1-hour average nitrogen dioxide (NO_2) concentrations were below the NSW EPA air criteria. The short term data (1-hour average) shows variability with higher levels in the cooler months when temperatures are low and there is less sunlight, making it more difficult for NO_2 to react in the atmosphere and convert to ozone.
- Annual average and 1-hour average sulfur dioxide (SO_2) concentrations were below the NSW EPA air criteria, with no discernible seasonal trends.
- Annual average and 1-hour average carbon monoxide (CO) concentrations were below the NSW EPA air criteria, with some increased levels corresponding to major bushfire events.
- Ozone levels, as 1-hour and 4-hour average concentrations regularly exceeded the NSW EPA air criteria in the summertime, with trends the reverse of that observed for NO_2.

5.2.2 Aircraft emissions

Emissions to air from the operation of aircraft have been assessed in Technical paper 2. The assessment has identified key pollutants relevant to aircraft emissions, as follows:

- Particulates, as fine particulates PM_{10} and $PM_{2.5}$
- Carbon monoxide (CO)
- Oxides of nitrogen, with nitrogen dioxide (NO_2) of key importance for the assessment of health
- Sulfur dioxide (SO_2)
- Volatile organic compounds (VOCs), with the key individual VOCs identified as benzene, toluene, xylenes and formaldehyde.

This assessment has assessed potential community exposures to these key pollutants.

Emissions to air relevant to the operation of aircraft within the air space has then considered a number of runway modes of operation (RMO) scenarios. These scenarios include 'selection rules' that define the conditions under which each mode would be selected by air traffic control were applied. The mode selection rules consider the meteorological conditions, hourly flight arrivals and departures, and the 'priority' assigned to each RMO – mostly reflecting a judgement on preference in relation to aircraft noise management and mitigation. The weekly schedules were annualised and combined with historic meteorological data, to determine the pattern of RMO scenario. Aircraft operating in a mode were assigned to flight paths based on the runway in use (i.e., 05, 23 or reciprocal runway operations (RRO) during night operations only), the type of aircraft, and the location of the airport of origin or its destination (O-D). Rather than solely assess average utilisation, the Air Quality assessment also considered demand, meteorological and seasonality variations across the year, as well as the potential for periods of respite. Table 5.1 presents a summary of the RMO scenarios considered.

Table 5.1 Summary of RMO scenarios

Scenario	RMO selection criteria	Day-time RMO priority (5:30 – 23:00)	Night-time RMO priority (23:00 – 5:30)
S1 (No preference)	No Priority	No Priority	No Priority
S2	No Priority with RRO	No Priority	1. RRO 2. No Priority
S3 (Prefer Runway 05)	Prioritise 05 with RRO	Runway 05 Preferred	1. RRO 2. No Priority
S4 (Prefer Runway 23)	Prioritise 23 with RRO	Runway 23 Preferred	1. RRO 2. No Priority
S5	Prioritise 05 with RRO. Limited Peak-Time Change	Runway 05 Preferred	1. RRO 2. No Priority
S6	Prioritise 23 with RRO Limited Peak-Time Change	Runway 23 Preferred	1. RRO 2. No Priority
S7	Prioritise 23 with a period of no priority during the day with RRO	Non-Peak Runway 23 Preferred Peak No Priority	1. RRO 2. No Priority

The rows shaded in blue indicate the scenarios considered in more detail in relation to the assessment of impacts on air quality. These scenarios, and the representative years of operation were determined on the basis of the following:

- No preference scenario – this represents a relatively even modal split between Runway 05 and Runway 23. Aircraft emissions from flight path use in this scenario were considered in 2033. This scenario has been chosen for detailed assessment as it is commensurate with the previous 2016 EIS and is used to assess relative differences arising from the application of current aircraft fleet emissions to essentially the same 50/50 runway split scenario of the 2016 EIS. The airspace design has evolved since 2016. While track deviation compared to the previous design could significantly change aircraft noise exposure away from the airport, the air quality assessment focuses on ground level impacts near the airport, where flight track deviations are insignificant in the near ground aircraft movements that are the focus of this assessment.
- Prefer Runway 05 and Prefer Runway 23 scenarios – these were chosen for detailed assessment as they prioritise the operation of Runway 05 and Runway 23 respectively. This means most aircraft arrive from southwest and depart to the northeast or arrive from the northeast and depart to the southwest. Aircraft emissions from flight path use under these scenarios were considered in 2033 and in 2055 in the air assessment. These scenarios result in the greatest aircraft movement intensities in the parts of the airshed (i.e., the volume of atmosphere above the area of interest) where the population is most susceptible to air quality impacts (noting that air quality varies spatially across the airshed according to the time of day, meteorological conditions, seasonal and other factors).

5.2.3 Potential for exposure

The key air pollutants identified and assessed in relation to the operation of aircraft within the air space are either vapours/gases or fine particulates that would be expected to behave as a gas, as is the case for $PM_{2.5}$. For PM_{10}, which includes some slightly larger, but still very fine, particulates, most of these particulates would stay suspended in air. The potential for these particles to deposit to the ground is very small. Hence the key pathway of exposure relevant to the community expose to aircraft emissions is inhalation.

Fine particles as $PM_{2.5}$ (and PM_{10}) and gases would remain in the atmosphere and would not deposit to the ground. However, concern has been raised in relation to aircraft emissions impacting on drinking water supplies and hence for the purpose of this assessment is has been assumed that deposition does occur. Where this occurs, these pollutants may deposit to the ground or to roof areas, where impacts on drinking water quality in drinking water catchments and rainwater tanks may occur. Impacts on drinking water quality, where such water may be used as potable water by the community has also been considered in this assessment. It is noted that advice from NSW Health indicates that rainwater tanks in urban areas, which includes the local and regional study areas, should not be used as potable water supply. The study area is supplied with reticulated water, from Sydney Water, and hence rainwater tanks would not be expected to be used for potable water. Other non-potable uses such as toilet flushing, filling swimming pools, garden watering, washing cars and firefighting may occur.

5.3 Hazard assessment

5.3.1 Introduction

Hazards associated with the key pollutants evaluated in this assessment need to be identified, and quantitative values or dose-response relationships identified for the assessment of potential impacts on health. This section provides a summary of the hazards relevant to the key pollutants and the quantitative approach adopted in this assessment. More detailed reviews relevant to these key pollutants is presented in Appendix A.

5.3.2 Fine particulates

5.3.2.1 General

Dust or particulate matter (PM) is a widespread air pollutant (that has and will always be present in air) with a mixture of physical and chemical characteristics that vary by location (and source). Unlike many other pollutants, particulates comprise a broad class of diverse materials and substances, with varying morphological, chemical, physical and thermodynamic properties, with sizes that vary from <0.005 micrometres (µm) to >100 µm. Particulates can be derived from natural sources such as crustal dust (soil), pollen and moulds, and other sources that include combustion and industrial processes. Secondary particulate matter is formed via atmospheric reactions of primary gaseous emissions. The gases that are the most significant contributors to formation of secondary particulates include: nitrogen oxides, ammonia, sulfur oxides, and certain organic gases (derived from vehicle exhaust; combustion sources; and agricultural, industrial and biogenic emissions).

Appendix A presents a review of fine particulates and the potential for health impacts. The following provides a summary of the review presented in Appendix A.

5.3.2.2 Key health issues relating to particle size

The size of particulates is important as it determines how far from an emission source the particulates may be present in air (with larger particulates settling out close to the source and smaller particles remaining airborne for greater distances) and also the potential for adverse effects to occur as a result of exposure (how far the particles can infiltrate into the respiratory system).

Only particulates that are small enough can penetrate into the lungs where there is the potential for effects to occur. If the particles are too large, they will be captured high up in the respiratory tract, trapped and flushed out and eventually swallowed.

Dust is commonly assessed on the basis of 4 types (or groups of) of particles: $PM_{2.5}$, PM_{10}, total suspended particulates (TSP) and deposited dust.

Deposited dust includes particles of any size, but it generally comprises large size dust particles; that is, greater than 20 microns in diameter[2]. These particles are too large to reach the lungs and are not considered to be of concern in relation to exposure. These particles have enough mass that they easily fall out of the air and deposit or accumulate on surfaces. These larger particles fall out and deposit onto surfaces close to specific sources, such as quarry activities. Sometimes sufficient dust can deposit so that it results in a visible layer of dust, which often considered to be a nuisance.

TSP refers to all particulates with an equivalent aerodynamic particle[3] size below 50 microns in diameter. It is a fairly gross indicator of the presence of dust with a wide range of sizes:

- Larger particles termed 'inspirable', comprise particles around 10 microns and larger, are more of a nuisance as they will deposit out of the air (measured as deposited dust) close to the source and, if inhaled, are mostly trapped in the upper respiratory system[4] and do not reach the lungs. This is the same with the even larger particles in deposited dust.
- Finer particles smaller than 10 microns, termed 'respirable', are transported further from the source and are of more concern with respect to human health as these particles can penetrate into the lungs (see discussion below).

The focus of any assessment addressing potential health effects relates to particulates of a size that are respirable. These particulates comprise the following (as illustrated in Figure 5.2):

- PM_{10} – particulate matter below 10 microns in diameter, µm
- $PM_{2.5}$ – particulate matter below 2.5 µm in diameter
- PM_1 – particulate matter below one µm in diameter, often termed very fine particles
- Ultrafine particles – particulate matter below 0.1 µm in diameter.

These particles are small and have the potential to penetrate beyond the body's natural clearance mechanisms of cilia and mucous in the nose and upper respiratory system, with smaller particles able to further penetrate into the lower respiratory tract[5] and lungs. Once in the lungs, adverse health effects may occur that include mortality and morbidity, which have been causally linked with a range of adverse cardiovascular and respiratory effects (USEPA 2019).

Figure 5.2 shows a general illustration to provide some context in relation to the size of different particles (discussed above) and their relevance and importance for the assessment of inhalation exposures.

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2 The size, diameter, of dust particles is measured in micrometers (microns).

3 The term equivalent aerodynamic particle is used to reference the particle to a particle of spherical shape and particle of density one gram per cubic metre.

4 The upper respiratory tract comprises the mouth, nose, throat and trachea. Larger particles are mostly trapped by the cilia and mucosa and swept to the back of the throat and swallowed.

5 The lower respiratory tract comprises the smaller bronchioles and alveoli, the area of the lungs where gaseous exchange takes place. The alveoli have a very large surface area and absorption of gases occurs rapidly with subsequent transport to the blood and the rest of the body. Small particles can reach these areas, be dissolved by fluids and absorbed.

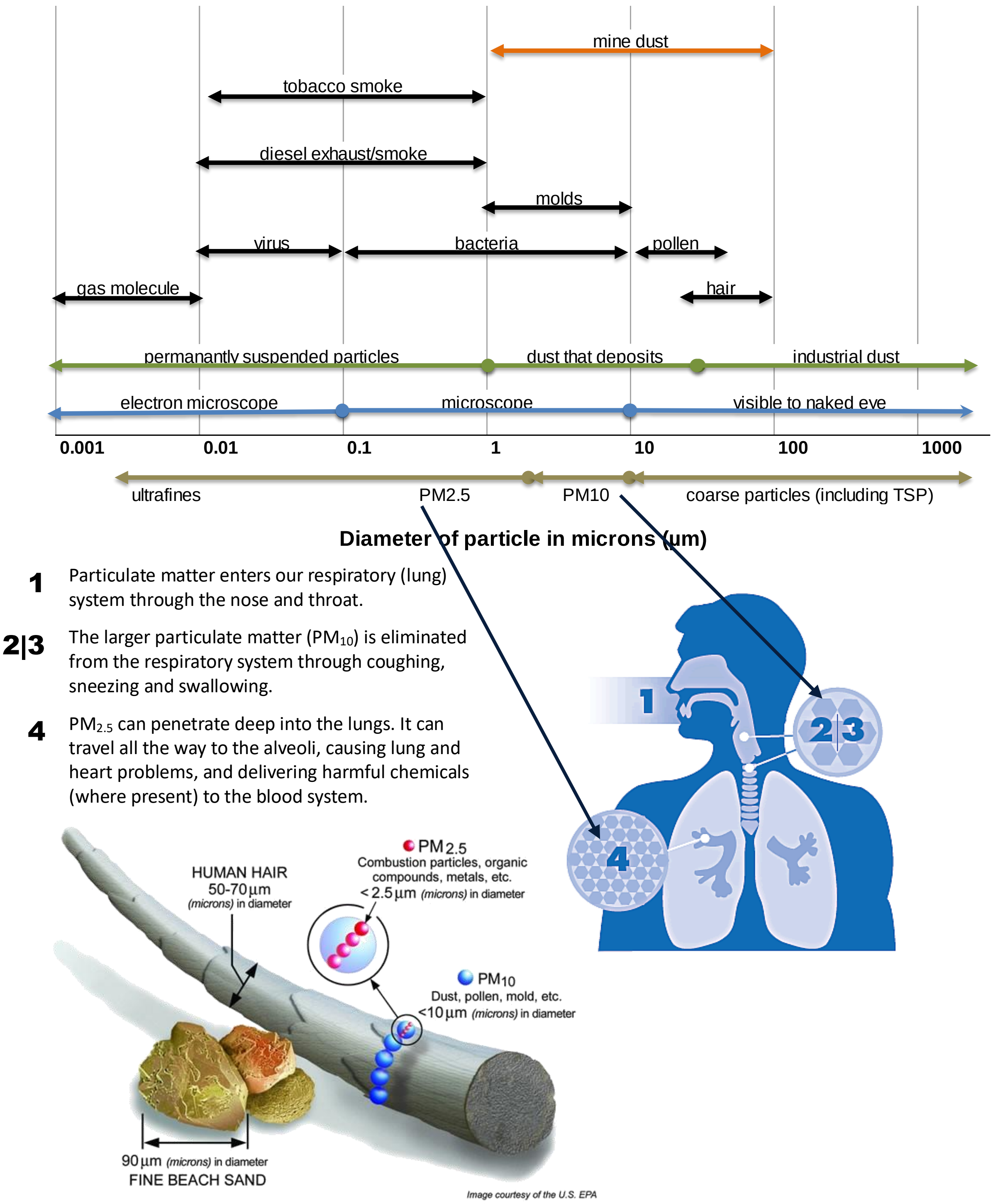

Figure 5.2 Illustrative representation of relative particle sizes and importance for health

Figure 5.2 shows that $PM_{2.5}$ and smaller is the particle size that may reach the lower parts of the respiratory tract (the smaller bronchioles and alveoli). This is the area of the lungs where gaseous exchange takes place and the area that may be impacted by fine particles.

Figure 5.2 also illustrates that particle sizes generated during excavation and other similar construction activities such as mining operations principally comprise sizes between 1 and 100 µm in diameter, with most of the dust considered coarse particles (comprising deposited dust and TSP), PM_{10} and some $PM_{2.5}$. For this reason, the focus of most dust assessments for such activities relates to deposited dust and PM_{10}. This is in contrast to combustion sources where particulate matter is dominated $PM_{2.5}$ and smaller particles.

In relation to the assessment of particulates derived from aircraft emissions, such emissions are expected to be dominated by $PM_{2.5}$. Hence modelled impacts presented in the AQIA relate to particulate matter, with concentrations of PM_{10} fraction assumed to be equal to the concentration of the $PM_{2.5}$ fraction.

5.3.2.3 Health effects

Adverse health effects associated with exposure to particulate matter have been well studied and reviewed by Australian and international agencies. Most of the studies and reviews have focused on population-based epidemiological studies in large urban areas in North America, Europe and Australia, where there have been clear associations determined between health effects and exposure to $PM_{2.5}$ and to a lesser extent, PM_{10}. These studies are complemented by findings from other key investigations conducted in relation to: the characteristics of inhaled particles; deposition and clearance of particles in the respiratory tract; animal and cellular toxicity studies; and studies on inhalation toxicity by human volunteers (NEPC 2010).

Particulate matter has been linked to adverse health effects after both short-term exposure (days to weeks) and long-term exposure (months to years). The health effects associated with exposure to particulate matter vary widely (with the respiratory and cardiovascular systems most affected) and include mortality and morbidity effects.

In relation to mortality, for short-term exposures in a population this relates to the increase in the number of deaths due to existing (underlying) respiratory or cardiovascular disease; for long-term exposures in a population this relates to mortality rates over a lifetime, where long-term exposure is considered to accelerate the progression of disease or even initiate disease.

In relation to morbidity effects, this refers to a wide range of health indicators used to define illness that have been associated with (or caused by) exposure to particulate matter. In relation to exposure to particulate matter, effects are primarily related to the respiratory and cardiovascular system and include (Morawska, Moore & Ristovski 2004; USEPA 2009, 2018a):

- aggravation of existing respiratory and cardiovascular disease (as indicated by increased hospital admissions and emergency room visits)
- changes in cardiovascular risk factors such as blood pressure
- changes in lung function and increased respiratory symptoms (including asthma)
- changes to lung tissues and structure
- altered respiratory defence mechanisms.

A substantial volume of literature is available that assesses potential associations between exposure or changes in exposures to particulate matter (as PM_{10} and/or $PM_{2.5}$), based on epidemiological studies. These studies need to be critically reviewed using robust methods, that include wight of evidence and mechanistic information to establish causation. Hence this review has not undertaken a detailed literature review or systematic review of published studies related to health effects of particulate matter.

The most recent and comprehensive reviews conducted by the USEPA (USEPA 2019, 2022a) summarised the strength of the evidence for $PM_{2.5}$ effects on various health outcomes ranging from causal (the evidence is strong enough to conclude that $PM_{2.5}$ exposure causes the health outcome) to suggestive (the evidence suggests that $PM_{2.5}$ might cause the health outcome). This is summarised in Table 5.2.

There is consensus in the available studies and detailed reviews that exposure to fine particulates, $PM_{2.5}$, is associated with (and causal to) cardiovascular and respiratory effects and mortality (all causes)(USEPA 2019, 2022a). While similar relationships have also been determined for PM_{10}, the supporting studies do not show relationships as clear as shown with $PM_{2.5}$ (USEPA 2019, 2022a). Hence the focus of any assessment of health impacts relates to $PM_{2.5}$, where the evidence is causal.

The International Agency for Research on Cancer (IARC) recently classified outdoor air pollution as a mixture, and particulate matter specifically, as carcinogenic to humans (IARC 2013).

There is no evidence of a threshold concentration below which adverse health effects of PM are not observed (Brook et al. 2010; Pope, CA & Dockery 2006; WHO 2013a, 2013b). A WHO (2013) review of the scientific literature since 2005 found strong evidence that the effects of $PM_{2.5}$ on a wide range of adverse health outcomes occurred at levels below those experienced in Australia, and followed a mostly linear concentration response relationship (Morgan, Broom & Jalaludin 2013). The USEPA reviews considered studies relating to exposures at near-ambient concentrations. Overall, these studies showed inconsistent results (USEPA 2022a).

Table 5.2 Summary of evidence for adverse health effects for particulate matter (USEPA 2019, 2022a)

Exposure duration and size fraction	Outcome	Causal determination	Susceptible populations (Morgan, Broom & Jalaludin 2013)
Long-term exposure			
$PM_{2.5}$	Cardiovascular effects	Causal	Adults and children and may relate to an increased risk of developing disease.
	Respiratory effects	Likely to be causal	
	Mortality	Causal	
	Metabolic effects	Suggestive	
	Reproductive and developmental effects	Suggestive	
	Cancer, mutagenicity and genotoxicity	Likely to be causal (based on IARC classification of outdoor air pollution as mixture) (IARC 2013)	
Short-term exposure			
$PM_{2.5}$	Cardiovascular effects	Causal	Elderly, infants and individuals with chronic cardiopulmonary disease, influenza or asthma.
	Respiratory effects	Likely to be causal	Adults and children, including those with asthma.
	Mortality	Causal	Elderly, infants and individuals with chronic cardiopulmonary disease, influenza or asthma. Health endpoint is relevant however assessing significance of outcomes is challenging.
	Metabolic effects	Suggestive	
PM_{10}-$PM_{2.5}$	Cardiovascular effects	Suggestive	
	Respiratory effects	Suggestive	
	Mortality	Suggestive	

A number of studies been undertaken where other health effects have been evaluated. These studies have a large degree of uncertainty or a limited examination of the relationship and are generally only considered to be suggestive or inadequate (in some cases) of an association with exposure to $PM_{2.5}$ (USEPA 2019, 2022a). This includes long-term exposures and metabolic effects, male and female reproduction and fertility, pregnancy and birth outcomes; and short-term exposures and nervous system effects (USEPA 2019, 2022a).

As the most robust evidence in relation to health effects of exposure to particulate matter relates to $PM_{2.5}$, and the modelling of particulate emissions from aircraft emissions has focused on $PM_{2.5}$ (the dominant fraction in such emissions), this assessment has focused on the health impacts of community exposures to $PM_{2.5}$.

5.3.2.4 Approach to the assessment of health impacts

In relation to the assessment of exposures to particulate matter there is sufficient evidence to demonstrate that there is an association between exposure to $PM_{2.5}$ and effects on health that are causal.

The available evidence does not suggest a threshold below which health effects do not occur. Accordingly, there are likely to be health effects associated with background levels of $PM_{2.5}$ and PM_{10}, even where the concentrations are below the current guidelines. Standards and goals are currently available for the assessment of $PM_{2.5}$ and PM_{10} in Australia (NEPC 2021). These standards and goals are not based on a defined level of risk that has been determined to be acceptable, rather they are based on balancing the potential risks/health burden due to background and urban sources with the aim of lower impacts on health in a practical way.

The air quality standards and goals relate to average or regional exposures by populations from all sources, not to localised 'hot-spot' areas such as locations near industry, busy roads or mining. They are intended to be compared against ambient air monitoring data collected from appropriately sited regional monitoring stations. In some cases, there may be local sources (including busy roadways and industry) that result in background levels of PM_{10} and $PM_{2.5}$ that are close to, equal to, or in exceedance of, the air quality standards and goals. Where impacts are being evaluated from a local source it is important to not only consider cumulative impacts associated with the project (undertaken using the current air quality goals) but also evaluate the impact of changes in air quality within the local community.

This assessment of health impacts from exposure to changes in particulate concentrations has therefore been undertaken to consider both cumulative exposure impacts and incremental exposure impacts associated with changes in $PM_{2.5}$ concentrations that are associated with the project. Incremental changes are those due to the project alone while cumulative changes are those where background air quality in addition to those due to the project alone are considered.

Assessment of cumulative exposures

The assessment of cumulative exposures to $PM_{2.5}$ is based on a comparison of the cumulative concentrations predicted with the current air quality standards and goals presented in the National Environment Protection Council (NEPC) (Ambient Air Quality) Measure (NEPM) (NEPC 2021), and have been adopted in NSW (NSW EPA 2022). These standards and goals are total concentrations in ambient air, within the community, that are based on the most current science in relation to health effects. The NEPC review that underpins these standards and goals include consideration of the epidemiological evidence.

The adopted health-based guidelines, relevant to cumulative exposures, for $PM_{2.5}$ are as follows:

- 24-hour average = 25 $\mu g/m^3$
- Annual average = 8 $\mu g/m^3$.

Assessment of incremental exposures (changes in air quality)

As no threshold has been determined for exposure to $PM_{2.5}$ the assessment of impacts on health has utilised robust, published, quantitative relationships (exposure-response relationships) that relate a change in $PM_{2.5}$ concentration with a change in a health indicator. The focus of this assessment relates to the assessment of health endpoints where causal associations have been identified, and robust exposure-response relationships are available. The specific health effects (or endpoints) evaluated in this assessment include:

- Primary health endpoints:
  - long-term exposure to $PM_{2.5}$ and changes in all-cause mortality (equal or greater than 30 years of age)
  - short-term exposure and changes to the rate of hospitalisations with cardiovascular and respiratory disease (equal or greater than 65 years of age).
- Secondary health endpoints (as subsets to the primary health endpoints and included to supplement the primary assessment):
  - short-term exposure to $PM_{2.5}$ and changes in cardiovascular and respiratory mortality (all ages)
  - short-term exposure to $PM_{2.5}$ and changes in emergency department admissions for asthma in children aged 1–14 years.

Table 5.3 summarises the health endpoints considered in this assessment, the relevant health impact functions (from the referenced published studies) and the associated β coefficient relevant to the assessment of health impacts.

The health impact functions presented in this table are the most current and robust values and are appropriate for the quantification of potential health effects for the health endpoints considered in this assessment.

Table 5.3 Adopted health impact functions and exposure-responses relationships for $PM_{2.5}$

Health endpoint	Exposure period	Age group	Published relative risk [95 confidence interval] per 10 µg/m³	Adopted β coefficient (as %) for 1 µg/m³ increase in PM	Reference
Primary assessment health endpoints					
$PM_{2.5}$: Mortality, all causes	Long-term	≥30yrs	1.06 [1.04–1.08]	0.0058 (0.58)	Relationship derived for all follow-up time periods to the year 2000 (for approx. 500,000 participants in the US) with adjustment for 7 ecologic (neighbourhood level) covariates (Krewski et al. 2009). This study is an extension (additional follow-up and exposure data) of the work undertaken by Pope (2002), is consistent with the findings from California (1999-2002) (Ostro et al. 2006) and is more conservative than the relationships identified in a more recent Australian and New Zealand study (EPHC 2010)
$PM_{2.5}$: Cardiovascular hospital admissions	Short-term	≥65yrs	1.008 [1.0059–1.011]	0.0008 (0.08)	Relationship established for all data and all seasons from US data for 1999 to 2005 for lag 0 (exposure on same-day)(strongest effect identified) (Bell 2012; Bell et al. 2008)
$PM_{2.5}$: Respiratory hospital admissions	Short-term	≥65yrs	1.0041 [1.0009–1.0074]	0.00041 (0.041)	Relationship established for all data and all seasons from US data for 1999 to 2005 for lag 2 (exposure 2 days previous)(strongest effect identified) (Bell 2012; Bell et al. 2008)

Health endpoint	Exposure period	Age group	Published relative risk [95 confidence interval] per 10 µg/m^3	Adopted β coefficient (as %) for 1 µg/m^3 increase in PM	Reference
Secondary assessment health endpoints					
$PM_{2.5}$: Mortality, all causes	Short-term	All ages*	1.0094 [1.0065–1.0122]	0.00094 (0.094)	Relationship established from study of data from 47 US cities for the years 1999 to 2005 (Zanobetti & Schwartz 2009)
$PM_{2.5}$: Cardiovascular mortality	Short-term	All ages*	1.0097 [1.0051–1.0143]	0.00097 (0.097)	Relationship established from study of data from 47 US cities for the years 1999 to 2005 (Zanobetti & Schwartz 2009)
$PM_{2.5}$: Respiratory mortality (including lung cancer)	Short-term	All ages*	1.0192 [1.0108–1.0278]	0.0019 (0.19)	Relationship established from study of data from 47 US cities for the years 1999 to 2005 (Zanobetti & Schwartz 2009)
$PM_{2.5}$: Asthma (emergency department admissions)	Short-term	1–14 years	--	0.0015 (0.15)	Relationship established from review conducted on Australian children (Sydney) for the period 1997 to 2001 (Jalaludin et al. 2008)

* Relationships established for all ages, including young children and the elderly

These exposure response relationships are considered appropriate and address the causal health effects associated with exposure to $PM_{2.5}$, in relation to mortality and hospital admissions. The health endpoints include asthma in children, specifical asthma emergency department admissions. These health endpoints and exposure-response relationships include a number that are consistent with those used in the revision of the NEPM.

Other exposure response relations evaluated in the NEPM are for similar health endpoints and while relevant to assessing impacts of regional scale changes to air policy, would not change an assessment conducted on the basis of the above.

It is noted that mortality, all cause, will be the key driver of any health impact calculations undertaken. It would be relevant and appropriate, and consistent with the way in which other chemical exposures are elevated, to focus on the key driver of impacts.

5.3.3 Nitrogen dioxide

Nitrogen oxides (NOx) refer to a collection of highly reactive gases containing nitrogen and oxygen, most of which are colourless and odourless. Nitrogen oxide gases form when fuel is burnt including when residual waste is used as fuel. Motor vehicles, along with industrial, commercial and residential (e.g., gas heating or cooking) combustion sources, are primary producers of nitrogen oxides.

In greater NSW, on-road vehicles accounted for about 15% of emissions of nitrogen oxides and industrial facilities accounted for 53%. In Sydney, a greater contribution is derived from on-road vehicles (approximately 53%, predominantly from diesel engines) (Ewald et al. 2020; NSW EPA 2019).

Appendix A presents a review of nitrogen dioxide and the potential for health impacts, with the following providing a summary.

In terms of health effects, nitrogen dioxide is the only oxide of nitrogen that may be of concern (WHO 2000b). Nitrogen dioxide is a colourless and tasteless gas with a sharp odour. Nitrogen dioxide can cause inflammation of the respiratory system and increase susceptibility to respiratory infection. Exposure to elevated levels of nitrogen dioxide has also been associated with increased mortality, particularly related to respiratory disease, and with increased hospital admissions for asthma and heart disease patients (WHO 2013b). However detailed reviews relating to the evidence of health effects associated with nitrogen dioxide exposures has identified that causal associations have only been identified for respiratory effects (in particular asthma and to a lesser extent respiratory mortality) (USEPA 2016a; WHO 2013b, 2021), which are the key focus of most guidelines established for nitrogen dioxide, and this assessment.

Asthmatics, the elderly and people with existing respiratory disease are particularly susceptible to the effects of elevated nitrogen dioxide (Morgan, Broom & Jalaludin 2013; NEPC 2010). The health effects associated with exposure to nitrogen dioxide depend on the duration of exposure as well as the concentration.

The current NEPM air quality standards (NEPC 2021) include guidelines for nitrogen dioxide on the basis of a 1-hour average (to address acute exposures) and an annual average (to address chronic exposures). The 2021 revision to the NEPM resulted in a reduction in the guidelines from previous standards based on consideration of the current health evidence and more stringent guidelines in other leading countries.

The health evidence available, particularly in relation to short-term community exposures to nitrogen dioxide evaluated on the basis of epidemiological studies has not identified a threshold. It is noted that the available data from clinical studies does provide evidence that exposures below 0.5 ppm (or 940 $\mu g/m^3$), and more significantly 0.2 ppm (376 $\mu g/m^3$) for periods up to an hour in duration are unlikely to be associated with respiratory effects (enRiskS 2018). For long-term exposures the WHO review (WHO 2013c) has identified a cut-off (or threshold) for effects of 20 $\mu g/m^3$ (NEPC 2019a) as an annual average.

These guidelines are based on protection from adverse health effects following both short term (acute) and longer term (chronic) exposure for all members of the population including sensitive populations like asthmatics, children and the elderly.

This assessment of health impacts from exposure to changes in nitrogen dioxide concentrations has therefore been undertaken to consider both cumulative exposure impacts and incremental exposure impacts associated with changes in nitrogen dioxide concentrations that are associated with the project. Incremental changes are those due to the project alone while cumulative changes are those where background air quality in addition to those due to the project alone are considered.

5.3.3.1 Assessment of cumulative exposures

The assessment of cumulative exposures to nitrogen dioxide is based on a comparison of the cumulative concentrations predicted with the current air quality standards and goals presented in the National Environment Protection Council (NEPC) (Ambient Air Quality) Measure (NEPM) (NEPC 2021), and have been adopted in NSW (NSW EPA 2022). These standards and goals are total concentrations in ambient air, within the community, that are based on the most current science in relation to health effects.

The NEPC air quality standards (NEPC 2021; NSW EPA 2022), which relate to the protection of short-term and long-term exposures, are as follows:

- Short-term (1 hour average) = 0.08 ppm = 164 $\mu g/m^3$
- Long-term (annual average) = 0.015 ppm = 31 $\mu g/m^3$.

5.3.3.2 Assessment of incremental exposures (changes in air quality)

The WHO and USEPA (USEPA 2016a; WHO 2013b, 2021) identified that the strongest evidence of health effects, including causal effects, relate to respiratory hospitalisations and emergency department admissions (particularly for asthma) and to a lesser extent mortality (associated with short-term exposures) and recommend that these health endpoints should be considered in any core assessment of health impacts associated with exposure. These health endpoints have been evaluated in relation to changes in nitrogen dioxide concentrations in air.

Table 5.4 summarises the health endpoints considered in this assessment, the β coefficient relevant to the calculation of a relative risk. The coefficients adopted for the assessment of impacts on mortality and asthma emergency department admissions are derived from the detailed assessment undertaken for the current review (NEPC 2019a) of health impacts of air pollution for the NEPC (2021) revision and are considered to be current and robust.

Table 5.4 Adopted health impact functions and exposure-responses relationships for nitrogen dioxide

Health endpoint	Exposure period	Age group	Adopted β coefficient (also as %) for 1 µg/m^3 increase in NO_2	Reference
Mortality, all causes	Short-term (1-hour)	All ages	0.0006 (0.06%)	Relationship adopted from the WHO (WHO 2013c) review, as adopted in the NEPC revision (NEPC 2019a)
Mortality, respiratory	Short-term	All ages*	0.00426 (0.43%)	Relationship derived for from modelling undertaken for 5 cities in Australia and 1 day lag (EPHC 2010; Golder 2013)
Asthma emergency department admissions	Short-term (24-hour)	1–14 years	0.00115 (0.12%)	Relationship established from review conducted on Australian children (Sydney) for the period 1997 to 2001 (Golder 2013; Jalaludin et al. 2008), as adopted in the NEPC revision (NEPC 2019a)

* Relationships established for all ages, including young children and the elderly

5.3.4 Carbon monoxide

Motor vehicles are the dominant source of carbon monoxide in air (DECCW 2009). Carbon monoxide is produced during combustion when there is a limited supply of oxygen. This includes combustion engines in vehicles.

The sorts of effects that can be expected due to exposure to CO are those linked with carboxyhaemoglobin (COHb) in blood – i.e., where CO replaces oxygen in the blood preventing oxygen from being transported around the body. In addition, association between exposure to carbon monoxide and cardiovascular hospital admissions and mortality, especially in the elderly for cardiac failure, myocardial infarction and ischemic heart disease; and some birth outcomes (such as low birth weights) have been identified (NEPC 2010). The current NEPC air standards are consistent with health based guidelines currently available from the WHO (WHO 2005, 2010) and the USEPA (2011[6], specifically listed to be protective of exposures by sensitive populations including asthmatics, children and the elderly). On this basis, the current NEPC standards are considered appropriate for the assessment of potential health impacts associated with the project.

The NEPC air standard relates to carbon monoxide exposures over an 8 hour averaging period (NEPC 2021). In addition, the NSW EPA has also adopted other short-term exposure periods on 15-minute and 1-hour averages (NSW EPA 2022). In relation to the protection of health the 1-hour average guideline is consistent with the WHO (WHO 2010) guideline[7], that is protective of all members of the community. Hence this assessment has considered the NEPC standard, based on an 8-hour average, and the NSW EPA guideline for a 1-hour average.

The adopted health-based guidelines for CO are as follows:

- 1-hour average = 25 ppm = 30,000 µg/m^3
- 8-hour average = 9 ppm = 10,000 µg/m^3.

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6 Review of the Primary National Ambient Air Quality Standards for Carbon Monoxide published by the USEPA in the Federal Register Volume 76, No. 169, 2011, available from: http://www.gpo.gov/fdsys/pkg/FR-2011-08-31/html/2011-21359.htm

7 It is noted that the WHO review in 2021 has established an air quality guideline for CO based on a 24-hour average concentration. This guideline has not been adopted in Australia, and use of the 1-hour average and 8-hour average guidelines is considered protective of longer duration exposures over 24-hours and are adequately protective of all adverse effects for all members of the community.

5.3.5 Sulfur dioxide

Sulfur oxides are formed during combustion when chemicals present in fuels (such as coal, gas, petrol etc) containing sulfur react with oxygen to form sulfur oxides. Burning of coal in power stations in Europe resulted in acid rain affecting forests. The acid rain was primarily a result of the formation of sulfur oxides as the coal was burnt. Sulfur oxides are also released from volcanos. Wildfires and other types of fires are also sources to the atmosphere of these chemicals (USEPA 2018b).

Sulfur dioxide (SO_2) is the main sulfur oxide that can have impacts on people. Exposure to elevated levels can result in irritation of the respiratory system and can make breathing difficult. The most affected by exposure to these chemicals are people with asthma (USEPA 2018b).

The NEPC has established a standard for SO_2 in air (NEPC 2021), based on a 1-hour and24-hour average, which has been adopted by the NSW EPA (NSW EPA 2022).

The review conducted to support the 2021 NEPM (NEPC 2019b) considered the large amount of research published since the previous review and evaluation (NEPC 2010). The findings of recent studies have strengthened the evidence that the main health effects associated with exposure to sulfur dioxide are short-term effects on the respiratory system, with children, people over 65 years of age and people with existing health conditions (respiratory, cardiovascular and asthma) the most susceptible groups of the effects of sulfur dioxide. Asthma remains the most sensitive health effect. Evidence for long-term health effects is weak, noting the available data is limited. Hence the NEPM has focused on establishing health protective guidelines of short-term exposures based on a 1-hour average and 24-hour average. The NEPM review also benchmarked the air guidelines in Australia against international guidelines, where it was clear lower guidelines for sulfur dioxide had been adopted in most other international jurisdictions.

As a result of the more recent review, the air quality guidelines for sulfur dioxide in the current NEPM for ambient air quality (NEPC 2021) are significantly lower than in the previous NEPM (NEPC 2016). These guidelines are based on protection from adverse health effects following for all members of the population including sensitive populations like asthmatics, children and the elderly.

Assessment of cumulative, or total, community exposures to sulfur dioxide has been undertaken on the basis of the NEPM standards, which are as follows:

- 1-hour average = 0.1 ppm = 286 $\mu g/m^3$
- 24-hour average = 0.02 ppm = 57 $\mu g/m^3$.

Review of the health evidence for the NEPC variation (NEPC 2014) considered the published epidemiological studies relating to short-term exposure to sulfur dioxide and effects on the respiratory system. The review identified an association between changes in 1 hour and 24-hour average sulfur dioxide concentrations and mortality and hospital admissions for respiratory causes. Other associations identified included cardiovascular disease and emergency department admissions for young children with asthma.

The epidemiological studies provide evidence of association; however, the strongest evidence of causation comes from clinical studies where short-term exposure to sulfur dioxide has been shown (at levels of 0.4 ppm and higher) to result in respiratory symptom and decreased lung function, particularly in asthmatics. While statistically significant respiratory effects were not shown at 0.2–0.3 ppm (and at 0.1 ppm in one small study), some effects were observed in asthmatics and found to be enhanced by exercise. The WHO (WHO 2006b) determined a wide range of sensitivities to the effects of sulfur dioxide in the community, with no threshold defined.

The detailed USEPA review (USEPA 2008) concluded that collectively, the human clinical, epidemiologic, and animal toxicological data are sufficient to conclude that there is a causal relationship between respiratory morbidity and short-term exposure to sulfur dioxide. The evidence is suggestive of a causal relationship between short-term exposure to sulfur dioxide and mortality, however the evidence linking exposure with cardiovascular effects and effects from long-term exposure is in adequate to infer a causal relationship. Further review of the evidence available to 2017 (USEPA 2017) available to did not change this outcome. The review did identify uncertainty regarding the influence of other pollutants or mixtures of pollutants observed in the associations with sulfur dioxides as many or most of the studies have not examined the potential for co pollutant confounding. This is also noted in the most recent WHO review (WHO 2021). Hence, while the work undertaken to review of the NEPM air standard included the use of exposure-response relationships for a range of health endpoints (not all identified to be causal), given the strength of the evidence and the uncertainties, it is appropriate to assess the potential for health effects in the community from exposure to sulfur dioxide on the basis of the NEPC standard.

5.3.6 Individual VOCs

VOCs can comprise a large number of individual chemicals. The assessment of potential health impacts from exposure to VOCs, requires assessment of individual chemicals as the toxicity of each individual chemical is different. Hence this assessment has focused on the key individual VOCs related to aircraft emissions, namely benzene, toluene, xylenes and formaldehyde.

This assessment has not considered polycyclic aromatic hydrocarbons (PAHs) as part of VOCs. PAHs are predominantly derived from diesel exhaust, not aircraft emissions, which are not considered in this assessment.

Assessment of potential health effects related to exposure to key individual VOCs has considered the following:

- Health based air guidelines or inhalation toxicity reference values (TRVs) for the key individual VOCs have been selected on the basis of guidance provided by enHealth (enHealth 2012). This requires consideration of the hazards identified and the mechanisms for action particularly in relation to the assessment of carcinogenic effects, transparency of the review (i.e. is all the information presented and the derivation of the guideline transparent), robustness of the evaluation (i.e. critical review and evaluation of all available and relevant studies), currency of the evaluation (including whether more recent key studies were considered) and the application of uncertainty factors.
- For VOCs identified as genotoxic carcinogens (consistent with guidance provided by enHealth (enHealth 2012)) an incremental lifetime carcinogenic risk has been calculated. For this assessment, only benzene has been identified as a genotoxic carcinogen, where carcinogenicity is assessed on the basis of a non-threshold TRV (specifically an inhalation unit risk. Assessment of carcinogenic risk relates to a chronic exposure, where the non-threshold TRV adopted is presented in Table 5.6.
- For other VOCs and the assessment of non-carcinogenic effects for benzene the health effects are associated with a threshold (i.e. a level below which there are no effects), a threshold or guideline value for assessing inhalation exposures has been adopted. The health-based guidelines adopted (identified on the basis of guidance from enHealth 2012) are relevant to exposures that may occur to all members of the general public (including sensitive individuals) with no adverse health effects. The guidelines available relate to inhalation exposures from all sources and reflect duration of exposure where:
  - Acute guidelines are based on exposures that may occur for a short period of time (typically between 1 hour or up to 14 days). These guidelines are available to assess peak exposures (based on the modelled one-hour maximum concentration) that may be associated with VOCs in the air and are presented in Table 5.5.
  - Chronic guidelines are based on exposures that may occur all day, every day for a lifetime. These guidelines are available to assess long-term exposures (based on the modelled annual average concentration) that may be associated with VOCs in the air and are presented in Table 5.6. Use of these values assumes the maximum impact occurs at a residential home where individuals are at home 24-hours per day for 365 days of the year.

Detailed reviews of the available information relevant to the health effects and quantification of hazards from exposure to benzene, toluene, xylenes and formaldehyde are presented in Appendix A.

Where a threshold is adopted for the purposes of assessing exposure, this relates to total or cumulative exposures (i.e. project plus background). This is particularly relevant to the assessment of chronic exposures. Background exposures relevant to the key VOCs evaluated in this assessment are also discussed in Appendix A and Table 5.6.

Table 5.5 Adopted acute inhalation guidelines based on protection of public health

Compound assessed	Acute health based guideline ($\mu g/m^3$)	Basis
Benzene	580	Acute 1-hour health-based guideline, based on depressed peripheral lymphocytes from the Texas Commission on Environmental Quality (TCEQ) evaluation (TCEQ 2015).
Toluene	15,000	Acute 1-hour health-based guideline, based on eye and nose irritation, increased occurrence of headache and intoxication in human male volunteers from TCEQ evaluation (TCEQ 2013b).
Xylenes	7,400	Acute 1-hour health-based guideline, based on mild respiratory effects and subjective symptoms of neurotoxicity in human volunteers from TCEQ evaluation (TCEQ 2013a).
Formaldehyde	100	Acute health-based guideline, based on changes in blink eye response in human volunteers (WHO 2000a, 2010).

Table 5.6 Adopted chronic guidelines and carcinogenic unit risk values based on protection of public health

Compound assessed	Chronic health based guideline	Basis
Threshold guidelines		
Benzene	30 $\mu g/m^3$	The most significant chronic health effect associated with exposure to benzene is the increased risk of cancer, specifically leukaemia, which is assessed separately (below). The assessment of other health effects (other than cancer) has been undertaken using a chronic guideline derived by the USEPA (USEPA 2002) based on haematological effects in an occupational inhalation study (converted to public health value using safety factors). This is the most current evaluation of effects associated with chronic inhalation exposure to benzene and is consistent with the value used to derive the NEPM (NEPC 1999 amended 2013c) health based guidelines. Based on the available data background exposures are conservatively assumed to comprise 20% of this threshold value.
Toluene	5,000 $\mu g/m^3$	Chronic guideline derived by the USEPA (USEPA 2005b) based on neurological effects in an occupational study (converted to public health value using safety factors). This is the most current evaluation of effects associated with chronic inhalation exposure to toluene and is consistent with the value used to derive the NEPM (NEPC 1999 amended 2013c) health based guidelines. Based on the available data background exposures are considered negligible.
Xylenes	220 $\mu g/m^3$	Chronic guideline derived by ATSDR (ATSDR 2007b) based on mild subjective respiratory and neurological symptoms in an occupational study (converted to public health value using safety factors). Based on the available data background exposures are conservatively assumed to comprise 15% of this threshold value.

Compound assessed	Chronic health based guideline	Basis
Formaldehyde	100 µg/m^3	Formaldehyde is classified by IARC as carcinogenic to humans. The guideline developed by the WHO (WHO 2000a, 2010) is considered to be protective of both short and long-term exposures, for non-carcinogenic and carcinogenic health effects. Some lower guidelines are available from the US, however these are based on approaches to the assessment of carcinogenic effects inconsistent with that adopted by enHealth (enHealth 2012) and the WHO (WHO 2010). Based on the available data background exposures are assumed to comprise 50% of this threshold value.
Carcinogenic inhalation unit risk values adopted for non-threshold carcinogenic risk calculation		
Benzene	6x10^{-6} (µg/m^3)$^{-1}$	Benzene is classified as a known human carcinogen by the International Agency for Research on Cancer (IARC). Inhalation unit risk value is from the WHO (WHO 2000a, 2010) and is based on excess risk of leukaemia from epidemiological studies. Background exposures are not relevant for the calculation of a non-threshold carcinogenic risk.

5.3.7 All exposure pathways relevant to potable water

Sections 5.3.2 to 5.3.6 outline the hazards, approaches and quantitative values adopted for the assessment of inhalation exposures to the key pollutants evaluated in relation to aircraft emissions. This assessment has also considered potential hazards and risks associated with project related impacts on potable water supplies, including rainwater tanks.
This assessment has adopted drinking water guidelines, which are established to be protective of all adverse health effects for all members of the community from all exposures (ingestion, dermal contact and vapour inhalation (where relevant)) relating to the presence of chemicals in drinking water, where the water is used as potable supply every day for a lifetime. For this assessment drinking water guidelines established in Australia by NHMRC (NHMRC 2011 updated 2022) have been adopted, as detailed in Table 5.7.

Table 5.7 Drinking water guidelines based on protection of public health

Compound assessed	Guideline (mg/L)	Basis
Benzene	0.001	Based on the protection of all adverse health effects. The most sensitive health effects relates to carcinogenicity where a 1 in 1,000,000 excess cancer risk has been adopted in the derivation of the guideline (NHMRC 2011 updated 2022). The guideline is consistent with that derived by the WHO (WHO 2017).
Toluene	0.8	Based on the protection of all adverse health effects, with the guideline based on a threshold determined from a subchronic study (NHMRC 2011 updated 2022).
Xylenes	0.6	Based on the protection of all adverse health effects, with the guideline based on a threshold determined from a chronic study (NHMRC 2011 updated 2022).
Formaldehyde	0.5	Based on the protection of all adverse health effects from ingestion, dermal contact and inhalation exposures, with the guideline based on a threshold determined from a chronic study (NHMRC 2011 updated 2022).

5.3.8 Uncertainties

In general, the available scientific information is insufficient to provide a thorough understanding of all of the potential toxic properties of chemicals to which humans may be exposed.

For many chemicals it is necessary to extrapolate these properties from data obtained under other conditions of exposure and involving experimental laboratory animals. In some cases data is available from human studies such as controlled exposure studies and occupational studies.

This may introduce 2 types of uncertainties into the risk assessment, as follows:

- those related to extrapolating from one species to another
- those related to extrapolating from high exposure doses, usually used in experimental animal studies, to lower doses usually estimated for human exposure situations.

The majority of the toxicological knowledge of chemicals comes from experiments with laboratory animals, although there may be interspecies differences in chemical absorption, metabolism, excretion and toxic response. There may also be uncertainties concerning the relevance of animal studies using exposure routes that differ from human exposure routes. In addition, the frequent necessity to extrapolate results of short-term or subchronic animal studies to humans exposed over a lifetime has inherent uncertainty.

In order to adjust for these uncertainties, ADIs and RfDs incorporate safety factors that may vary from 10 to 1000.

There are no specific data available in relation to interactions (particularly those that result in more than additive health effects, or synergistic effects) of the range of individual chemicals identified and addressed in this assessment. Hence the approach adopted for evaluating risks to mixtures of chemicals assumes dose additivity as required in Australian guidance (enHealth 2012; NEPC 1999 amended 2013b). Dose additivity is based on the assumption that the components in the mixture have the same mode of action and elicit the same effects. For the individual VOCs evaluated this is likely to be relevant, however for the assessment of key air pollutants such as particulate matter, nitrogen dioxide, carbon monoxide and sulfur dioxide this is not the case.

The assessment of hazards associate with exposure to fine particulates and nitrogen dioxide has largely relied on information from large epidemiological studies. The use of epidemiological studies needs to be undertaken with caution, as many of these studies may identify an association, however the strength of the evidence in relation to causation is of greatest importance. This assessment has only evaluated potential health outcomes that have been identified, through detailed systematic reviews, as causal – where the strength of evidence is sufficiently strong to support that exposure to these pollutants may cause the health effect identified. It is not appropriate to consider other health outcomes where associations may be identified, where causation is not.

For the key (causal) health endpoints identified, this assessment has then utilised exposure-response function derived from the epidemiological studies. The choice of exposure-response functions for the quantification of potential health impacts is important. For mortality health endpoints, many of the exposure-mortality functions have been replicated throughout the world. While many of these have shown consistent outcomes, the calculated relative risk estimates for these studies do vary. In addition, these exposure-response relationships apply to very large populations and changes in regional air quality. Application to assessing smaller populations (such as within the study area) from changes associated with a specific source is not well established and adds in a level of uncertainty.

The shape of the exposure-response function and whether there is a threshold for some of the effects endpoints remains an uncertainty. Reviews of the currently available data (that includes studies that show effects at low concentrations) have not shown evidence of a threshold. However, as these conclusions are based on epidemiological studies, discerning the characteristics of the particulates or nitrogen dioxide responsible for these effects and the observed shape of the dose-response relationship is complex. Most studies have demonstrated a linear relationship between relative risk and ambient concentration however for long-term exposure-related mortality a log-linear relationship is more plausible and should be considered where there is the potential for exposure to very high concentrations of pollution. In this assessment, the impact considered is a localised impact with low level incremental increases in concentration. At low levels the assumption of a linear relationship is considered appropriate.

For the assessment of nitrogen dioxide, particulates and noise (refer to Chapter 6), the exposure-response relationships used in this assessment are based on large epidemiology studies where exposures have occurred in urban areas. These exposures do not relate to only one pollutant or exposures (noise) but a mix of these, and others including occupational and smoking. While many of the studies have endeavoured to correct for exposures to other pollutants and exposures, no study can fully correct for these and there would always be some level of influence from other exposures on the relationships adopted.

In relation to air quality, many of the pollutants evaluated come from a common source (e.g. fuel combustion) so the use of only particulate matter or nitrogen dioxide as an index for the mix of pollutants that is in urban air at the time of exposure is reasonable but will be conservative.

5.4 Exposure assessment

5.4.1 Exposure concentrations in air

The focus of this assessment relates to changes in air quality as a result of aircraft emissions associated with the project. The key pathway of exposure relevant to these emissions is inhalation of gases and volatile organic chemicals, as well as fine particulates which would comprise PM2.5 which essentially behave like a gas in air, where inhalation The exposure concentrations evaluated in this assessment have been derived from the modelling undertaken for the local study area as presented in the Technical paper 2.

This assessment has utilised the following exposure concentrations for the assessment of potential impacts on community health:

- maximum concentrations predicted in the community, anywhere off-site regardless of land use
- maximum concentrations predicted from all residential and community receptors assessed in the community
- maximum and average concentrations in residential areas surrounding the site.

The exposure concentrations considered for the assessment of each pollutant is noted in the relevant impact assessment section.

5.4.2 Exposure concentrations in water

The pollutants related to aircraft emissions comprise gases, vapours and very fine particles that would not be expected to deposit to the ground. However, concern has been raised in relation to the deposition of aircraft emission related pollutants and the potential for such pollutants to impact on drinking water quality. The air modelling completed for the local study area and presented in the Technical paper 2 included deposition modelling of particulates from aircraft emissions for the maximum emission scenarios in 2055, namely Prefer Runway 23 scenario. This modelling indicates that particulate deposition rates would be very low, ranging from 0.00001 to 0.0001 g/m^2/month. In terms of impacting water quality, the present of particulates alone is not meaningful, as it is the presence of individual chemicals that may be present on the particulates as deposited to the ground that are relevant.

For this assessment estimated deposition rates for key pollutants, namely benzene, toluene, xylenes and formaldehyde that are relevant to the presence of potential chemicals in drinking water have been provided from the air modelling. These chemicals have been assumed to be sorbed to the fine particulates in air, and deposited to the ground.

In terms of drinking water supplies, Prospect Reservoir is the closest potable water reservoir to the site.

The concentration of pollutants in Prospect Reservoir depends on the deposition rate of dust onto the surface of the water and onto the surrounding catchment, the volume of the reservoir and the volume of rainfall each year.

One part of the calculation is to determine the concentrations of relevant chemical due to deposition on the surface of the reservoir and mixing into the dam water. Another part of the calculation is to determine the additional amount of each chemical that could be due to deposition on the ground surrounding the reservoir (the catchment) that then get washed into the reservoir during rain.

In both cases there are other sources of these chemicals in normal urban environments (particularly from vehicle emission and other combustion, petroleum sources). These calculations have just addressed the additional amounts of these chemicals that could be present due to emissions related to this project.

The calculations have used the deposition rate for each of the chemicals (as provided from the air modelling) and the area over which such deposition occurs to determine the mass of each chemical that may get mixed into the dam. This mass is then mixed into the entire volume of the reservoir and adjusted based on solubility to get the concentration that could be present in the water.

The mass has only been mixed into the dam as a static water body with no water entering or leaving the dam – a volume of 1.25×10^{11} L. In reality, rain would add water into the dam across the year which would add an additional 8.7×10^{9} L on average (another 10% approximately). Water would also be added as needed using the pipeline from Warragamba Dam. Water would be removed from the dam to move into the distribution system (which would take the dissolved chemicals with it) and by evaporation (which would leave some of the dissolved chemicals in the reservoir). It is considered that assuming the dam is a static water body is a conservative assessment – i.e. it will overestimate the concentrations that could be present in the reservoir and, therefore, the risks.

The concentration in water in the reservoir due to the potential emissions from the project is determined using the following with the parameters adopted for this assessment are detailed in Table 5.8.

$$C_W = \frac{DM}{\text{Volume x Kd x } \rho}$$

The same equation has also been used to calculate a concentration that may be present in rainwater tanks, where deposition occurs onto a roof, and then washes into the tank. While rainwater tanks in Greater Sydney are not suitable for the supply of potable water, non-potable uses may occur. The assumptions adopted are also included in Table 5.8.

Table 5.8 Assumptions adopted to estimate concentration in Prospect Reservoir and rainwater tanks

Parameter		Value adopted		Basis
		Prospect reservoir	Rainwater tanks	
DM	Mass of chemical deposited on the reservoir and the surrounding land, or a roof for a year (mg)	DR x Area for reservoir or tank and DR x Area x runoff coefficient (Rc) x 1 year		Calculated
DR	Deposition rate (mg/m^2/year)	Modelled across for the local study area, with data for R72 adopted as the closest community receptor evaluated to Prospect Reservoir	Based on the maximum modelled deposition rate from all residential areas	Receptor modelled that is closest to the reservoir – R72. This will remain conservative as the reservoir is further from the site that this receptor. This will also be conservative for the catchment of the reservoir.
Area	Area of the catchment and reservoir, or roof of house (m^2)	10000000 m^2 (5200000 m^2 of which is the reservoir itself)	200 m^2	Water NSW fact sheet on Prospect Reservoir (https://www.waternsw.com.au/supply/Greater-Sydney/dams/prospect-dam) 5.2 km^2 surface area for reservoir and 10 km^2 for catchment. Area of roof based on a typical 4 bedroom Australian home.

Parameter		Value adopted		Basis
		Prospect reservoir	Rainwater tanks	
Volume	Volume of water in the reservoir or water collected in rainwater tank (L)	5200000 m^2 (surface area) * 24 m (deep) = 1.25×10^8 m^3 = 1.25×10^{11} L	Calculated based on yearly rainfall, roof area and runoff coefficient = 123 m^3 = 123000 L	Water NSW fact sheet on Prospect Reservoir (https://www.waternsw.com.au/supply/Greater-Sydney/dams/prospect-dam) 5.2 km^2 surface area and 24 m depth. For rainwater tanks it is assumed that the capacity of the tank will hold all runoff from the roof throughout the year.
R	Rainfall each year (mm)	878.6		Average rainfall at Prospect Reservoir for all years of records (1887 – 2023).
Rc	Runoff coefficient	0.7		Assumes 70% of the chemicals which deposit on to the ground get washed off into the reservoir. This is based on the value used for runoff from a roof into a rainwater tank (Lizárraga-Mendiola et al. 2015). The value is also adopted for rainwater tanks. It is expected that the runoff coefficient will be lower for wash off from the ground due to the interaction with soil, vegetation and structures.
1000	Conversion from mm to m	--		Conversion factor
Kd	Soil-water partition coefficient (cm^3/g)	Chemical-specific		All values from RAIS (RAIS)
ρ	Soil bulk density (g/m^3)	0.5		Assumed for loose deposited dust on ground (upper end measured for powders)

It is the dissolved concentration in Prospect Reservoir and rainwater tanks that is relevant to the assessment of exposure in the community.

5.4.3 Uncertainties

The quantification or modelling of impacts on air quality as a result of the project, namely the operation of aircraft has been undertaken and presented Technical paper 2, which indicates that the assessment presented is conservative for the following reasons:

- emissions from aircraft engines have been assumed to remain the same as current emission rates, with no improvements in emissions for new or future aircraft
- background levels of key pollutants such as particulates and nitrogen dioxide in 2055 have been estimated based on existing information, however it is likely that changes in the vehicle fleet over time (e.g. more electric vehicles) and other sources may result in different levels of background air quality in 2055
- the estimation of the concentration of nitrogen dioxide as a proportion of total oxides of nitrogen has used a conservative approach
- the modelling assumes the worst-case scenario, in terms of emissions, occurs every hour of the year (which would not occur)
- the deposition of particulates is highly conservative as it assumes that the emissions from the aircraft will include particulates that are large enough to deposit to the ground. Such emissions, however are dominated by $PM_{2.5}$ which essentially acts like a gas in the atmosphere with little to no deposition. Hence deposition of pollutants to the ground at all is considered to be highly unlikely to ever occur, however to enable an assessment of impacts on water supplies, a conservative assumption relating to deposition has to be used.

The methods used to estimate concentrations of pollutants that may accumulate in reservoirs and rainwater tanks are conservative, making a number of unrealistic assumptions including:

- pollutants would absorb to particulates and deposit to the ground
- the pollutants do not degrade in air or on the ground, or in water (which will occur for all the pollutants evaluated)
- conservative assumptions relating to the accumulation of pollutants, particularly in reservoirs, have been adopted.

As a result of the above the exposure concentrations used in this assessment are expected to be highly conservative, i.e. overestimate actual impacts as a result of the project.

5.5 Impact assessment

5.5.1 Fine particulates

5.5.1.1 General

As detailed in Section 5.3.2, the focus of this assessment relates to $PM_{2.5}$. This assessment has assessed potential impacts on community health on the basis of an assessment of cumulative exposures (i.e. project plus background) and incremental exposures (i.e. from the project alone).

5.5.1.2 Cumulative impacts

Table 5.9 presents a comparison of the maximum incremental and total concentration of $PM_{2.5}$ predicted within the residential receptors, with comparison against the NEPC air standard. The modelling of air quality impacts has considered background concentrations as well as the contribution at residential receptors from ground-based operations from the 2016 EIA.

Table 5.9 Assessment of cumulative exposure to $PM_{2.5}$

Scenario evaluated	Modelled concentration of $PM_{2.5}$ in air (µg/m^3)			
	Maximum 24-hour average (residential)		Maximum annual average (residential)	
	2033	2055	2033	2055
No preference				
Incremental – project	0.45	--	0.086	--
Background, including ground-based operations from 2016 EIS	21.44	--	7.71	--
Total/cumulative	21.9	--	7.8	--
Prefer Runway 05				
Incremental – project	0.52	1.28	0.11	0.29
Background, including ground-based operations from 2016 EIS	22.06	23.22	7.71	7.93
Total/cumulative	22.6	24.5	7.8	8.2

Scenario evaluated	Modelled concentration of $PM_{2.5}$ in air (µg/m³)			
	Maximum 24-hour average (residential)		Maximum annual average (residential)	
	2033	2055	2033	2055
Prefer Runway 23				
Incremental – project	0.61	1.42	0.13	0.32
Background, including ground-based operations from 2016 EIS	22.06	23.22	7.71	7.93
Total/cumulative	22.7	24.6	7.8	8.3
NEPC Air standard	**25**	**25**	**8**	**8**

Review of Table 5.9 indicates that the maximum predicted 24- hour average air concentration, including the project remains below the NEPC air standard. In relation to the annual average air concentrations, impacts predicted in 2033 would not result in exceedance of the NEPC air standard, however the cumulative concentration predicted in 2055 may exceed the NEPC air standard. This would occur at the most impacted residential receptor (R19 near the northern boundary of the airport) and the assessment has assumed background air quality, which dominates the impacts identified, remains unchanged in 2055. The impact of emissions from aircraft is very low, comprising 4% of the NEPM air standard. Further assessment of the incremental impact of community exposures to aircraft emissions from the project are presented in the following section.

5.5.1.3 Incremental impacts

The assessment of incremental impacts associated with exposure to $PM_{2.5}$ has evaluated the maximum increase in annual average $PM_{2.5}$ predicted from community receptors evaluated each of the SALs in the local study area. Not all the SALs in the local study area have been evaluated, only those located closer to the airport flight paths (including take-off and landing) and assessed in detail in Technical paper 2.

Assessment of incremental impacts has addressed the primary and secondary health endpoint relevant to the assessment of potential exposures to $PM_{2.5}$ from the project, as identified and discussed in Section 5.3.2.4. For these health endpoints a population health incidence has been calculated as detailed in Appendix B. The calculation of the number of cases is calculated as follows:

$$\text{Number of attributable cases} = \beta \times \Delta X \times B \times P$$

Where

B = relationship between a change in 1 µg/m³ exposure and a health outcome (as per Table 5.3)

ΔX = change in $PM_{2.5}$ concentration (µg/m³) or exposure relevant to the population evaluated

B = baseline incidence of the health outcome or endpoint evaluated, relevant to the population evaluated (refer to Table 4.5) (rate per person)

P = population exposed, as relevant to each SAL (refer to Table 4.1).

The calculation presented assumes that 100% of the population living in each SAL is always exposed to the maximum increase in $PM_{2.5}$ predicted in that SAL, and that the population remains at that same location 24-hours per day for 365 days per year.

Table 5.10 presents a summary of the attributable cases calculated for all each SAL evaluated and for each scenario assessed. The table also includes the total number of attributable cases over the study area evaluated. The number of cases presented have been rounded to one significant figure. Detailed calculations are included in Appendix C.

Note that the most significant impact relates to the assessment of all-cause mortality (long-term) with the total impact (total attributable case) is dominated by the impacts reported in the Luddenham area.

Table 5.10 Calculated health impacts in local study area, as attributable cases, relevant to increased exposure to $PM_{2.5}$ from aircraft emissions

Scenario and SAL	Number of cases attributed to change in $PM_{2.5}$						
	Primary Indicators		Secondary Indicators				
	Mortality - All Causes, Long-term	Hospitalisations Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
2033 – No preference							
Austral	0.0001	0.00005	0.00002	0.00004	0.00001	0.000007	0.00004
Badgerys Creek	0.00002	0.00002	0.000007	0.000006	0.000002	0.000001	0.000004
Bringelly	0.0009	0.0005	0.0002	0.0002	0.00006	0.00004	0.0001
Cecil Park	0.00002	0.00001	0.000004	0.000005	0.000001	0.0000008	0.000002
Cobbitty	0.0005	0.0002	0.00009	0.0001	0.00003	0.00002	0.0001
Greendale	0.00008	0.00004	0.00002	0.00002	0.000005	0.000004	0.00001
Kemps Creek	0.0002	0.0001	0.00004	0.00005	0.00001	0.000008	0.00003
Luddenham	0.004	0.002	0.0006	0.001	0.0003	0.0002	0.001
Mount Vernon	0.00004	0.00002	0.000008	0.00001	0.000003	0.000002	0.000008
Mulgoa	0.0002	0.00009	0.00003	0.00004	0.00001	0.000007	0.00003
Rossmore	0.0001	0.00009	0.00003	0.00004	0.00001	0.000007	0.00003
Wallacia	0.0002	0.0001	0.00004	0.00005	0.00001	0.000009	0.00004
Total (all SALs)	**0.007**	**0.003**	**0.001**	**0.002**	**0.0005**	**0.0003**	**0.001**
2033 – Prefer Runway 05							
Austral	0.0002	0.00006	0.00002	0.00005	0.00001	0.000009	0.00004
Badgerys Creek	0.00002	0.00002	0.000006	0.000006	0.000002	0.000001	0.000004
Bringelly	0.0009	0.0005	0.0002	0.0002	0.00006	0.00004	0.0001
Cecil Park	0.00002	0.00001	0.000004	0.000005	0.000001	0.0000008	0.000002
Cobbitty	0.0005	0.0002	0.00008	0.0001	0.00003	0.00002	0.00010
Greendale	0.00007	0.00004	0.00001	0.00002	0.000005	0.000003	0.00001
Kemps Creek	0.0002	0.0001	0.00004	0.00005	0.00001	0.000008	0.00003
Luddenham	0.004	0.002	0.0006	0.001	0.0003	0.0002	0.0009
Mount Vernon	0.00004	0.00002	0.000008	0.00001	0.000003	0.000002	0.000008
Mulgoa	0.0002	0.00009	0.00003	0.00004	0.00001	0.000008	0.00003
Rossmore	0.0002	0.00009	0.00003	0.00004	0.00001	0.000007	0.00003
Wallacia	0.0002	0.0001	0.00004	0.00005	0.00001	0.000008	0.00003
Total (all SALs)	**0.006**	**0.003**	**0.001**	**0.002**	**0.0004**	**0.0003**	**0.001**

Scenario and SAL	Number of cases attributed to change in $PM_{2.5}$						
	Primary Indicators			Secondary Indicators			
	Mortality - All Causes, Long-term	Hospitalisations Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
2033 – Prefer Runway 23							
Austral	0.0002	0.00006	0.00002	0.00006	0.00001	0.00001	0.00005
Badgerys Creek	0.00003	0.00002	0.000008	0.000007	0.000002	0.000001	0.000005
Bringelly	0.0009	0.0005	0.0002	0.0002	0.00006	0.00004	0.0001
Cecil Park	0.00002	0.00001	0.000004	0.000005	0.000001	0.0000009	0.000003
Cobbitty	0.0004	0.0002	0.00007	0.0001	0.00003	0.00002	0.00009
Greendale	0.00006	0.00003	0.00001	0.00001	0.000004	0.000003	0.00001
Kemps Creek	0.0002	0.0001	0.00005	0.00005	0.00001	0.000009	0.00003
Luddenham	0.005	0.002	0.0007	0.001	0.0003	0.0002	0.001
Mount Vernon	0.00005	0.00002	0.000008	0.00001	0.000003	0.000002	0.000008
Mulgoa	0.0002	0.00008	0.00003	0.00004	0.00001	0.000007	0.00003
Rossmore	0.0002	0.0001	0.00004	0.00005	0.00001	0.000008	0.00003
Wallacia	0.0002	0.00008	0.00003	0.00004	0.00001	0.000007	0.00003
Total (all SALs)	**0.007**	**0.003**	**0.001**	**0.002**	**0.0005**	**0.0003**	**0.001**
2055 - Prefer Runway 05							
Austral	0.0005	0.0002	0.00006	0.0001	0.00003	0.00002	0.0001
Badgerys Creek	0.00006	0.00005	0.00002	0.00002	0.000004	0.000003	0.00001
Bringelly	0.002	0.001	0.0005	0.0006	0.0002	0.0001	0.0003
Cecil Park	0.00005	0.00003	0.00001	0.00001	0.000003	0.000002	0.000006
Cobbitty	0.001	0.0006	0.0002	0.0003	0.00009	0.00006	0.0003
Greendale	0.0002	0.0001	0.00004	0.00005	0.00001	0.000008	0.00003
Kemps Creek	0.0005	0.0003	0.0001	0.0001	0.00003	0.00002	0.00007
Luddenham	0.01	0.004	0.001	0.003	0.0007	0.0005	0.002
Mount Vernon	0.0001	0.00006	0.00002	0.00003	0.000008	0.000006	0.00002
Mulgoa	0.0004	0.0002	0.00008	0.0001	0.00003	0.00002	0.00008
Rossmore	0.0004	0.0003	0.0001	0.0001	0.00003	0.00002	0.00007
Wallacia	0.0005	0.0002	0.00009	0.0001	0.00003	0.00002	0.00009
Total (all SALs)	**0.02**	**0.007**	**0.003**	**0.004**	**0.001**	**0.0008**	**0.003**

Scenario and SAL	Number of cases attributed to change in $PM_{2.5}$						
	Primary Indicators			Secondary Indicators			
	Mortality - All Causes, Long-term	Hospitalisations Cardiovascular, Short-term	Hospitalisations - Respiratory, Short-term	Mortality - All Causes, Short-term	Mortality - Cardiovascular, Short-term	Mortality - Respiratory, Short-term	Morbidity - Asthma ED Admissions - Short-term
2055 – Prefer Runway 23							
Austral	0.0005	0.0002	0.00006	0.0001	0.00004	0.00003	0.0001
Badgerys Creek	0.00007	0.00006	0.00002	0.00002	0.000005	0.000003	0.00001
Bringelly	0.002	0.001	0.0005	0.0006	0.0002	0.0001	0.0004
Cecil Park	0.00005	0.00003	0.00001	0.00001	0.000003	0.000002	0.000007
Cobbitty	0.001	0.0005	0.0002	0.0003	0.00008	0.00005	0.0002
Greendale	0.0001	0.00008	0.00003	0.00004	0.00001	0.000007	0.00003
Kemps Creek	0.0006	0.0003	0.0001	0.0001	0.00004	0.00002	0.00008
Luddenham	0.01	0.005	0.002	0.003	0.0008	0.0006	0.003
Mount Vernon	0.0001	0.00006	0.00002	0.00003	0.000009	0.000006	0.00002
Mulgoa	0.0004	0.0002	0.00008	0.0001	0.00003	0.00002	0.00007
Rossmore	0.0005	0.0003	0.0001	0.0001	0.00003	0.00002	0.00008
Wallacia	0.0004	0.0002	0.00008	0.0001	0.00003	0.00002	0.00008
Total (all SALs)	**0.02**	**0.008**	**0.003**	**0.005**	**0.001**	**0.0009**	**0.004**

The predicted number of attributable cases, relevant to all scenarios is very low, well below one case per year. Assuming the maximum impacts always occurred each year, and the population was at that same location all day every day for a lifetime, the number of attributable cases may be up to 2 over a 100-year period, within the whole population evaluated. For Luddenham, the most impacted SAL, the calculations presented indicate the number of attributable cases may be up to 1 over a 100-year period. Such a low level of impact would be negligible in relation to the health statistics relevant to the study area.

It is noted that the calculated population incidence presented in Table 5.10, are lower than those presented in the 2016 EIS, however the location of higher levels of impacts are different reflecting the current flight path scenarios.

On the basis of the calculations presented in terms of cumulative and incremental impacts of exposure to $PM_{2.5}$, there are no health risk issues of concern in relation to $PM_{2.5}$ derived from the operation of aircraft associated with the project.

5.5.2 Nitrogen dioxide

5.5.2.1 General

This assessment has assessed potential impacts of exposure to nitrogen dioxide from aircraft emissions on community health on the basis of an assessment of cumulative exposures (i.e. project plus background) and incremental exposures (i.e. from the project alone).

5.5.2.2 Cumulative impacts

Table 5.11 presents a comparison of the maximum incremental and total concentration of nitrogen dioxide predicted within the residential receptors, with comparison against the NEPC air standard. The modelling of air quality impacts has considered background concentrations as well as the contribution at residential receptors from ground-based operations from the 2016 EIA.

Table 5.11 Assessment of cumulative exposure to nitrogen dioxide

Scenario evaluated	Modelled concentration of nitrogen dioxide in air (µg/m^3)			
	Maximum 24-hour average (residential)		Maximum annual average (residential)	
	2033	2055	2033	2055
No preference				
Incremental – project	113.8	--	10.9	--
Background, including ground-based operations from 2016 EIS	8.2	--	1.5	--
Total/cumulative	121.9	--	12.3	--
Prefer Runway 05				
Incremental – project	112.1	185.3	12.1	19.8
Background, including ground-based operations from 2016 EIS	8.2	16.1	1.5	3.6
Total/cumulative	120.3	201.5	13.5	23.4
Prefer Runway 23				
Incremental – project	112.9	238.1	12.8	21.0
Background, including ground-based operations from 2016 EIS	8.2	16.1	1.5	2.9
Total/cumulative	121.0	254.2	14.3	31.0
NEPC Air standard	**164**	**164**	**31**	**31**

Review of Table 5.11 indicates that the maximum predicted annual average air concentration, including the project remains below the NEPC air standard.

In relation to the assessment of short-term exposures, the maximum 24-hour average concentrations predicted in 2055 for both scenarios Prefer Runway 05 and Prefer Runway 23 exceed the NEPC standard. Review of the nitrogen dioxide impacts predicted in Technical paper 2 indicates the following:

- the predicted levels of nitrogen dioxide are likely to be conservative (i.e. potentially overstated), due to:
  - the modelling has used a conservative approach for assessing chemical transformations to predict nitrogen dioxide levels
  - the modelling assumes the worst-case scenario occurs for every hour of the year
  - the modelling does not take into account future improvements in emissions due to better fuel or engine emission controls
- as a result, the predicted impacts detailed above are unlikely to actually occur
- the impacts identified relate to a few hours of the year and only at a few locations close to the WSI, specifically receptor R19 located in Luddenham
- the next highest impact is at receptor 135 (also in Luddenham) where the maximum 24-hour average concentration of nitrogen dioxide is below the NEPC standard.

Location R19 is located northwest of the site, as shown in Figure 5.3. This is in an area rezone by the State Government as per the planning initiatives for Western Sydney Aerotropolis. Specifically, the area of R19 is now zoned for agribusiness use as shown in Figure 5.3, which includes restrictions on the intensification of residential development. Where the area assessed associated with receptor R19 is no longer used for residential purposes, but is redeveloped for business purposes, that does not include childcare uses, the potential for impacts on respiratory health is low.

Further assessment of the incremental impacts of nitrogen dioxide emissions related to the project is presented in the following section.

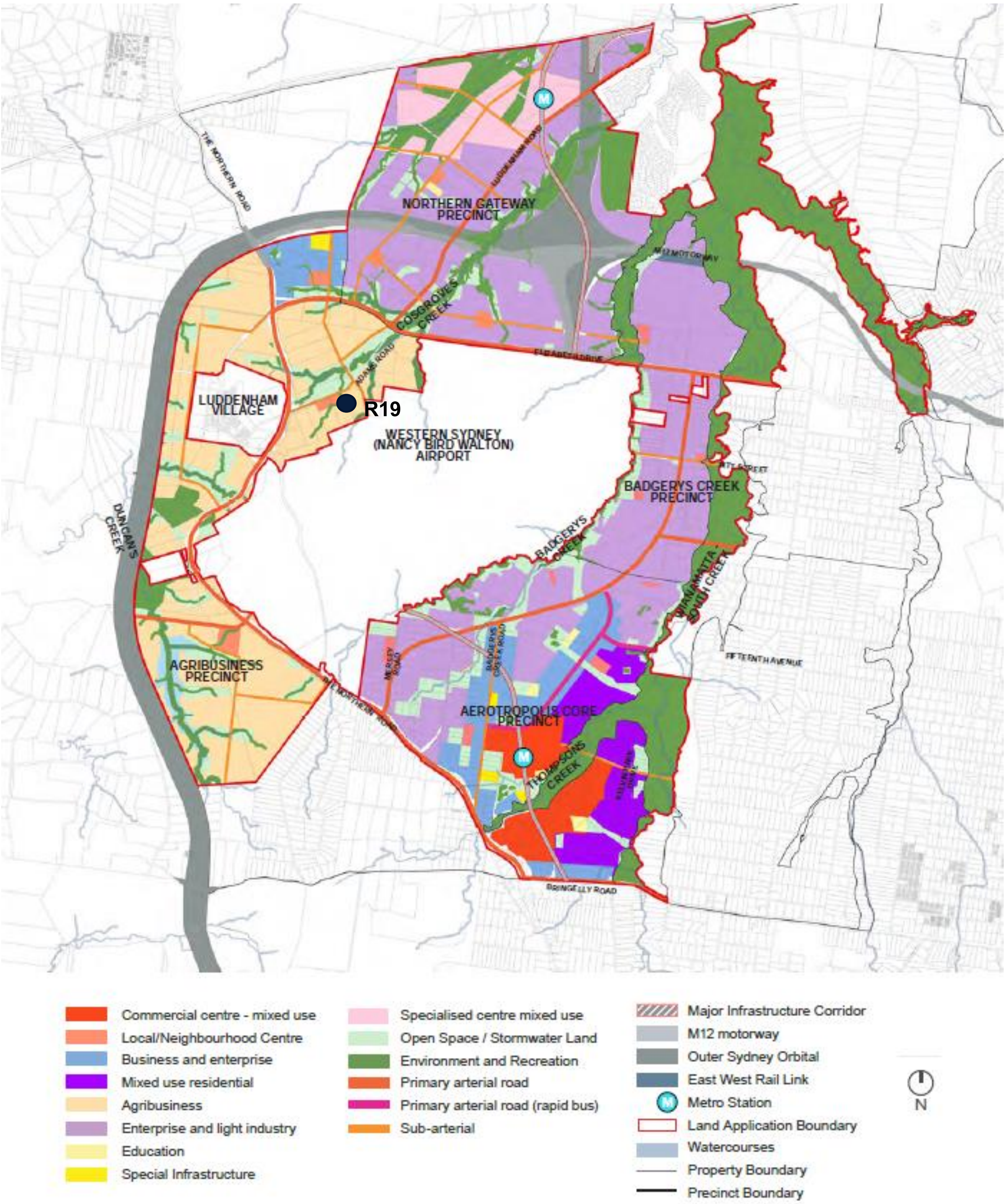


Figure 5.3 **Aerotropolis land use and structure plan, showing location of R19 (source NSW DEP 2022)**

5.5.2.3 Incremental impacts

The assessment of incremental impacts associated with exposure to nitrogen dioxide has evaluated the maximum increase in annual average annual average predicted from community receptors evaluated each of the SALs in the local study area. Note that the annual average includes all 24-hour changes to nitrogen dioxide. Not all the SALs in the local study area have been evaluated, only those located closer to the airport flight paths (including take-off and landing) and assessed in detail in Technical paper 2.

Assessment of incremental impacts has addressed the primary and secondary health endpoint relevant to the assessment of potential exposures to nitrogen dioxide from the project, as identified and discussed in Section 5.3.3. For these health endpoints a population health incidence has been calculated as detailed in Appendix B and Section 5.5.1.3.

The calculation presented assumes that 100% of the population living in each SAL is always exposed to the maximum increase in nitrogen dioxide predicted in that SAL, and that the population remains at that same location 24-hours per day for 365 days per year.

Table 5.12 presents a summary of the attributable cases calculated for all each SAL evaluated and for each scenario assessed. The table also includes the total number of attributable cases over the study area evaluated. The number of cases presented have been rounded to one significant figure. Detailed calculations are included in Appendix D.

Table 5.12 Calculated health impacts in local study area, as attributable cases, relevant to increased exposure to nitrogen dioxide from aircraft emissions

Scenario and SAL	Number of cases attributed to change in nitrogen dioxide					
	2033			2055		
	Mortality - all causes (ages 30 years and over)	Mortality - respiratory (all ages)	Asthma - ED hospital admissions (children aged 1 to 14 years)	Mortality - all causes (ages 30 years and over)	Mortality - respiratory (all ages)	Asthma - ED hospital admissions (children aged 1 to 14 years)
No preference						
Austral	0.007	0.002	0.004	--	--	--
Badgerys Creek	0.0007	0.0002	0.0003	--	--	--
Bringelly	0.02	0.006	0.007	--	--	--
Cecil Park	0.0008	0.0002	0.0003	--	--	--
Cobbitty	0.02	0.006	0.008	--	--	--
Greendale	0.002	0.0007	0.0010	--	--	--
Kemps Creek	0.007	0.002	0.002	--	--	--
Luddenham	0.06	0.02	0.03	--	--	--
Mount Vernon	0.002	0.0006	0.0008	--	--	--
Mulgoa	0.007	0.002	0.003	--	--	--
Rossmore	0.005	0.002	0.002	--	--	--
Wallacia	0.008	0.002	0.004	--	--	--
Total (all SALs)	0.1	0.05	0.07	**--**	**--**	**--**

Scenario and SAL	Number of cases attributed to change in nitrogen dioxide					
	2033			2055		
	Mortality - all causes (ages 30 years and over)	Mortality - respiratory (all ages)	Asthma - ED hospital admissions (children aged 1 to 14 years)	Mortality - all causes (ages 30 years and over)	Mortality - respiratory (all ages)	Asthma - ED hospital admissions (children aged 1 to 14 years)
Prefer Runway 05						
Austral	0.007	0.003	0.004	0.02	0.007	0.01
Badgerys Creek	0.0007	0.0002	0.0003	0.002	0.0006	0.0008
Bringelly	0.02	0.006	0.007	0.05	0.02	0.02
Cecil Park	0.0008	0.0002	0.0003	0.002	0.0007	0.0007
Cobbitty	0.02	0.005	0.008	0.04	0.01	0.02
Greendale	0.002	0.0007	0.0009	0.005	0.002	0.002
Kemps Creek	0.007	0.002	0.002	0.02	0.006	0.007
Luddenham	0.07	0.02	0.04	0.2	0.05	0.08
Mount Vernon	0.002	0.0006	0.0008	0.005	0.002	0.002
Mulgoa	0.007	0.002	0.003	0.02	0.006	0.008
Rossmore	0.005	0.002	0.002	0.02	0.005	0.006
Wallacia	0.007	0.002	0.003	0.02	0.006	0.009
Total (all SALs)	0.1	0.05	0.07	0.4	0.1	0.2
Prefer Runway 23						
Austral	0.007	0.003	0.005	0.02	0.008	0.01
Badgerys Creek	0.0008	0.0003	0.0003	0.002	0.0007	0.0009
Bringelly	0.02	0.007	0.008	0.05	0.02	0.02
Cecil Park	0.0008	0.0003	0.0003	0.002	0.0007	0.0008
Cobbitty	0.01	0.005	0.008	0.04	0.01	0.02
Greendale	0.002	0.0006	0.0007	0.004	0.001	0.002
Kemps Creek	0.007	0.002	0.003	0.02	0.006	0.007
Luddenham	0.09	0.03	0.05	0.2	0.07	0.1
Mount Vernon	0.002	0.0006	0.0008	0.006	0.002	0.002
Mulgoa	0.007	0.002	0.003	0.02	0.006	0.008
Rossmore	0.006	0.002	0.003	0.02	0.005	0.007
Wallacia	0.006	0.002	0.003	0.02	0.005	0.008
Total (all SALs)	0.2	0.05	0.08	0.4	0.1	0.2

The predicted number of attributable cases, relevant to all scenarios is low, below one case per year. Assuming the maximum impacts always occurred each year, and the population was at that same location all day every day for a lifetime, the number of cases may be up to 40 over a 100-year period. This is considered to be overly conservative particularly within Luddenham, where the calculated health incidence is dominated by the maximum impact identified at receptor R19. Where the land use of this area is changed, consistent with the rezoning of the land adjacent to the Aerotropolis (excluding childcare uses) the potential health impacts would be significantly lower.

As detailed in Technical paper 2 the incremental impacts identified at R19 only occur for a few hours each year, under worst-case assumptions. Review of the hourly concentrations predicted at R19 indicates only a few hours where an hourly-average concentration between 200 µg/m^3 and 240 µg/m^3 may occur. These concentrations are below a level at which respiratory effects, including asthma, would be expected to occur within the population, from incidental short-term peak 1-hour average exposures of 376 µg/m^3 to 940 µg/m^3 (enRiskS 2018). Hence the potential for health impacts to occur as a result of these predicted worst-case limited, short duration elevated nitrogen dioxide concentrations is considered to be negligible.

Further where the average increase in nitrogen dioxide in the Luddenham area is assessed, which is more relevant to the assessment of population incidence rather than the maximum increase, for 2055-Prefer Runway 23 scenario, the calculated population incidence is as follows:

- Mortality all cause (ages 30 years and over) = 0.08
- Respiratory mortality (all ages) = 0.027
- Asthma emergency department admissions (ages 1–14) = 0.0071.

These population incidence levels are significantly lower and more representative of the population in the Luddenham area. The predicted number of attributable cases is low, well below one case per year. Assuming the maximum impacts always occurred each year, and the population remained in Luddenham all day every day for a lifetime, the number of cases may by up to 8 over a 100-year period. This incidence would be low in relation to the health statistics relevant to the study area.

It is noted that the calculated population incidence presented in Table 5.12 are lower than those presented in the 2016 EIS, however the location of higher levels of impacts are different reflecting the current flight path scenarios.

5.5.3 Carbon monoxide

As detailed in Section 5.5.3, health impacts associated with exposure to carbon monoxide in air has been assessed on the basis of a threshold, or guideline value. The guideline value adopted, namely the NEPC air standard, relates to total or cumulative exposures, and is protective of all adverse health effects for all members of the community. Table 5.13 presents a comparison of the maximum incremental and total concentration of carbon monoxide predicted anywhere off-site, within the local study area, with comparison against the NEPC air standard. Given that the maximum concentration of carbon monoxide presented in the table is well below the standard, only the maximum concentration is presented.

Table 5.13 Assessment of exposure to carbon monoxide

Scenario evaluated	Modelled concentration of carbon monoxide in air (µg/m^3)			
	Maximum 1 hour average off-site		Maximum 8 hour average off-site	
	2033	2055	2033	2055
No preference				
Incremental – project	389	--	181	--
Background	6,125		3,250	
Total/cumulative	6,514	--	3,431	--
Prefer Runway 05				
Incremental – project	389	1066	175	519
Background	6,125	6,125	3,250	3,250
Total/cumulative	6,514	7,191	3,425	3,769
Prefer Runway 23				
Incremental – project	422	1098	181	538
Background	6,125	6,125	3,250	3,250
Total/cumulative	6,547	7,223	3,431	3,788
NEPC Air standard	**30,000**	**30,000**	**10,000**	**10,000**

All concentrations of carbon monoxide predicted in the local study area are well below the relevant air standards. Hence there are no health risk issues of concern in relation to carbon monoxide emissions from the operation of aircraft associated with the project.

5.5.4 Sulfur dioxide

As detailed in Section 5.5.4, health impacts associated with exposure to sulfur dioxide in air has been assessed on the basis of a threshold, or guideline value. The guideline value adopted, namely the NEPC air standard, relates to total or cumulative exposures, and is protective of all adverse health effects for all members of the community. Table 5.14 presents a comparison of the maximum incremental and total concentration of sulfur dioxide predicted anywhere off-site, within the local study area, with comparison against the NEPC air standard. Given that the maximum concentration of sulfur dioxide presented in the table is well below the standard, only the maximum concentration is presented.

Table 5.14 Assessment of exposure to sulfur dioxide

Scenario evaluated	Modelled concentration of sulfur dioxide in air (µg/m^3)			
	Maximum 1 hour average		Maximum 24-hour average	
	2033	2055	2033	2055
No preference				
Incremental – project	47	--	6.3	--
Background	80		10.3	
Total/cumulative	127	--	16.6	--
Prefer Runway 05				
Incremental – project	118	106	13	16
Background	80	80	10.3	10.3
Total/cumulative	198	186	23.3	26.3
Prefer Runway 23				
Incremental – project	118	117	15	18
Background	80	80	10.3	10.3
Total/cumulative	198	197	25.3	28.3
NEPC Air standard	**286**	**286**	**57**	**57**

All concentrations of sulfur dioxide predicted in the local study area are well below the relevant air standards. Hence there are no health risk issues of concern in relation to sulfur dioxide emissions from the operation of aircraft associated with the project.

5.5.5 Individual VOCs

5.5.5.1 General

As detailed in Section 5.5.5, assessment of exposure to individual VOCs has involved assessment of acute and chronic inhalation exposures. Assessment of potential health impact has involved 2 calculation methods, one for the assessment of threshold effects and another for the assessment of non-threshold carcinogenic effects (relevant to benzene exposures).

5.5.5.2 Threshold effects

Acute and chronic inhalation exposures, where a threshold is relevant, have been assessed on the basis of a calculated risk index (RI), calculated as follows for each individual chemical:

$$\text{Risk Index (RI)} = \frac{\text{Exposure concentration}}{\text{TRV - background (where relevant)}}$$

Each individual RI is added up to obtain a total RI for all the threshold VOCs considered. The total RI is a sum of the potential hazards associated with all the threshold VOCs together assuming the health effects are additive, and is evaluated as follows (enHealth 2012):

- a total RI less than or equal to one means that all the maximum predicted concentrations are below the health based guidelines and there are no additive health impacts of concern
- a total RI greater than one means that the predicted concentrations (for at least one individual compound) are above the health based guidelines, or that there are at least a few individual VOCs where the maximum predicted concentrations are close to the health based guidelines such that there is the potential for the presence of all these together (as a sum) to result in adverse health effects.

Table 5.15 presents the calculated individual RI and total RI relevant to the assessment of acute inhalation exposures.

Table 5.16 presents the calculated individual RI and total RI relevant to the assessment of chronic inhalation exposures. It is noted that for the assessment of chronic exposures, the approach adopted assumes that the community is exposed at the location of maximum concentration 24-hours per day, every day for a lifetime. This results in a conservative assessment of exposure and health impacts.

The calculated RI relevant to acute and chronic exposures to VOCs in air presented in Table 5.15 and Table 5.16 are all below the target RI. Hence there are no risk issues of concern in relation to community exposures to these individual VOCs in air as a result of aircraft emissions from the project.

5.5.5.3 Non-threshold carcinogenic risk

Calculation of non-threshold carcinogenic risks involves the calculation of an incremental lifetime cancer risk, non-threshold risk. This is calculated as follows:

$$\text{Incremental lifetime risk (or non-threshold risk)} = \text{Exposure concentration x TRV}$$

This calculation relates to chronic exposures where the approach adopted assumes that the community is exposed at the location of maximum concentration 24-hours per day, every day for a lifetime. This results in a conservative assessment of exposure and health impacts.

Based on guidance from enHealth (enHealth 2012), an incremental lifetime risk less than or equal to 1 in 1,000,000 or 1×10^{-6} is considered so low it is negligible. Calculated individual risks of less than or equal to 1 in 100,000 or 1×10^{-5} are considered to be acceptable. Calculated individual risks that exceed 1 in 100,000 or 1×10^{-5} are considered to be elevated and potentially unacceptable. Table 5.17 presents the calculated incremental lifetime risk for benzene.

The calculated risks (as an incremental carcinogenic risk) relevant to exposures to benzene in air, for all scenarios evaluated, are well below the target risk level. Hence there are no risk issues of concern in relation to community exposures to benzene in air as a result of aircraft emissions from the project.

Table 5.15 Calcuated health impacts – Acute exposure to VOCs

Compound assessed	Acute health based guideline (µg/m³)	Maximum 1-hour average concentration (µg/m³)					Calculated RI				
		2033			2055		2033			2055	
		No preference	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23
Benzene	580	1.0	1.0	1.1	2.2	2.3	0.0017	0.0017	0.0019	0.0038	0.0039
Toluene	15,000	0.28	0.28	0.30	0.61	0.62	0.000018	0.000018	0.000020	0.000041	0.000041
Xylenes	7,400	0.25	0.25	0.27	0.54	0.55	0.000034	0.000034	0.000036	0.000073	0.000074
Formaldehyde	100	8.0	8.0	8.7	17.4	17.8	0.080	0.080	0.087	0.17	0.18
						Total RI	**0.082**	**0.082**	**0.089**	**0.18**	**0.18**
						Acceptable RI	**≤1**	**≤1**	**≤1**	**≤1**	**≤1**

Table 5.16 Calcuated health impacts – Chronic exposure to VOCs

Compound assessed	Chronic health based guideline (TRV) (µg/m³)	B* (% of TRV)	Maximum annual average concentration from project (µg/m³)					Calculated RI				
			2033			2055		2033			2055	
			No preference	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23
Benzene	30	20%	0.028	0.031	0.033	0.083	0.086	0.0012	0.0013	0.0014	0.0035	0.0036
Toluene	5,000	0%	0.0077	0.0086	0.0089	0.023	0.024	0.0000015	0.0000017	0.0000018	0.0000046	0.0000048
Xylenes	200	15%	0.0069	0.0077	0.008	0.02	0.021	0.000041	0.000045	0.000047	0.00012	0.00012
Formaldehyde	11	50%	0.22	0.25	0.26	0.66	0.68	0.040	0.045	0.047	0.12	0.12
							Total RI	**0.041**	**0.047**	**0.049**	**0.12**	**0.13**
							Acceptable RI	**≤1**	**≤1**	**≤1**	**≤1**	**≤1**

* B = background exposures to VOC as percentage of the TRV adopted

Table 5.17 Calcuated health impacts – Incremental lifetime carcinogenic risk

Compound assessed	Non-threshold TRV (µg/m³)⁻¹	Maximum annual average concentration – incremental (µg/m³)					Calculated RI				
		2033			2055		2033			2055	
		No preference	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23	Prefer Runway 05	Prefer Runway 23
Benzene	6×10^{-6}	0.028	0.031	0.033	0.083	0.086	1.7×10^{-7}	1.9×10^{-7}	2.0×10^{-7}	5.0×10^{-7}	5.2×10^{-7}
						Acceptable risk	**$\leq 1 \times 10^{-5}$**	**$\leq 1 \times 10^{-5}$**	**$\leq 1 \times 10^{-5}$**	**$\leq 1 \times 10^{-5}$**	**$\leq 1 \times 10^{-5}$**

5.5.6 Regional impacts

In addition to the localised impacts associated with changes in air quality, which are highest in the local study area, Technical paper 2 has also assessed impacts of the project on regional air quality. Specifically, the assessment has considered how emissions from aircraft associated with the project impact on concentrations of ozone and nitrogen dioxide within the regional study area. For the scenarios evaluated in 2033 and 2055 the NEPM criteria (NEPC 2021), which relates to an 8-hour average, are generally met. Where the NEPM criteria are exceeded, these exceedances relate to background levels with no contribution from the project related emissions.

The maximum increased in ozone concentration is 0.006 ppm for an 8 hour average. This maximum impact is 10% of the NEPM criteria of 0.065 ppm.

In relation to nitrogen dioxide the regional modelling shows the localised impacts, addressed in Section 5.5.2. Outside of these localised impacts there are no regional changes in nitrogen dioxide.

5.5.7 Impacts on drinking water quality

As detailed in Section 5.4.2 it has been conservatively assumed that key chemicals such as benzene, toluene, xylenes and formaldehyde are sorbed to particulates in air, and these will be large enough to deposit to the ground. While such chemicals would not be expected to deposit at all (as these are vapours and would degrade in air) a highly conservative approach has been adopted to predict concentrations that may be present in Prospect Reservoir and in residential rainwater tanks. These concentrations have been compared against the drinking water guidelines and a Risk Index (ratio of the concentration predicted with the drinking water guideline) is presented in Table 5.18. It is noted that water in rainwater tanks in urban areas such as Greater Sydney are not suitable for potable uses and hence this comparison is conservative.

Table 5.18 Calcuated health impacts – Impacts to drinking water

Pollutant evaluated	Calculated worst-case concentration in water (mg/L)		Drinking water guideline (mg/L)	Calculated RI	
	Prospect Reservoir	Rainwater tank		Prospect Reservoir	Rainwater tank
Benzene	2×10^{-9}	3×10^{-6}	0.001	0.000002	0.003
Toluene	3×10^{-9}	5×10^{-7}	0.8	0.000000004	0.0000006
Xylenes	2×10^{-9}	3×10^{-7}	0.6	0.000000003	0.0000004
Formaldehyde	2×10^{-6}	3×10^{-3}	0.5	0.000004	0.006
			Total RI	**0.000005**	**0.009**
			Acceptable RI	**≤1**	**≤1**

Based on the above calculations concentrations that may be present in drinking water supplies as a result of the project are negligible and potential impacts on community health are negligible.

Further, the predicted concentrations in drinking water are so low that they could never be measured (i.e. below the analytical limit of reporting that can be achieved by laboratories).

5.5.8 Uncertainties

The characterisation of impacts on community health from changes in air quality has utilised information available on exposure, which is expected to be conservative or provide an overestimation of actual exposures (refer to Section 5.4.3) and information on the hazards associated with exposure and quantitative values/approaches to assessing these hazards (where uncertainties relating to these values is discussed in Section 5.3.8). Where these uncertainties are considered, the approach adopted in this assessment is expected to provide a conservative evaluation of potential impacts on health from the project.

It is important to emphasise that the calculations undertaken in relation to estimating concentrations in Prospect Reservoir and rainwater tanks are highly conservative. The chemicals assessed are gases that readily degrade in the atmosphere, with the potential for sorption to particulates and deposition to the ground highly unlikely.

5.6 Outcomes in relation to impacts on community health

This assessment has addressed potential impacts on community health as a result of changes in air quality from the project, specifically emissions to air from the operation of aircraft in the local study area.

The assessment undertaken has not identified any risk issues of concern in relation to impacts on community health in the local study area. More specifically the assessment has identified the following:

- impacts on community health as a result of exposure to fine particulates (as $PM_{2.5}$) are low
- impacts on community health as a result of exposure to nitrogen dioxide are considered to be low. While there may be the potential for elevated exposures to occur close to the WSI, however further review of these impacts indicates that the potential impact on respiratory health is considered to be low. It is noted that the areas where elevated exposures are identified are expected to be rezoned such that residential use is no longer relevant
- impacts on community health as a result of exposure to carbon monoxide are low, and essentially negligible
- impacts on community health as a result of exposure to sulfur dioxide are low, and essentially negligible
- impacts on community health as a result of exposure to individual volatile organic compounds derived from aircraft emissions are low, and essentially negligible
- emissions to air derived from the operation of aircraft would have a negligible impact on water quality in Prospect Reservoir or rainwater tanks in the community. Potential impacts on these water supplies would be so low they would not be measured.

In addition to the above, no risk issues of concern in relation to community health has been identified in relation to changes in regional air quality.

Chapter 6 Assessment of health impacts: changes in noise

6.1 Introduction

The operation of aircraft as a result of the project results in the generation of noise that has the potential to impact on the community, particularly within the local study area. This assessment provides an assessment of the potential for aircraft noise from the project to impact on community health. This assessment has drawn on the assessment of noise impacts presented in Technical paper 1.

The assessment of aircraft noise impacts on community health has been undertaken on the basis of guidance detailed in Chapter 3. Figure 6.1 provides an overview of the approach adopted in this assessment.

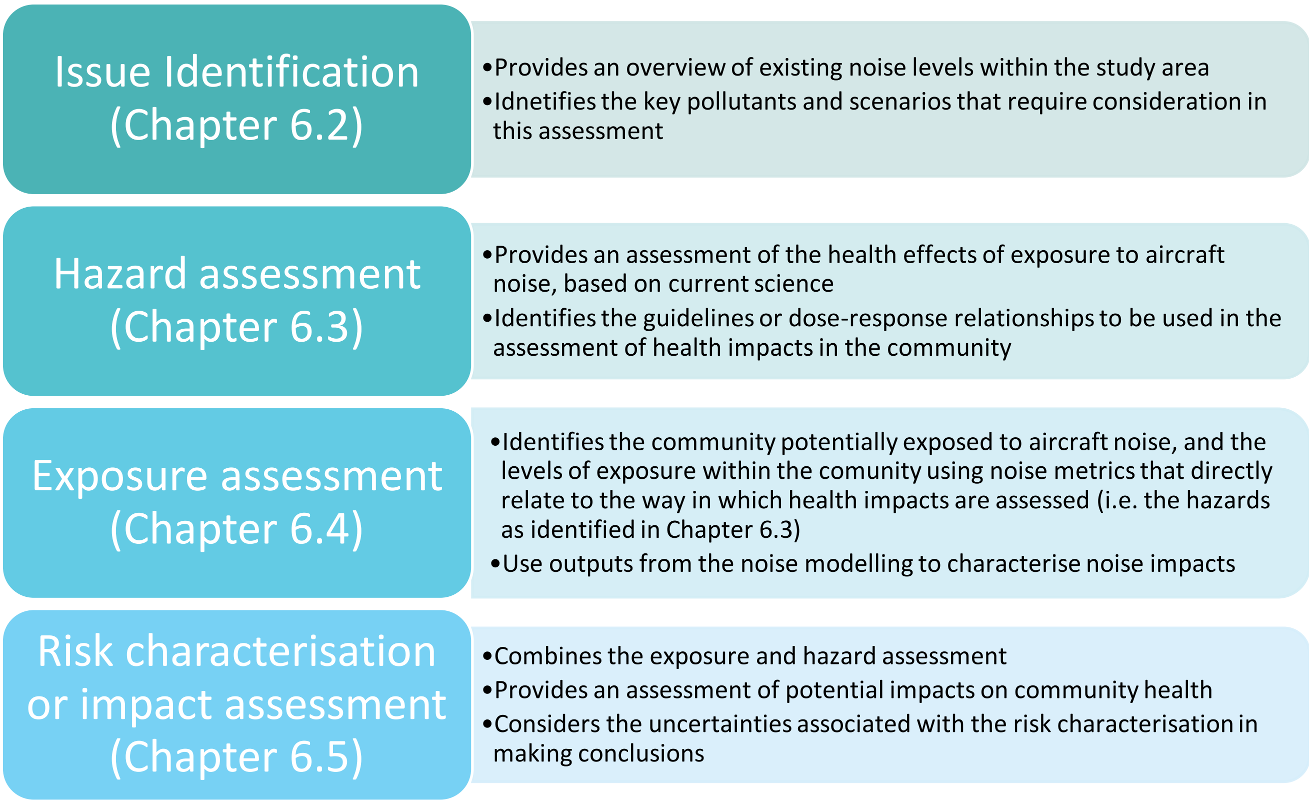


Figure 6.1 Approach to the assessment of health impacts from aircraft noise

6.2 Issue identification

6.2.1 Existing noise in the local study area

There are a variety of acoustic environments within the WSI study area. Ambient noise environments within the study area range from urban areas such as Penrith's CBD to rural areas that are largely removed from human-induced noise to the natural environments of the Greater Blue Mountains Area (World Heritage and National Heritage Place).

The existing ambient noise environment is mostly dominated by road traffic noise which is audible at nearly all locations emanating from a combination of relatively busy roads, up to and including the Western Motorway (M4), Westlink (M7 Motorway) and a hierarchy of other connector and local roads that carry varying levels of traffic.

Technical Paper 1 conducted ambient noise monitoring from August to October 2022 at 29 noise monitoring terminals (NMT) in the local and regional study area. This work measured the L_{Aeq} noise levels for the day, evening and night time periods, which was then used to establish Rating Background Levels (RBL) as defined by NSW EPA as the overall background noise level for each period.

In the NMT areas close to the airport, as the South West Departure, North East Departure and North East Runway, measured background noise levels as L_{Aeq} were in the range 58–67 dB(A) during the day, 47–53 dB(A) during the evening and 43–53 dB(A) at night-time. Within the other NMTs measured noise levels were fairly similar (with the exception of Luddenham where the highest background noise levels were reported, away from the WSI), with L_{Aeq} in the range 46–62 dB(A) during the day, 42–59 dB(A) during the evening and 41-58 dB(A) at night-time.

6.2.2 Aircraft noise

6.2.2.1 General

Aircraft noise is generated from the operation of aircraft related to this project. As the noise sources evaluated are operated on the ground, and in the air, noise is transmitted in all directions and from different elevations and during different phases of aircraft operation (such as approach and landing, climb, cruise and decent, take off and initial climb). Generally, noise on the ground from departing aircraft is louder than from that of an arriving aircraft, and long-range heavy, widebody aircraft with a full payload climb more slowly than smaller aircraft and therefore can be heard at high noise levels for longer. On approach, arriving aircraft are operating at a lower altitude further out from the airport which may cause noise impacts at large distances as well. Improvements in both airframe and engine technology have resulted in modern civil aircraft being more efficient and quieter.

Hence it is important that all aspects of aircraft operations are addressed when assessing impacts on community health.

Assessing the potential for aircraft noise to impact on community health has relied upon the modelling of noise presented in Technical paper 1. The modelling of aircraft noise takes into account a number of key variables that include the following:

- the projection of noise levels on the ground from specific aircraft along WSI's proposed arrival and departure flight path corridors
- the impacts of operational procedures, including the selection of a runway mode of operation (RMO) based on meteorological conditions, and any runway bias considered for noise abatement
- respite opportunities, specifically if reciprocal runway operations (i.e. head-to-head operations) (RRO), which directs all arrivals and departures in one direction (to the south-west) can be used during the sensitive night period (11 pm to 5.30 am local time) when decreased Sydney Basin air traffic with the Sydney (Kingsford Smith) Airport curfew creates opportunities for RRO).

More specifically the aircraft noise assessment considered the following:

- the flight path, its lateral and vertical profile and the nature of the terrain overflown, the level of precision assumed for visual, instrument or satellite-based navigation
- the typical operating aircraft, jet or non-jet, size and weight category and whether the operation is a departure or arrival
- stage lengths as classified in AEDT (i.e., stage 1 from 0 to 500 nm (926 km) from WSI to stage 9 over 6,500 nm (12,038 km) from WSI), fuel loads on departure and take-off weight, engine thrust settings and vertical profiles
- the frequency of use and time of day (day or night definitions and weightings depending on the metric involved), and
- the proximity of noise sensitive receivers (NSRs).

These aspects are addressed by describing the noise events (from aircraft movements on the ground and all phases of the flight in the air), the frequency of these events occurring and where these occur, and the time of these noise events.

6.2.2.2 Noise measures/metrics

The assessment of aircraft noise utilises a number of different metrics and standardised measures, not all of which can be directly used in the assessment of health impacts. Figure 6.2 shows the commonly used measures to describe noise impacts and Figure 6.3 further illustrates the relationship between these noise metrics (generic representation only, not representative of WSI operation). This shows the variability in noise levels that can occur during aircraft operation, nothing that the L_{Aeq} value as an averaging metric can be significantly exceeded in noise levels by a number of overflight events across the day.

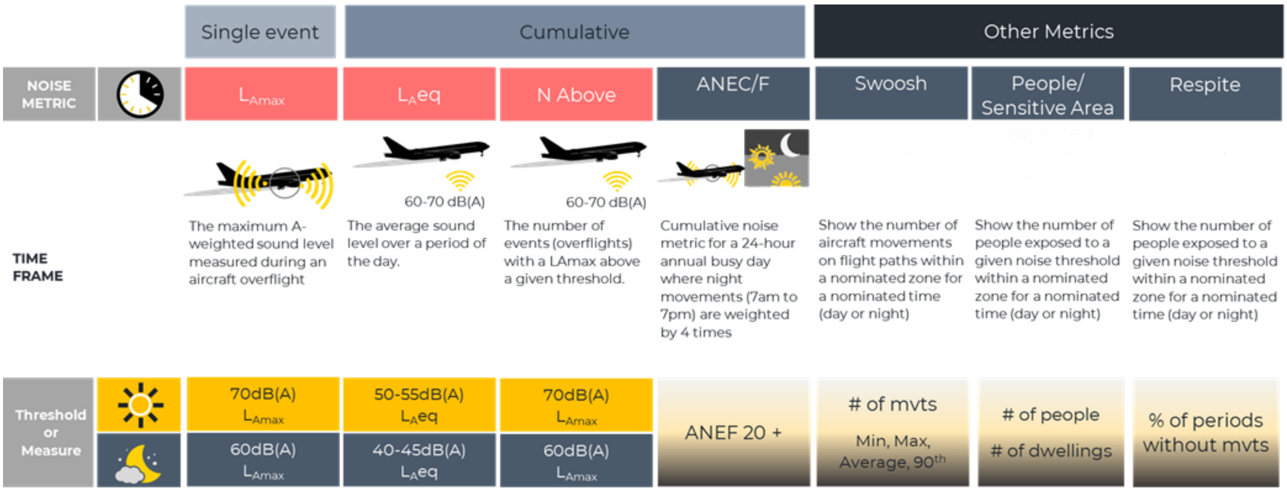


Figure 6.2 Noise measures or metrics to describe and assess aircraft noise impacts

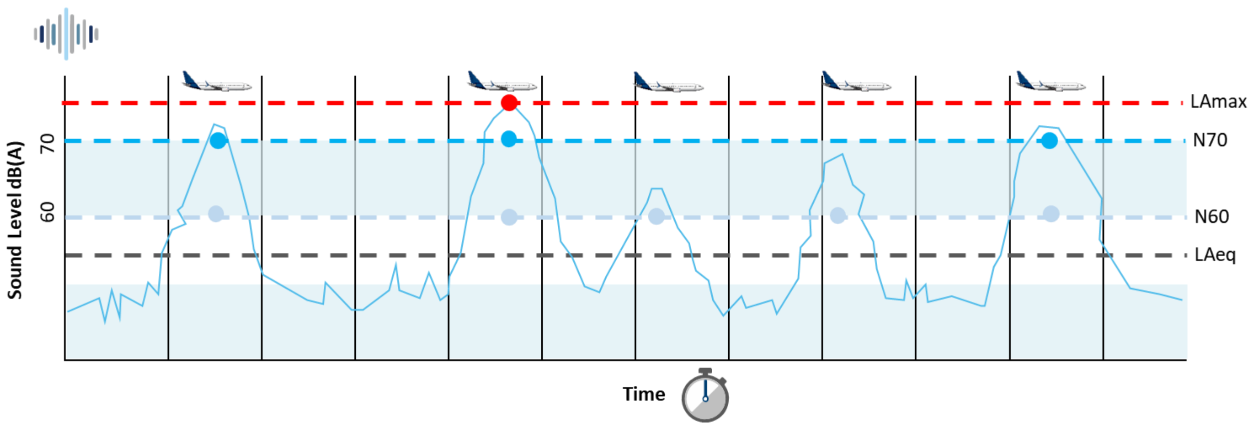


Figure 6.3 Relationship between different noise metrics (generic representation only)

A number of aircraft noise specific metrics are used to describe noise impacts. These include the following:

- ANEF: The metric adopted for land use planning in the vicinity of airports in Australia is the Australian Noise Exposure Forecast (ANEF) system. It is based on the international NEF (Noise Exposure Forecast) metric, which uses a cumulative aircraft noise for an average day based on one year of projected future air traffic movements. The ANEF system guides land use based on a "noise-dose" response curve from data from carefully designed social surveys. It correlates the noise exposure with the proportion of people who describe themselves as "seriously affected by aircraft noise". It is the basis of Australian Standard AS2021:2015 – Acoustics – Aircraft Noise Intrusion – Building Siting and Construction. AS2021 contains advice on the acceptability of building sites based on ANEF zones. The ANEF definition is complex, and as a single-number index rather than a noise measure in decibels, it does not provide the level of information generally sought by community stakeholders. For these reasons, the ANEF is limited in its applicability to an assessment of changing aircraft noise exposure and land-use planning implications of an airport operation.
- ANEC: An Australian Noise Exposure Concept (ANEC) is a noise exposure chart produced for a projected future airport usage scenario and is useful for considering the land use planning consequences of alternative operating strategies. ANEC noise exposure contours are calculated using the same methods as the ANEF. However, they use indicative data on aircraft types, aircraft operations and flight paths and are generally used in environmental assessments to depict and compare noise exposure levels for different runway or flight path options.

  For the assessment of potential impacts of aircraft noise on community health the metrics of ANEF and ANEC have not been used.
- 'N-above' of N60 (24-hour), N60 (night-time) and N70 (24-hour). These describe aircraft noise impacts by the number of noise events (or the number of aircraft fly-over noise events) that exceed a certain noise level. These noise metrics relate to A-weighted decibel levels of 60 dBA (for N60) and 70 dBA (for N70). The most commonly used N-above level is N70, as outdoor levels of 70 dB(A) can lead to indoor levels around 60 dB(A) which is enough to disturb normal conversation. At night, the N60 level is commonly used, as this reflects and indoor noise level of 50 dB(A) which has been found to trigger awakenings in some people.
- N-above values for future operating scenarios are based on an average day schedule based on historical meteorological data (i.e., wind speed and direction) and used to allocate the flight paths to distribute the traffic.
- In addition to these metrics another commonly used metric is L_{Amax} with is the average (mean) of the maximum noise level predicted at a location, during a series of flyovers. This metric utilises an A-weighted decibel measure.
- The 'N-above contours' provide a cumulative-event descriptor, which provides an assessment of the sustained exposure to aircraft noise. For the assessment of aircraft noise, the following metrics have been used:
  - N70 (24-hour) contours, which represents a defined number of aircraft noise events (with 5, 10, 20, 50 and 100 evaluated) with L_{Amax} that exceed 70 dB(A) over a 24-hour period. N70 is typically used to assess day-time noise impacts. An outside noise event of 70 dB(A) (such as aircraft flyover) can lead to an indoor sound level of 60 dB(A) when windows are open (enough to disturb conversation)
  - N60 (24-hour) contours represent a defined number of aircraft noise events (with 10, 20, 50, 100 and 200 evaluated) with L_{Amax} that exceed 60 dB(A) over a 24-hour period
  - N60 (night-time) contours, which represent a defined number of aircraft noise events (with 2, 5, 10, 20 and 50 evaluated) with L_{Amax} that exceed 60 dB(A) over the night-time period (defined as 11 pm to 5:30 am). An outside noise event of L_{Amax} that exceeds 60 dB(A) results in an indoor maximum sound level of 50 dB(A) with windows open, or 40 dB(A) with windows closed.

The measures above, while relevant to assessing and managing aircraft noise, do not incorporate noise measures that specifically relate to health impacts (refer to Section 6.3). The assessment of potential health impacts requires the use of more commonly used noise metrics as follows:

- L_{Aeq} – this represents the level of average noise energy over the period of measurement and takes account of noise peaks and fluctuations. This noise measure is used over specific assessment periods, as day, evening and night
- L_{den} – this represents the average noise energy over a 24-hour period, i.e. over the day, evening and night (as L_{Aeq})
- L_{night} – this represents the average noise level over the night-time period and is a key measure to inform the assessment of sleep disturbance.

These are the noise measures that have been further considered in this assessment.

6.2.3 Noise sensitive receivers

Technical paper 1 has predicted sound levels from the WSI aircraft operations at a number of specific noise sensitive receivers (NSRs). These are specific locations in the community that include schools, community centres, hospitals, aged-care centres, childcare, residential areas, shopping malls, recreation areas and places of worship.

The NSRs and NMTs are shown in Figure 6.4.

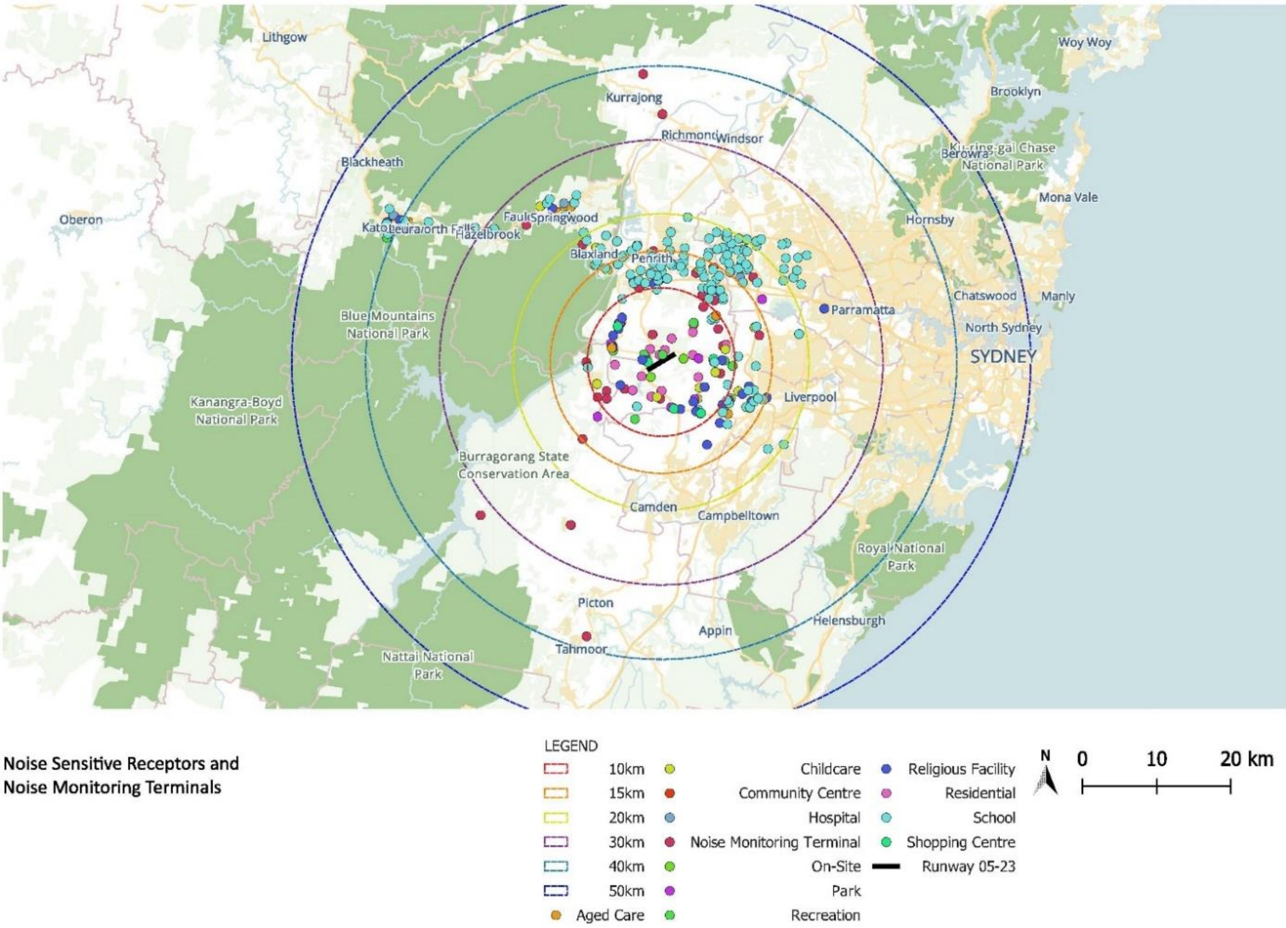


Figure 6.4 Noise sensitive receptors (NSRs) and noise monitoring terminals (NMTs)

6.2.4 Scenarios evaluated

Technical paper 1 has evaluated representative or reference years of operation. These reference years are as follows:

- 2033 – Early years with 81,000 air traffic movements (ATMs)
- 2040 – Interim year with 107,000 ATMs
- 2055 – Capacity with around 226,000 ATMs.

This assessment has only considered noise impacts associated with operations in 2033 and 2055.

The assessment has considered operations on a single runway, which will operate in 2 runway directions which can be used by either departing or arriving aircraft. The runway modes of operation have been addressed through scenarios S1 to S7, with noise modelling presented for the following key scenarios:

- No preference: No priority for runways during day or night time operations (which would provide the worst-case night-time operations)
- Prefer Runway 05: Prioritise 05 with RRO, with day operations preferring runway 05 and night-time operations as RRO or no priority
- Prefer Runway 23: Prioritise 23 with RRO, with day operations preferring runway 23 and night-time operations as RRO or no priority.

These scenarios have been evaluated in this assessment for operational years 2033 and 2055.

6.3 Hazard assessment – health effects of aircraft noise

6.3.1 General

Environmental noise has been identified (I-INCE 2011; WHO 2011a, 2018) as a growing concern in urban areas because it has negative effects on quality of life and wellbeing and has the potential for causing harmful physiological health effects. With increasingly urbanised societies, impacts of noise on communities have the potential to increase over time.

Sound is a natural phenomenon that only becomes noise when it has some undesirable effect on people or animals. Unlike chemical pollution, noise energy does not accumulate either in the body or in the environment, but it can have both short-term and long-term adverse effects on people. These health effects include (WHO 1999, 2011a, 2018):

- sleep disturbance (sleep fragmentation that can affect psychomotor performance, memory consolidation, creativity, risk-taking behaviour and risk of accidents)
- annoyance
- cardiovascular health
- hearing impairment and tinnitus
- cognitive impairment (effects on reading and oral comprehension, short and long-term memory deficits, attention deficit).

Other effects for which evidence of health impacts exists, and are considered to be important, but for which the evidence is weaker, include:

- effects on quality of life, well-being and mental health (usually in the form of exacerbation of existing issues for vulnerable populations rather than direct effects)
- adverse birth outcomes (pre-term delivery, low birth weight and congenital abnormalities)
- metabolic outcomes (type 2 diabetes and obesity).

Within a community, the severity of the health effects of exposure to noise and the number of people who may be affected are schematically illustrated in Figure 6.5.

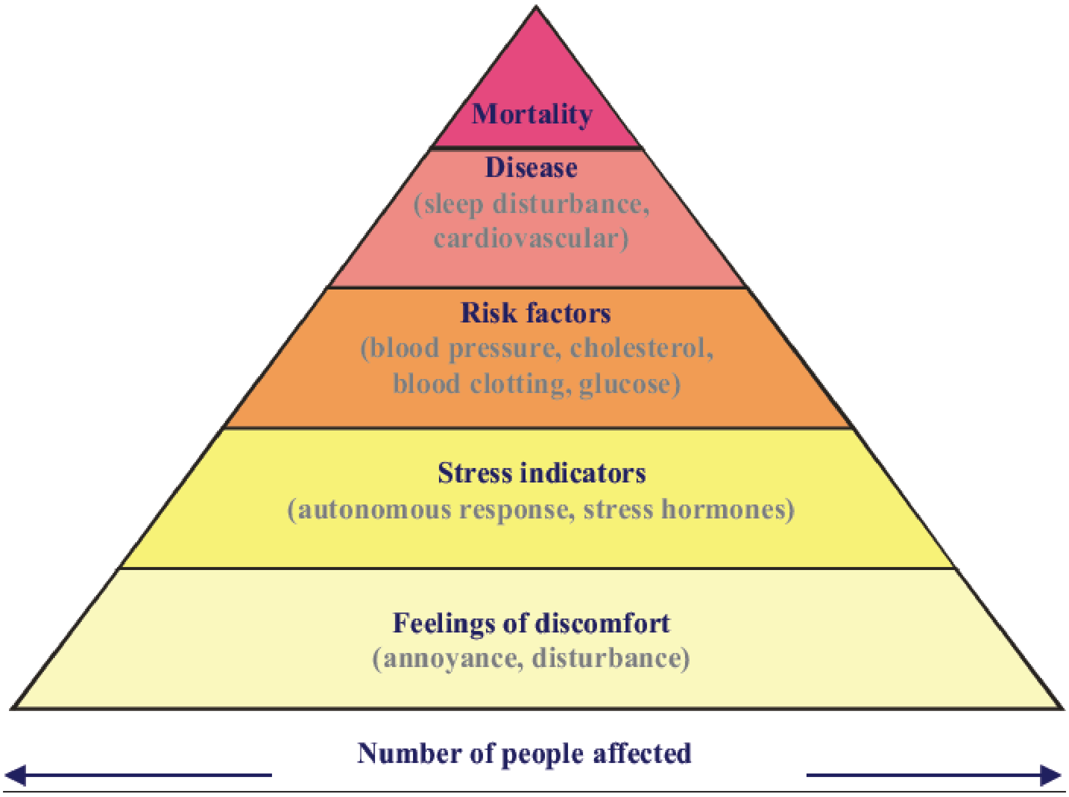


Figure 6.5 Schematic of severity of health effects of exposure to noise and the number of people affected (WHO 2011a)

Often, annoyance is the major consideration because it reflects the community's dislike of noise and their concerns about the full range of potential negative effects, and it affects the greatest number of people in the population (I-INCE 2011; WHO 2011a, 2018).

There are many possible reasons for noise annoyance in different situations. Noise can interfere with speech communication or other desired activities. Noise can contribute to sleep disturbance which has the potential to lead to other long-term health effects. Sometimes noise is just perceived as being inappropriate in a particular setting without there being any objectively measurable effect at all. In this respect, the context in which sound becomes noise can be more important than the sound level itself (I-INCE 2011; WHO 2011a, 2018).

Different individuals have different sensitivities to types of noise and this reflects differences in expectations and attitudes more than it reflects any differences in underlying auditory physiology. A noise level that is perceived as reasonable by one person in one context (e.g. in their kitchen when preparing a meal) may be considered completely unacceptable by that same person in another context (e.g. in their bedroom when they are trying to sleep). In this case the annoyance relates, in part, to the intrusion from the noise. Similarly, a noise level considered to be completely unacceptable by one person, may be of little consequence to another even if they are in the same room. In this case, the annoyance depends almost entirely on the personal preferences, lifestyles and attitudes of the listeners concerned (I-INCE 2011; WHO 2011a, 2018).

When characterising the potential for aircraft noise to be of concern to community health it is important to consider the available studies and evidence that underpins these effects. In this review, and consistent with a number of published reviews, the strength of evidence for adverse health effects presented in different studies has been undertaken on the basis of the WHO approach (WHO 2009, 2018), which considers the following:

- whether there is a causal relationship that is biologically plausible
- whether there are consistent findings reported across a range of different methodologies or studies
- if the study identifies an exposure-response relationship.

This enables the strength of the evidence to be classified as, noting the WHO (2018 review utilised the GRADE system to establish these aspects):

- Sufficient: where there is clear evidence of a causal relationship and biological plausibility is established. In these cases, the studies are not confounded by coincidence, bias or distortion.
- Limited: where there is some evidence to support a causal relationship, however confounding factors cannot be excluded. These studies may also include indirect evidence and is supported by biological plausibility.
- Insufficient: where the available studies are of low quality and lack significance to allow conclusions about causality. The biological plausibility is limited or absent.

The key health outcomes for which effects are considered by the WHO (WHO 2018) to be critical, and for which impacts can be quantified for transport noise sources, relate to annoyance, cardiovascular effects, cognitive impairment and sleep disturbance. Other health outcomes that were identified by the WHO (2018) as important include adverse birth outcomes, quality of life, well-being and metal health, and metabolic outcomes. These health effects, as they relate to aircraft noise, are further discussed in the following sections.

Based on the WHO (2018) review of the health effects of noise the following noise levels were recommended:

- noise levels from aircraft should be 45 dB(A) as L_{den} or lower, as noise levels above this level is associated with adverse health effects
- noise levels from aircraft should be 40 dB(A) as L_{night} or lower, as noise levels above this level is associated with adverse effects on sleep, noting the WHO guidelines for night time noise (WHO 2009) indicate a threshold of 42 dB(a) indoors as L_{max}, which is equivalent to 52 dB(A) as L_{max} outdoors for awakenings
- WHO (WHO 1999) indicate that hearing impairment can occur where L_{max} is 110 dB(A) and higher, or 70 dB(A) as $L_{Aeq,T}$ (as day, evening or night).

6.3.2 Annoyance

Annoyance is a feeling of displeasure associated with any agent or condition known or believed by an individual or group to adversely affect them. It is one of the most prevalent responses to noise, and it is described as a stress reaction that encompasses a wide range of negative feelings, including disturbance, dissatisfaction, distress, displeasure, irritation and nuisance. The individual response to noise depends not only on exposure levels but also on contextual, situational and personal factors. It can initiate physiological stress reactions that, if long-term, could trigger the development of cardiovascular disease.

Annoyance levels can be reliably measured by means of an ISO 15666 defined questionnaire, which has enabled the identification of relationships between annoyance and noise sources. There is evidence of sufficient strength of evidence for environmental noise annoyance (van Kamp, I. et al. 2020). Exposure-response relationships have been established for noise annoyance from transport sources, including aircraft noise, road traffic noise and rail noise, with the measure of the percentage of the population highly annoyed (%HA) to levels of noise reported as L_{den} (i.e. average noise level over a 24-hour period) considered to be the most appropriate health outcome for evaluating and quantifying effects from noise exposure.

A number of reviews (AEF 2016; Clark 2015; EC 2002a; Manchester Metropolitan University 2009; WHO 2011a, 2018) have determined that there is sufficient evidence linking aircraft noise and annoyance in the community. Major studies in the UK and worldwide have concluded that aircraft noise is associated with a stronger annoyance response than road traffic noise at the same average level (AEF 2016; WHO 1999) and that annoyance is increasing even as individual aircraft become quieter.

The WHO evaluation on annoyance from environmental noise (Guski, Schreckenberg & Schuemer 2017) evaluated studies published between 2000 and 2014, with the DEFRA review (van Kamp, I. et al. 2020) including studies to 2019. These reviews included pooled data for use in meta-analysis, where exposure-response functions were determined in relation to the % of population that is highly annoyed (%HA) by L_{den} noise. The quality of the evidence for an association between aircraft noise and %HA was judged to be moderate. The data and exposure response functions relating to aircraft noise, however, have then subject to further debate in relation to the validity of the evidence (in particular some studies have not used standardised methods) used for assessing and determining exposure response functions published by Guski et al (Guski, Schreckenberg & Schuemer 2017).

Figure 6.6 presents a summary of the data points from each of the 12 studies evaluated in the meta-analysis by Guski et al (2017), along with the aggregated exposure-response function from the meta-analysis (labelled 'Regr WHO fill dataset'), with comparison against the exposure-response functions used by regulatory agencies prior to the WHO (2018) evaluation, namely the relationships from Miedema and Ousdhom (Miedema, HM & Oudshoorn 2001) and Janssen and Vos (Janssen & Vos 2009). It is clear from this figure that the exposure-response relationship developed by the WHO (2018) is different to the relationship from Miedema and Ousdhom (2001), with the WHO suggesting a greater %HA at the same level of noise exposure.

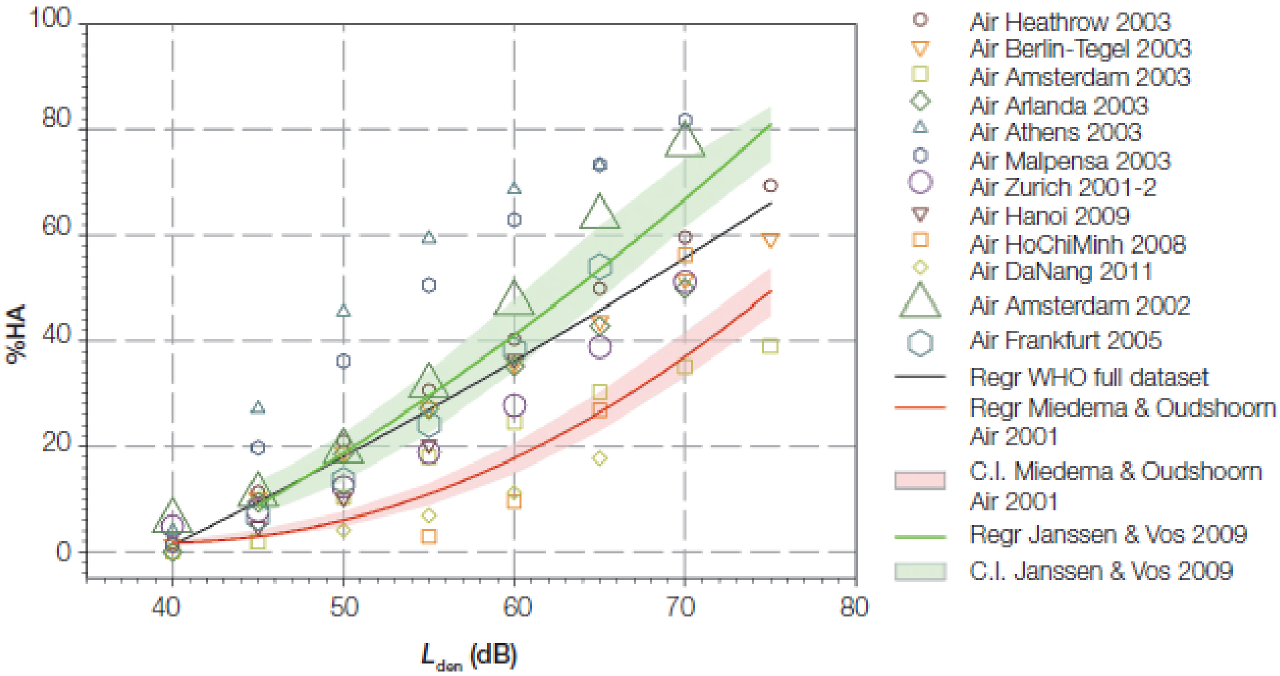


Figure 6.6 Scatterplot of response data from 12 studies included in WHO review and exposure-response function for aircraft noise determined from WHO meta-analysis, with comparison against former exposure-response functions (the size of the markers correspond to the number of respondents in each study) (Guski, Schreckenberg & Schuemer 2017)

The exposure-response function developed in the WHO (2018) (Guski, Schreckenberg & Schuemer 2017) review for aircraft noise has been the subject of considerable debate in the literature, with critiques suggesting that the former exposure-response function adopted by the EU (Miedema, HM & Oudshoorn 2001; Miedema, HME & Vos 1998) should be retained in preference. Given the new studies that are available, many of which indicate exposure-response relationships between these 2 curves, it is reasonable that an updated meta-analysis be undertaken to incorporate all suitable studies to update the exposure-response function adopted for aircraft noise. This has yet to be undertaken.

In the absence of an updated relationship for aircraft noise, the relationships established by Guski et al (2017) has been used in this assessment. A sensitivity analysis has also been included where the former EU relationship (Miedema, HM & Oudshoorn 2001; Miedema, HME & Vos 1998) has been considered. This relationship is as follows:

$$\%HA = -50.9693 + 1.0168 \times L_{den} + 0.0072 \times L_{den}^2$$

For annoyance, which is considered a less serious health effect than self-reported sleep disturbance, the relevant risk has been determined by the WHO (WHO 2018) to be 10%HA. This means the absolute risk associated with exposure should be close to, but not above 10%HA, to be health protective.

6.3.3 Sleep disturbance

Sleep serves to facilitate vital functions in our body. It is relatively well-established that night time noise exposure can have an impact on sleep (enHealth 2018; WHO 2009, 2011a). Noise can cause difficulty in falling asleep, awakening and alterations to the depth of sleep, especially a reduction in the proportion of healthy rapid eye movement sleep. Other primary physiological effects induced by noise during sleep can include changes in glucose metabolism and appetite regulation, impaired memory consolidation and a dysfunction in blood vessels. Long-term sleep disturbance can also lead to cardiovascular health issues (WHO 2011a, 2018). Exposure to night-time noise also may induce secondary effects, or so-called after-effects. These are effects that can be measured the day following exposure, while the individual is awake, and include increased fatigue, depression and reduced performance.

When assessing health issues related to exposure to night-time noise there are a number of aspects that need to be considered:

- **Length of the night**: Individuals may sleep for varying different durations at night. To capture the time over which most sleep activity will occur, an 8 hour time period, usually between 10 pm and 6 am or 11 pm and 7 am (adopted in the UK and the Netherlands), is used in noise studies and guidelines to define the night-time period.
- **Noise measure**: When assessing noise, a wide range of studies are undertaken that are used to evaluate long-term exposures, using L_{Aeq} over the night-time period, and single noise events using L_{Amax} or a sound exposure level (SEL). Both these measures are of importance for characterising noise exposures at night time (WHO 2009).
- **Assessment point**: The measurement of noise relevant to evaluating sleep disturbance issues can be based on data collected from a range of sleep studies where the noise measure is indoors where the sleeping occurs. There are other studies where the noise measures relate to modelled or measured values outside, commonly assumed to be at the facade of the building. The relationship between indoor and outdoor noise levels will depend on the location, aircraft used and the outdoor to indoor attenuation levels which will vary significantly with different home constructions and if windows are open, partially open or closed. Many of these factors are not known and cannot be controlled. Hence it is more useful to consider noise measures that relate to outdoor noise levels, rather than indoors. However, it should be noted that guidelines are available that relate to both measures.

When considering the available studies, it is important that the above aspects are considered to ensure the studies can be compared on the same basis. This has been undertaken in the detailed reviews undertaken and considered in this assessment.

The WHO (2009) has determined that there is sufficient evidence for a causal relationship between exposure to night noise (in general) and health effects, that include:

- biological effects, based on direct evidence: increased heart rate, arousals, sleep stage changes and awakening; and
- indirect evidence: Self-reported sleep disturbance, increased in medication use, increase in body movements and (environmental) insomnia.

The biological plausibility of health effects associated with noise-induced sleep disturbance has also been well established. Noise-induced sleep disturbance is considered to be a health problem in itself; however, it can also lead to other effects on health and well-being.

Review by the WHO (WHO 2018) concluded that the key outcome of percentage of the population that is highly sleep disturbed (%HSD) was considered most appropriate for determining actions and outcomes in relation to transport noise, with relationships established on the basis of night-time noise as L_{night}. Hence this assessment has focused on %HSD. The quality of the available studies included in the WHO review (Basner, Mathias & McGuire 2018), relevant to assessing sleep disturbance from aircraft noise was determined to be verry low. Further review of the impacts of aircraft noise by DEFRA (van Kamp, I. et al. 2020; van Kamp et al. 2019) indicated that the exposure-response relationships established by WHO (2018) was expected to be conservative, based on the outcomes of additional studies not considered by the WHO. No new meta-analysis of all relevant studies has been undertaken and hence the current exposure-response relationship established by WHO has been adopted for this assessment, which is as follows (with the quality of evidence determined to be moderate (Basner, Mathias & McGuire 2018)):

$$\%HSD = 16.7885 – 0.9293 \times L_{night} + 0.0198 \times L_{night}^2$$

The WHO (2009) review identified a threshold for effects on sleep disturbance which ranged from 40–42 dBA as L_{night} outside (for effects with sufficient evidence).

The study by Elmenhorst (Elmenhorst, E-M et al. 2019) involved pooled results from 3 small laboratory studies with 237 individuals. These pooled results showed that the 3 major transport noise sources differ in their impact on sleep. Results indicate that different traffic noise sources induce different awakening probabilities, even at equal maximum A-weighted sound pressure level (SPL) and even after adjusting for acoustical parameters as well as physiological parameters. At equal maximum A-weighted SPL the awakening probability due to the 3 traffic noise sources increased in the order aircraft < road < railway noise. These findings support results from field studies conducted by the authors (Basner, M., Müller & Elmenhorst 2011; Elmenhorst, EM et al. 2010; Elmenhorst, EM et al. 2012; Marks, Griefahn & Basner 2008) that also indicated a higher awakening probability due to railway noise in comparison to aircraft noise, as well as outcomes on sleep continuity. The order, however, is inverse to that associated with noise annoyance. Further, the susceptibility to noise induced awakenings or arousals is highly variable among individuals. The exposure-response functions adopted for assessing noise impacts on communities represent an individual with average noise susceptibility. These relationships do not address susceptible groups.

6.3.4 Cardiovascular effects

Noise is an important risk factor for chronic diseases. Noise exposure activates stress reactions in the body, leading to increases in blood pressure, a changing heart rate and a release of stress hormones.

Cardiovascular diseases are the class of diseases that involve the heart or blood vessels, both arteries and veins. These diseases can be separated by end target organ and health outcomes. Strokes reflecting cerebrovascular events and ischaemic heart disease (IHD) or coronary heart disease (CHD) are the most common representation of cardiovascular disease.

High-quality epidemiological evidence on cardiovascular and metabolic effects of environmental noise indicates that exposure to environmental noise, including aircraft noise increases the risk of IHD.

A link between noise and hypertension is relatively well established in the relevant literature. Whilst there is not a consensus on the precise causal link between the two, there are a number of credible hypotheses. A leading hypothesis is that exposure to noise could lead to triggering of the nervous system (autonomic) and endocrine system which may lead to increases in blood pressure, changes in heart rate, and the release of stress hormones. Depending on the level of exposure to excess noise, the duration of the exposure and certain attributes of the person exposed, this can cause an imbalance in the person's normal state (including blood pressure and heart rate), which may make a person hypertensive (consistently increased blood pressure) which can then lead to other cardiovascular diseases (DEFRA 2014).
This hypothesis is illustrated in Figure 6.7.

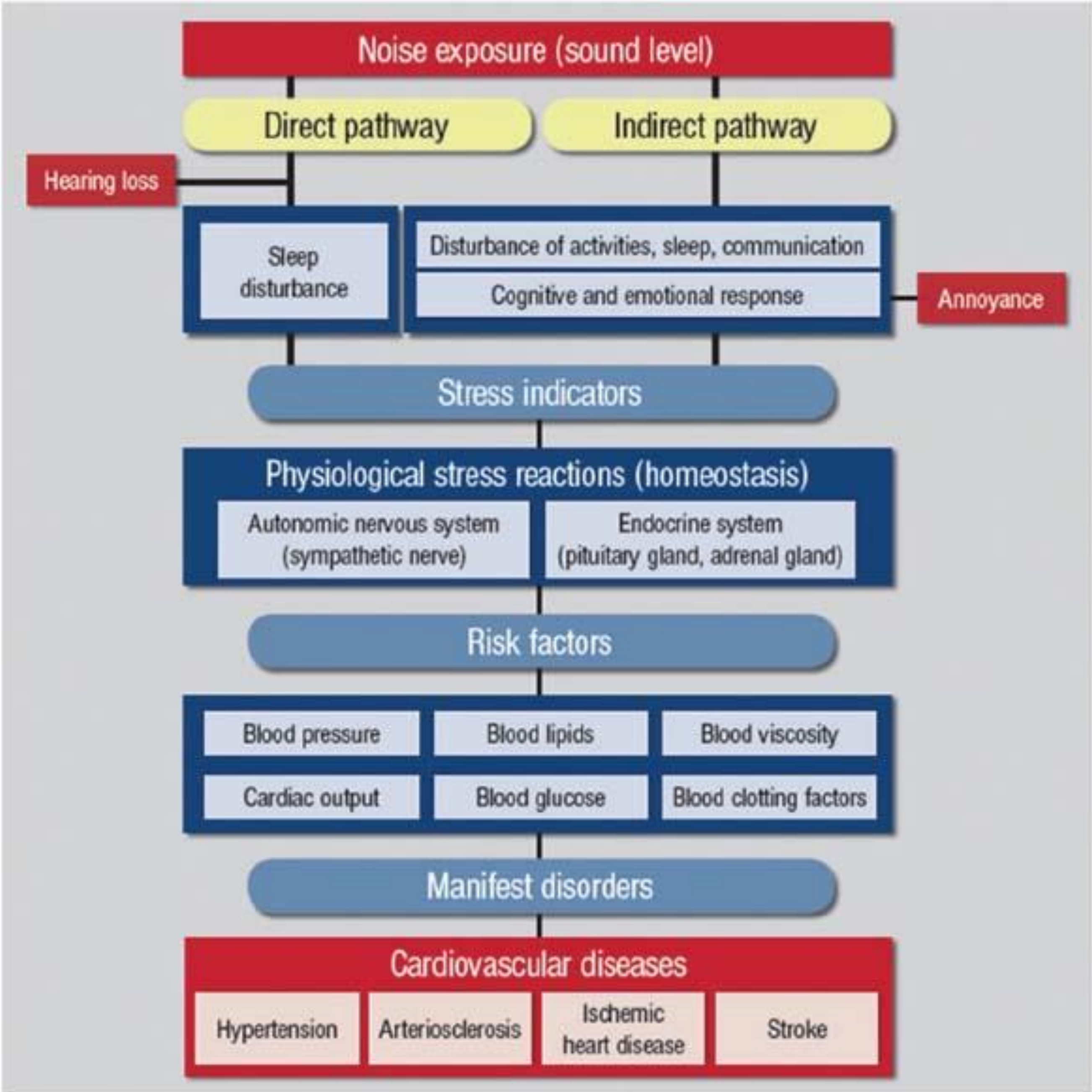


Figure 6.7 Noise reaction model/hypothesis for cardiovascular effects (Babisch 2014)

A more recent review (Münzel et al. 2020) of evidence provided from epidemiological, translational, and basic science models shows that night-time noise compared with daytime noise is associated with more adverse cardiovascular effects. Compared with daytime noise, night-time noise leads to a stronger stress reaction as indicated by higher neurohormone levels, higher increases in oxidative stress, more pronounced vascular stiffness, and arterial hypertension, as well as perhaps a higher incidence of cardiovascular and metabolic diseases (refer to Figure 6.8). Also, some evidence suggests that intermittent noise with peaks clearly above the background levels (as an intermittency ratio [IR] (Wunderli et al. 2016)) during the night-time may be particularly harmful, with the associations with cardiovascular mortality stronger with moderate IR levels during the night-time (Héritier et al. 2017; Münzel et al. 2020).

Animal models provide some insight on the mechanisms behind the effects of night-time noise on CVD, including a disturbance of the circadian clock (body's internal clock) due to downregulation of genes responsible for regulating the circadian rhythm (24-hour cycles which are part of the body's internal clock). Furthermore, animals exposed to noise revealed significant changes in the expression of genes responsible for the regulation of vascular function, vascular remodelling, and cell death (Münzel et al. 2020).

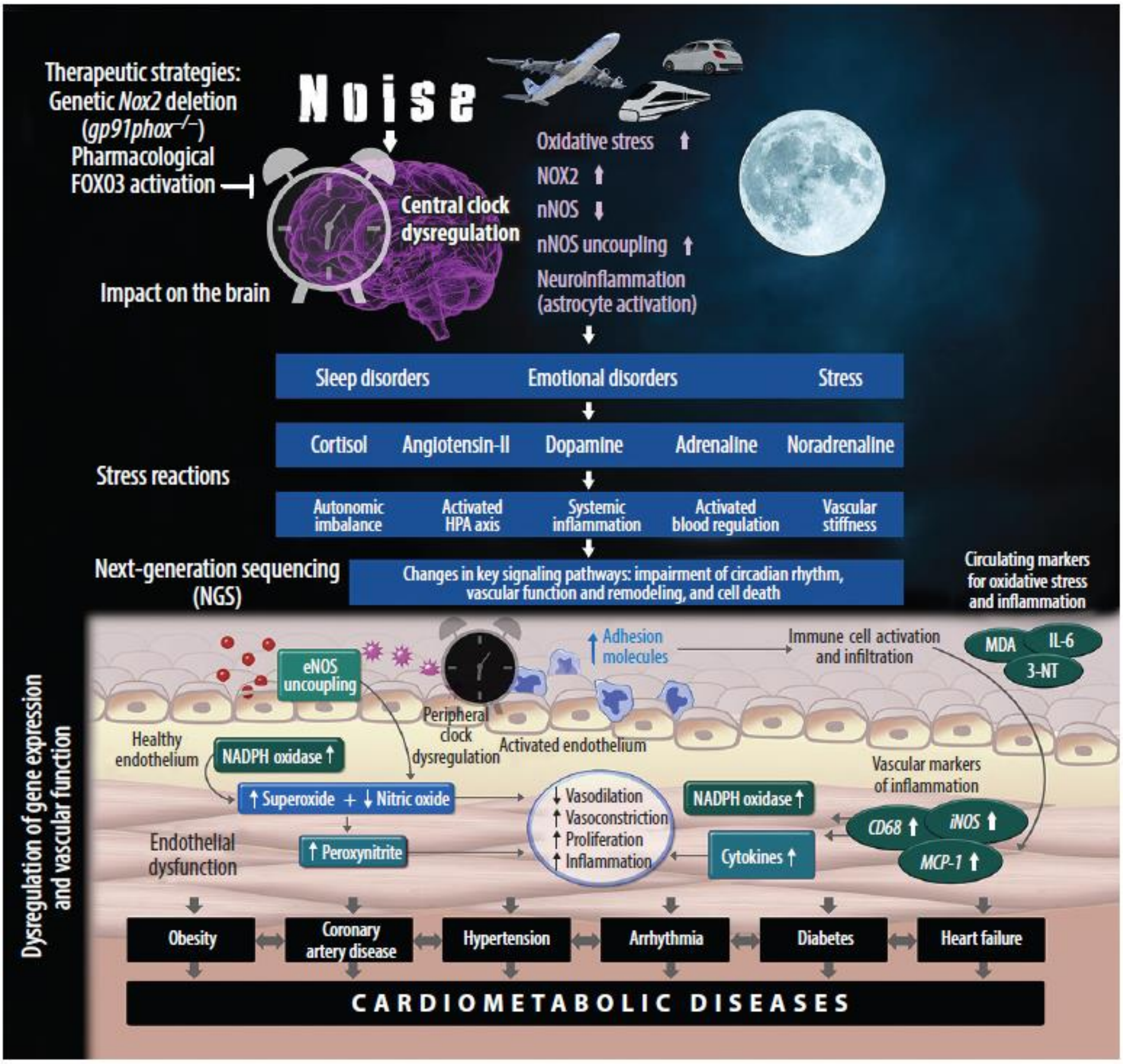


Figure 6.8 **Pathophysiology of night-time noise–induced cardiovascular and brain disease.** Genetic *Nox2* deficiency and pharmacological FOXO3 activation by bepridil prevented the adverse noise effects. Abbreviations: 3-NT, 3-nitrotyrosine; CD68, macrosialin; eNOS, endothelial nitric oxide synthase; HPA, hypothalamic-pituitaryadrenal; IL-6, interleukin 6; iNOS, inducible nitric oxide synthase; MCP-1, monocyte chemoattractant protein-1; MDA, malondialdehyde. (Münzel et al. 2020)

It is clear from the available information/data, including the most recent reviews, that there is sufficient evidence of a causal relationship between exposure to environmental noise and cardiovascular disease outcomes (enHealth 2018; WHO 2018). The health measures to be used in the quantification of cardiovascular effects is important.

The following presents a summary of the strength of evidence relevant to other cardiovascular effects considered in the available studies:

- Hypertension in children – limited evidence (CAA 2016; Stansfeld, Stephen & Clark 2015)
- Stroke – insufficient evidence (Weihofen, V.M. et al. 2016; WHO 2011a) with recent reviews not identifying a statistically significant relationship (Weihofen, V. M. et al. 2019)
- Myocardial infarction – insufficient evidence in relation to aircraft (and other transport noise) (Khosravipour & Khanlari 2020).

Hypertension in adults has been previously considered to be a potential health impact of aircraft noise (AEF 2016; WHO 2011a), however review of the available studies by the WHO (2018) indicates that the quality of evidence in the studies for aircraft noise is very low. The WHO (2018) review included hypertension regardless of the low quality of evidence and inconsistent outcomes, as it was considered to be a key health indicator. It is expected that effects captured in the measure of hypertension would be captured in the IHD outcomes. Hence the need to include hypertension as a health indicator regardless of quality is questionable. This may or may not be the case as it is also important to consider how the health measure would be quantified, as the incidence of hypertension in the community is not well reported. The more recent evaluations of hypertension outcomes have not changed the quality of evidence in relation to transport sources (remaining low). The only exposure-response relationships with statistically significant outcomes relates to road traffic noise. There is insufficient quality and consistency of evidence to include evaluations of hypertension for rail and air traffic noise sources.

In relation to IHD, the meta-analysis by Vienneau et al (2020) is considered to be an update of the WHO meta-analysis, incorporating all published studies to 2019, however the only statistically significant relationship was established for riad noise. In relation to the assessment of aircraft noise, the WHO (van Kempen et al. 2018) relationship has been adopted as it is considered the most current and relevant relationship. The quality of the evidence remains low (van Kempen et al. 2018). The relationship adopted is as follows:

- Incidence of IHD (as hospitalisations): RR = 1.09 [1.04-1.15].

The study conducted by Saucy et al (2020) was a time-stratified case-crossover study that involved the assessment of aircraft noise and mortality from cardiovascular disease in 24,886 participants near Zurich Airport between 2000 and 2015. The study focused on night-time noise exposures in the 2 hours preceding death and found associations between aircraft noise and mortality for IHD, MI, heart failure and arrhythmia (heart rhythm problems). While the outcomes of the study are not comparable to other key studies, due to the limited/specific time period of exposure, the study provides some important observations (Saucy et al. 2020):

- risk of mortality is higher for female participants than male participants, where it is suggested that females may be more susceptible to stress response, with higher levels of salivary cortisol in response to noise exposure
- the associations between aircraft noise and night-time cardiovascular death was significantly stronger for people living in quiet areas compared with areas with higher night-time levels of road and railway nose and for people living in older buildings, most likely with less sound insulation
- the study data suggests a threshold for effects in the range of 30 to 50 dB (for 2-hour L_{Aeq}).

6.3.5 Cognitive impairment (children)

There is evidence for effects of noise on cognitive performance in children, in particular lower reading performance (WHO 2011a, 2018). Cognitive impairment in children is defined by WHO as a reduction in cognitive ability in school age children that occurs while exposed to noise and persists afterwards, but it is not a health outcome that can be clinically diagnosed (WHO 2011a).

Noise in classrooms affects children in many ways, including lowering their motivation, reducing speech intelligibility, listening comprehension and concentration, producing annoyance and disturbance, and increasing restlessness. As a result, children exposed to noise at school may experience poorer reading ability, memory and performance. Cognitive impairment could also be linked to noise exposure at home during night-time hours, which can cause low mood, fatigue and impaired task performance the next day. Noise at home may also be linked to hyperactivity and inattention problems, which can cause lower academic performance (EEA 2020).

The European Network on Noise and Health (ENNAH 2013) developed a causal diagram that related to both aircraft and road noise exposures and learning impairment, as shown in Figure 6.9. This illustrates the range of variables and intermediate terms that affect the pathways identified. At the presentation of this causal diagram, several exposure modifying factors in the school were mentioned such as window glazing and classroom design (e.g. type of flooring, furniture). Air pollution was included as an intermediate factor between road traffic and indoor air quality. Home noise exposure, rather than aircraft or road traffic noise was believed to affect sleep and psychological restoration. Another factor on the causal pathway from road traffic noise exposure to learning impairment is the stress response and noise annoyance, which was thought to be both an intermediate variable between noise exposure and the outcome, but also affected by personal characteristics which could act as confounding variables (ENNAH 2013).

The earlier WHO evaluation (WHO 2011a) focused on evidence from a major study in the EU (RANCH). The study found sufficient evidence to support an exposure response relationship between noise and cognitive performance in children for aircraft noise but the relationship between performance and noise for road traffic was much less clear (Stansfeld, S. et al. 2005a; Stansfeld, S. et al. 2005b; WHO 2011a, 2018). For children, the NORAH study (Klatte et al. 2017; Spilski et al. 2016) found results similar to the earlier RANCH study, where an association between aircraft noise and reading comprehension was identified.

The WHO (2018) (Clark & Paunovic 2018b) review identified cognitive impairment as a critical health outcome for the assessment of exposure to noise, particularly for the most sensitive group - children, with the key health measures being reading and oral comprehension. Other measures include short and long-term memory deficit, attention deficit and executive function deficit. Most of the studies reviewed (Clark & Paunovic 2018b) showed a statistically significant association between higher aircraft noise and poorer reading comprehension. The relationship was supported by other evidence relating to cognition (including standardised test performance, poorer long-term memory). There was no substantial evidence of an association with attention or executive function.

Cognitive impairment, evaluated in this assessment, relates to long-term changes in reading and oral comprehension as a result of long-term exposure to aircraft noise. The impacts are of most significance for primary school aged children. This assessment has utilised an established exposure-response relationship where it is assumed the effects occur as a result of long-term exposure to noise. The primary study used to establish the exposure response relationship (Clark et al 2005) relates to delays in comprehension at the end of primary school (assuming long-term exposure to aircraft noise). Hence it is inferred that the relationship relates to long-term exposures to aircraft noise over childhood to the end of primary school. For this assessment the relationship has been used to assess potential cognitive delays in children at the end of pre-school or childcare, end of primary school and the end of high school. This is a conservative use of the exposure-response relationship as exposures at pre-school/childcare and primary school should be combined, and applying the same relationship to high-school students is expected to be conservative as the relationship is weak for older children and poor for adults.

For the assessment of aircraft noise, the exposure response relationship identified by WHO (2018) is a 1–2 month delay in reading and oral comprehension per 5 dB increase in L_{den}.

In relation to other effects, there is insufficient evidence of effects on cognitive learning and memory in adults and mental health (Stansfeld, Stephen & Clark 2015).

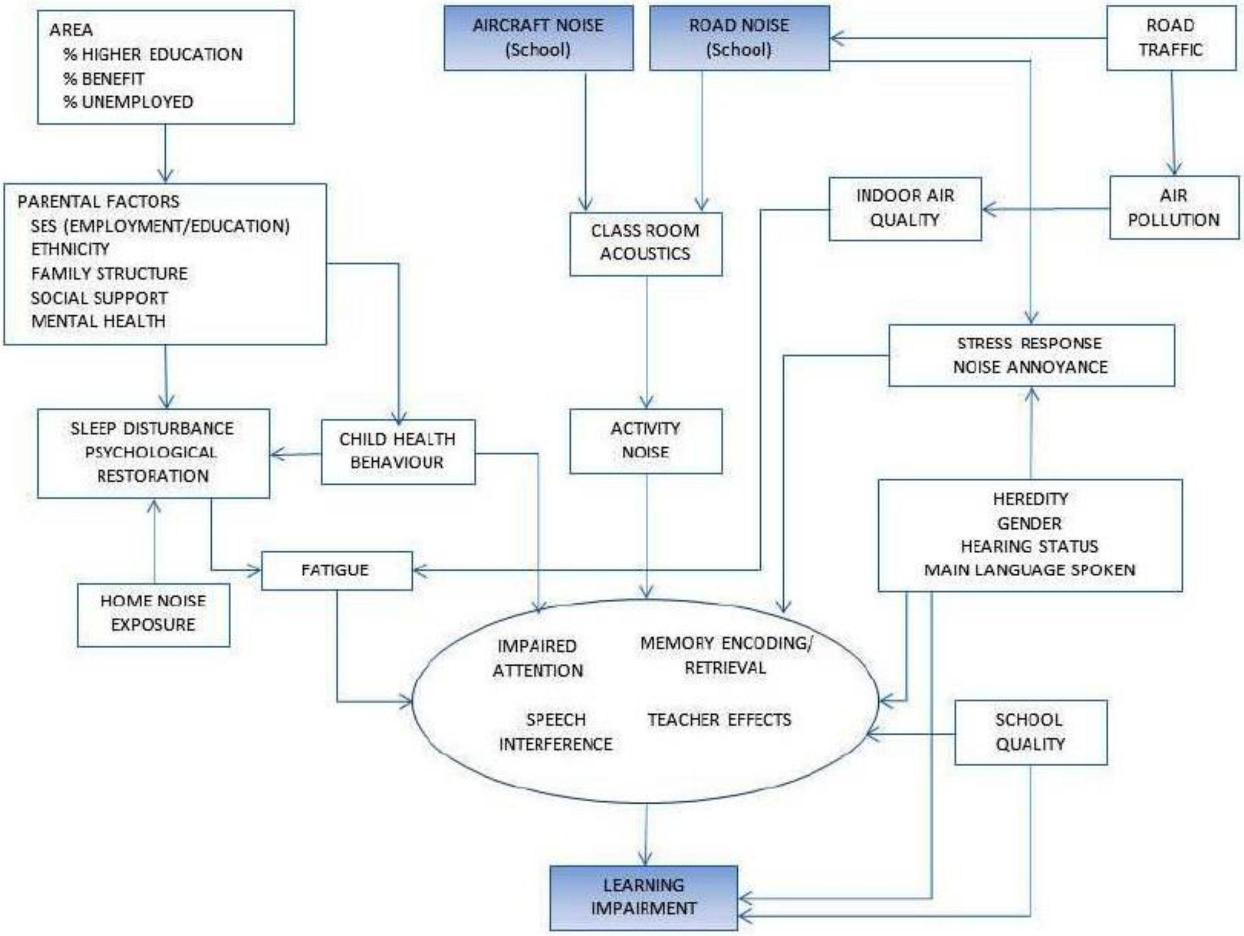


Figure 6.9 Causal diagram: aircraft and road noise association with learning impairment (ENNAH 2013)

6.3.6 Metabolic outcomes

Consistent with the review by Munzel et al (Münzel et al. 2020) that provided a more detailed review of the mechanisms for adverse effects on the cardiovascular system, these mechanisms are also considered to result in metabolic effects. The hypothesis is that noise exposure is related to stress-hormone-mediated increase in cortisol and deposition of fat centrally, as well as other impacts on metabolic functioning and/or adverse effects of disturbed sleep on metabolic and endocrine function (Kim et al. 2017; Münzel et al. 2020; Sparrow et al. 2020). This hypothesis is somewhat supported by a limited number of studies that have found associations between noise exposure and diabetes.

Review of the available studies by the WHO (van Kempen et al. 2018) and DEFRA (van Kamp, I. et al. 2020; van Kamp et al. 2019) determined that the quality of the studies was low with inconsistent outcomes in relation to diabetes, obesity, body mass index (BMI) and waist circumference. No statistically significant relationships have been identified for exposures to aircraft noise. This outcome was further supported by the review of aircraft noise by NatCen (Grollman, Maerin & Mhonda 2020) where a number of individual studies and the meta-analysis from Vienneau et al (Vienneau et al. 2019) was included. It is noted that a number of the studies identified relate to the assessment of co-exposures to noise and air pollution, both of which have been associated with metabolic disease. These co-exposures make interpretation of the outcomes of many of these studies complex.

Overall, the quality of evidence for quantifying effects of transport noise on metabolic outcomes (diabetes and obesity) is low and these measures have not been included in this assessment, not should they be considered in any quantitative evaluation of population health burden.

6.3.7 Other effects

The current detailed reviews by the WHO (WHO 2018) and DEFRA (ARUP 2020; Clark, Crumpler & Notley 2020) reviewed studies relating to a range of other potential health effects associated with exposure to transport noise. This includes dementia, birth weight and birth outcomes, cancer, mental health and quality of life (including depression, anxiety, psychological symptoms; and hyperactivity and ADHD in children). The evidence available for most of these health effects is mixed (with insufficient evidence of associations) with low quality of evidence. In relation to evidence relating to mental health, wellbeing and quality of life outcomes, the following provides a summary of the strength of evidence relevant to aircraft noise.

Table 6.1 Comparison of the strength of evidence for the assessment of mental health, wellbeing and quality of life outcomes – Aircraft noise (modified from (ARUP 2020; Clark, Crumpler & Notley 2020))

<table>
<tr><th rowspan="2">Health outcome</th><th colspan="3">Quality of evidence and assessment of effect</th></tr>
<tr><th>WHO review to 2015 (Clark & Paunovic 2018a)</th><th>DEFRA review 2015 to 2019 (ARUP 2020; Clark, Crumpler & Notley 2020)</th><th>Further meta-analysis to 2019 or 2020*</th></tr>
<tr><td>Self-reported quality of life on health</td><td>Very low quality – no effect</td><td>Very low quality – no effect</td><td>NA</td></tr>
<tr><td>Medication intake for treatment of anxiety and depression</td><td>Very low quality – potential harmful effect</td><td>NA</td><td rowspan="3">Low quality – statistically significant effect for depression, non-significant effect for anxiety</td></tr>
<tr><td>Self-reported depression, anxiety and psychological symptoms</td><td>NA</td><td>NA</td></tr>
<tr><td>Interview measures of depressive and anxiety disorders</td><td>Very low quality – potential harmful effect</td><td>Low quality – potential harmful effect</td></tr>
<tr><td>Emotional and conduct disorders in children</td><td>Low quality – no effect</td><td>NA</td><td>NA</td></tr>
<tr><td>Hyperactivity</td><td>Low quality – potential harmful effect</td><td>NA</td><td>NA</td></tr>
<tr><td>Wellbeing</td><td>Not evaluated</td><td>Very low quality – potential harmful effect</td><td>NA</td></tr>
</table>

* additional reviews published post WHO and DEFRA evaluations (Dzhambov & Lercher 2019; Lan et al. 2020; Schubert et al. 2019)

In relation to the mechanisms by which exposure to noise adversely affects mental health, this is explained by stress and behavioural processes. The stress-diathesis hypothesis suggests that transportation noise, as an environmental stressor, can increase physiological arousal and stress hormone secretion (e.g., adrenaline and cortisol) through repeated stimulation of the endocrine system and autonomic nervous system. Prolonged activation of these responses may cause mental disorders including anxiety. According to the behavioural mechanism, it emphasises that people proactively deal with exposure to noise by adjusting their behaviour in noisy conditions to reduce exposure through the appraisal of noise (in terms of danger, loss of quality, the meaning of the noise, challenges for environmental control, etc.) and coping strategies. As a result, actively coping with noise may be sufficient to mitigate the ill effects (Lan et al. 2020).

In relation to wellbeing and quality of life indicators, the available data is of limited quality with no statistically significant exposure-response relationships identified that would be sufficiently robust to include in any quantitative analysis. Hence these health outcomes have not been further considered in this assessment.

6.3.8 Overview of health outcomes assessed

On the basis of the current information relating to the impacts of aircraft noise on community health, the following thresholds and exposure response functions have been adopted in this assessment.

Table 6.2 Summary of recommended exposure-response relationships for the assessment of health impacts of aircraft noise

Health outcome	Noise metric	Lowest level of exposure (dB (A))	Exposure-response relationship per 10 dB increase (RR= relative risk or OR = odds ratio) [95% confidence interval]	Quality of evidence
All adverse effects	L_{den}	45	Recommended threshold from WHO (2018) for aircraft noise	
Sleep disturbance	L_{night}	40	Recommended threshold from WHO (2018) for aircraft noise	
	L_{max}	52	Prevent awakenings (WHO 2009)	
Hearing impairment	L_{max}	110	Thresholds from WHO (WHO 1999)	
	L_{day}, $L_{evening}$ or L_{night}	70		
Cardiovascular effects – incidence of IHD	L_{den}	47	RR = 1.09 [1.04-1.15]	Very low
Annoyance (as % highly annoyed, %HA)	L_{den}	40	OR = 4.78 [2.28-10.05] %HA = −50.9693 + 1.0168 × L_{den} + 0.0072 × L_{den}^2	Moderate
Annoyance – sensitivity analysis	L_{den}	40	%HA = -9.199*10^{-5} (L_{den}-42)^3 + 3.932*10^{-2} (L_{den}-42)^2+ 0.2939 (L_{den}-42)	Moderate
Cognitive impairment in children (as reading and oral comprehension)	L_{den}	55	1–2 month delay (45 days adopted in this assessment) per 5 dB increase	Moderate
Sleep disturbance (as % highly sleep disturbed, %HSD)	L_{night}	35	OR = 1.94 [1.61 – 2.33] %HSD = 16.7885–0.9293 × L_{night} + 0.0198 × L_{night}^2	Moderate

RR = relative risk; OR = odds ratio, %HA = percentage of population highly annoyed; %HSD = percentage of population highly sleep disturbed

6.4 Exposure assessment

The assessment of potential health impacts from aircraft noise has utilised modelled average sound levels as L_{Aeq} (in db(A)) at each of the NSRs and NMTs, for each operational scenario, as L_{day}, $L_{evening}$ and L_{night} (as A-weighted equivalents over these periods) as well as L_{max} (for operations 2055). These noise predictions relate to noise from aircraft operations. These noise measures relevant to the assessment of potential health impacts as summarised in Section 6.3.8 require the use of L_{max}, L_{night} and L_{den}.

L_{den} is the day-evening-night noise level based on energy equivalent noise level (L_{eq}) with a penalty of 10 dB(A) for night time noise and an additional penalty of 5 dB(A) for evening noise. The penalty is applied to address higher levels of nuisance (annoyance and sleep disturbance) during the typically quieter night and evening periods. L_{den} is calculated using the following (Brink et al. 2018; EC 2002b; Naish, Tan & Nur Demirbilek 2011):

$$L_{den} = 10 \times \log_{10}\left[\frac{1}{24} \times \left(12 \times 10^{\frac{L_{day}}{10}} + 4 \times 10^{\frac{(L_{evening}+5)}{10}} + 8 \times 10^{\frac{(L_{night}+10)}{10}}\right)\right]$$

Thresholds relevant to specific health effects (as summarised in Table 6.2) have been applied for each receptor evaluated. The receptors evaluated are all receptors considered in the noise modelling, and include the noise monitoring terminals (NMTs, M1-M30) and all NSRs (R1-R141 excluding R24 and R25 as these are located onsite (on the WSI) and N1-N203).

The results for each receptor evaluated have been assumed to be representative of noise impacts in residential and community areas for each SAL, with the maximum and average noise levels relevant to each SAL in the local study area evaluated. As the noise modelling results provided do not address each individual residential home in the local study area, all noise receptors evaluated including community locations, such as schools, community centres, parks, religious facilities, shopping centres or aged care have been considered to be representative of the community in the vicinity of the receptor.

It is recognised that aircraft noise from the operation of the project would be combined with existing noise levels. To provide some context to the assessment of health impacts this assessment has also considered existing noise, measured at the ambient noise monitoring locations (NMTs) as L_{day}, $L_{evening}$ and L_{night} (as A-weighted equivalents over these periods), with L_{den} calculated from these values as discussed above.

6.5 Impact assessment

6.5.1 General

Due to the nature of the exposure-response relationships identified and relevant to the assessment of specific health impacts, a number of different types of calculations have been undertaken. These are discussed in the following sections.

6.5.2 WHO thresholds

6.5.2.1 Hearing impairment

Where significantly elevated levels of noise are present, there is the potential for such noise levels to result in hearing impairment. Review of the predicted noise levels from aircraft operations against WHO thresholds relevant to hearing impairment indicates the following:

- L_{max}: there are no predicted maximum levels of noise for all scenarios evaluated in 2055 at any of the noise sensitive receivers (receptors) that exceed the threshold of 110 dB(A)
- L_{day}, $L_{evening}$ or L_{night}: there are no L_{Aeq} levels of noise for all scenarios evaluated in 2033 and 2055 at any of the sensitive receivers (receptors) that exceed the threshold of 70 dB(A).

On the basis of the above noise derived from aircraft operations would not be expected to result in hearing impairment in any of the areas surrounding the WSI.

6.5.2.2 All adverse health effects

In relation to aircraft noise, the WHO recommends that noise in the community as L_{den} should not exceed 45 dB(A), to protect against all health impacts (including annoyance). It is noted that the L_{den} levels in the existing environment already exceed 45 dB(A), with levels measured at the NMTs in the range 50.5 to 69 dB(A).

Review of L_{den} levels predicted from aircraft operations has identified a number of receptors where the threshold of 45 dB(A) is exceeded in 2033 and 2055.

As there are a number of exceedances, further assessment of specific health impacts is required and presented in Sections 6.5.3 to 6.5.6.

6.5.2.3 Sleep disturbance

In relation to aircraft noise, the WHO recommends that noise in the community as L_{night} should not exceed 40 dB(A), and L_{max} should not exceed 52 dB(A) to protect against sleep disturbance issues. It is noted that the L_{night} levels in the existing environment already exceed 40 dB(A), with levels measured at the NMTs in the range 41 to 58 dB(A).

Review of L_{night} levels predicted from aircraft operations has identified a number of receptors where the threshold of 40 dB(A) is exceeded in 2033 and 2055.

Review of L_{max} levels at night time predicted from aircraft operations has identified a significant number of receptors where the threshold of 52 dB(A) is exceeded in 2055.

As there are a number of exceedances, further assessment of sleep disturbance impacts is required and presented in Section 6.5.3.

6.5.3 Sleep disturbance

Assessment of potential sleep disturbance impacts associated with aircraft noise have been assessed on the basis of the exposure-response relationships summarised in Section 6.3.8. These result in the calculation of the %HSD within a population. The assessment undertaken has utilised the predicted night-time noise levels as $L_{Aeq,night}$ (or L_{night}) and the exposure-response relationship detailed in Table 6.2.

Table 6.3 presents a summary of the calculated %HSD for the receptors located within each of the SALs evaluated in the local study area from the project as well as existing/background noise. Calculations conducted for each receptor are presented in Appendix E.

The assessment of sleep disturbance requires some consideration of what may be of concern in terms of health, and complaints. There are no specific guidelines available for determining what would be an acceptable, or unacceptable level of %HSD in a community from a specific project. The WHO (2018) also recommends the use of 3 per cent highly sleep disturbed for the development of guidelines. For the purpose of this assessment, where the calculated %HSD derived from aircraft noise is 3 per cent or more than the %HSD relevant to the existing noise environment, these levels of %HSD in the community are considered to be of significance. The level of %HSD that are considered to be of significance for each SAL evaluated are shaded in blue in Table 6.3.

Table 6.3 Summary of sleep disturbance impacts from aircraft noise

SAL	% population in area highly sleep disturbed (%HSD) as average [minimum – maximum] from all receptors evaluated						
	Existing/ background	2033			2055		
		No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
Austral	12#	0	0	0	0	0	0
Badgerys Creek	12#	14*	9*	9*	18*	12*	12*
Bringelly	14	0	1 [0-9]	1 [0-9]	2 [0-10]	3 [0-11]	3 [0-11]
Cecil Park	12#	0	0	0	0	0	0
Cobbitty	12#	0*	15*	15*	0	19*	19*
Glenmore Park	16	0	0	0	0	0	0
Greendale	15-17	1 [0-26]	17 [9-26]	17 [9-26]	19 [10-33]	21 [11-33]	21 [11-33]
Horsley Park	20	0	0	0	0	0	0
Kemps Creek	15	4 [0-19]	1 [0-15]	1 [0-15]	7 [0-25]	4 [0-20]	4 [0-20]
Luddenham	15-29	16 [10-29]	15 [0-33]	15 [0-33]	21 [13-35]	19 [10-40]	19 [10-40]
Mount Vernon	20	0	0	0	3 [0-9]	0	0
Mulgoa	12#	12 [9-13]	1 [0-9]	1 [0-9]	14 [11-17]	9 [0-12]	9 [0-12]
Rossmore	12#	0	0	0	1 [0-9]	1 [0-9]	1 [0-9]
Silverdale	14	17 [12-22]	16 [11-21]	16 [11-21]	22 [15-28]	21 [14-27]	21 [14-27]
Wallacia	13-15	3 [3-22]	15 [13-15]	15 [13-21]	11 [9-28]	20 [17-27]	20 [17-27]
Warragamba	16	0	3 [0-9]	3 [0-9]	6 [0-9]	11 [11-12]	11 [11-12]
Other residential areas assessed as NMTs							
Orchard Hills	23	10	0	0	15	0	0
Oxley Park	12#	0	0	0	10	0	0
St Marys	14	10	0	0	16	0	0
Rooty Hill	16	9	0	0	11	9	9
St Clair	19	10	0	0	14	0	0
Werombi	15	0	0	0	9	0	0
Linden	13	0	0	0	10	14	14

* Only one receptor in this SAL

Blue shaded values are 3% or more higher than the %HSD calculated on each area based on existing or background noise (noting that where no background data is available for a SAL, the lowest level of background %HSD of 12% has been adopted, as flagged with #)

Review of Table 6.3 indicates there are a number of areas where the %HSD is considered to be of potential significance. The calculated %HSD is variable throughout many of these areas, with the highest levels estimated in:

- Luddenham where up to 33% in 2033 and 40% in 2055 may be highly sleep disturbed in some locations (including residential areas, with the maximum impacts at the corner of Willowdene Ave and Vicar Park Lane (R21)), which exceed existing levels of %HSD particularly where the lower end of the existing range is used (15–29% existing)
- Greendale where up to 26% in 2033 and 33% in 2055 may be highly sleep disturbed in some locations (including residential areas), which exceed the existing %HSD of 15–17%
- Silverdale where up to 22% in 2033 and 28% in 2055 may be highly sleep disturbed in some locations, in particular the residential area represented by receptor M22, which exceed the existing %HSD of 14%
- Wallacia where up to 22% in 2033 and 28% in 2055 may be highly sleep disturbed in some locations, including residential areas, which exceed the existing %HSD or 13–15%
- Kemps Creek where up to 19% in 2033 and 25% in 2055 may be highly sleep disturbed in some locations, including residential areas, which exceed the existing %HSD or 15%.

6.5.4 Annoyance

Assessment of potential noise annoyance impacts associated with aircraft noise have been assessed on the basis of the exposure-response relationships summarised in Section 6.3.8. These result in the calculation of the %HA within a population. The assessment undertaken has utilised the predicted L_{den} noise level and the exposure-response relationship detailed in Table 6.2.

Table 6.4 presents a summary of the calculated %HA for the receptors located within each of the SALs evaluated in the local study area from the project as well as existing/background noise. Calculations conducted for each receptor are presented in Appendix F.

The assessment of annoyance requires some consideration of what may be of concern in terms of health, and complaints. Where noise levels change, community reaction to these changes can vary. There is evidence to suggest that reaction to a newly introduced noise source (including new aircraft noise) is considerably higher than a source that has been present for a long time (NSW DECCW 2011).

There are no specific guidelines available for determining what would be an acceptable, or unacceptable increase in annoyance from a specific project. Most health-based noise guidelines are set at a level that corresponds with 10% of the residents highly annoyed (NSW DECCW 2011; WHO 2018). The NSW Road Noise Policy (NSW DECCW 2011) indicates that a relative increase of 12 dB represents slightly more than a doubling of perceived loudness and is likely to trigger community reaction (i.e. complaints). A change of 12 dB corresponds to an increase of 9 per cent population highly annoyed and 8 per cent highly sleep disturbed. This is similar to the 10 per cent population highly annoyed which is the basis for many health-based guidelines, including the WHO (WHO 1999, 2011a, 2018). When evaluating noise annoyance in an urban environment, where there are a number of existing sources, the application of a total 10 per cent highly annoyed criteria is not helpful.

Further review of criteria (Schomer 2005) that may be considered for evaluating noise annoyance identified a change of 5 dB as a level that would be considered an acceptable change in noise levels in a residential home. Health Canada (Health Canada 2017) uses the change in %HA as an indicator for noise-induced health impacts of specific projects. More specifically, Health Canada (Health Canada 2017) has identified that noise mitigation measures should be considered where the change in %HA exceeds 6.5 per cent. This is consistent with the use of a change of 6.5 per cent in %HA in the US (Federal Transit Authority) to identify highly noise impacted locations in a community. This value is also further justified in other reviews (Hanson, Towers & Meister 2006; Michaud, Bly & Keith 2008; Quagliata et al. 2018).

On this basis, significant levels of the population considered highly annoyed as a result of the project are identified as the calculated %HA that is 6.5 per cent or higher than existing levels of noise annoyance in the community (from existing/background levels of noise). The level of %HA that are considered to be of significance for each SAL evaluated are shaded in blue in Table 6.4.

Table 6.4 Summary of noise annoyance within the community from aircraft noise

SAL	% population in area highly annoyed (%HA) as average [minimum – maximum] from all receptors evaluated						
	Existing/ background	2033			2055		
		No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
Austral	19#	0	0	0	0	0	0
Badgerys Creek	19#	21*	19*	12*	27*	24*	18*
Bringelly	23	0 [0-2]	1 [0-4]	1 [0-5]	2 [0-8]	3 [0-10]	3 [0-11]
Cecil Park	19#	0	0	0	1 [0-2]	1 [0-2]	0
Cobbitty	19#	0*	19*	19*	3*	25*	25*
Glenmore Park	30	0	0	0	5 [4-5]	0 [0-1]	4 [4-5]
Greendale	23-38	18 [2-40]	22 [5-40]	23 [6-40]	26 [9-50]	11 [30-50]	11 [30-49]
Horsley Park	31	0	0	0	2 [0-3]	0	1 [0-2]
Kemps Creek	29	9 [0-30]	9 [0-25]	5 [0-30]	14 [0-39]	13 [0-34]	10 [0-38]
Luddenham	22-46	24 [9-44]	22 [4-48]	21 [4-50]	31 [15-53]	28 [10-57]	27 [10-58]
Mount Vernon	30	1 [0-2]	1 [0-3]	0	7 [5-9]	6 [5-8]	3 [1-5]
Mulgoa	19#	11 [4-15]	1 [0-5]	1 [0-6]	17 [9-22]	7 [1-12]	7 [3-13]
Rossmore	19#	0	0	0	1 [0-5]	1 [0-6]	1 [0-5]
Silverdale	22	24 [14-34]	22 [11-33]	24 [14-33]	32 [21-43]	31 [19-43]	31 [21-42]
Wallacia	25-29	5 [1-34]	19 [15-33]	19 [15-33]	10 [6-43]	27 [22-42]	27 [22-42]
Warragamba	24	0	3 [2-3]	4 [4-4]	4 [4-5]	10 [10-11]	11 [11-11]
Other residential areas assessed as NMTs							
Orchard Hills	46	17	18	6	25	25	14
Penrith	21	0	2	0	6	8	0
Oxley Park	54	1	1	0	8	4	0
St Marys	28	13	12	2	22	18	9
Rooty Hill	26	5	1	4	13	7	12
St Clair	31	15	15	4	23	22	11
Erskine Park	31	9	10	0	15	16	6
Werombi	29	0	0	0	5	3	3
Blaxland	19	0	0	0	3	5	0
Linden	21	3	6	8	9	16	16
The Oaks	27	0	0	0	0	1	1
Nattai (Lake Burragorang)	19	0	0	0	4	0	3

* Only one receptor in this SAL

Blue shaded values are 6.5% or more higher than the %HA calculated on each area based on existing or background noise (noting that where no background data is available for a SAL, the lowest level of background %HA of 19% has been adopted, as flagged with #).

Review of Table 6.4 indicates there are a number of areas where the %HA is considered to be of potential significance, with many of these areas a subset of those identified as of potential significance in relation to sleep disturbance. The calculated %HA is variable throughout many of these areas, with the highest levels estimated in:

- Luddenham where up to 50% in 2033 and 58% in 2055 may be highly annoyed in some locations (including residential areas, with the maximum impacts at the corner of Willowdene Ave and Vicar Park Lane (R21)), which exceed existing levels of %HA particularly where the lower end of the existing range is utilized (22–46% existing)
- Greendale where up to 40% in 2033 and 50% in 2055 may be highly annoyed in some locations (including residential areas), which exceed the existing %HSD of 22–38%
- Silverdale where up to 34% in 2033 and 43% in 2055 may be highly annoyed in some locations, in particular the residential area represented by receptor M22, which exceed the existing %HSD of 23–38%
- Wallacia where up to 34% in 2033 and 43% in 2055 may be highly annoyed in some locations, including residential areas, which exceed the existing %HSD of 25–29%.

It is noted that additional calculations of noise annoyance have been presented in Appendix F, that utilise the alternate exposure-response relationship (sensitivity analysis) discussed in Section 6.3.2. These calculations show a lower level of noise annoyance from aircraft noise, which highlights that the calculations presented are expected to be conservative.

6.5.5 Cognitive impairment

Assessment of potential delays in learning (for children) from exposure to aircraft noise have been assessed on the basis of the exposure-response relationships summarised in Section 6.3.8. These result in the calculation in the number of days of learning delay for children, at the end of the developmental/schooling period (pre-school/childcare, primary school and high school). The assessment undertaken has utilised the predicted L_{den} noise level and the exposure-response relationship detailed in Table 6.2.

Table 6.5 presents a summary of the calculated number of days delayed for all the receptors located within each of the SALs evaluated in the local study area from the project as well as existing/background noise. The receptors evaluated include all residential, childcare and schools. Calculations conducted for each receptor are presented in Appendix G.

The assessment of cognitive impairment/learning delays requires some consideration of what may be of concern in terms of health and long-term outcomes (as delays in childhood can have an impact later in life). There are no specific guidelines available for determining what would be an acceptable, or unacceptable level of learning delays in a community from a specific project. The WHO (2018) The WHO (2018) has identified that a one-month delay (i.e. 30 days) in reading and oral comprehension should be adopted as the level of cognitive impairment for the purpose of establishing guideline levels for noise. Hence for this assessment, where the calculated learning delay is 30 days or more, and this differs from existing/background, the impacts from the project have been considered to be of potential significance.

Table 6.5 Summary of cognitive impairment, as learning delays in children

SAL	Days of learning delay during childhood from noise exposures as average [minimum – maximum] from all receptors evaluated						
	Existing/ background	2033			2055		
		No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
Austral	0#	0	0	0	0	0	0
Badgerys Creek	0#	0*	0*	0*	2*	0*	0*
Bringelly	0	0	0	0	0	0	0
Cecil Park	0#	0	0	0	0	0	0
Cobbitty	0#	0*	0*	0*	0*	0*	0*
Glenmore Park	14	0	0	0	0	0	0
Greendale	0-53	14 [0-65]	15 [0-66]	17 [0-64]	31 [0-109]	38 [0-110]	39 [0-107]
Horsley Park	22	0	0	0	0	0	0
Kemps Creek	13	1 [0-18]	0	1 [0-14]	3 [0-62]	3 [0-34]	3 [0-57]
Luddenham	0-92	7 [0-85]	7 [0-103]	7 [0-109]	25 [0-123]	18 [0-143]	18 [0-147]
Mount Vernon	18	0	0	0	0	0	0
Mulgoa	0#	0	0	0	0	0	0
Rossmore	0#	0	0	0	0	0	0
Silverdale	0	17 [0-34]	17 [0-33]	15 [0-31]	38 [0-77]	38 [0-76]	37 [0-73]
Wallacia	0-11	3 [0-34]	3 [0-30]	3 [0-30]	7 [0-76]	12 [0-73]	12 [0-72]
Warragamba	0	0	0	0	0	0	0

* Only one receptor in this SAL

Blue shaded values relate to learning delays of 30 days or more, which are considered to be different to existing/background (assuming the lower levels of the background range)

Review of Table 6.5 indicates there are a number of areas where learning delays are considered to be of potential significance, with many of these areas consistent with those identified as of potential significance in relation to sleep disturbance and annoyance. The calculated learning delays in these areas is variable, with the highest levels estimated in Luddenham, Greendale, Silverdale, Wallacia and Kemps Creek. The more significant impacts relate to operations in 2055. For operations in 2055, Table 6.6 provides the calculated learning delays specifically relevant to childcare and schools located within these SALs.

Table 6.6 Summary of cognitive impairment, as learning delays in children at childcare and schools in key SALs in 2055

Childcare centre or school	SAL	Days of learning delay* from noise exposures as average [minimum – maximum] from all receptors evaluated		
		2055		
		No preference	Prefer Runway 05	Prefer Runway 23
Childcare centres				
Mamre After School and Vacation Care	Kemps Creek	1	11	0
Little Smarties Childcare Centre	Kemps Creek	1	11	0
The Grove Academy	Kemps Creek	0	0	0
Kemps Creek Childrens Cottage	Kemps Creek	0	0	0
MindChamps Early Learning & Preschool @ Kemps Creek	Kemps Creek	0	0	0
Kemps Creek Childrens Cottage	Kemps Creek	0	0	0
Schoolies at Mulgoa	Luddenham	6	4	5
Luddenham Child Care Centre	Luddenham	0	0	0
Silverdale Child Care Centre	Silverdale	0	0	0
Schools				
Emmaus Catholic College	Kemps Creek	0	0	0
Christadelphian Heritage College Sydney	Kemps Creek	0	0	0
Mamre Anglican School	Kemps Creek	2	11	0
Kemps Creek Public School	Kemps Creek	0	0	0
Trinity Catholic Primary School	Kemps Creek	0	0	0
Christadelphian Heritage College Sydney	Kemps Creek	0	0	0
Luddenham Public School	Luddenham	24	19	18
Holy Family Catholic Primary and Church	Luddenham	4	4	5
Wallacia Public School	Wallacia	0	0	0

* Days of learning delay assumed to apply to the total delay at the end of the developmental/learning period, i.e. at the end of pre-school or childcare, end of primary school or the end of high school

Blue shaded values relate to learning delays of 30 days or more, which are considered to be significant in terms of health impacts

Review of Table 6.6 indicates that for the childcare centres and schools located in the key SALs where learning delays may be of potential significance, none of the noise impacts associated with the project at these locations are high enough to be of concern in relation to community health (i.e. learning delays are all less than 30 days).

6.5.6 Cardiovascular effects

The assessment of health impacts from exposure to aircraft noise has evaluated the maximum increase in L_{den} within each of the SALs for each scenario. Not all the SALs in the local study area have been evaluated, only those relevant to the populations exposed to aircraft noise, particularly beneath or close to the flight paths.

For assessing potential impacts associated with cardiovascular effects, specifically the incidence of IHD, a population health incidence has been calculated as detailed in Appendix B. The calculation of the number of cases is calculated as follows:

$$\text{Number of attributable cases} = \beta \times \Delta X \times B \times P$$

Where

β = relationship between a change in 1 dB(A) exposure and a health outcome (as per Table 6.2)

ΔX = change in average noise exposure in SAL from the threshold of 47 dB(A) as a result of the project in dB(A) as L_{den} relevant to the population evaluated

B = baseline incidence of the health outcome or endpoint evaluated, relevant to the population evaluated (refer to Table 4.5) (rate per person), noting that data for coronary artery disease (another name for ischaemic heart disease) has been used, and is 415.8 per 100,000 population for South Western Sydney LHD (2020-2021 data)

P = population exposed, as relevant to each SAL (refer to Table 4.1)

The calculation presented assumes that 100% of the population living in each SAL is remains in these areas 24-hours per day for 365 days per year.

Table 6.7 presents a summary of the attributable cases calculated for all each SAL evaluated, where L_{den} is above the threshold of 47 dB(A) and for each scenario assessed. The table also includes the total number of attributable cases over the study area evaluated. The number of cases presented have been rounded to one significant figure. Detailed calculations are included in Appendix H.

Table 6.7 Calculated health impacts in local study area, as attributable cases, relevant to increased exposure to aircraft noise

SAL	Ischaemic heart disease - Number of cases attributed to aircraft noise exposures (IHD hospitalisations, all ages)					
	2033			2055		
	No preference	Prefer Runway 05	Prefer Runway 23	No preference	Prefer Runway 05	Prefer Runway 23
Badgerys Creek	0.03	0.02	0.0	0.05	0.04	0.02
Greendale	0.03	0.06	0.06	0.08	0.1	0.1
Luddenham	0.4	0.3	0.3	0.7	0.5	0.5
Mulgoa	0.0	0.0	0.0	0.1	0.0	0.0
Silverdale	1.0	0.8	1.0	2	2	2
Wallacia	0.0	0.2	0.2	0.0	0.5	0.5
Total (all SALs)	**1.4**	**1.5**	**1.6**	**2.6**	**2.7**	**2.7**

The predicted number of attributable cases, relevant to all scenarios is generally low. Assuming the predicted noise impacts always occurred each year, and the population was at that same location all day every day for a lifetime, the number of cases may by up to 270 over a 100-year period. Interpretation of this value should also consider the incidence of IHD in the same population, based on existing/background noise levels. For the same SALs evaluated above, this is calculated to be 2.5 per year, which is up to 250 cases over a 100-year period. The calculated impacts from aircraft operations are not additive to the background, however the impacts on the incidence of IHD are similar. Hence the impact of the operation of the project on the incidence of IHD from project related noise is considered to be low and similar to existing/background rates of IHD in the community.

6.5.7 Overview of impacts identified

The assessment has identified the potential for significant impacts on community health as a result of exposure to noise from the project, specifically in relation to sleep disturbance, noise annoyance and potentially cognitive impairment (as learning delays in children). These impacts are highest close to the ends of the runways, with other impacts identified in areas beneath departure and approach flight paths close to WSI. The assessment presented provides indicative locations where there is the potential for these impacts to be considered to be of significance, due to a range of uncertainties associated with the identification of potential health impacts (refer to Section 6.7). The potential for significant impacts is consistent with the conclusions of Technical paper 1, where significant and unavoidable levels of noise exposure have been identified.

Review of these impacts have been considered in the context of land use planning protections that are already in place following previous EISs (one in 1985, the next between 1997 and 1999 and most recently in 2016). The indicative ANEC for WSI provided in the Airport Plan and SEPP (Precincts – Western Parkland City) 2021 (NSW) was generated based on the runway direction, dual runway operations and indicative flight paths as presented in the 2016 EIS. An updated ANEC is presented in Technical paper 1 for single runway operations. In the lead up to the airport becoming operational, a formalised ANEF (as a more refined ANEC) will be generated for WSI based on the final approved single-runway flight path design and longer-term dual runway operations. In addition, the Airport Plan will eventually be replaced by a Master Plan. The ANEC 20 contour defined in the Airport Plan and SEPP, and updates based on the assessment of noise impacts for this project, is used for the purpose of managing land use in the vicinity of WSI, in areas where noise impacts may be of significance. This includes the following:

- existing residential land uses can continue, however developments such as dual occupancies, secondary dwellings and subdivision of land for sensitive uses not already approved would not be permitted
- no new noise sensitive development, that includes residential, schools and childcare centres cannot be developed
- if a development site is found to be 'conditionally acceptable' this means that any proposed buildings would be required to be designed to result in a reduced noise level indoors in accordance with AS 2021:2015.

With consideration of the above, the following provides further discussion in relation to the predicted impacts of noise on community health presented in Sections 6.5.3, 6.5.4 and 6.5.5.

6.5.7.1 Sleep disturbance

- The most significant health impact identified, where there is the highest number of receptors potentially impacts, is sleep disturbance.
- The potential for sleep disturbance impacts will depend on the sensitivity of individuals in the community.
- Figure 6.10 shows the locations where there is the potential for sleep disturbance to be of potential significance in the local study area. The figure relates to worst-case impacts in 2055, where the predicted level of sleep disturbance in the community is considered to be of potential significance for at least one of the RMO scenarios evaluated (No preference, Prefer Runway 05 or Prefer Runway 23). However, not all the locations identified as being potentially significant are used for residences, schools or childcare centres and have been used as an indicator of where issues may arise.
- The majority of the locations identified and shown on Figure 6.10, where sleep disturbance is of potential significance in 2055 sit within the existing SEPP (Western Sydney Aerotropolis) 2020 ANEC 20 contour and 2055 ANEC 20 contour. These are all areas where existing planning controls limit future developments including residential developments. The exceptions are as follows:
  - 2 areas located to the northwest, one of which is located outside of all the ANEC contours, and the other located outside of the 2033 and 2055 ANEC 20 composite contours
  - a group of receptors located in Wallacia to the northwest of the runway, and further distant from all the ANEC contours.

These additional locations were not identified as potentially significant, in terms of sleep disturbance, in 2033.

It is expected that by 2055 the presence of aircraft noise in the local study area will have been present for a significant period of time, where some members of community may have adjusted to the presence of aircraft noise at night. In addition, changes in night time noise levels between 2033 and 2055 would be gradual and hence it is expected that the community would adjust to these changes over time. Changes in percentage of the population considered highly sleep disturbed between 2033 and 2055 may not be considered significant given the uncertainty in relation to assessing changes in background/ambient noise and predicting impacts on sleep disturbance. However, the calculations undertaken suggest that by 2055 there may be some additional areas of the community in Wallacia where sleep disturbance may be impacted.

For existing residential homes in the area of the ANEC 20 contours, there is the potential for increased level of sleep disturbance with the operation of aircraft. However, not all the locations identified as being potentially significant are used for residences, schools or childcare centres and have been used as an indicator of where issues may arise.

6.5.7.2 Annoyance

- Receptors where annoyance, as percentage of the population considered highly annoyed, has been identified as of potential significance are a subset of those identified for sleep disturbance.
- Increased levels of noise annoyance is expected to result in increased levels of noise complaints from the community.
- Guidance from Health Canada (Health Canada 2017) indicates that assessment of the %HA is the most appropriate indicator for establishing potential management measures or mitigation.
- Figure 6.11 shows the locations where there is the potential for the percentage of the population highly annoyed to be of potential significance in the local study area. The figure relates to worst-case impacts in 2055, where the predicted %HA in the community is considered to be of potential significance for at least one of the RMO scenarios evaluated (No preference, Prefer Runway 05 or Prefer Runway 23).
- The majority of the locations identified, and shown on Figure 6.11, where the %HA is of potential significance in 2055 sit within the existing SEPP (Western Sydney Aerotropolis) 2020 ANEC 20 contour and 2055 ANEC 20 contour. These are all areas where existing planning controls limit future developments including sensitive developments. The exception is one location in Wallacia to the northwest just outside of the ANEC contours. This location is not identified as potentially significantly impacted, in relation to %HA, in 2033.

It is expected that by 2055 the presence of aircraft noise in the local study area will have been present for a significant period of time, where some members of the community may have adjusted to the presence of aircraft noise in the environment. In addition, the change in noise levels between 2033 and 2055 would be expected to be gradual where adjustment to changes in noise levels would be expected to occur.

Changes in percentage of the population considered highly annoyed between 2033 and 2055 may not be considered significant given the uncertainty in relation to assessing changes in background/ambient noise and predicting impacts on sleep disturbance. However, the calculations undertaken suggest that by 2055 some additional residential areas adjacent close to the existing ANEC contours may experience aircraft noise at levels that are considered highly annoying.

For existing residential homes in the area of the ANEC 20 contours, there is the potential for a higher proportion of the population to be considered highly annoyed by noise.

Changes in the levels of %HA in the community are expected to result in a higher level of noise complaints, particularly at the start of the project where aircraft noise was a new source of noise in the environment.

6.5.7.3 Cognitive impairment (children)

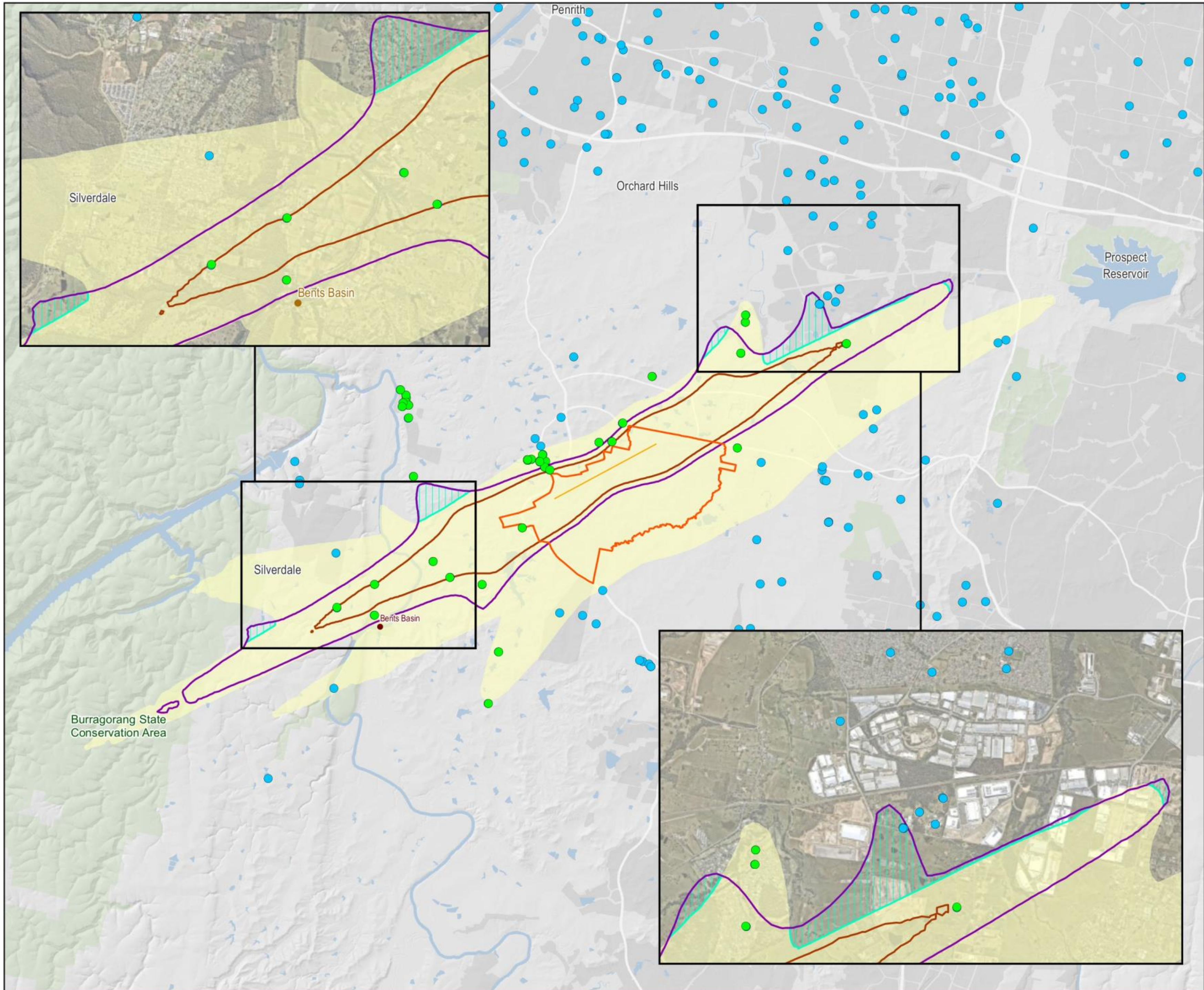
- Receptors where cognitive impairment (in children) has been identified as of potential significance are a further smaller subset of both sleep disturbance and annoyance.
- While there are no impacts that are considered to be significant at existing childcare centres and schools in the community, it is important to evaluate whether the existing ANEC 20 contours that define planning controls surrounding WSI are sufficient.
- It is also important to note that both Luddenham Public School (Primary) and Mamre Anglican Schools are either located within the Western Parkland City SEPP ANEC 20 contour or the predicted 2055 ANEC 20 contour. In terms of cognitive impairment the impacts predicted at these schools is not considered to be of significance and these schools would be expected to continue to operate due to 'existing use rights' under Section 4.65 of the NSW EP&A Act. However future developments at these schools would require approval of the relevant consent authority and consideration of the indoor sound requirements relevant to these areas.
- Figure 6.12 shows the locations where the potential for impacts on children's learning as cognitive impairment is considered to be of potential significance. The figure relates to worst-case impacts in 2055, where the predicted level of cognitive impairment in the community is considered to be of potential significance for at least one of the RMO scenarios evaluated (No preference, Prefer Runway 05 or Prefer Runway 23).
- The majority of the locations identified, and shown on Figure 6.12, where cognitive impairment is of potential significance in 2055 sit within the existing SEPP (Western Sydney Aerotropolis) 2020 ANEC 20 contour and 2055 ANEC 20 contour. These are all areas where existing planning controls limit future developments including sensitive developments including future childcare and schools. The exception is one location in Wallacia to the northwest just outside of the ANEC contours. This location is not identified as potentially significantly impacted, in relation to cognitive impairment, in 2033. Hence this location relates to potential future impacts.

Based on the above the existing planning controls, based on the existing and modelled ANEC 20 contours would prevent the development of new childcare centres and schools in areas where impacts on children's learning would be of significance. The exception being a location just outside of the 2055 ANEC 20 contour where the development of a new childcare centre or school should be considered in more detail at the time and using measured noise levels from the operation of the project, should a planning application be submitted.

It is noted that the above discussion does not mean that people living in the local or regional study area would not notice aircraft noise at some point, with the operation of the project. It is expected that aircraft noise would be noticeable particularly at the start of the project when aircraft noise is new for a number of areas. Noise perception is not the same as noise exposures that are sufficiently elevated to result in impacts on health. The discussion above and the following figures are specifically focused on the identification of areas where there key health impacts from aircraft noise, namely sleep disturbance, annoyance and cognitive impairment (children) are of potential significance.

Figure 6.10

Noise Receptors - Sleep Disturbance



Legend

WSI Runway

- WSI Runway
- Western Sydney International (Nancy-Bird Walton) Airport land boundary
- Potential additional area impacted by ANEC 20
- 2055 ANEC20 Composite
- 2033 ANEC20 Composite
- Receptors - above assessment threshold
- Receptors - below assessment threshold
- Aboriginal Places raised during consultation (NPW Act)
- Site of Aboriginal significance

State Environmental Planning Policy (Western Sydney Aerotropolis) 2020 Noise Exposure Concept (units)

- ANEC 20 and above

Coordinate system: GDA 1994 NSW Lambert

Scale ratio correct when printed at A3

1:120,000 Date: 27/06/2023

Data sources: - DITRDC, DCS, Geoscience Australia
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Airbus,USGS,NGA,NASA,CGIAR,NCEAS,NLS,OS,NMA,Geodatastyrelsen,GSA,GSI and the GIS User

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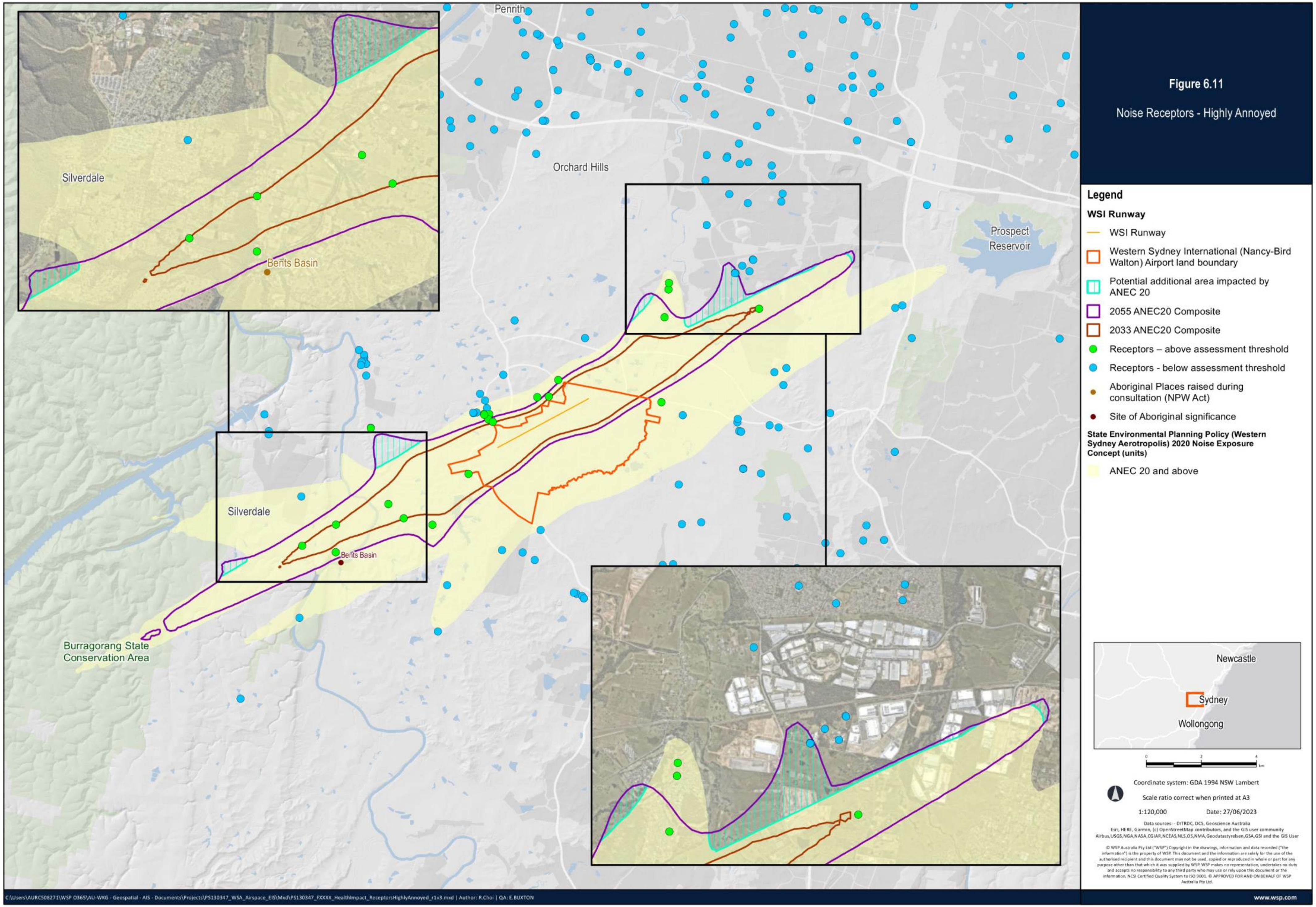

Figure 6.11
Noise Receptors - Highly Annoyed
Legend
WSI Runway
WSI Runway
Western Sydney International (Nancy-Bird Walton) Airport land boundary
Potential additional area impacted by ANEC 20
2055 ANEC20 Composite
2033 ANEC20 Composite
Receptors – above assessment threshold
Receptors - below assessment threshold
Aboriginal Places raised during consultation (NPW Act)
Site of Aboriginal significance
State Environmental Planning Policy (Western Sydney Aerotropolis) 2020 Noise Exposure Concept (units)
ANEC 20 and above
Penrith
Orchard Hills
Prospect Reservoir
Silverdale
Bents Basin
Silverdale
Bents Basin
Burragorang State Conservation Area
Newcastle
Sydney
Wollongong
0
2
4
km
Coordinate system: GDA 1994 NSW Lambert
Scale ratio correct when printed at A3
1:120,000
Date: 27/06/2023
Data sources: - DITRDC, DCS, Geoscience Australia
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Airbus,USGS,NGA,NASA,CGIAR,NCEAS,NLS,OS,NMA,Geodatastyrelsen,GSA,GSI and the GIS User
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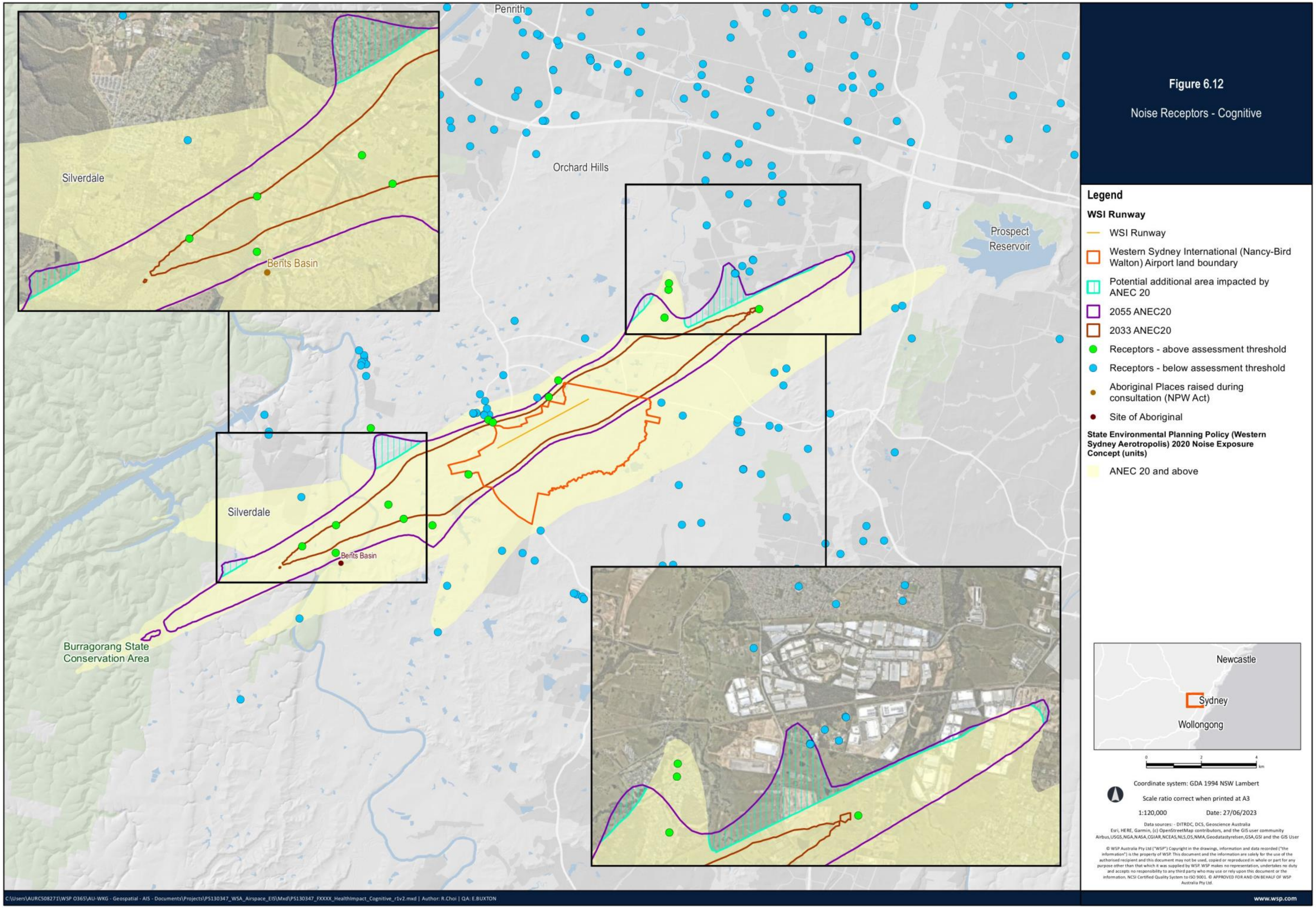

Figure 6.12
Noise Receptors - Cognitive
Penrith
Orchard Hills
Prospect Reservoir
Silverdale
Bents Basin
Burragorang State Conservation Area
Legend
WSI Runway
WSI Runway
Western Sydney International (Nancy-Bird Walton) Airport land boundary
Potential additional area impacted by ANEC 20
2055 ANEC20
2033 ANEC20
Receptors - above assessment threshold
Receptors - below assessment threshold
Aboriginal Places raised during consultation (NPW Act)
Site of Aboriginal
State Environmental Planning Policy (Western Sydney Aerotropolis) 2020 Noise Exposure Concept (units)
ANEC 20 and above
Newcastle
Sydney
Wollongong
0 2 4 km
Coordinate system: GDA 1994 NSW Lambert
Scale ratio correct when printed at A3
1:120,000
Date: 27/06/2023
Data sources: - DITRDC, DCS, Geoscience Australia
Esri, HERE, Garmin, (c) OpenStreetMap contributors, and the GIS user community
Airbus,USGS,NGA,NASA,CGIAR,NCEAS,NLS,OS,NMA,Geodatastyrelsen,GSA,GSI and the GIS User
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C:\Users\AURC508271\WSP O365\AU-WKG - Geospatial - AIS - Documents\Projects\PS130347_WSA_Airspace_EIS\Mxd\PS130347_FXXXX_HealthImpact_Cognitive_r1v2.mxd | Author: R.Choi | QA: E.BUXTON
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6.6 Noise management and mitigation

Land-use planning has been an effective means to ensure that land use near WSI is compatible with noisy aviation activities, with a primary goal of minimising the population affected by aircraft noise, through implementation of land-use planning measures, such as land use zoning around WSI.

As discussed in Section 6.5.7, there are existing planning controls relating to future developments in the area surrounding WSI, which are expected to be updated to inform land use planning policy. In particular the ANEC 20 contours are utilised for the purpose of preventing future noise sensitive development in the community surrounding the WSI.

The *Western Sydney Aerotropolis Precinct Plan* identifies the Agribusiness Precinct to the west of WSI and surrounding Luddenham Village. The Agribusiness Precinct is proposed to increase agricultural and agribusinesses uses, building on successful agricultural operations and developing new agribusiness opportunities.

It is understood that the Australian Government would continue to work closely with the NSW Government and local governments to implement any long term planning protections that have been put in place around the proposed airport to minimise incompatible development.

The existing Airport Plan will eventually be replaced by a Master Plan. The Master Plan is required to include a number of measures relevant to noise including an endorsed ANEF chart, flight paths and plans for managing aircraft noise intrusion in areas forecast to be subject to exposure above the significant ANEF/ANEC levels. While the ANEF charts are expected to consider the predicted ANEC 20 contours, consideration should also be given to ensuring land use planning controls incorporate areas where potential impacts on community annoyance and cognitive learning are of potential significance. If such measures cannot be included in ANEF charts, consideration to ensuring an appropriate noise assessment is undertaken for future developments in these areas, that includes noise monitoring at the time of development.

DITRDCA has developed a draft Noise Insulation and Property Acquisition Policy (NIPA) in relation to aircraft overflight noise for buildings outside the Airport Site and regarding the 24-hour, 7 days a week operation. This draft policy is based on the aircraft noise results from this assessment and provides the local community and other important stakeholders with the chance to be consulted and fully informed of the final expected impacts before the airport commences operations.

A WSI Community Aviation Consultation Group (CACG) would evolve from the current Forum on Western Sydney Airport (FOWSA) to ensure appropriate community engagement on airport planning and operations.

Other mechanisms supporting the WSI operational framework would include:

- The Airservices Australia Noise Complaints and Information Service – to handle complaints and enquiries about aircraft noise and operations associated with WSI to help identify issues of community concern and provide opportunities for improvement.
- The Aircraft Noise Ombudsman (ANO) (an independent administrative office) – to conduct reviews of Airservices Australia's and Defence's management of aircraft noise-related activities. The ANO would also monitor and report on the effectiveness of the community consultation processes related to aircraft noise for WSI and the presentation and distribution of aircraft noise-related information.

As a major new international airport, it is expected that a system of permanent noise monitoring terminals (loggers) would be installed at suitable locations around WSI and incorporated into Airservices Australia's NFPMS network and reporting systems. This system operates 24-hours-a-day, 7-days-a-week, collecting data from every aircraft operating to and from each of these airports[8].

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8 Refer to Technical paper 1 and the Airservices website for additional information: https://www.airservicesaustralia.com/community/environment/aircraft-noise/monitoring-aircraft-noise/noise-monitor-reporting/

6.7 Uncertainties

The assessment of potential health impacts on the community from exposure to aircraft noise has drawn on robust and current evaluations that have specifically assessed the available data and evidence of such effects.

The association between exposure to noise and adverse health effects is well documented and there are a number of robust studies available to characterise these effects. A number of relationships adopted in this assessment come from research where data from a number of studies have been combined. The available studies that are used to determine these relationships often utilise different measures of noise levels (differing between covering average day and evening or day evening and night) and different methods for measuring the disease end-points. This results in the use of some conservative assumptions when combining these data.

As the studies relating to health effects of noise are primarily derived from epidemiological studies, the limitations associated with the quality and robustness of such studies is important. Hence this review has only addressed health effects where a causal link has been established between noise exposure (specifically aircraft noise exposure) and health outcomes. This assessment has relied on detailed systematic reviews of the available studies conducted by key organisations such as the WHO and UK DEFRA (ARUP 2020; van Kamp, Irene et al. 2020; WHO 2018).

There are a range of potential adverse health effects that have been evaluated in relation to potential exposure to aircraft noise, for which the evidence is not sufficiently robust to be confident that aircraft noise is associated with and/or is the cause of these effects. These effects include incidence of dementia, multiple sclerosis, Parkinson's Disease, low birth weight, cancer, self-reported quality of life, medication intake for depression and anxiety, emotional conduct disorders in children and hyperactivity.

The exposure-response relationships identified from various studies are variable and hence only those recommended from detailed reviews of all studies, including pooled meta-analysis (where data from numerous studies is combined) adopted. These provide a more robust assessment of health impacts compared with small studies where variability is much more significant. The assessment of community annoyance in response to aircraft noise remains the subject of debate as discussed in Section 6.3.2. To assist in evaluating these issues calculations of %HA in the community has been undertaken based on the exposure-response relationships recommended by the WHO (2018). A sensitivity assessment has included the calculation of %HA from previously established relationships, which some professionals believe are more robust. The calculated %HA using both approaches are presented in Appendix F. This shows that the % HA calculated using the WHO (2018) approach is more conservative. If the alternate approach is adopted, the %HA in the community would be lower (for background/ambient as well as project related noise). The use of the alternative (sensitivity assessment) exposure-response relationships does not change the outcome of this assessment.

This assessment has utilised a change in a calculated health effect/aspect from existing/background to identify where project related impacts may be of potential significance. There is limited information relating to background levels of noise in the community. Actual background levels of noise are expected to be variable, and also expected to change over time. Hence background levels of noise in 2033 and 2055 are expected to be different to those considered in this assessment. Hence the approach adopted only provides indicative areas where impacts may be of potential significance to health.

The modelling of aircraft noise has not considered the introduction of new quieter aircraft over time, as the assessment is based on noise information relevant to aircraft currently in service. Hence it is likely that by 2055, the noise impacts predicted would be conservative for the aircraft fleet operating at that time. In addition, it is expected that aircraft noise would not be a new noise source in the community after a period of operation. In particular aircraft noise in 2055 would not be considered to be a new source of noise. Levels of noise annoyance, as well as sleep disturbance are influenced by the how long the noise source has been present, with many members of the community adjusting to, or getting used to the noise source over time. The operation of aircraft in the local and regional study areas is expected to result in a change in background noise relevant to a range of communities. This change in background noise may result in a reduced percentage of the population that are noise annoyed. However, given the individual variability in response to noise, it is not possible to quantify these changes in noise perception over time.

For the assessment of changes in air quality, specifically nitrogen dioxide and particulates, and noise, the exposure-response relationships used in this assessment are based on large epidemiology studies where exposures have occurred in urban areas. These exposures do not relate to only one pollutant or exposures (noise) but a mix of these, and others including occupational and smoking. While many of the studies have endeavoured to correct for exposures to other pollutants and exposures, no study can fully correct for these and there would always be some level of influence from other exposures on the relationships adopted.

In relation to the assessment of cardiovascular effects from aircraft noise, these effects are also associated with (and occur together with) increased exposures to pollutants from combustion sources including vehicle emissions. The relationships established to assess this health endpoint are considered to provide a very low quality of evidence. Hence inclusion of this health endpoint would be expected to be confounded with the outcomes considered less reliable.

Due to the confounding effects noted above, it is important the health risks and incidence evaluations presented for exposure to nitrogen dioxide, particulates and noise should not be added together as these effects are not necessarily additive, due to the relationships already including co-exposures to all these aspects (and others).

6.8 Summary of outcomes in relation to noise

This assessment has addressed potential impacts on community health associated with aircraft noise derived from the operation of the project.

The assessment has identified that there is the potential for noise from the project to result in significant increases in sleep disturbance, noise annoyance (and therefore complaints) and, to a lesser extent, cognitive impairment for children (as learning delays). These impacts have been identified at a number of receptors located close to the runway as well as beneath the approaches and take off routes away from the runway.

Most of the impacts on community health that are considered to be significant are located within the existing or predicted ANEC 20 contours where existing and potentially future land use planning controls are in place to prevent future noise sensitive development, which includes new residential development, and construction of new childcare centres and schools. By 2055 there are some additional locations, outside of the modelled ANEC 20 contours where impacts on community health may be of significance. Changes in noise as a result of operations between 2033 and 2055 would be expected to be gradual, and hence the significance of the impacts identified may be influenced by community adjustment to the presence of aircraft noise in the environment. These changes, however may remain of significance to some members of the community.

For existing residential properties located in the existing ANEC 20 contours, there is the potential for the community in these areas to experience increased and significant levels of annoyance and sleep disturbance.

There are a range of measures outlined to address noise impacts, which include land use planning controls, NIPA (once developed) and community engagement. These measures should be implemented to minimise the potential impacts on community health as a result of the project.

Chapter 7 Assessment of health impacts: changes in hazard and risks

7.1 Introduction

Technical paper 4 provides an assessment of hazards and risks related to the operation of the airspace. The assessment has used a risk assessment approach to the assessment, which includes hazard identification and risk characterisation incorporating likelihood and consequence. This approach is a little different to, and in some cases more qualitative, than that adopted in this assessment for evaluating changes in air quality and noise on community health.

This section provides an overview of the outcomes of the hazard and risk assessment in relation to impacts on community health. This includes any hazard that has the potential to result in injury or death, damage to health infrastructure and contamination of the environment such that the community may be exposed to elevated levels of contamination.

It is noted that the operation of the WSI will introduce additional flights into an existing busy Sydney Basin airspace, which requires substantial airspace redesign. The existing airspace and need for redesign have been considered in the hazard and risk assessment.

7.2 Existing airspace

The existing airspace in the Sydney Basin, or the baseline conditions are defined primarily by the various established airports, heliports, military aviation facilities, and associated flight paths sin. This baseline comprises the following facilities:

- **Sydney (Kingsford Smith) Airport**, located approximately 43 km east of WSI, handling predominantly scheduled regular passenger transport (RPT) and some air freight transport services with more than 345,000 movements per annum reported in 2019 (BITRE Air Traffic Data).
- **Bankstown Airport,** located approximately 26 km east of WSI, handling a range of general aviation (GA), charter and flying training services with around 250,000 movements per annum. Aircraft flight operations primarily involve single-engine and twin-engine piston aircraft (circa. 80 per cent), some helicopter aircraft (circa. 15 per cent) and a smaller number of turboprop and jet aircraft (circa. 5 per cent).
- **Camden Airport,** a relatively busy GA facility, located approximately 17 km south of WSI, handling just over 100,000 movements per annum. Aircraft flight operations involve recreational gliders, powered fixed-wing, and helicopter aircraft.
- **Westmead Hospital Helipads,** located approximately 27 km east-northeast of WSI, comprising 3 separate roof top helipads and a ground support base landing site.
- **Royal Australian Air Force (RAAF) Base Richmond**, located approximately 31 km north of WSI, from which C-130 Hercules medium transport aircraft operate.
- **Holsworthy Military Airport**, located approximately 23 km east-south-east of WSI.
- **Defence Establishment Orchard Hills** restricted area to the north of WSI.

In addition to flight operations to and from these facilities, there are enroute flight paths that cross the Sydney Basin and a few restricted areas and danger areas over which flying is restricted within the Sydney Basin.

It is noted that the civilian facilities listed above are located relatively close to areas of urban development. In contrast, the vicinity of the WSI is more sparsely developed and areas beneath runway-aligned flight paths are generally devoid of any development out to distances of several kilometres from each runway.

7.3 Assessing risk

Technical paper 4 has detailed the methods used to evaluate hazards and risks relevant to the project. For the hazards identified, the risk assessment has considered the likelihood of such events occurring, and should they occur, the consequence of such events. The assessment has evaluated individual risks as well as societal or community risks:

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

In relation assessing the significance of individual risks associated with specific hazards this has followed a well defined set of internationally recognised qualitative criteria, as detailed in Table 7.1.

Table 7.1 Assessment criteria for individual risk significance

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

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

Assessing the significance of societal risks requires consideration of the accident frequency as well as the number of fatalities.

Operational risks have also been assessed against the goals of being ALARP (as low as reasonably practicable) and achieving an acceptable level of safety.

Hazards and risks, where quantified, have been evaluated for 2 operational reference years, 2033 and 2055.

7.4 Summary of impacts

Based on the detailed assessment presented in Technical paper 4, Table 7.2 presents an overview of the hazards identified and assessed and the outcomes relevant to community health (and safety).

Table 7.2 Summary of community impacts – hazards and risks

Hazard evaluated	Potential consequence – community health	Calculated risks	Outcomes in terms of community health
Airspace conflicts	Airspace conflicts relates to the safety of the whole airspace and the potential for mid-air collisions	The broader Sydney Basin airspace has been redesigned to meet operational needs and meet the goals of ALARP and an acceptable level of safety.	
Off-airport crash risks, which may impact:	Whilst aircraft crashes are rare events, the majority occur during take-off and landing operations such that crash risks are more concentrated along flight paths close to runway ends. Accordingly, people and critical infrastructure located in the vicinity of airports can be expected to be exposed to an elevated risk above the background levels that apply more generally.		
People	Aircraft crashes can cause significant injury and fatalities within the community	Individual risks have been modelled, with risk contours corresponding with the risk levels in Table 7.1 presented. For 2033 and 2055, the 1 in 10,000 risks are confined within the airport boundary. In 2033, the impacts are categorised as 'slight effects' as there are no homes within the 1 in 100,000 risk contour, and 6 homes (22 people) in the 1 in 1,000,000 risk contour. In 2055, the impacts are categorised as 'moderate effects' as there are 2 homes (5 people) within the 1 in 100,000 risk contour, and 30 homes (108 people) in the 1 in 1,000,000 risk contour.	A limited number of people reside close to the runway ends. The overall risks (as individual and societal) are considered negligible for most of the study area, however close to the runway ends the risk increases to slight, but are considered ALARP. To ensure these risks do not increase, land use planning at the ends of the runways should not future involve residential development.
Critical infrastructure, in particular hospitals and water reservoirs (supplying drinking water)	Incidents that impacts on critical health facilities (such as hospitals) and drinking water reservoirs are of particular relevance.	The probability of a crash at the 3 major hospitals a in the general vicinity of WSI are in the range of 1 in 7 million years to 1 in 19 million years. The probability of a crash into Warragamba Dam is 1 in 13 million to 40 million years and for Prospect Reservoir is 1 in 7 million to 21 million years, but for Lake Burragorang is higher (as this is much larger in size) is 1 in 87,000 to 240,000 years. While contamination.	Overall, taking further account of the low event frequencies, the risk associated with these scenarios can be considered to be low and acceptable when assessed against the available societal risk criteria

Hazard evaluated	Potential consequence – community health	Calculated risks	Outcomes in terms of community health
Other hazards			
Aircraft fuel jettisoning	Where fuel jettisoning occurs over a populated area, there is the potential for fuel exposures and contamination to occur. Such events are rare and conducted in accordance with existing procedures (Manual of Air Traffic Services – Section 4.2.11 Fuel Dumping). Where jettisoned at sufficient altitude, fuel would volatilise prior to reaching the ground.	Potential risks to land from such incidents, principally related to take-off and climbing was evaluated, in conjunction with historical incident data and the likelihood that fuel would reach or impact the ground during such events. Risks were concluded to be remote.	The risk assessment did not identify any significant impacts to land from such incidents. Hence risks to community health are considered low and acceptable.
Objects falling from aircraft	This relates to objects falling from airborne aircraft and causing injury or fatalities to individuals on the ground.	The historical incident record shows that occurrences involving objects falling from aircraft are uncommon and typically involve small objects with limited hazard potential. Taking account of the relative size of the objects concerned and frequency of these occurrences compared with aircraft crashes, it may readily be concluded that the risks to people and sites on the ground are very small compared with the risks associated with aircraft crashes.	Given that the risks associated with aircraft crashes have been shown to be low and acceptable (as noted above), it may be concluded that the lesser risks associated with objects falling from aircraft can similarly be considered to be low and acceptable.
Aircraft wake vortex strikes	This relates to vortices from the wingtips that, during landing when aircraft are close to the ground, shortly before touchdown, can reach the ground and have sufficient power to cause damage to buildings (roof structures/tiles in particular). There is no direct evidence of direct adverse impacts of wake vortices on people.	There are a limited number of buildings in areas where wake vortex damage may be a possibility and given the type of roof construction and the low probability of impacts, the risk of damage was determined to be low.	Risk of damage is considered to be low, and with the potential for injury to people being much lower, risks to community safety are expected to be negligible.

Hazard evaluated	Potential consequence – community health	Calculated risks	Outcomes in terms of community health
Local meteorological hazards	This relates to events such as windshear, lightning strike, unforeseen weather and icing that have the potential to result in accidents, with injury and fatalities occurring.	While there is the potential for turbulence, windshear and thunderstorm activity to occur, the historical evidence indicates the threat to aircraft safety is limited. Measures to avoid adverse weather conditions are applied in the aviation industry to limit safety risks. An Automated Thunderstorm Alert Service (ATSAS) is proposed to be implemented at WSI to improve the accuracy of thunderstorm forecasting for the airport.	No significant weather related risks were identified for WSI operations where appropriate mitigation measures were implemented. Where this occurs risks to the community would be low and acceptable. It is noted that the ATSAS is proposed to be installed. Technical paper 4 recommended that consideration should be given to implementation of a Doppler LIDAR to support the identification of turbulence and wind shear, subject to the conclusions of an appropriate cost-benefit study.
Wildlife hazards	This particularly relates to bird strike that may result in aircraft damage and incidents, potentially resulting in injury or fatality.	Risks posed by wildlife has been assessed in detail in the Technical paper 5: Wildlife strike risk (Avisure 2022). Where wildlife strike risk mitigation for WSI is implemented an acceptable level of safety can be achieved.	Where risks are managed the potential impact on community safety is considered low and acceptable. It is noted that an appropriate site-specific wildlife management program should be implemented at WSI.

Technical paper 4 outlines a range of risk mitigation measures recommended to be implemented at WSI, which are:

- airspace conflicts: continued attention to hazard identification and risk mitigation during the remainder of the design process and on-going safety performance monitoring post-implementation
- residual off-airport aircraft crash risks to third parties and critical infrastructure: the choice of runway mode of operation to be guided by the balance between operational efficiency and safety objectives on the one hand and the minimisation of noise and risk impacts on the other
- contingency planning to respond to the impacts of crash events, for example to address potential water contamination events
- aircraft fuel jettisoning: identification of appropriate procedures to deal with such occurrences when and where they arise at WSI and more widely in the Sydney Basin, as part of the airspace design and implementation process
- objects falling from aircraft: no site-specific measures identified, given the minimal scale of the risk that can best be addressed by general aviation industry safety improvement efforts
- aircraft wake vortex strikes: covered by the compensation scheme operated by Airservices and no further mitigation required
- local meteorological hazards: ATSAS to be implemented by the Bureau of Meteorology to provide improved thunderstorm forecasting and consideration to be given to implementation of a Doppler LIDAR to support the identification of turbulence and wind shear, subject to the conclusions of an appropriate cost-benefit study, and
- local bird and bat strike hazards: implementation of a rigorous and integrated wildlife management program, in accordance with the detailed recommendations set out elsewhere (Avisure 2022).

Where these are implemented, risks to community safety and health would be considered low and acceptable.

Chapter 8 Equity aspects

Equity relates to the potential for the project to lead to impacts that are differentially distributed in the surrounding population. Population groups may be advantaged or disadvantaged based on age, gender, socioeconomic status, geographic location, cultural background, aboriginality, and current health status and existing disability.

The health effects associated with impacts related to transport projects, including impacts from the operation of the flight paths, are not equally distributed across the community. Groups at higher risk, or more sensitive to impacts, include:

- elderly (which is considered to be those over 65 years in this assessment)
- individuals with pre-existing health problems
- infants and young children
- individuals with disabilities
- individuals who live in areas with higher levels of pre-existing air or noise pollution.

Often the impacts can accumulate in the same areas, which may already have poorer socioeconomic and health status, most commonly due to the affordability of housing in areas that are closer to main roads, industry or rail infrastructure. Disadvantaged urban areas are commonly characterised by high traffic volumes, higher levels of air and noise pollution, feelings of insecurity and lower levels of social interactions and physical activity in the community.

To further evaluate potential equity issues associated with the project, the location of the most significant impacts identified in relation to air quality and noise were reviewed individually and in combination, in conjunction with available information on the location of sensitive community groups.

For this project the most significant impacts occur closer to the runways, which is the source of emissions to air and noise during take-off, climbing, approach and landing operations. The impacts identified are lower, further from the runways and flight paths. However, in relation to potential impacts from changes in both air quality and noise, the following SALs are the most impacted:

- Luddenham (most impacted SAL in relation to air quality and noise)
- Greendale (key impacts relate to noise)
- Silverdale (key impacts relate to noise)
- Wallacia (key impacts relate to noise).

In relation to these SALs, the following provides a summary of the characteristics of the population/community in these areas (compared with Greater Sydney and NSW), in relation to potential vulnerability (refer to information presented in Chapter 4):

- Luddenham – the characteristics of the population is not considered vulnerable to project related impacts, as:
  - most of the population is similar to Greater Sydney and NSW, however this SAL has a lower proportion of older people (aged 65 years and older)
  - the SAL does not have social housing and the population has does not have any significant housing affordability stress, in relation to rental or mortgages
  - the SAL has a lower proportion of people born overseas
  - the population is considered somewhat disadvantaged, with a higher level of economic resources than average with low rates on unemployment.

- Greendale – the characteristics of the population may have some vulnerability to project related impacts, as:
  - the population is no different in terms of age distribution than Greater Sydney and NSW
  - the SAL has no social housing with no mortgage stress, but rental stress has been identified in more than 30% of households (which is consistent with Greater Sydney and NSW)
  - the population is considered relatively disadvantaged with a lower level of economic resources and education/ occupational resources available.
- Silverdale – the characteristics of the population is generally not considered vulnerable to project related impacts, as:
  - the population comprises a higher proportion of young children (0-4 years) and lower proportion of older people (aged 65 years and older)
  - the SAL has no social housing with no mortgage stress, but rental stress has been identified in more than 30% of households (which is consistent with Greater Sydney and NSW)
  - the SAL comprises a higher proportion of population that identify as First Nations people, but there is a lower proportion born overseas
  - the population is considered less disadvantaged, with a higher level of economic resources than average and low rates on unemployment.
- Wallacia – the characteristics of the population is not considered vulnerable to project related impacts, as:
  - the population is no different in terms of age distribution than Greater Sydney and NSW
  - the SAL has no social housing with no mortgage stress, but rental stress has been identified in more than 30% of households (which is consistent with Greater Sydney and NSW)
  - the SAL has a lower proportion of people born overseas
  - the SAL is generally similar to Greater Sydney and NSW in terms of disadvantage and resources, with a low rate of unemployment.

The available data on baseline health for the populations in these SALs indicates the following (in comparison to NSW):

- in general, the population has a higher number of older people hospitalised for cardiovascular and respiratory disease
- there is a higher proportion of people aged 5 to 34 years hospitalised for asthma
- the rates of asthma are variable between the LGAs and South Western Sydney LHD
- the population has a lower rate of prescriptions for antidepressants.

This data suggests some increased vulnerability for older age groups to project related impacts on respiratory and cardiovascular outcomes. None of the populations identified with the more significant impacts comprise higher proportions of older people. In addition, the guidelines and methodology adopted has incorporated the increased vulnerability for older people, with the baseline health data adopted in the calculations of health impacts.

Overall, the SALs where the more significant impacts are identified are not considered to be significantly more vulnerable to project related impacts, compared with Greater Sydney or NSW. In addition, the location of these impacts is not considered to be focused or distributed in areas of disadvantage in the community. Future noise sensitive developments would not be permitted in the key areas of impact identified, further limiting the potential for inequitable developments/exposures in areas where health impacts are of potential significance.

It is noted that insufficient evidence is available that has identified a robust relationship between exposure to changes in air quality and noise and effects on wellbeing and mental health. Hence it is not possible to undertake a more detailed assessment of potential impacts of aircraft emissions and noise on community wellbeing. Within the existing population poorer wellbeing and mental health is expected to be more significant in areas with greater socioeconomic disadvantage. Hence it is not possible to consider these aspects in the assessment of equity impacts of the flight paths.

Chapter 9 Mitigation

This assessment has focused on impacts from changes in air quality, noise and other hazards and risks associated with the operation of the flight paths for WSI. A number of mitigation measures are required to be implemented to minimise impacts on community health in relation to changes in noise and hazards and risks associated with operating the flight paths, which are summarised in the following.

No project specific air quality mitigations are proposed. As the air quality assessment did not identify any significant changes in the approved ground level impacts per the 2016 EIS, no additional monitoring for aircraft emissions is required.

9.1 Noise

The potential for significant impacts on community health as a result of aircraft noise from the operation of WSI requires management and mitigation.

Future development in areas where potential noise impacts may be significant including planning protections to prevent noise sensitive development. Such protections include the existing Airport Plan and SEPP (Precincts – Western Parkland City) 2021 (NSW) and revisions expected to be made based on this project, with a formalised ANEF (as a more refined ANEC) chart generated and implemented. The Airport Plan is expected to be replaced by a Master Plan.

The Master Plan is required to include a number of measures relevant to noise including an endorsed ANEF chart, flight paths and plans for managing aircraft noise intrusion in areas forecast to be subject to exposure above the significant ANEF/ANEC levels. While the ANEF charts are expected to consider the predicted ANEC 20 contours, consideration should also be given to ensuring land use planning controls incorporate areas where potential impacts on community annoyance and cognitive learning are of potential significance. If such measures cannot be included in ANEF charts, consideration to ensuring an appropriate noise assessment is undertaken for future developments in these areas, that includes noise monitoring at the time of development.

DITRDCA has developed a draft Noise Insulation and Property Acquisition Policy (NIPA) in relation to aircraft overflight noise for buildings outside the Airport Site and regarding the 24-hour, 7 days a week operation. This draft policy is based on the aircraft noise results from this assessment and provides the local community and other important stakeholders with the chance to be consulted and fully informed of the final expected impacts before the airport commences operations.

Other measures to manage noise impacts on the community includes appropriate community engagement, which includes the Airservices Australia Noise Complaints and Information Service and Aircraft Noise Ombudsman (ANO).

As a major new international airport, it is expected that a system of permanent noise monitoring terminals (loggers) would be installed at suitable locations around WSI and incorporated into Airservices Australia's NFPMS network and reporting systems. This system operates 24-hours-a-day, 7-days-a-week, collecting data from every aircraft operating to and from each of these air.

9.2 Hazards and risks

Hazards and risks associated with the project can be managed as follows:

- airspace conflicts: continued attention to hazard identification and risk mitigation during the remainder of the design process and on-going safety performance monitoring post-implementation
- residual off-airport aircraft crash risks to third parties and critical infrastructure: the choice of runway mode of operation to be guided by the balance between operational efficiency and safety objectives on the one hand and the minimisation of noise and risk impacts on the other
- contingency planning to respond to the impacts of crash events, for example to address potential water contamination events
- aircraft fuel jettisoning: identification of appropriate procedures to deal with such occurrences when and where they arise at WSI and more widely in the Sydney Basin, as part of the airspace design and implementation process
- objects falling from aircraft: no site-specific measures identified, given the minimal scale of the risk that can best be addressed by general aviation industry safety improvement efforts
- aircraft wake vortex strikes: covered by the compensation scheme operated by Airservices and no further mitigation required
- local meteorological hazards: ATSAS to be implemented by the Bureau of Meteorology to provide improved thunderstorm forecasting and consideration to be given to implementation of a Doppler LIDAR to support the identification of turbulence and wind shear, subject to the conclusions of an appropriate cost-benefit study, and
- local bird and bat strike hazards: implementation of a rigorous and integrated wildlife management program, in accordance with the detailed recommendations set out elsewhere (Avisure 2022).

Where these are implemented, risks to community safety and health would be considered low and acceptable.

Chapter 10 Cumulative impacts

This study relates to impacts associated with the operation of the flight paths. These impacts would occur following construction of WSI, where impacts associated with construction would no longer be relevant. Impacts related to ground operations of the WSI were considered in the 2016 EIS. The 2016 EIS identified a number of localised impacts associated with surrounding roadways, particularly in relation to air quality.

The project flight paths do not lead to any significant changes in other activities (i.e. projected traffic, ground activities etc, remain unchanged) and hence the impacts predicted in the 2016 EIS do not change the outcome of this assessment.

Given the size of the study area and operational timeframes of the project, other relevant projects or developments considered likely to contribute to cumulative impacts have been restricted to those of sufficient scale to contribute materially to cumulative impacts at a regional level with similar or overlapping spatial or temporal characteristics. A list of major projects and strategic developments considered for cumulative impacts is provided in Chapter 22 of the Draft EIS.

Many of the screened projects are ground-surface infrastructure projects that would, or have assessed impacts during construction and operation, including consideration of cumulative impacts and implementation of mitigation measures. Such measures are consistent with those implemented on major construction sites. Impacts relating to the operation of new road and rail infrastructure would result in localised impacts close to these areas. Cumulative impacts on community health cannot be assessed as insufficient information is available. It would be expected that future developments in the area would need to consider impacts derived from the operation of WSI.

Chapter 11 Conclusion

This assessment has been undertaken to evaluate the potential for the project, that relates to the operation of the flight paths by aircraft, to impact on community health. This assessment has focused on changes in air quality, noise and other hazards and risks associated with the operation of aircraft from WSI.

Based on the assessment undertaken, with consideration of the population located in the community surrounding WSI and the uncertainties identified, the following is concluded in relation to potential impacts on community health:

11.1 Air quality

The assessment undertaken has not identified any risk issues of concern in relation to impacts on community health in the local study area as a result of exposure to pollutants derived from aircraft emissions. More specifically the assessment has identified the following:

- impacts on community health as a result of exposure to fine particulates (as $PM_{2.5}$) are low
- impacts on community health as a result of exposure to nitrogen dioxide are considered to be low. While there may be the potential for elevated exposures to occur close to the WSI, however further review of these impacts indicates that the potential impact on respiratory health is considered to be low. It is noted that the areas where elevated exposures are identified are expected to be rezoned such that residential use is no longer relevant
- impacts on community health as a result of exposure to carbon monoxide are low, and essentially negligible
- impacts on community health as a result of exposure to sulfur dioxide are low, and essentially negligible
- impacts on community health as a result of exposure to individual volatile organic compounds derived from aircraft emissions are low, and essentially negligible
- emissions to air derived from the operation of aircraft would have a negligible impact on water quality in Prospect Reservoir or rainwater tanks in the community. Potential impacts on these water supplies would be so low they would not be measured.

In addition to the above, no risk issues of concern in relation to community health has been identified in relation to changes in regional air quality.

11.2 Noise

This assessment has addressed potential impacts on community health associated with aircraft noise derived from the operation of the project.

The assessment has identified that there is the potential for noise from the project to result in significant increases in sleep disturbance, noise annoyance (and therefore complaints) and, to a lesser extent, cognitive impairment for children (as learning delays). These impacts have been identified at a number of receptors located close to the runway as well as beneath the approaches and take off routes away from the runway.

Most of the impacts on community health that are considered to be significant are located within the existing or predicted ANEC 20 contours where existing and potentially future land use planning controls are in place to prevent future noise sensitive development, which includes new residential development, and construction of new childcare centres and schools. By 2055 there are some additional locations, outside of the modelled ANEC 20 contours where impacts on community health may be of significance. Changes in noise as a result of operations between 2033 and 2055 would be expected to be gradual, and hence the significance of the impacts identified may be influenced by community adjustment to the presence of aircraft noise in the environment. These changes, however may remain of significance to some members of the community.

For existing residential properties located in the existing ANEC 20 contours, there is the potential for the community in these areas to experience increased and significant levels of annoyance and sleep disturbance.

There are a range of measures outlined to address noise impacts, which include land use planning controls, NIPA and community engagement. These measures should be implemented to minimise the potential impacts on community health as a result of aircraft noise.

11.3 Hazards and risk

A range of hazards and risks have been identified that relate to the operation of aircraft in the airspace above and around WSI and within the Sydney area. A range of mitigation measures have been identified to manage these hazards and risks, consistent with the way such risks are managed for all aircraft and airports. Where these are implemented, risks to community safety and health would be considered low and acceptable.

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Appendix A

Hazard assessment – detailed reviews for key pollutants

A1 Fine particulates

A1.1 General

Particulate matter is a widespread air pollutant with a mixture of physical and chemical characteristics that vary by location (and source). Unlike many other pollutants, particulates comprise a broad class of diverse materials and substances, with varying morphological, chemical, physical and thermodynamic properties, with sizes that vary from less than 0.005 microns to greater than 100 microns. Particulates can be derived from natural sources such as crustal dust (soil), pollen and moulds, and other sources that include combustion and industrial processes. Secondary particulate matter is formed via atmospheric reactions of primary gaseous emissions. The gases that are the most significant contributors to secondary particulates include nitrogen oxides, ammonia, sulfur oxides, and certain organic gases (derived from vehicle exhaust, combustion sources, agricultural, industrial and biogenic emissions).

The potential for particulate matter to result in adverse health effects depends on the size and composition of the particulate matter.

A1.2 Key issues relating to particle size

The size of particulates is important as it determines how far from an emission source the particulates may be present in air (with larger particulates settling out close to the source and smaller particles remaining airborne for greater distances) and also the potential for adverse effects to occur as a result of exposure (how far the particles can infiltrate into the respiratory system).

Only particulates that are small enough can penetrate into the lungs where there is the potential for effects to occur. If the particles are too large, they will be captured high up in the respiratory tract, trapped and flushed out and eventually swallowed.

Dust is commonly assessed on the basis of 4 types (or groups of) of particles: $PM_{2.5}$, PM_{10}, total suspended particulates (TSP) and deposited dust.

Deposited dust includes particles of any size, but it generally comprises large size dust particles; that is, greater than 20 microns in diameter[9]. These particles are too large to reach the lungs and are not considered to be of concern in relation to exposure. These particles have enough mass that they easily fall out of the air and deposit or accumulate on surfaces. These larger particles fall out and deposit onto surfaces close to specific sources, such as quarry activities. Sometimes sufficient dust can deposit so that it results in a visible layer of dust, which often considered to be a nuisance.

TSP refers to all particulates with an equivalent aerodynamic particle[10] size below 50 microns in diameter. It is a fairly gross indicator of the presence of dust with a wide range of sizes:

- Larger particles termed 'inspirable', comprise particles around 10 microns and larger, are more of a nuisance as they will deposit out of the air (measured as deposited dust) close to the source and, if inhaled, are mostly trapped in the upper respiratory system[11] and do not reach the lungs. This is the same with the even larger particles in deposited dust.
- Finer particles smaller than 10 microns, termed 'respirable', are transported further from the source and are of more concern with respect to human health as these particles can penetrate into the lungs (see discussion below).

The deposition of dust based on the different particle sizes is illustrated in the following figure.

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9 The size, diameter, of dust particles is measured in micrometers (microns).

10 The term equivalent aerodynamic particle is used to reference the particle to a particle of spherical shape and particle of density one gram per cubic metre.

11 The upper respiratory tract comprises the mouth, nose, throat and trachea. Larger particles are mostly trapped by the cilia and mucosa and swept to the back of the throat and swallowed.

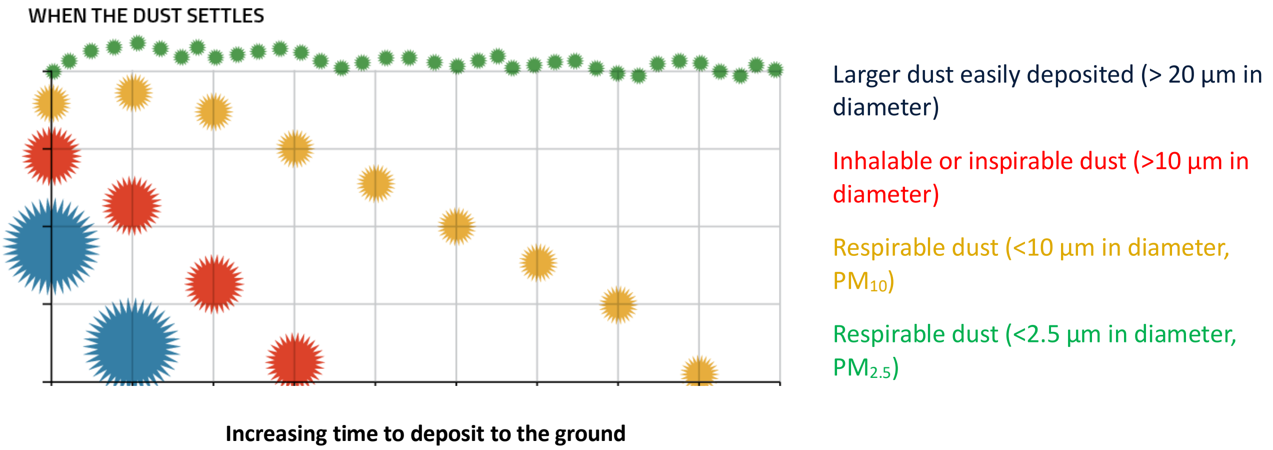


Figure A.1 Deposition of dust particles

The focus of any assessment addressing potential health effects relates to particulates of a size that are respirable. These particulates comprise the following (as illustrated in Figure A.2):

- PM_{10} – particulate matter below 10 microns in diameter, µm
- $PM_{2.5}$ – particulate matter below 2.5 µm in diameter
- PM_1 – particulate matter below one µm in diameter, often termed very fine particles
- Ultrafine particles – particulate matter below 0.1 µm in diameter.

These particles are small and have the potential to penetrate beyond the body's natural clearance mechanisms of cilia and mucous in the nose and upper respiratory system, with smaller particles able to further penetrate into the lower respiratory tract[12] and lungs. Once in the lungs, adverse health effects may occur that include mortality and morbidity, which have been causally linked with a range of adverse cardiovascular and respiratory effects (USEPA 2019).

The following figure shows a general illustration to provide some context in relation to the size of different particles (discussed above) and their relevance and importance for the assessment of inhalation exposures.

[12] The lower respiratory tract comprises the smaller bronchioles and alveoli, the area of the lungs where gaseous exchange takes place. The alveoli have a very large surface area and absorption of gases occurs rapidly with subsequent transport to the blood and the rest of the body. Small particles can reach these areas, be dissolved by fluids and absorbed.

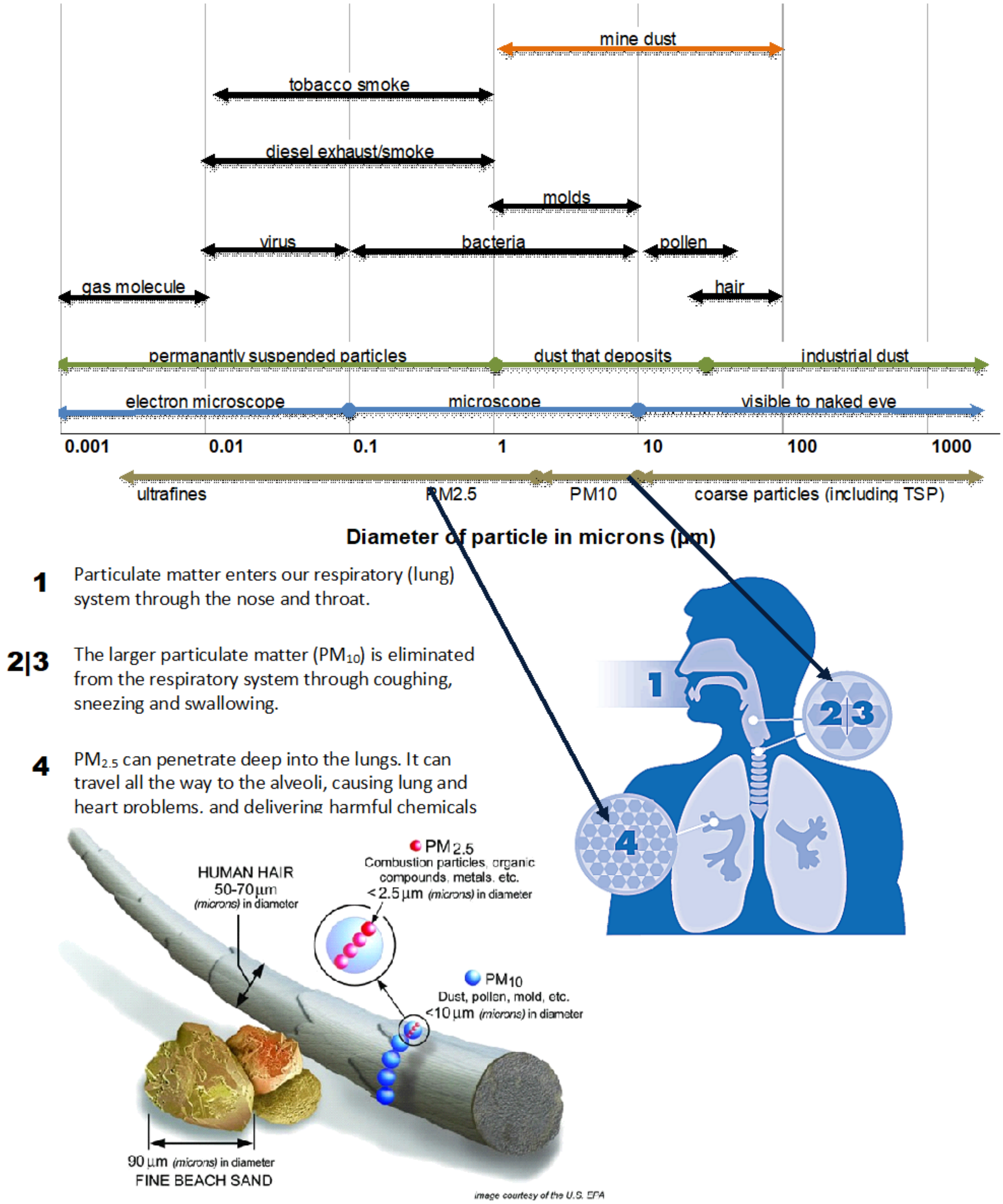


Figure A.2 Illustrative representation of relative particle sizes and importance for health

The above figure shows that $PM_{2.5}$ and smaller is the particle size that may reach the lower parts of the respiratory tract (the smaller bronchioles and alveoli). This is the area of the lungs where gaseous exchange takes place and the area that may be impacted by fine particles that have specific characteristics.

This figure also illustrates that particle sizes generated during excavation and other similar construction activities such as mining operations principally comprise sizes between 1 and 100 µm in diameter, with most of the dust considered coarse particles (comprising deposited dust and TSP), PM_{10} and some $PM_{2.5}$. For this reason, the focus of most dust assessments for such activities relates to deposited dust and PM_{10}. This is in contrast to combustion sources where particulate matter is dominated by vehicle emissions and smoke (from woodfired heaters) which are dominated by $PM_{2.5}$ and smaller particles.

A1.3 Health effects

A1.3.1 Overview

Adverse health effects associated with exposure to particulate matter have been well studied and reviewed by Australian and international agencies. Most of the studies and reviews have focused on population-based epidemiological studies in large urban areas in North America, Europe and Australia, where there have been clear associations determined between health effects and exposure to $PM_{2.5}$ and to a lesser extent, PM_{10}. These studies are complemented by findings from other key investigations conducted in relation to: the characteristics of inhaled particles; deposition and clearance of particles in the respiratory tract; animal and cellular toxicity studies; and studies on inhalation toxicity by human volunteers (NEPC 2010).

Particulate matter has been linked to adverse health effects after both short-term exposure (days to weeks) and long-term exposure (months to years). The health effects associated with exposure to particulate matter vary widely, with the respiratory and cardiovascular systems most affected, and include mortality and morbidity effects.

In relation to mortality, for short-term exposures in a population this relates to the increase in the number of deaths due to existing (underlying) respiratory or cardiovascular disease; for long-term exposures in a population this relates to mortality rates over a lifetime, where long-term exposure is considered to accelerate the progression of disease or even initiate disease.

In relation to morbidity effects, this refers to a wide range of health indicators used to define illness that have been associated with (or caused by) exposure to particulate matter. In relation to exposure to particulate matter, effects are primarily related to the respiratory and cardiovascular system and include (Morawska, Moore & Ristovski 2004; USEPA 2009, 2018a):

- aggravation of existing respiratory and cardiovascular disease (as indicated by increased hospital admissions and emergency room visits)
- changes in cardiovascular risk factors such as blood pressure
- changes in lung function and increased respiratory symptoms (including asthma)
- changes to lung tissues and structure
- altered respiratory defence mechanisms.

A substantial volume of literature is available that assesses potential associations between exposure or changes in exposures to particulate matter (as PM_{10} and/or $PM_{2.5}$), based on epidemiological studies. These studies need to be critically reviewed using robust methods, that include wight of evidence and mechanistic information to establish causation. Hence this review has not undertaken a detailed literature review or systematic review of published studies related to health effects of particulate matter.

However key detailed evaluations of such studies conducted by the WHO (WHO 2013b, 2016), Australia (Jalaludin & Cowie 2012; Morgan, Broom & Jalaludin 2013; NEPC 2011, 2014) and USEPA (USEPA 2019, 2022a) have been relied upon for identifying health effects that are considered to be caused by exposure to particulate matter.

The most recent and comprehensive reviews conducted by the USEPA (USEPA 2019, 2022a) summarised the strength of the evidence for $PM_{2.5}$ effects on various health outcomes ranging from causal (the evidence is strong enough to conclude that $PM_{2.5}$ exposure causes the health outcome) to suggestive (the evidence suggests that $PM_{2.5}$ might cause the health outcome). This is summarised in Table A.1.

$PM_{2.5}$ is considered to have a *causal* or *likely causal* relationship with a small number of health outcomes and a *suggestive* relationship with many other health outcomes.

The International Agency for Research on Cancer (IARC) recently classified outdoor air pollution as a mixture, and particulate matter specifically, as carcinogenic to humans (IARC 2013).

There is no evidence of a threshold concentration below which adverse health effects of PM are not observed (Brook et al. 2010; Pope, CA & Dockery 2006; WHO 2013a, 2013b). A WHO (2013) review of the scientific literature since 2005 found strong evidence that the effects of $PM_{2.5}$ on a wide range of adverse health outcomes occurred at levels below those experienced in Australia, and followed a mostly linear concentration response relationship (Morgan, Broom & Jalaludin 2013). The USEPA reviews considered studies relating to exposures at near-ambient concentrations. Overall, these studies showed inconsistent results (USEPA 2022a).

The WHO (2013) review also found that particles in the PM_{10} size fraction have health effects independent of $PM_{2.5}$. There is increasing evidence of the adverse effects on health of coarse particles in the size range from $PM_{2.5}$ to PM_{10}, and studies show associations between long-term exposure to PM_{10} and health, especially for respiratory outcomes (Morgan, Broom & Jalaludin 2013).

Coarse and fine particles deposit at different locations in the respiratory tract, have different sources and composition, act through partly different biological mechanisms, and result in different health outcomes. The WHO (2013) review concluded that there is good evidence to support maintaining independent short-term and long-term standards for ambient PM_{10} in addition to $PM_{2.5}$ to protect against the health effects of both fine and coarse particles (Morgan, Broom & Jalaludin 2013).

Table A.1 Summary of evidence for adverse health effects for particulate matter (USEPA 2019, 2022a)

Exposure duration and size fraction	Outcome	Causal determination	Susceptible populations (Morgan, Broom & Jalaludin 2013)
Long-term exposure			
$PM_{2.5}$	Cardiovascular effects	Causal	Adults and children and may relate to an increased risk of developing disease
	Respiratory effects	Likely to be causal	
	Mortality	Causal	
	Metabolic effects	Suggestive	
	Reproductive and developmental effects	Suggestive	
	Cancer, mutagenicity and genotoxicity	Likely to be causal (based on IARC classification of outdoor air pollution as mixture) (IARC 2013)	

Exposure duration and size fraction	Outcome	Causal determination	Susceptible populations (Morgan, Broom & Jalaludin 2013)
Short-term exposure			
$PM_{2.5}$	Cardiovascular effects	Causal	Elderly, infants and individuals with chronic cardiopulmonary disease, influenza or asthma.
	Respiratory effects	Likely to be causal	Adults and children, including those with asthma
	Mortality	Causal	Elderly, infants and individuals with chronic cardiopulmonary disease, influenza or asthma. Health endpoint is relevant however assessing significance of outcomes is challenging.
	Metabolic effects	Suggestive	
PM_{10}-$PM_{2.5}$	Cardiovascular effects	Suggestive	
	Respiratory effects	Suggestive	
	Mortality	Suggestive	

These effects are commonly used as measures of population exposure to particulate matter in community epidemiological studies (from which most of the available data in relation to health effects is derived) and are more often grouped (through the use of hospital codes) into the general categories of cardiovascular morbidity/effects and respiratory morbidity/effects. The available studies provide evidence for increased susceptibility for various populations, particularly older populations, children and those with underlying health conditions (USEPA 2009, 2019).

There is consensus in the available studies and detailed reviews that exposure to fine particulates, $PM_{2.5}$, is associated with (and causal to) cardiovascular and respiratory effects and mortality (all causes)(USEPA 2019, 2022a). While similar relationships have also been determined for PM_{10}, the supporting studies do not show relationships as clear as shown with $PM_{2.5}$ (USEPA 2019, 2022a). Hence the focus of any assessment of health impacts relates to $PM_{2.5}$, where the evidence is causal.

A number of studies been undertaken where other health effects have been evaluated. These studies have a large degree of uncertainty or a limited examination of the relationship and are generally only considered to be suggestive or inadequate (in some cases) of an association with exposure to $PM_{2.5}$ (USEPA 2018a). This includes long-term exposures and metabolic effects, male and female reproduction and fertility, pregnancy and birth outcomes; and short-term exposures and nervous system effects (USEPA 2018a).

In relation to the key health endpoints relevant to evaluating exposures to $PM_{2.5}$, there are some associated health measures or endpoints where the exposure-response relationships are not as strong or robust as those for the key health endpoints and are considered to be a subset of the key health endpoints. This includes mortality (for different age groups), chronic bronchitis, medication use by adults and children with asthma, respiratory symptoms (including cough), restricted work days, work days lost, school absence and restricted activity days (Anderson et al. 2004; EC 2011; Ostro 2004; WHO 2006a).

The available studies have also shown that people with low socioeconomic status are also more vulnerable to the effects of air pollution. This is likely a result of a residing in areas of higher pollution (which are often more affordable), poorer health status for these individuals, and potentially poorer access to health care (USEPA 2022a).

The following provides further discussion in relation to reviews conducted by NEPC, WHO and EPA Victoria in relation to the health effects of particulates.

A1.3.2 NEPM review

The scope of the NEPM review undertaken by Jalaludin et al (Jalaludin & Cowie 2012) specifically excluded undertaking a weight of evidence approach, as this involves *evaluating the quality of measurement methods, size and power of study design, consistency of results across studies, and biological plausibility of CRFs* (Concentration Response Functions) *and statistical associations*. This was beyond what could be done for this project. Instead the NEPM review undertaken (Jalaludin & Cowie 2012) pointed to the weight of evidence reviews undertaken by organisations such as the World Health Organization (WHO) and the US EPA, while documenting CRFs found in the literature that may be considered relevant to Australia. The report does provide recommended CRFs, but this needs to be considered in the context that a weight of evidence approach was not applied when recommending these CRFs.

The selection of recommended CRFs within the NEPM process are identified in the 2013 NEPM Report Exposure Assessment and Risk Characterisation to Inform Recommendations for Updating Ambient Air Quality Standards for $PM_{2.5}$, PM_{10}, O_3, NO_2, SO_2 (Golder 2013). For particulates, these are summarised below:

- Short Term (24-hour) PM_{10}:
  - Mortality
    - Cardiovascular (all ages)
  - Morbidity
    - Asthma (Emergency Department)
    - Cardiovascular (65+ years)
    - Cardiac including Cardiac Failure (ICD 10:I50)
    - Respiratory (<= 14 years)
    - Pneumonia & Acute bronchitis (65+ years)
- Short Term (24-hour) $PM_{2.5}$:
  - Mortality
    - Cardiovascular (all ages)
  - Morbidity
    - Asthma (Emergency Department)
    - Cardiovascular (65+ years)
    - Cardiac including Cardiac Failure (ICD 10:I50)
- Long Term (Annual) $PM_{2.5}$
  - Mortality
    - Cardiopulmonary (30+ years)
    - Ischaemic Heart Disease (30+ years)
    - Lung Cancer (30+ years).

As this report was designed to look at regional effects of air pollution, some of the above health endpoints may not have the localised data necessary to calculate out the impact at a local scale.

Referring to the NEPM review undertaken by Jalaludin et al (Jalaludin & Cowie 2012) and its reference to the weight of evidence approach undertaken by the WHO and US EPA, these organisations recommend the following health endpoints.

A1.3.3 World Health Organization

In 2013 the WHO released its Review of evidence on health aspects of air pollution – REVIHAAP Project (WHO 2013b). This report made suggestions for core health outcome related to NO_2 exposure, however for particulate matter it summarised the health endpoints identified in published Health Impact Assessments. More recent review by the WHO (WHO 2021) has emphasised that evidence of causality is important for establishing health endpoints relevant particulate matter.

The following health outcomes are noted.

- Short Term (24-hour) $PM_{2.5}$:
  - Mortality (causal)
    - All Cause (all ages)
- Long Term (Annual) $PM_{2.5}$
  - Mortality (causal)
    - All Cause (30+ years)
    - Cardiovascular (30+ years)
    - Cardiopulmonary and Lung Cancer (30+ years)
    - Respiratory
- Other effects associated with PM exposure (not critically reviewed by WHO):
  - Mortality
    - Infant (0-1 years)
  - Morbidity (noting that many of these outcomes will be difficult to estimate given the lack of baseline incidence rates)
    - Bronchitis symptoms (<18 years)
    - Chronic bronchitis (30+ years)
    - Asthma attacks (all ages)
    - Cardiovascular, cerebrovascular (possibly) and respiratory hospital admissions (all ages)
    - Urgent care visits due to asthma (and possible other respiratory outcomes) and cardiovascular disease (all ages)
    - Restricted activity days (adults).

A1.3.4 United States Environmental Protection Agency (USEPA)

The US EPA undertook a 'strength of evidence' approach to assess the quality and consistency of epidemiological evidence regarding health effects from exposure to $PM_{2.5}$ in 2009 (USEPA 2009) with an update and further review of the science based on published studies to March 2021 (USEPA 2019, 2022a). A strength of evidence approach will generally follow key parameters outlined by Braford Hill (Hill 1965). In the case of the US EPA they assessed 'strength of evidence' based on consistency of finding the health outcome across multiple epidemiological studies, coherence of the evidence across disciplines and across related health endpoints, and biological plausibility of the health outcome (USEPA 2019, 2022a). In doing so, they classify the relationship between the pollutant and health outcome as either:

1. causal
2. likely to be causal
3. suggestive
4. not sufficient to infer a causal relationship, or
5. not likely to be causal.

In estimating the health impacts from $PM_{2.5}$ the US EPA only used health outcomes that were classified as either causal or likely to be causal (USEPA 2009, 2018a), those being (also refer to the summary table above):

For short term $PM_{2.5}$ exposure

- Mortality (causal relationship)
  - non-accidental
  - cardiovascular-related
  - respiratory-related
- Cardiovascular effects (causal relationship)
  - cardiovascular-related hospital admissions
- Respiratory effects (likely causal relationship)
  - respiratory-related hospital admissions
  - asthma-related emergency department visits

For long term $PM_{2.5}$ exposure:

- Mortality (causal relationship)
  - all-cause
  - ischemic heart disease (IHD)-related
  - cardiopulmonary-related
  - lung cancer
- Cardiovascular effects (causal relationship)
  - cardiovascular-related hospital admissions
- Respiratory effects (likely causal relationship)
  - respiratory-related hospital admissions
  - asthma-related emergency department visits

- Nervous system effects (likely causal relationship, noting evidence for these effects most strongly observed in animal studies)
- Cognitive deficits
- All cause dementia.

Only suggestive relationships were identified for effects associated with short term $PM_{10-2.5}$ exposure, and inadequate evidence is available for the assessment of long-term exposure to $PM_{10-2.5}$.

Note it's important to understand that the use of multiple endpoints may involve double counting of the health impacts.

A1.3.5 EPA Victoria review

EPA Victoria has recently released an overview of air pollution issues relevant to Victoria (EPA Victoria 2018). This included a summary of the health effects of exposure to air pollution, including particulates (principally reviews from open access publications, noting the review does not provide a critical appraisal of the studies). The following are relevant excerpts from the 2018 review:

General

There is a large body of evidence that demonstrates that air pollution, even at concentrations below the current air quality standards, is associated with adverse health effects (Brook et al. 2010; Burnett et al. 2014; Lim et al. 2012; USEPA 2009; WHO 2006a). The strongest evidence relates to premature mortality and effects on the respiratory and cardiovascular system. In 2013, the International Agency for Research on Cancer classified outdoor air pollution and particulate matter as carcinogenic to humans (IARC 2016).

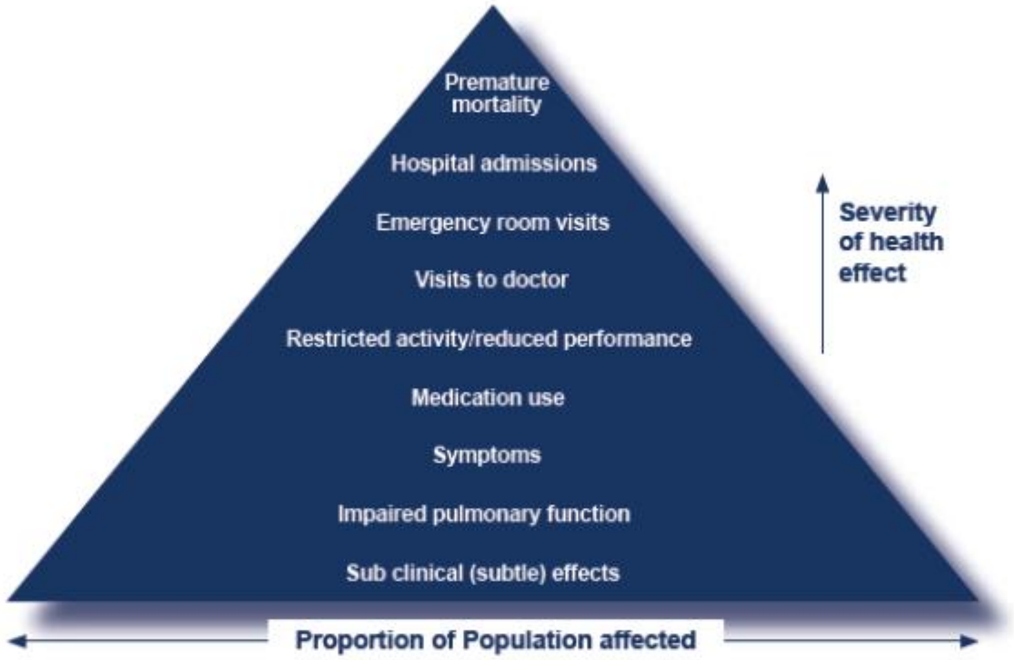
Particulate matter is estimated to be the individual pollutant responsible for the largest burden of disease from outdoor pollution (GBD Risk Factors Collaborators 2017). This is mainly due to its effects on the cardiovascular and respiratory system as the small particles can penetrate deep into the lung (GBD Risk Factors Collaborators 2017). In fact, on a global scale, ambient particulate matter is estimated to be responsible for approximately 4.1 million premature deaths (7.5 per cent of global deaths). These deaths are largely caused by chronic lung diseases and lung cancer, heart disease and stroke, and respiratory infections.

Outdoor air pollution is a complex mixture of pollutants that often have similar sources which generally result in a high correlation between pollutants. This can make it difficult to determine the health effects attributable to individual air pollutants. However, PM_{10}, $PM_{2.5}$ and ozone are of most concern in Victoria, as these pollutants present in the highest concentrations with relation to the air quality standards , and they have well-documented adverse health effects such as premature mortality, and acute and chronic respiratory morbidity (Jerrett et al. 2009; Peng et al. 2013; WHO 2006b).

Population level impacts and susceptibility

Most epidemiological studies that investigate the association between air pollution and health have used existing health registries, such as mortality registries, and registries of hospital admissions and emergency presentations to establish an association. These are all high-level health outcomes in the pyramid of health effects (Figure A.3), meaning they are the least common but have the most severe health effects. There are a whole range of effects that are less severe and are generally not captured by existing health registries, such as symptoms, and sub-clinical health effects. Generally, the only way to measure these less severe health effects are by collecting information on individuals, such as blood markers of inflammation or coagulation which can indicate an effect on the heart, or exhaled nitric oxide which can indicate lung inflammation. Therefore, the studies of the higher-level health outcomes are very informative, but it is important to consider that these only include a small part (the tip of the pyramid) of the wide range of health effects of air pollution.

The impacts on individuals exposed to similar levels of air pollutants can vary considerably, depending on their susceptibility to the effects of air pollutants. Individuals that are generally considered to be more susceptible are those who have existing lung or heart disease, the young and the elderly (Pope, CA & Dockery 2006).



(from EPA Victoria 2018)

Figure A.3 The air pollution health effects pyramid (Dennekamp & Abramson 2011; adapted from ATS 2000)

Ambient particulate matter

$PM_{2.5}$ is a component of PM_{10} and both size fractions show clear evidence of being associated with health effects, with $PM_{2.5}$ generally showing stronger associations. Ultrafine particles (UFP), which are a subset of $PM_{2.5}$, are much smaller and can therefore penetrate further into the lungs. They can only be measured by number due to their small size and are therefore more difficult to measure. Unlike $PM_{2.5}$ and PM_{10}, UFPs are not regulated. A smaller number of studies have investigated the health effects of UFPs. There is some evidence that there is an association of UFPs with cardiovascular health effects (HEI 2013; Pieters et al. 2015; Stone et al. 2017). In epidemiological studies, it is difficult to determine whether UFPs have independent effects, with more research needed. This section (as provided by EPA Victoria) will therefore focus on the health effects of $PM_{2.5}$.

Systematic reviews and meta-analyses investigating the association between $PM_{2.5}$ and effects on health have mainly focused on effects on the respiratory and cardiovascular system. There is clear evidence that there is an association between increases in daily average $PM_{2.5}$, and emergency presentations and hospital admissions for respiratory and cardiovascular conditions and mortality (Atkinson et al. 2014; Katsouyanni et al. 2009; Simpson et al. 2005; WHO 2006b, 2013b). There is now also evidence from a meta-analysis of an association between increased $PM_{2.5}$ with increased out-of-hospital cardiac arrest using data from Europe, North America, Asia and Australia (Zhao et al. 2017). This included a study conducted in Melbourne (Dennekamp & Carey 2010). In addition, many studies have also shown an association between exposure to PM_{10} and $PM_{2.5}$, and reduced lung function, respiratory symptoms, and physiological and sub-clinical changes, such as heart rate variability, blood markers of inflammation and coagulation (Gold et al. 2000; Gotschi et al. 2008; WHO 2013b)(Brook et al. 2010). It is generally accepted that there is a linear relationship between exposure to particulate matter PM_{10} and $PM_{2.5}$, and health outcomes, and that there is no safe PM_{10} and $PM_{2.5}$ level below which no effects are expected (Pope, CA & Dockery 2006).

Studies investigating long-term exposure to $PM_{2.5}$ have also shown associations with effects on the respiratory and cardiovascular system, in particular cardiopulmonary mortality (WHO 2013b). A comprehensive review by the American Heart Association concluded that long-term exposures increased the risk of cardiovascular mortality to an even greater extent than exposures over a few days (Brook et al. 2010). They also concluded that reductions in $PM_{2.5}$ levels were associated with decreases in cardiovascular mortality. These conclusions have been confirmed by more reviews and meta-analyses published subsequently (Cesaroni et al. 2014; Hoek et al. 2013). A critical review by the Health Effects

Institute (HEI 2010) concluded that exposure to traffic air pollution adversely affected lung development in childhood. A recent meta-analysis supported the hypothesis that childhood exposure to traffic air pollution contributes to the development of childhood asthma (Khreis et al. 2017).

Using the results from a large meta-analysis done for the WHO (WHO 2013b, 2013c), a study by Hoek et al. (Hoek et al. 2013) concluded that for every 10 µg/m^3 increase in $PM_{2.5}$, the risk of all-cause mortality increased by 6.2 per cent (95 per cent confidence interval 4.1–8.4 per cent). This is similar to results from the earlier American Cancer Society Study (Pope, CA, 3rd et al. 2002). This estimate is most commonly used in health impact assessments (as stated by EPA Victoria). However, a more recent analysis using data from European Cohorts found an even greater increase in all-cause mortality of 13 per cent per 10 µg/m^3 increase (95 per cent confidence interval 1–25 per cent) (Beelen et al. 2014). However, the confidence interval around this estimate was much larger, reducing the confidence in the estimate.

A1.3.6 Vehicle emissions

A recent review conducted by Hime et al (Hime, Marks & Cowie 2018) involved a review of evidence of health effects associated with exposure to particulate matter from 5 common outdoor emission sources, that include traffic emissions and diesel emissions.

The review was not a comprehensive assessment of all evidence of health effects associated with particulate matter, but presents a review of the available studies and findings of comparative studies. The paper did not include a systematic review of the quality of the available studies.

The review is noted to be limited, as the different methods that have been used in epidemiological studies, along with the differences in populations, emission sources, and ambient air pollution mixtures between studies, make the comparison of results between studies problematic.

In relation to traffic emissions, the review identified the following (Hime, Marks & Cowie 2018):

- Traffic generates airborne particles via exhaust emissions from fuel combustion, as well as the resuspension of non-exhaust PM from road, tyre, and brake wear. Non-exhaust PM is predominantly in the coarse fraction between 2.5 and 10 µm in diameter and is an important source of trace metals in PM in urban environments. Particles from vehicle exhaust constitute the major source of ultrafine particles, <0.1 µm in diameter ($PM_{0.1}$), in urban environments. Traffic-generated PM includes secondary PM formed from hot exhaust gases (carbon dioxide, carbon monoxide, hydrocarbons, and nitrogen oxides) expelled from vehicle tailpipes.
- Traffic is a significant contributor to urban air pollution and the health effects of exposure to traffic-related air pollution (TRAP) have been extensively reviewed. An expert panel for the US Health Effects Institute concluded that while many health effects have been associated with exposure to TRAP, only the evidence related to the exacerbation of childhood asthma was sufficient to assign causality. The panel categorized the evidence linking the onset of childhood asthma, respiratory symptoms, impaired lung function, all-cause mortality, and cardiovascular morbidity with exposure to TRAP, as ‘suggestive but not sufficient’ to infer causation.
- The US Environmental Protection Agency (EPA) has implicated TRAP as a risk factor for myocardial infarction and also concluded that associations between ambient $PM_{2.5}$ and cardiovascular disease hospitalisations may be primarily due to particles from traffic.
- Various toxicological and epidemiological studies implicate traffic-related PM as likely to be causal in the associations between TRAP and cardiovascular health effects $PM_{2.5}$ apportioned to traffic has been associated with all-cause, respiratory, and cardiovascular mortality, and daily hospital admissions for cardiovascular disease, stroke, and heart failure. In the Harvard Six Cities cohort the magnitude of the effect of exposure to traffic-related $PM_{2.5}$ on daily mortality was greater than that for $PM_{2.5}$ from coal combustion, crustal dust, or total $PM_{2.5}$ mass. In the multi-country study, Air Pollution on Health: A European Approach Study (APHEA2), PM from areas with higher ambient nitrogen dioxide (a marker of traffic emissions) was associated with greater acute health effects, suggesting that PM emitted by traffic is more toxic than PM from other sources.

- Findings from toxicological studies conducted within the NPACT project suggest that $PM_{2.5}$ from vehicle exhaust emissions has greater cardiovascular toxicity than non-exhaust $PM_{2.5}$, however epidemiological investigations within the project were inconclusive in their support Particles from traffic have high oxidative potential, possibly due to metals arising from engine and brake abrasion. Some studies, but not all, have demonstrated that as traffic density increases, the capacity of roadside PM to generate tissue-damaging reactive oxygen species increases.

In relation to diesel emissions the review identified the following (Hime, Marks & Cowie 2018):

- Diesel exhaust particles from modern, optimal combustion engines are primarily $PM_{2.5}$, a considerable component of which are $PM_{0.1}$. They are highly complex particles with a core of elemental carbon and adsorbed organic compounds, as well as small amounts of sulphate, nitrate, metals, and many trace elements.
- The study of the health effects of diesel exhaust PM is complicated by the fact that diesel exhaust PM varies in chemical composition and size according to engine type (heavy-duty, light-duty, method of fuel injection), engine operating conditions (idle, accelerating, decelerating), and fuel formulations (high/low sulfur fuel, petroleum-based diesel, biodiesel). It is unclear how these differences change toxicity.
- A more recent analysis of pooled data from 11 case-control occupational epidemiology studies conducted in Europe and Canada found that cumulative diesel exhaust exposure was associated with an increased lung cancer risk, and in 2012 the International Agency for Research on Cancer (IARC) classified diesel engine exhaust as ‘carcinogenic to humans’ based on findings from occupational epidemiological studies and toxicological investigations conducted in research animals. The occupational epidemiological studies on which the IARC conclusions were based were limited by a general lack of objective measure of diesel exposure. Recent cohort and nested case-control studies in 12,000 US mine workers, which included PM measurements in their exposure assessment, observed that exposure to diesel exhaust PM was associated with lung and oesophageal cancer mortality. However, not all reports have found such links between diesel exposure and cancer. A systematic review published in 2014 of 42 cohort and 32 case-control studies did not find a clear relationship between diesel exposure and lung cancer. A literature review published in 2012 concluded that the occupational epidemiological evidence was inadequate to confirm a link between diesel exhaust exposure and lung cancer, and suggested that weak exposure–response associations could be explained by bias, confounding, chance, or exposure misclassification.
- Due to the difficulty in distinguishing PM derived from diesel exhaust from PM arising from other emission sources, most epidemiological studies have not assessed the effects of exposure to ambient diesel exhaust PM. It is noteworthy that the IARC deliberately excluded evidence from non-occupational exposure of diesel exhaust in their assessment of the carcinogenicity of diesel exhaust emissions because of the difficulty in assessing the contribution to cancer risk of diesel exhaust in ambient air.
- The majority of evidence indicating the potential for diesel exhaust PM to cause health effects has come from human chamber studies and studies in research animals. Controlled exposures of humans to diesel exhaust have resulted in various cardiovascular changes indicative of increased acute coronary event risk, mild constriction and inflammation of lung airways, nose and throat irritation, and changes in lung function.
- Many research animal studies support the biological plausibility of the health effects observed in humans exposed to diesel exhaust. As with PM from other sources, it is thought that oxidative stress underpins the mechanism by which diesel exhaust causes health effects, and the effects of diesel exhaust PM may be accentuated in individuals with conditions associated with oxidative stress, such as diabetes and obesity. Diesel exhaust PM has also been shown to enhance susceptibility to infection and increase the atopic response to allergens. Exposure of pregnant mice to diesel exhaust PM has been found to affect the central nervous and immune systems of offspring, as well as their susceptibility to asthma and heart failure. However, there is no evidence of inherited health effects from exposure to diesel exhaust at levels that are typical of ambient environments.

A1.3.7 Assessment of asthma

In relation to respiratory effects associated with exposure to $PM_{2.5}$, the quantitative assessment has focused on children aged 1–14 years where emergency department admissions has been used as the health endpoint. This health endpoint is considered to provide an indication of the impact of changes in $PM_{2.5}$ (and NO_2) on the exacerbation of asthma, utilising the key public health measure (namely emergency department admissions) where exposure-response relationships can be measured and risks calculated. Children with asthma as a pre-existing health condition are considered to be a sensitive sub-group in relation to respiratory effects. Individuals, in particular children, with asthma tend to have a higher degree of oronasal breathing that can result in a greater penetration of PM into the lower respiratory tract (USEPA 2018a). There is also evidence that those with asthma may have altered particulate clearance mechanisms (USEPA 2018a). Review of the epidemiological evidence by the USEPA determined a causal relationship between short-term exposure to $PM_{2.5}$ and exacerbation of asthma. The available studies show the strongest relationships with exacerbation of asthma in children, with some long-term studies providing suggestive evidence of impaired lung function growth in children (USEPA 2018a).

Review of exposures to traffic related air pollution (TRAP), in particular particulate matter, by Hime et al (Hime, Marks & Cowie 2018) indicated that detailed reviews by an expert panel for the US Health Effects Institute concluded that while many health effects have been associated with exposure to TRAP, only the evidence related to the exacerbation of childhood asthma was sufficient to assign causality.

A current review of exposures to $PM_{2.5}$, ozone and NO_2 on asthma (Anenberg et al. 2018) provides a review of the available exposure-response relationships derived from a range of epidemiological studies of varying quality. For the assessment of the exacerbation of asthma and exposure to $PM_{2.5}$ the there are no long-term studies (that develop exposure-response relationships) for adults aged 18–64 or older adults aged 65 years and over. The only studies relate to children aged <18 years. In relation to short-term exposures to $PM_{2.5}$ most studies identify relationships for children <18 years) with only a few identifying relationships for adults. Review of these relationships, and relationships relevant to emergency department visits for asthma by the USEPA (USEPA 2018a) indicates the relationships are more significant for children than for adults.

Where NO_2 is considered the most significant exposure-response relationships relate to exposures to children, again with few relationships identified for adults and, where they are identified they are of less significance.

The rate of asthma hospitalisations for children is typically higher than for adults. This same pattern is also expected for emergency department admissions. Hence the calculation of incremental risks associated with exposure to $PM_{2.5}$ (and NO_2) and exacerbation of asthma (where emergency department admissions are used as the public health measure) for children will provide a conservative (i.e. overestimate) estimate of potential risks relevant to asthmatic adults. No separate assessment of asthma health effects on adults has been undertaken.

A1.4 Approach to the assessment of particulate exposures

In relation to the assessment of exposures to particulate matter there is sufficient evidence to demonstrate that there is an association between exposure to $PM_{2.5}$ (and to a lesser extent PM_{10}) and effects on health that are causal.

The available evidence does not suggest a threshold below which health effects do not occur. Accordingly, there are likely to be health effects associated with background levels of $PM_{2.5}$ and PM_{10}, even where the concentrations are below the current guidelines. Standards and goals are currently available for the assessment of $PM_{2.5}$ and PM_{10} in Australia (NEPC 2021). These standards and goals are not based on a defined level of risk that has been determined to be acceptable, rather they are based on balancing the potential risks/health burden due to background and urban sources with the aim of lower impacts on health in a practical way.

The air quality standards and goals relate to average or regional exposures by populations from all sources, not to localised ‘hot-spot’ areas such as locations near industry, busy roads or mining. They are intended to be compared against ambient air monitoring data collected from appropriately sited regional monitoring stations. In some cases, there may be local sources (including busy roadways and industry) that result in background levels of PM_{10} and $PM_{2.5}$ that are close to, equal to, or in exceedance of, the air quality standards and goals. Where impacts are being evaluated from a local source it is important to not only consider cumulative impacts associated with the project (undertaken using the current air quality goals) but also evaluate the impact of changes in air quality within the local community.

This assessment of health impacts from exposure to changes in particulate concentrations has therefore been undertaken to consider both cumulative exposure impacts and incremental exposure impacts associated with changes in $PM_{2.5}$ concentrations that are associated with the project . Incremental changes are those due to the project alone while cumulative changes are those where background air quality in addition to those due to the project alone are considered.

A1.4.1 Assessment of cumulative exposures

The assessment of cumulative exposures to $PM_{2.5}$ is based on a comparison of the cumulative concentrations predicted with the current air quality standards and goals presented in the National Environment Protection Council (NEPC) (Ambient Air Quality) Measure (NEPM) (NEPC 2021), and have been adopted in NSW (NSW EPA 2022). These standards and goals are total concentrations in ambient air, within the community, that are based on the most current science in relation to health effects. The NEPC review that underpins these standards and goals include consideration of the epidemiological evidence.

In relation to the current NEPM PM_{10} standard, the following is noted (NEPC 1998, 2010, 2014, 2016, 2021):

- The standard was derived through a review of appropriate health studies by a technical review panel of the NEPC where short-term exposure-response relationships for PM_{10} and mortality and morbidity health endpoints were considered.
- Mortality health impacts were identified as the most significant and were the primary basis for the development of the standard.
- On the basis of the available data for key air sheds in Australia, the criterion of 50 micrograms per cubic metre was based on analysis of the number of premature deaths that would be avoided and associated cost savings to the health system (using data from the US). The development of the standard is not based on any acceptable level of risk.
- The assessment undertaken considered exposures and issues relevant to urban air environments that are expected to also be managed through the PM_{10} standard. These issues included emissions from vehicles and wood heaters.

A similar approach has been adopted by NEPC (Burgers & Walsh 2002; NEPC 2002, 2014) in relation to the derivation of the $PM_{2.5}$ air quality standards, with specific studies related to $PM_{2.5}$ and mortality and morbidity indicators considered. Goals for lower $PM_{2.5}$ standards to be met by 2025 are also outlined by NEPC (NEPC 2021), and are:

- 24-hour average = 25 $\mu g/m^3$
- Annual average = 8 $\mu g/m^3$.

A1.4.2 Assessment of incremental exposures (changes in air quality)

As no threshold has been determined for exposure to $PM_{2.5}$ the assessment of impacts on health has utilised robust, published, quantitative relationships (exposure-response relationships) that relate a change in $PM_{2.5}$ concentration with a change in a health indicator. The focus of this assessment relates to the assessment of health endpoints where causal associations have been identified, and robust exposure-response relationships are available. The specific health effects (or endpoints) evaluated in this assessment include:

- Primary health endpoints:
  - long-term exposure to $PM_{2.5}$ and changes in all-cause mortality (equal or greater than 30 years of age)
  - short-term exposure and changes to the rate of hospitalisations with cardiovascular and respiratory disease (equal or greater than 65 years of age).
- Secondary health endpoints (to supplement the primary assessment):
  - short-term exposure to PM_{10} and changes in all-cause mortality (all ages)
  - long-term exposure to $PM_{2.5}$ and changes in cardiopulmonary mortality (equal or greater than 30 years of age)
  - short-term exposure to $PM_{2.5}$ and changes in cardiovascular and respiratory mortality (all ages)
  - short-term exposure to $PM_{2.5}$ and changes in emergency department admissions for asthma in children aged 1–14 years.

The following table summarises the health endpoints considered in this assessment, the relevant health impact functions (from the referenced published studies) and the associated β coefficient relevant to the calculation of a relative risk.

The health impact functions presented in this table are the most current and robust values and are appropriate for the quantification of potential health effects for the health endpoints considered in this assessment.

Table A.2 Adopted health impact functions and exposure-responses relationships

Health endpoint	Exposure period	Age group	Published relative risk [95 confidence interval] per 10 µg/m^3	Adopted β coefficient (as %) for 1 µg/m^3 increase in PM	Reference
Primary assessment health endpoints					
$PM_{2.5}$: Mortality, all causes	Long-term	≥30yrs	1.06 [1.04–1.08]	0.0058 (0.58)	Relationship derived for all follow-up time periods to the year 2000 (for approx. 500,000 participants in the US) with adjustment for 7 ecologic (neighbourhood level) covariates (Krewski et al. 2009). This study is an extension (additional follow-up and exposure data) of the work undertaken by Pope (2002), is consistent with the findings from California (1999-2002) (Ostro et al. 2006) and is more conservative than the relationships identified in a more recent Australian and New Zealand study (EPHC 2010)
$PM_{2.5}$: Cardiovascular hospital admissions	Short-term	≥65yrs	1.008 [1.0059–1.011]	0.0008 (0.08)	Relationship established for all data and all seasons from US data for 1999 to 2005 for lag 0 (exposure on same-day)(strongest effect identified) (Bell 2012; Bell et al. 2008)
$PM_{2.5}$: Respiratory hospital admissions	Short-term	≥65yrs	1.0041 [1.0009–1.0074]	0.00041 (0.041)	Relationship established for all data and all seasons from US data for 1999 to 2005 for lag 2 (exposure 2 days previous)(strongest effect identified) (Bell 2012; Bell et al. 2008)
Secondary assessment health endpoints					
PM_{10}: Mortality, all causes	Short-term	All ages*	1.006 [1.004–1.008]	0.0006 (0.06)	Based on analysis of data from European studies from 33 cities and includes panel studies of symptomatic children (asthmatics, chronic respiratory conditions) (Anderson et al. 2004)
$PM_{2.5}$: Mortality, all causes	Short-term	All ages*	1.0094 [1.0065–1.0122]	0.00094 (0.094)	Relationship established from study of data from 47 US cities for the years 1999 to 2005 (Zanobetti & Schwartz 2009)
$PM_{2.5}$: Cardio-pulmonary mortality	Long-term	≥30yrs	1.14 [1.11–1.17]	0.013 (1.3)	Relationship derived for all follow-up time periods to the year 2000 (for approx. 500,000 participants in the US) with adjustment for 7 ecologic (neighbourhood level) covariates (Krewski et al. 2009)
$PM_{2.5}$: Cardiovascular mortality	Short-term	All ages*	1.0097 [1.0051–1.0143]	0.00097 (0.097)	Relationship established from study of data from 47 US cities for the years 1999 to 2005 (Zanobetti & Schwartz 2009)

Health endpoint	Exposure period	Age group	Published relative risk [95 confidence interval] per 10 µg/m^3	Adopted β coefficient (as %) for 1 µg/m^3 increase in PM	Reference
$PM_{2.5}$: Asthma (emergency department admissions)	Short-term	1-14 years	--	0.0015 (0.15)	Relationship established from review conducted on Australian children (Sydney) for the period 1997 to 2001 (Jalaludin et al. 2008)
$PM_{2.5}$: Respiratory mortality (including lung cancer)	Short-term	All ages*	1.0192 [1.0108–1.0278]	0.0019 (0.19)	Relationship established from study of data from 47 US cities for the years 1999 to 2005 (Zanobetti & Schwartz 2009)

* Relationships established for all ages, including young children and the elderly

These exposure response relationships are considered appropriate and address the causal health effects associated with exposure to $PM_{2.5}$, in relation to mortality and hospital admissions. The health endpoints include asthma in children, specifical asthma emergency department admissions. These health endpoints and exposure-response relationships include a number that are consistent with those used in the revision of the NEPM.

Other exposure response relations evaluated in the NEPM are for similar health endpoints and while relevant to assessing impacts of regional scale changes to air policy, would not change an assessment conducted on the basis of the above.

It is noted that mortality, all cause, will be the key driver of any health impact calculations undertaken. It would be relevant and appropriate, and consistent with the way in which other chemical exposures are elevated, to focus on the key driver of impacts.

A2 Nitrogen dioxide

A2.1 General

Nitrogen oxides (NOx) refer to a collection of highly reactive gases containing nitrogen and oxygen, most of which are colourless and odourless. Nitrogen oxide gases form when fuel is burnt including when residual waste is used as fuel. Motor vehicles, along with industrial, commercial and residential (e.g., gas heating or cooking) combustion sources, are primary producers of nitrogen oxides.

In greater NSW, on-road vehicles accounted for about 15% of emissions of nitrogen oxides and industrial facilities accounted for 53%. In Sydney, a greater contribution is derived from on-road vehicles (approximately 53%, predominantly from diesel engines) (Ewald et al. 2020; NSW EPA 2019).

In terms of health effects, nitrogen dioxide is the only oxide of nitrogen that may be of concern (WHO 2000b). Nitrogen dioxide is a colourless and tasteless gas with a sharp odour. Nitrogen dioxide can cause inflammation of the respiratory system and increase susceptibility to respiratory infection. Exposure to elevated levels of nitrogen dioxide has also been associated with increased mortality, particularly related to respiratory disease, and with increased hospital admissions for asthma and heart disease patients (WHO 2013b). Asthmatics, the elderly and people with existing cardiovascular and respiratory disease are particularly susceptible to the effects of elevated nitrogen dioxide (Morgan, Broom & Jalaludin 2013; NEPC 2010). The health effects associated with exposure to nitrogen dioxide depend on the duration of exposure as well as the concentration.

Guidelines are available from the NEPC (NEPC 2016, 2021) which indicate concentrations of nitrogen dioxide considered to be acceptable by national health authorities. The 2021 update (NEPC 2021) resulted in a reduction of the national air quality standard for nitrogen dioxide based on consideration of the current health evidence and more stringent guidelines in other leading countries.

When reviewing the available literature on the health effects associated with exposure to nitrogen dioxide it is important to consider the following:

- whether the evidence suggests that associations between exposure to nitrogen dioxide concentrations and effects on health are causal
- whether the reported associations are distinct from, and additional to, those reported and assessed for exposure to particulate matter
- whether the assessment of potential health effects associated with exposure to different levels of nitrogen dioxide can be undertaken on the basis of existing guidelines, or whether specific risk calculations are required to be undertaken.

A2.2 Causality

The most current review undertaken by the USEPA (USEPA 2016a) specifically evaluated evidence of causation. The review considered the findings from studies and reports published to August 2014 relating to epidemiological, controlled human studies and toxicological studies, as well as an understanding of biological plausibility. Importantly, the review conducted a systematic review of the quality of the studies (including the epidemiological studies) to ensure that the data could be relied upon.

The USEPA review recognised the variability of nitrogen dioxide in urban air environments, and exposures both outdoors and indoors, and the reliance on data relating to ambient exposures from monitoring conducted at only a few locations, typically away from specific sources. Hence there is some error in the use of such data in defining people's actual exposure, or the individual exposures that would be reflected in health data (where relevant). The following table presents a summary of the findings of the USEPA review, in relation to causal effects relevant to nitrogen dioxide.

Table A.3 Summary of causal determinations for relationships between nitrogen dioxide exposures and health effects (USEPA 2016a)

Exposure duration and health effects	Causal determination
Short-term exposure (minutes to a month)	
Respiratory effects, with the key effects related to asthma	Causal
Cardiovascular effects	Suggestive of, but insufficient to infer, a causal relationship
Total mortality	Suggestive of, but insufficient to infer, a causal relationship
Long-term exposure (more than a month to years	
Respiratory effects	Likely to be a causal relationship
Cardiovascular effects and diabetes	Suggestive of, but insufficient to infer, a causal relationship
Reproductive and developmental effects	
Fertility, reproduction and pregnancy	Inadequate to infer a causal relationship
Birth outcomes	Suggestive of, but insufficient to infer, a causal relationship
Postnatal development	Inadequate to infer a causal relationship
Total mortality	Suggestive of, but insufficient to infer, a causal relationship
Cancer	Suggestive of, but insufficient to infer, a causal relationship

The associations identified by the USEPA (2016) in relation to respiratory effects are consistent with those identified in the WHO review (WHO 2013b) and considered in the more recent NEPM revision (NEPC 2019a).

The key causal relationship relates to short-term effects on asthma (reflected in hospitalisations and emergency department admissions for asthma and supported by data from controlled human studies) and potentially longer term effects such as the development of asthma. The following figure provides a summary of the evidence and biological pathways that supports these outcomes.

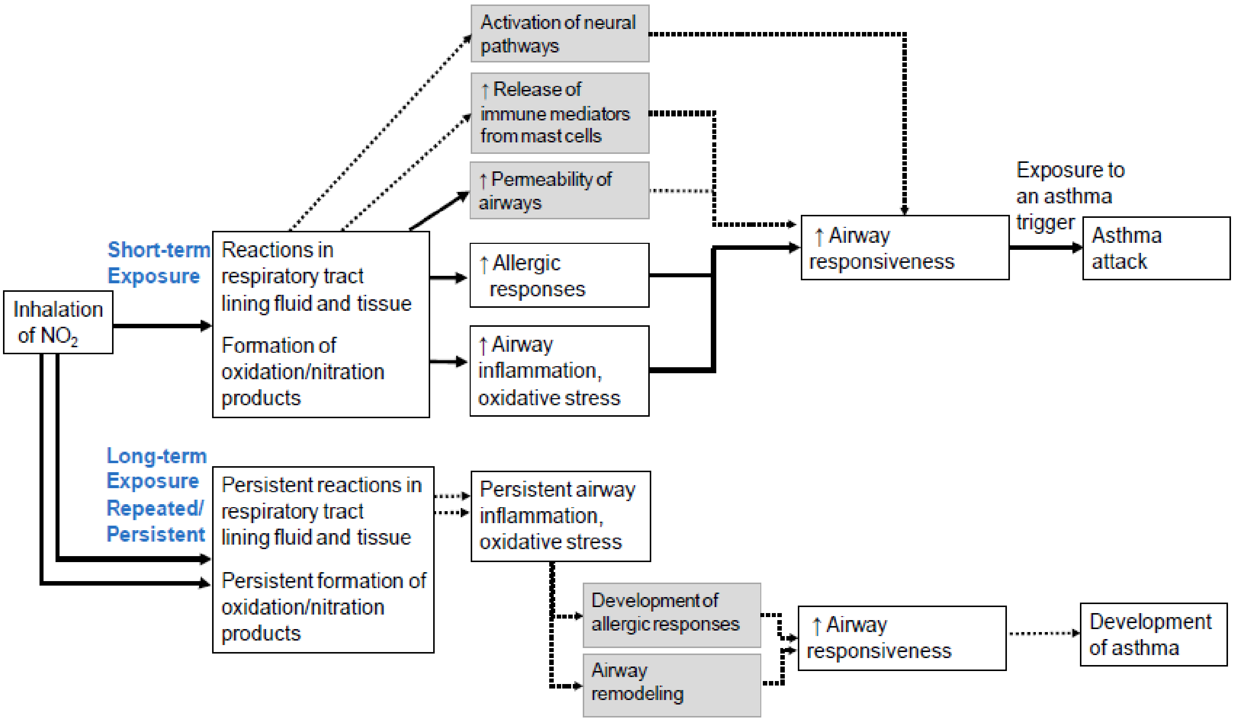


Figure A.4 **Evidence for relationships of short-term and long-term nitrogen dioxide exposure with asthma as biological pathways** (white boxes and solid lines describe pathways well supported by evidence, and grey boxes and dotted arrows describe potential pathways where evidence is limited or inconsistent) (USEPA 2016a)

There is more uncertainty about relationships of nitrogen dioxide exposure with health effects outside of the respiratory system. Nitrogen dioxide itself is unlikely to enter the bloodstream, and reactions caused by ambient-relevant concentrations of nitrogen dioxide in the airways do not clearly affect concentrations of reaction products, such as nitrite, in the blood. Some but not all results suggest that substances that can cause inflammation or oxidative stress may enter the blood from the respiratory tract in response to nitrogen dioxide exposure. This uncertainty about the effects of nitrogen dioxide exposure on underlying biological mechanisms is common to non-respiratory health effects (USEPA 2016a).

In relation to susceptibility, people with asthma, children and older adults are at increased risk for nitrogen dioxide related effects.

The USEPA review indicated that it is not clear whether there is an exposure concentration below which effects do not occur, i.e. a threshold.

The NEPM review (NEPC 2019a) includes discussion on the USEPA (USEPA 2016a) and WHO (WHO 2013b) evaluations and key studies that underpin these evaluations. In relation to Australian studies and data, these have been found to report similar associations between hospitalisations for respiratory effects, including asthma, and short-term changes in nitrogen dioxide. The Australian studies also showed associations between changes in short-term nitrogen dioxide and cardiovascular hospital admissions (in particular cardiac failure) (Barnett et al. 2006). The Australian studies were not critically reviewed in terms of robustness and causation, with effects where associations were identified considered in the NEPM review (NEPC 2019a). These included the following (where a number of exposure-response relationships were utilised):

- increases in daily mortality
- increases in hospital admissions for:
  - respiratory disease
  - cardiovascular disease
- increase in emergency room attendances for asthma.

Susceptible populations were identified as the elderly, people with existing cardiovascular disease and respiratory disease, people with asthma, low socioeconomic groups and children.

The more recent review from WHO (WHO 2021) only considered epidemiological data based on outcomes of systematic reviews completed in 2020 and 2021 (Huangfu & Atkinson 2020; Whaley et al. 2021), and did not include consideration of mechanistic, toxicological and human clinical studies. The previous WHO review focused on non-accidental mortality and respiratory mortality in establishing an air quality guideline. The review also considered new studies published since the systematic reviews, which included 2 studies from Australia (Dirgawati et al. 2019; Hanigan et al. 2019). Review of causation by the WHO (WHO 2021) indicated data on long-term exposure to nitrogen dioxide and non-accidental mortality, specifically respiratory mortality could be supported. In relation to short-term exposures, the association with respiratory effects was determined to be causal, with strong support for the association with asthma hospital admissions and emergency room visits. These causal relationships were the focus of the studies considered in establishing the revised air quality guidelines.

enRiskS (enRiskS 2018) have undertaken a detailed review of health effects associated with acute exposures to nitrogen dioxide (up to an hour) to specifically address situations where exposure to nitrogen dioxide from vehicle emissions may be elevated, such as within long tunnels. The review examined experimental studies to determine if exposures of nitrogen dioxide at 0.5 ppm for up to 60 minutes was likely to cause a clinically relevant health effect. Seventy-eight studies were reviewed and although twelve studies examining health effects of nitrogen dioxide exposure up to 0.5 ppm for up to 60 minutes found a statistically significant result, none of these studies were determined to have a clinically relevant health effect. The review did not identify any studies that contained clinically relevant health results at nitrogen dioxide concentrations less than or equal to 0.5 ppm. There are however limitations with this evidence, including the ability of the 0.5 ppm value to consider health effects that severe asthmatics and those with significant cardiopulmonary issues may experience. Reducing exposure to 0.2 ppm provides a margin of safety for severe asthmatics or those with cardiopulmonary issues and is consistent with the lowest effect levels reported in experimental studies (including some effects that are not clinically significant).

A2.3 Co-exposures and distinct health effects

Co-exposures to nitrogen dioxide and particulate matter complicates review and assessment of many of the epidemiology studies as both these air pollutants occur together in urban areas. There is sufficient evidence (epidemiological and mechanistic) to suggest that some of the health effect associations identified relate to exposure to nitrogen dioxide after adjustment/correction for co-exposures with particulate matter (COMEAP 2015). The epidemiological studies utilised in establishing exposure-response relationships are derived from urban air environments where co-exposures with other pollutants, in particular particulate matter and ozone, where the same health endpoints are identified. Some studies attempt to adjust for such co-exposures but it is not possible to preclude all influence of co-exposures in epidemiological studies. Hence, while effects of exposure to nitrogen dioxide have been identified as relevant, co-exposures will have some effect or influence on the studies that are used to quantify such effects.

The current guidelines in Australia for the assessment of nitrogen dioxide in air relate to cumulative (total) exposures and adopt criteria that are considered to be protective of short and long term exposures. These guidelines have utilised the studies as discussed above with limited discussion on the effects of co-exposures. It is noted that the key health endpoints assessed in relation to nitrogen dioxide exposures are the same as those identified for $PM_{2.5}$ and are therefore not distinct.

It is also noted that the current standards relate to regional air quality, not localised sources and hence use of such standards for the assessment of localised exposures is of limited value. This is of particular importance as there are significant limitations in the use of epidemiological studies as discussed by the USEPA (USEPA 2016a).

A2.4 Approach to the assessment of nitrogen dioxide exposure

Based on the available evidence, a threshold for the health effects of short-term exposure to nitrogen dioxide in the community has not been identified. This may be due to the limitations with the epidemiological studies, however such a threshold has not been established (NEPC 2019a; WHO 2013b). In relation to long-term effects of exposure to nitrogen dioxide the WHO assessment (HRAPIE) (WHO 2013c) identified a cut-off for long-term adverse health effects of 20 $\mu g/m^3$ (NEPC 2019a). Such a cut-off (applied as an annual average) may be considered in an assessment of health impacts.

Based on the above, potential health effects associated with exposure to nitrogen dioxide have been undertaken on the basis of both comparison with guidelines (assessing cumulative exposures) and an assessment of incremental impacts on health (associated with changes in air quality from a specific project as these impact on larger communities).

A2.4.1 Assessment of cumulative exposures

This has been undertaken on the basis of the current NEPC air quality standards (NEPC 2021), which relate to the protection of short-term and long-term exposures, as follows:

- Short-term (1 hour average) = 0.08 ppm = 62 $\mu g/m^3$
- Long-term (annual average) = 0.015 ppm = 28 $\mu g/m^3$.

A2.4.2 Assessment of incremental exposures

The WHO and USEPA (USEPA 2016a; WHO 2013b, 2021) identified that the strongest evidence of health effects, including causal effects, relate to respiratory hospitalisations and emergency department admissions (particularly for asthma) and to a lesser extent mortality (associated with short-term exposures) and recommend that these health endpoints should be considered in any core assessment of health impacts associated with exposure. These health endpoints have been evaluated in relation to changes in nitrogen dioxide concentrations in air.

The following table summarises the health endpoints considered in this assessment, the β coefficient relevant to the calculation of a relative risk. The coefficients adopted for the assessment of impacts on mortality and asthma emergency department admissions are derived from the detailed assessment undertaken for the current review (NEPC 2019a) of health impacts of air pollution for the NEPC (2021) revision and are considered to be current and robust.

A3 Benzene

A3.1 General

Benzene found in the environment is from both human activities and natural processes. Benzene was first discovered and isolated from coal tar in the 1800s. Today, benzene is made mostly from petroleum sources. Benzene, also known as benzol is a volatile, colourless liquid with a characteristic "aromatic" odour. Benzene evaporates into air very quickly and dissolves slightly in water. Benzene is highly flammable (ATSDR 2007a).

Exposure of the general population to benzene may occur in all urban areas, as motor vehicle emissions are a contributor to benzene levels. Inhalation is the primary route of exposure in industrial and everyday settings. Cigarette smoke contains benzene and is a significant exposure for active smokers. Other exposures include furnishings, solvents, adhesives, pumping petrol and residential areas near chemical manufacturing sites. Trace amounts are typically found in food and water (ATSDR 2007a).

A3.2 Exposure, absorption, health effects

There is no clinical disease which is unique to benzene toxicity. However, the effects on the haemotopoietic and immune systems are well recognised. Data from animal and human studies indicates that benzene is rapidly absorbed through the lungs. Definitive scientific data on the rate of absorption after ingestion of benzene in humans are not available. However, case studies of accidental or intentional poisoning indicate that it is absorbed readily. Benzene can be absorbed through the skin, however the rate of absorption is much lower than that for inhalation (ATSDR 2007a).

Once absorbed, benzene partitions to lipid-rich tissues due to the lipophilic nature of the chemical with total uptake dependant on fat content and metabolism. Benzene accumulates in the adipose tissue, bone marrow and brain. The metabolism of benzene is rapid with water-soluble metabolites excreted within 2 hrs of exposure. A substantial proportion of absorbed benzene is eliminated unchanged in exhaled air, with the remainder eliminated in the urine, principally as metabolites. Benzene is metabolised primarily in the liver and to a lesser extent, in the bone marrow. There is no evidence that the route of administration has any substantial effect on subsequent metabolism of benzene in humans or animals (ATSDR 2007a).

Acute benzene exposure produces central nervous system excitation and depression. Acute exposure to high concentrations of benzene in air results in neurological toxicity and may sensitize the myocardium to endogenous catecholamines. Acute ingestion of benzene causes gastrointestinal and neurological toxicity (WHO 1993).

Chronic exposure to benzene results primarily in haematotoxicity, including aplastic anaemia, pancytopenia, or any combination of anaemia, leukopenia, and thrombocytopenia. Chronic benzene exposure is associated with an increased risk of leukaemia. In chronic exposures, benzene metabolites are considered the toxic agents, not the parent compound. The relative contribution of different benzene metabolic pathways may be dose related, with more toxic agents produced by high affinity low capacity pathways (WHO 1993).

A3.3 Classification

Benzene is classified as a “known” human carcinogen (Category A) by the USEPA for all routes of exposure based upon convincing human evidence as well as supporting evidence from animal studies. IARC has classified benzene in Group 1 (known human carcinogen) (IARC 2012; USEPA 2005c, 2005d).

NICNAS (NICNAS 2001) has classified benzene as a “Carcinogen, Category 1” and “Toxic: Danger of serious damage to health by prolonged exposure through inhalation, in contact with skin and if swallowed”. In addition, benzene is classified as “Irritating to eyes, respiratory system and skin” and as a mutagenic substance in Category 3 “Possible risks of irreversible effects”.

Benzene is carcinogenic via oral and inhalation routes of exposure (ATSDR 2007a; IARC 2012; UK EA 2009b; WHO 1993) indicates that the overall results of available studies show that it is appropriate to consider benzene (and/or its metabolites) as genotoxic (though the genotoxic profile is considered unusual (Baars et al. 2001)).

A3.4 Quantitative toxicity reference values

On the basis that benzene is considered a genotoxic carcinogen (and not mutagenic) it is appropriate that carcinogenic endpoints are assessed on the basis of a non-threshold approach. In addition there is the potential for mixtures of benzene with toluene, ethylbenzene and xylenes to result in additive effects associated with non-carcinogenic/ neurological effects (ATSDR 2004). Hence both threshold and non-threshold endpoints require quantification with respect to potential exposures to benzene, where also present with TEX. The following non-threshold and threshold chronic values are available from Level 1 Australian and International sources:

Table A.4 Summary of relevant toxicity information for benzene

Source	Value	Basis/comments
ADWG (NHMRC 2011 updated 2022)	**SF = 0.035 $(mg/kg/day)^{-1}$**	A drinking water guideline was derived on the basis of the WHO evaluation (see below) with consideration of a 1 in 1,000,000 lifetime risk level.
NEPM (NEPC 2004)	No unit risk presented Investigation level = 0.003 ppm	A regional air investigation level of 0.003 ppm (chronic yearly exposures) is recommended as an 8-year goal. The basis for the air guideline value is not clear from the supporting information, however the value is intended to be used as an ambient goal associated with all sources and is not directly relevant for the assessment of exposures from one source.
New Zealand (MfE 2002)	Air GV = 0.03 mg/m^3	Air guideline value (as an annual average) based on the WHO upper value inhalation unit risk (as below) and an acceptable carcinogenic risk between 1 in 10,000 and 1 in 100,000.
WHO	**SF = 0.035 $(mg/kg/day)^{-1}$** **UR =$6x10^{-6}$ $(ug/m^3)^{-1}$**	Oral SF derived (WHO 2011b) based on route extrapolation of the data considered in the derivation of the inhalation UR. Consideration of oral data from a 2-year gavage study on rats and mice with a linearised multistage model resulted in a similar oral slope factor as derived on the basis of the epidemiological data (from inhalation studies. Inhalation UR derived (WHO 2000c) based on data on leukaemia from epidemiological inhalation studies where a range of unit risk values were derived (4.4-$7.5x10^{-6}$ $(ug/m^3)^{-1}$). The geometric mean value was adopted for the purpose of deriving an air guideline.
UK (UK EA 2009b)	Derived index doses	Oral index dose derived on the basis of US EPA approach and a lifetime cancer risk of 10^{-5}. Inhalation index dose based on WHO approach and adopting an air guideline of 3.2 ug/m^3 equivalent to a lifetime cancer risk of $1x10^{-5}$, and consideration of a range of non-cancer effects that would be relevant at concentrations above 1.7–3.2 ug/m^3.

Source	Value	Basis/comments
Texas (TCEQ 2013d)	Chronic ESL (non-threshold) = 0.0045 mg/m^3, UR = 2.2 x 10^{-6} (ug/m^3)$^{-1}$ Chronic ESL (threshold) = 0.084 mg/m^3 Acute ESL (health) = 0.17 mg/m^3 Acute ESL (odor) = 8.7 mg/m^3	Chronic ESL for threshold effects based on an occupational exposure study with decreased ALC as the critical effect, uncertainty factor of 30 and HI of 0.3 (to account for mixture exposures) Chronic ESL for threshold effects consistent with the derivation present by the USEPA.
ATSDR (ATSDR 2007a)	Inh MRL = 0.0098 mg/m^3	Chronic inhalation MRL has been derived on the basis of a benchmark dose (lower limit 0.25 sd) of 0.098 mg/m^3 associated with decreased lymphocyte counts in humans and an uncertainty factor of 10.
USEPA (USEPA 1998, 1999) (non-threshold)	SF = 0.015 to 0.055 (mg/kg/day)$^{-1}$ UR =2.2 to 7.8x10^{-6} (ug/m^3)$^{-1}$	Oral SF (last reviewed in 2000) derived on the basis of route extrapolation of the data considered in the derivation of the inhalation UR. The range presented is consistent with that considered by the WHO where the same approach was used. Inhalation UR based on a linear model from data on leukaemia from epidemiological inhalation studies (same studies considered by the WHO).
USEPA (USEPA 2002) (threshold)	Oral RfD = 0.004 mg/kg/day Inhal RfC = 0.03 mg/m^3	Non-carcinogenic threshold values are available from the US EPA. The oral RfD and Inhalation RfC are derived on the basis of a benchmark dose (lower limit) of 1.2 mg/kg/day associated with decreased lymphocyte counts in human studies (inhalation study) and an uncertainty factor of 300.

The non-threshold values available from the WHO and USEPA are derived from the same studies and consider similar approaches. The USEPA provides a range of values while the WHO has adopted the geometric mean. As the 2 approaches are similar the values derived by the WHO (also adopted in the ADWG, NHMRC 2022) have been adopted for the quantification of carcinogenic risks.

Where relevant, the quantification of non-carcinogenic chronic effects, the threshold values available from the USEPA are current and appropriate for use in this assessment:

- for inhalation exposures a chronic RfC = 0.03 mg/m^3 has been adopted
- for oral/dermal exposures a chronic RfD = 0.004 mg/kg/day has been adopted.

It is noted that where risk-based criteria that may be derived for benzene will be dominated by the calculation of criteria based on non-threshold effects. Hence, only non-threshold TRVs are adopted for the derivation of such criteria.

No quantitative data are available to assess dermal exposures; therefore the oral value has been adopted for the purpose of assessing both oral and dermal exposures. Dermal permeability and other physical/chemical properties relevant to the quantification of volatilisation have been obtained from RAIS website (RAIS).

A3.5 Background intake

Background intakes of benzene relevant for urban and rural areas are based on inhalation exposure being the major contributor. Data collected in Sydney (NSW EPA 2004) for the period 1996 to 2001 reported a range of average concentrations that included 0.0074 mg/m^3 in Sydney CBD, 0.0035 mg/m^3 in Rozelle (inner city area) and 0.00128 mg/m^3 in western Sydney (St Marys). These concentrations comprise between 4% and 25% of the adopted TRV. Concentrations of benzene in other cities are noted to contribute 2.5% (in Perth) and 6% (Melbourne) of the TRV. It is noted that the CRC CARE (Friebel & Nadebaum 2011) derivation of HSLs adopted the maximum background level of 20% from the DEC (2004) study for Sydney CBD.

The data reported by DEC (2004) is dated and is not considered to reflect more current benzene emissions. Specifically, since 2006 the national cleaner fuel standards required that refineries reduce benzene levels in petrol from around 4 per cent to less than one per cent (Fuel Standard (Petrol) Determination 2001). This has resulted in lower levels of benzene in ambient air in all cities in Australia. Monitoring of benzene at 5 locations in Sydney in 2006, and 2 sites in 2008-2009 reported lower levels of benzene in the range 0.0006 to 0.0016 mg/m^3 (NSW EPA 2013) (consistent with the lowering of benzene content in fuel). These levels are more relevant to current levels of benzene in urban air and comprise up to 5% of the TRV. To be conservative a background intake of 10% of the TRV has been considered where the threshold TRVs are adopted. It is noted that this is lower than the default adopted in the development of the HSLs (Friebel & Nadebaum 2011) however it is based on more current data that reflects lower standards for benzene in fuel.

These background intakes are only of significance for the assessment of chronic exposures, and where the data is from one source only. Where the data is from measured air concentrations that include all significant air sources then background intakes from water or food are negligible.

Background intakes are only relevant where the threshold TRVs are utilised. They are not applicable to the assessment of non-threshold effects.

A4 Toluene

A4.1 General

Toluene is a clear, colourless liquid with a distinctive smell. Toluene occurs naturally in crude oil and in the tolu tree. It is produced in the process of making petrol and other fuels from crude oil, in making coke from coal, and as a by-product in the manufacture of styrene. Toluene is used in making paints, paint thinners, fingernail polish, lacquers, adhesives, and rubber and in some printing and leather tanning processes. Inhalation is the primary route of toluene exposure for the general population and for occupationally exposed individuals. Evaporation of petrol and vehicle exhaust is the largest source of toluene in the environment, and industries that use toluene as a solvent are the second largest source. Toluene is also a common indoor contaminant due to releases from common household products and from cigarette smoke.

A4.2 Exposure, absorption, health effects

There is no clinical disease which is unique to toluene toxicity. However the effects on the central nervous system (CNS) are well recognised and associated with acute, intermediate and chronic exposures.

With respect to oral exposures the following are the primary target organs:

- Central nervous system
- Kidneys: Subchronic exposure to toluene produced nephrosis, damage to tubular epithelium, and increased kidney weights in rats
- Liver: Subchronic exposure to toluene produced increased liver weights in rats and mice and hepatocellular hypertrophy in rats
- Reproduction: Embryonic deaths, reduced foetal weights, and cleft palates were observed in mice exposed to toluene during gestation
- Other target organs associated with oral exposure to toluene include the immune system, urinary and bladder systems.

With respect to inhalation exposures the following are the primary target organs:

- Central nervous system: Chronic occupational exposure to toluene has resulted in headaches, dizziness, and impaired neurobehavioral performance. Brain dysfunction, abnormal encephalograms, brain atrophy, mental retardation, and visual and hearing impairment have been reported in long-term abusers of toluene. Subchronic exposure of rats produced a high frequency hearing loss.
- Kidneys: Chronic exposure of workers to toluene has resulted in abnormalities of kidney function. Renal tubular effects have been associated with abuse of toluene-containing solvents. Chronic exposure to toluene has caused nephropathy in rats.
- Liver: Hepatomegaly has been reported in workers chronically exposed to toluene. Increased liver weights were reported in rats following subchronic exposure to toluene.
- Respiratory system: Sore throat was one of the symptoms reported in workers chronically exposed to toluene. Chronic exposure of rats has produced lesions in olfactory and respiratory epithelia.
- Other target organs associated with inhalation exposure to toluene include the reproductive system.

Repeated or prolonged contact with toluene via skin contact may cause drying and dermatitis. Toluene is readily absorbed from the lungs and gastrointestinal tracts and, to a lesser extent, through the skin. Following absorption into the body, toluene is widely distributed to tissues with total uptake dependant on fat content and metabolism with accumulation in adipose tissue, other tissues with high fat content, and highly vascular tissues. There is no evidence that the route of administration has any substantial effect on subsequent metabolism of toluene in humans or animals. It is metabolised in the liver, primarily to hippuric acid and benzoyl glucuronide, compounds that are rapidly excreted in the urine.

A4.3 Classification

Under the *Guidelines for Carcinogen Risk Assessment* (USEPA 2005c), *there is inadequate information to assess the carcinogenic potential* of toluene because studies of humans chronically exposed to toluene are inconclusive and toluene was not carcinogenic in adequate inhalation cancer bioassays of rats and mice. Toluene has not been shown to be genotoxic. The previous IRIS assessment classified toluene as Group D (*not classifiable as to human carcinogenicity*).

IARC has classified toluene in Group 3 (not classifiable as to human carcinogenicity) on the basis that there is inadequate evidence for the carcinogenicity of **toluene** in humans and there is evidence suggesting lack of carcinogenicity of **toluene** in experimental animals.

A4.4 Quantitative toxicity reference values

There is insufficient data to assess the carcinogenic potential of toluene. Review of available data (Baars et al. 2001; UK EA 2009a; USEPA 2005b; USEPA IRIS; WHO 2011b) suggest that toluene has not been demonstrated to be genotoxic. On the basis of the available information it is considered appropriate that a threshold dose-response approach be adopted for toluene. The following chronic values are available from Level 1 Australian and International sources:

Table A.5 Summary of relevant toxicity information for toluene

Source	Value	Basis/comments
Australian		
ADWG (NHMRC 2011 updated 2022)	TDI = 0.22 mg/kg/day	The current ADWG have derived a TDI based on a NOEL of 312 mg/kg/day associated with liver effects in a 13-week study in rats and an uncertainty factor of 1000 and conversion factor of 5/7 (exposure duration adjustment).
NEPM (NEPC 2004)	GV = 0.38 mg/m^3	A regional air investigation level (chronic yearly exposures) is recommended as an 8-year goal. The basis for the air guideline value is not clear from the supporting information. However it is noted that the annual average value adopted is similar to (but slightly greater than) the guideline value established by the WHO.
International		
WHO (WHO 2000c)	GV = 0.26 mg/m^3	WHO (2000) provide a review of inhalation exposures to toluene, utilising a LOAEL of 332 mg/m^3 associated with central nervous effects from an occupational study, and a conversion (exposure duration) of 4.2 and an uncertainty factor of 300 (including 10 for database deficiencies). The guideline value (GV) is noted to be based on a 1 week average. However the US EPA review of the available LOAEL with other studies available has observed that the LOAEL derived from the study (used by the WHO and previous US EPA evaluation) shows a lack of duration response with respect to CNS effects and hence the LOAEL derived from the study can be taken to be relevant for all durations of exposure (sub-chronic and chronic).
WHO DWG (WHO 2017)	TDI = 0.22 mg/kg/day	TDI derived as noted in the ADWG (above).
RIVM (Baars et al. 2001)	TDI = 0.22 mg/kg/day TC = 0.4 mg/m^3	Oral TDI adopted from the WHO DWG review. Inhalation TC was derived on the basis of a LOAEC (adjusted) 119 mg/m^3 (same study as considered by the WHO) associated with CNS effects in an occupational study and an uncertainty factor of 300. The difference between the RIVM and WHO values are the extrapolation between study duration and continuous exposure.

Source	Value	Basis/comments
UK (UK EA 2009a)	TDI = 0.22 mg/kg/day TC = 5 mg/m^3	TDI value adopted derived from the same approach as considered in the WHO DWG and ADWG. The review did not recommend the use of the US EPA (2005) revised RfD as the uncertainty factor adopted (3000) was considered overly precautionary. If an uncertainty factor of 1000 was considered the threshold value would have been consistent with that available from the WHO. TC adopted based the review conducted by the US EPA where a more comprehensive review of larger database including studies not available when other agencies derived air guidelines.
Texas (TCEQ 2013b)	Chronic ESL = 1.2 mg/m^3 Acute ESL (health) = 4.5 mg/m^3 Acute ESL (odor) = 0.64 mg/m^3	Chronic ESL based on an occupational exposure study, with colour vision impairment identified as sensitive endpoint and an uncertainty factor of 10 (and HI of 0.3)
ATSDR (ATSDR 2000)	Inhalation MRL = 0.3 mg/m^3	Chronic inhalation MRL based on a LOAEL (adjusted) of 8ppm associated with vision impairment in an occupational study and an uncertainty factor of 1000. No chronic oral MRL was derived, however an intermediate MRL of 0.02 mg/kg/day was derived.
US EPA (IRIS)	RfD = 0.08 mg/kg/day	Oral RfD (revised in 2005) based on a benchmark approach where a $BMDL_{05}$ of 238 mg/kg/day associated with kidney effects in rats (study also considered by the WHO and RIVM reviews) and an uncertainty factor of 3000.
US EPA (USEPA 2005b)	RfC = 5 mg/m^3	Inhalation RfC (revised in 2005) is based review of a much broader range of epidemiological studies (compared with the few studies considered by WHO, RIVM etc) including studies not available at the time of review by other agencies enabling a better definition of the dose-response associated with the most sensitive end-point, neurotoxicity. The RfC was derived on the basis of a mean adjusted NOAEL (from 4 studies) of 46 mg/m^3 associated with neurotoxicological effects and an uncertainty factor of 10 (no additional factor for database deficiencies (included in reviews of a small database by other agencies) was included by the US EPA).

With respect to oral intakes, the same study and similar adjustment/uncertainty factors have been used by all sources noted above (with the exception of the US EPA where review by the UK (UK EA 2009a) considered the uncertainty factors adopted to be overly conservative). Hence the chronic TDI from the current ADWG and WHO DWG has been adopted.

With respect to inhalation data, the chronic threshold value derived on the basis of the more current and comprehensive review undertaken by the USEPA (USEPA 2005b), and adopted by the UK (UK EA 2009a) has been adopted. The US EPA review considered a number of studies not available when the WHO, RIVM and ATSDR derived their current guidelines and the more comprehensive review undertaken has enabled a better understanding of the dose-response relationship associated with neurotoxicity. The most significant difference in the US EPA review is the adoption of a much lower uncertainty factor of 10. As the database was considered adequate no additional uncertainty factors (as adopted by other agencies) was considered necessary.

For the quantification of non-carcinogenic chronic effects the threshold values identified above are current and appropriate for use in this assessment.

- for inhalation exposures, a chronic RfC = 5 mg/m^3 has been adopted
- for oral/dermal exposures a chronic TDI = 0.22 mg/kg/day has been adopted.

No quantitative data are available to assess dermal exposures; therefore the oral value has been adopted for the purpose of assessing both oral and dermal exposures. Dermal permeability and other physical/chemical properties relevant to the quantification of volatilisation have been obtained from RAIS (RAIS).

A4.5 Background intake

Background intakes have been estimated to be essentially negligible based on available air data from personal air monitoring conducted in a number of Australian cities (EA 2003).

A5 Xylenes

A5.1 General

There are 3 forms of xylene in which the methyl groups vary on the benzene ring: *meta*-xylene, *ortho*-xylene, and *para*-xylene (*m*-, *o*-, and *p*-xylene). These different forms are referred to as isomers. The term total xylenes refer to all 3 isomers of xylene (*m*-, *o*-, and *p*-xylene). Xylene is primarily a synthetic chemical. Chemical industries produce xylene from petroleum. Xylene also occurs naturally in petroleum and coal tar and is formed during forest fires. It is used as a solvent (a liquid that can dissolve other substances) in the printing, rubber, and leather industries.

A5.2 Exposure, absorption, health effects

Inhalation is the primary route of xylene exposure for the general population and for occupationally exposed individuals. However, xylenes are ubiquitously distributed in the environment and have been detected in air, rainwater, soils, surface waters, sediments, drinking water, aquatic organisms, human blood, urine and expired breath.

Exposure of the general population to xylene may occur through contact with petrol, evaporation of petrol, vehicle exhaust, workplace air, solvents and ingestion of contaminated drinking water. Xylene is also a common contaminant due to releases from cigarette smoke.

Health effects of mixed xylenes, o-xylene, m-xylene and p-xylene appear to be similar, although the individual isomers are not necessarily equal in potency with respect to a particular effect. Studies indicate that the central nervous system (CNS) is a major and sensitive target of xylene toxicity via inhalation and oral routes. The primary target organs following chronic oral and inhalation exposures are likely to be the CNS and development. Some studies indicate enlargement of the liver and kidneys following oral exposure to mixed xylene. Other target organs identified following inhalation exposure include the respiratory system, altered haematological parameters, nose and throat irritation.

Xylene is readily absorbed from the respiratory and gastrointestinal tracts and, to a lesser extent, through the skin (following exposure to vapours and contact with liquid). Following absorption into the body, xylene is mainly distributed to lipid-rich tissues, particularly adipose and brain. High uptake also occurs in well-perfused organs such as the liver and kidneys. There is no evidence that the route of administration has any substantial effect on subsequent metabolism of xylene in humans or animals. Xylene is almost completely (95%) converted to soluble metabolites, which are excreted rapidly in urine, with most of the remaining amount eliminated in exhaled air.

A5.3 Classification

Xylene is classified by the US EPA as "*not classifiable as to human carcinogenicity*" (Category D) due to the lack of animal bioassays and human studies. IARC (IARC 1999) has classified xylene in Group 3 (*not classifiable as to their carcinogenicity to humans*) on the basis that there is inadequate evidence for the carcinogenicity in animals and humans.

A5.4 Quantitative toxicity reference values

No conclusive association has been found between the occurrence of cancer in humans and occupational exposure to xylene via inhalation, oral or dermal exposure. In addition the available studies suggest that xylenes are not considered genotoxic (UK EA 2009c; USEPA IRIS; WHO 1997). On the basis of the available information it is considered appropriate that a threshold dose-response approach be adopted for xylenes. The following chronic values are available from Level 1 Australian and International sources:

Table A.6 Summary of relevant toxicity information for xylenes

Source	Value	Basis/comments
Australian		
ADWG (NHMRC 2011 updated 2022)	TDI = 0.18 mg/kg/day	TDI based on a NOEL of 250 mg/kg/day associated with decreased body weight in a 2-year gavage study in rats, application of a 5/7 exposure adjustment factor and uncertainty factor of 1000.
NEPM (NEPC 2004)	GV = 0.87 mg/m^3	A regional air investigation level (chronic yearly exposures) is recommended as an 8-year goal. The basis for the air guideline value is not clear from the supporting information. However it is noted that the annual average value adopted is the same as the guideline value established by the WHO (1997).
International		
WHO (WHO 1997)	TC = 0.87 mg/m^3	TC in air based on a LOAEL of 870 mg/m^3 associated with developmental neurotoxicity from animal studies and an uncertainty factor of 1000. Value also presented in WHO (WHO 2000c).
WHO DWG (WHO 2017)	TDI = 0.18 mg/kg/day	TDI derived as noted in the ADWG (above).
RIVM (Baars et al. 2001)	TDI = 0.15 mg/kg/day TC = 0.87 mg/m^3	Oral TDI was derived on the basis of a LOAEL of 150 mg/kg/day associated with nephropathy in female rats in a 90-day oral study and an uncertainty factor of 1000. Value is noted to be similar to that derived by the WHO. TC derived on the same basis as the WHO (1997).
UK (UK EA 2009c)	TDI = 0.18 mg/kg/day TC = 0.2 mg/m^3	TDI value adopted derived from the same approach as considered by WHO. TC adopted based on the review undertaken by the EU Joint Research Centre (JRC 2005) where a guideline for indoor air of 0.2 mg/m^3 was derived on the basis of a LOAEL (adjusted) of 22 mg/m^3 associated with neurological effects and other mild effects in an occupational study and an uncertainty factor of 100.
Texas (TCEQ 2013a)	Chronic ESL = 0.18 mg/m^3 Acute ESL (health) = 2.2 mg/m^3 Acute ESL (odor) = 0.18 mg/m^3	Chronic Inhalation ESL derived on the basis of mild respiratory and subjective neurological effects in factory workers. ESL is based on a HI of 0.3, relevant for assessing air quality impacts.

Source	Value	Basis/comments
ATSDR (ATSDR 2007b)	Oral MRL = 0.2 mg/kg/day Inhalation MRL = 0.2 mg/m^3	Oral chronic MRL derived on the basis of a NOAEL (adjusted) of 179 mg/kg/day and an uncertainty factor of 1000 (including a modifying factor of 10), and rounded up to 0.2 mg/kg/day. Value same as presented in WHO DWG and ADWG. Inhalation MRL based on a LOAEL of 61 mg/m^3 based on respiratory and neurological effects in occupation studies and an uncertainty factor of 300 (including a modifying factor of 3 to account for a lack of supporting studies evaluating chronic neurotoxicity).
US EPA (USEPA 2003)	RfD = 0.2 mg/kg/day RfC = 0.1 mg/m^3	Oral RfD derived on the same basis as ATSDR and WHO. Inhalation RfC is based on a NOAEL (HEC) of 39 mg/m^3 neurotoxicological effects in a 13-week rat study associated with m-xylene and an uncertainty factor of 300.

With respect to chronic oral intakes, the same study and uncertainty factors have been used by most sources noted above. The only difference if the rounding of the calculated TDI from 0.18 mg/kg/day (ADWG, WHO and UK) to 0.2 mg/kg/day (ATSDR and US EPA). Hence the chronic oral value available from the ADWG has been adopted in this assessment.

With respect to chronic inhalation data, the evaluations presented have considered similar databases; just the selection of key studies and uncertainty factors differs. More recent reviews of inhalation data relevant to xylenes (ATSDR 2007b; UK EA 2009c; USEPA 2003) identified lower, more conservative toxicity reference values when compared with the older reviews conducted by the WHO (WHO 1997), as adopted by NEPM (NEPC 2004). The more current chronic threshold inhalation values available from ATSDR and the UK have been adopted in this assessment.

For the quantification of non-carcinogenic chronic effects, the threshold values identified above are current and appropriate for use in this assessment.

- for inhalation exposures, the ATSDR inhalation MRL = 0.2 mg/m^3 has been adopted
- for oral/dermal exposures the chronic TDI = 0.18 mg/kg/day has been adopted.

No quantitative data are available to assess dermal exposures; therefore the oral value has been adopted for the purpose of assessing both oral and dermal exposures. Dermal permeability and addition other physical/chemical properties relevant to the quantification of volatilisation have been obtained from RAIS (RAIS).

A5.5 Background intake

Background intakes have been estimated to be 15% of the TC of 0.2 mg/m^3 based on air data from personal air monitoring conducted in a number of Australian cities (EA 2003) (EA, 2003), that is consistent with intakes estimated by the UK (UK EA 2009c) and Canada (Health Canada 1993). These background intakes are only of significance for the assessment of chronic exposures, and where the data is from one source only. Where the data is from measured air concentrations that include all significant air sources then background intakes from water or food are negligible. The background intake is more conservative than approach adopted in the derivation of the HSLs (CRC CARE 2011) as a more conservative TRV has been adopted in this assessment.

A6 Formaldehyde

A6.1 General

Formaldehyde is a colourless, highly flammable gas that is sold commercially as 30 to 50% (by weight) aqueous solutions. Formaldehyde enters the environment from natural sources and from direct human sources, such as automotive and other fuel combustion and industrial onsite uses. Secondary formation also occurs, by the oxidation of natural and anthropogenic organic compounds present in air. Motor vehicles are the largest direct human source of formaldehyde in the environment with releases from industrial processes generally lower (WHO 2002).

When formaldehyde is released to or formed in air, most of it degrades, and a very small amount moves into water. Formaldehyde does not persist in the environment, but its continuous release and formation result in long-term exposure near sources of release and formation (WHO 2002).

The reported odour threshold for formaldehyde is variable, listed in the range 0.02 to 1 ppm (ACGIH 2017; DECOS 2003; NICNAS 2006; WHO 2010). Human subjects in chamber tests have been reported to readily detect formaldehyde concentrations of 0.01 ppm in air (U.S. NRC 1980; 1981).

A6.2 Exposure, absorption, health effects

Formaldehyde is formed endogenously (i.e. naturally in the body) during the metabolism of amino acids and xenobiotics, with much of it bound to macromolecules. In addition, formaldehyde is a metabolite of methanol (WHO 2002). Studies have indicated that exposure to 2.5 mg/m^3 or less does not increase blood formaldehyde concentrations and exposure to 0.5 mg/m^3 or less does not increase the presence of metabolites of formaldehyde in urine (WHO 2010).

Formaldehyde is a highly reactive gas that is soluble and absorbed quickly at the point of contact. It is rapidly metabolised, such that exposure to high concentrations (up to 15 ppm in rats) does not result in increased blood concentrations. More than 90% of inhaled formaldehyde gas is absorbed and rapidly metabolized to formate in the upper respiratory tract. Repeated formaldehyde exposure caused toxic effects only in the tissues of direct contact after inhalation, oral or dermal exposure characterised by local cytotoxic destruction and subsequent repair of the damage.

Sensory irritation of the eyes and respiratory tract by formaldehyde has been observed consistently in clinical studies and epidemiological surveys in occupational and residential environments. At concentrations higher than those generally associated with sensory irritation, formaldehyde may also contribute to the induction of generally small, reversible effects on lung function (WHO 2002).

Amounts of formaldehyde which produce marked toxic effects at the portal of entry, do not lead to an appreciable systemic dose and thus do not produce systemic toxicity. This is consistent with formaldehyde's high reactivity with many cellular nucleophiles and its rapid metabolic degradation. The available data does not indicate any reproductive or developmental effect (UNEP 2002).

A6.3 Classification

Epidemiological studies taken as a whole do not provide strong evidence for a causal association between formaldehyde exposure and human cancer, although the possibility of increased risk of respiratory cancers, particularly those of the upper respiratory tract, cannot be excluded on the basis of available data. Therefore, based primarily upon data derived from laboratory studies, the inhalation of formaldehyde under conditions that induce cytotoxicity and sustained regenerative proliferation is considered to present a carcinogenic hazard to humans.

IARC (IARC 2006) has classified formaldehyde as Group 1 (carcinogenic to humans) with the older review completed by the USEPA (in 1991) classifying it as B1 (probable human carcinogen).

There is sufficient evidence that formaldehyde causes nasal cancer in animals and nasopharyngeal cancer in humans with a non-linear, biphasic concentration/dose-response relationship. Carcinogenicity studies in rats, mice and hamsters do not show a consistent association between formaldehyde and lymphohaematopoetic malignancies. Associations between exposure to formaldehyde and nasopharyngeal malignancies and leukaemia in humans are limited to high exposure concentrations. Increased cell proliferation due to cell damage is considered a key mechanism for the development of nasal malignancies following exposure to formaldehyde, where a threshold has been identified (WHO 2010).

Review of formaldehyde genotoxicity by the WHO and UNEP (UNEP 2002; WHO 2002) indicates that it is considered to be weakly genotoxic, with good evidence of an effect at site of contact, but less convincing evidence at distal sites. Further review by IARC (IARC 2006) determined that both genotoxicity and cytotoxicity play important roles in the carcinogenicity of formaldehyde in nasal tissues, with the dose-response relationships identified to be non-linear and bi-phasic. Hence, a threshold approach to setting a guideline for cancer effects is appropriate (WHO 2010).

Overall, inhalation exposure effects of formaldehyde are expected to be limited to the site of contact, generally the nasal and upper airways and guidelines derived on the basis of a threshold that consider both non-cancer and carcinogenic endpoints are relevant to consider.

A6.4 Quantitative toxicity reference values

The following table provides an overview of the available TRVs relevant to the assessment of inhalation exposures for formaldehyde.

Table A.7 Toxicity reference values (TRV) related to formaldehyde exposure

Source	Value	Basis/comments
WHO (WHO 2002)	0.1 mg/m^3 relevant to 30-minute exposure	Guideline protective of nose and throat irritation in humans. No chronic guideline has been developed by the WHO
ATSDR (ATSDR 1999)	Acute MRL = 0.05 mg/m^3 Chronic MRL = 0.01 mg/m^3	The acute MRL is based on a range of clinical symptoms in humans. The chronic MRL is based on histological evidence of mild damage to the nasal epithelial tissue for workers in an occupational environment and application of a 30 fold uncertainty factor.
OEHHA (OEHHA 2013)	Acute REL = 0.055 mg/m^3 for 1-hour average Acute REL = 0.009 mg/m^3 for 8-hour average Chronic REL = 0.009 mg/m^3	ORHHA RELs based on protection of eye irritation in humans (acute REL) and respiratory effects (8-hour and chronic guideline)
TCEQ (TCEQ 2013c, 2014)	Acute = 0.05 mg/m^3 as 1-hour average Acute = 0.05 mg/m^3 as 24-hour average Chronic = 0.011 mg/m^3	Acute inhalation guideline based on protection of short-term eye and nose irritation in humans. It is noted that the odour threshold for formaldehyde is 0.62 mg/m^3. Chronic inhalation guideline based on elevated rates of eye, nasal and lower airway discomfort in humans. The TCEQ evaluation considered both threshold effects and non-threshold effects (specifically nasopharyngeal cancer), with the guideline established on the basis of a threshold being the driving (lower) health endpoint/approach. Hence the threshold guideline has been adopted.
USEPA IRIS (USEPA 2022b)	Chronic RfC = 0.007 mg/m^3	The USEPA evaluation is based on outcomes from a range of studies relating to asthma, decreased pulmonary function, allergic conditions and sensory irritation in humans and application of a 3 or 10 fold uncertainty factor. This threshold value is not considered different to that derived by TCEQ.

Based on the available data, the acute and chronic guidelines established by TCEQ have been adopted for the assessment of inhalation exposures to formaldehyde. For the public, not workers or smokers, background intakes of formaldehyde have been assumed to be a small proportion, i.e. negligible (refer to discussion below) of the chronic TRV adopted.

A6.5 Background intake

As discussed above, formaldehyde is found ubiquitously in the environment, from natural sources including biomass combustion (forest and bush fires), decomposition and volcanoes. Direct human sources, such as automotive and other fuel combustion and industrial onsite uses, also contribute formaldehyde to the environment, with motor vehicles considered to be the largest direct human source (releases from industrial processes are generally lower) (WHO 2002). Formaldehyde is also formed in the atmosphere due to the breakdown of hydrocarbons in the troposphere (HSDB database).

The indoor air concentration depends somewhat on the types of materials used in construction (ATSDR 1999, 2010). The major sources of formaldehyde in indoor air are combustion processes (e.g. smoking cigarettes, heating, cooling, candle burning) and building materials and consumer products including (WHO 2010):

- furniture and wooden products containing formaldehyde-based resins such as particleboard, plywood and medium-density fibreboard
- insulating materials
- textiles
- do-it-yourself products such as paints, wallpapers, glues, adhesives, varnishes and lacquers
- Household cleaning products such as detergents, disinfectants, softeners, carpet cleaners and shoe products
- cosmetics such as liquid soaps, shampoos, nail varnishes and nail hardeners
- electronic equipment, including computers and photocopiers
- other consumer items such as insecticides and paper products.

Studies investigating formaldehyde concentrations in indoor air areas such as bedrooms have reported average formaldehyde concentrations in the range 0.009 to 0.03 ppm (or 0.011 to 0.36 mg/m^3). This includes a study of 185 homes in Perth, where indoor air formaldehyde concentrations ranged between 0.002 and 0.11 ppm (0.0025 to 0.135 mg/m^3) (consistent with data from other studies) (WHO 2010). The ATSDR indicates that indoor air concentrations range from 0.08 to 0.03 ppm in most homes (ATSDR 1999, 2010), with concentrations in some mobile homes reported up to 0.8 ppm (Paustenbach et. al. 1997). One study in China reported a mean formaldehyde concentration of 0.19 ppm in recently refurbished houses. It is also noted that indoor air concentrations can reach more than 0.16 to 0.27 ppm close to someone who is smoking cigarettes in the room (Paustenbach et. al. 1997; WHO 2010).

Formaldehyde concentrations in outdoor air are generally much lower than indoor air concentrations. Study data indicates that outdoor air concentrations in US cities are in the range 0.0008 to 0.01 ppm (ATSDR 1999, 2010; Paustenbach et. al. 1997), with concentrations reported up to 0.09 to 0.15 ppm in areas with photochemical smog and heavy traffic (Paustenbach et. al. 1997). The mean outdoor air concentration from a study across Brazil, Canada, Germany, Italy, Mexico, the Netherlands and the US was 0.006 ppm (range of 0.001 to 0.01 ppm). The mean outdoor air concentration in China was 0.01 ppm (WHO 2010). The greatest sources of formaldehyde in outdoor air in the Sydney metropolitan area are residential wood heaters and non-road diesel equipment and transport. Monitoring of outdoor air at 5 sites in 2006 and 2 sites in 2008 to 2009 reported concentrations of 0.002 to 0.003 ppm (0.0025 to 0.0037 mg/m^3) (NSW EPA 2013).

As formaldehyde levels indoors and outdoors vary significant, background exposures relevant to formaldehyde have been assumed to comprise 50% of the adopted chronic air guideline.

Appendix B

Calculation of health impacts – Population incidence

B1 Mortality and morbidity health endpoints

A quantitative assessment of risk for these endpoints uses a mathematical relationship between an exposure concentration (i.e. concentration in air or noise level in the community) and a response (namely a health effect). This relationship is termed an exposure-response relationship and is relevant to the range of health effects (or endpoints) identified as relevant (to the nature of the emissions assessed) and robust (as identified in the main document). An exposure-response relationship can have a threshold, where there is a safe level of exposure, below which there are no adverse effects; or the relationship can have no threshold (and is regarded as linear) where there is some potential for adverse effects at any level of exposure.

In relation to the health effects associated with exposure to nitrogen dioxide and particulate matter, no threshold has been identified. For the assessment of noise, exposures above a threshold have been defined on the basis of an exposure-response relationship. Non-threshold exposure-response relationships have been identified for the health endpoints considered in this assessment.

B2 Mortality and morbidity health endpoints

The assessment of health impacts for a particular population associated with exposure to particulate matter has been undertaken utilising the methodology presented by the WHO (Ostro 2004)[13] where the exposure-response relationships identified have been directly considered on the basis of the approach outlined below.

The calculation of changes in health endpoints associated with exposure to nitrogen dioxide, particulate matter or noise as outlined by the WHO (Ostro 2004) has considered the following 4 elements:

- estimates of the changes in particulate matter exposure levels or noise levels (i.e. incremental impacts) due to the project for the relevant modelled scenarios
- estimates of the number of people exposed to particulate matter or noise at a given location
- baseline incidence of the key health endpoints that are relevant to the population exposed
- exposure-response relationships expressed as a percentage change in health endpoint per µg/m^3 change in NO_2 or particulate matter exposure or per dB(A) for noise, where a relative risk (RR) is determined.

From the above, the increased incidence of a health endpoint corresponding to a particular change in exposure can be calculated using the following approach:

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[13] For regional guidance, such as that provided for Europe by the WHO WHO 2006a, Health risks or particulate matter from long-range transboundary air pollution regional background incidence data for relevant health endpoints are combined with exposure-response functions to present an impact function, which is expressed as the number/change in incidence/new cases per 100,000 population exposed per microgram per cubic metre change in particulate matter exposure. These impact functions are simpler to use than the approach adopted in this assessment, however in utilising this approach it is assumed that the baseline incidence of the health effects is consistent throughout the whole population (as used in the studies) and is specifically applicable to the sub-population group being evaluated. For the assessment of exposures in the areas evaluated surrounding the project it is more relevant to utilise local data in relation to baseline incidence rather than assume that the population is similar to that in Europe (where these relationships are derived).

B2.1 Noise

Noise impacts have been calculated on the basis of the following:

Equation 1 $AF_{Noise} = \frac{RR_{dB} - 1}{RR_{dB}} \times P \times B$

Where:
B = baseline incidence of a given health effect (e.g. mortality rate per person per year)
P = relevant exposed population
RR_{dB} = relative risk, which is given per 10 dB increase, which is then scaled to be a change per dB as outlined in Equation 2

Equation 2 $RR_{dB} = 1 + \left((RR_{10} - 1)x\frac{dB}{10}\right)$

Where:
dB = is the noise exposure, or change in noise exposure
P = relevant exposed population
RR10 = relative risk per 10 dB increase from publications

B2.2 Air quality

For the assessment of changes in air pollution, the attributable fraction/portion (AF) of health effects from air pollution, or impact factor, can be calculated from the relative risk as:

Equation 3 $AF_{air} = \frac{RR-1}{RR}$

The assessment of potential risks associated with these exposures involves the calculation of a relative risk (RR). For the purpose of this assessment the shape of the exposure response function used to calculate the relative risk is assumed to be linear[14]. The calculation of a relative risk based on the change in relative risk exposure concentration from baseline/existing (i.e. based on incremental impacts from the project) can be calculated on the basis of the following equation (Ostro 2004):

Equation 4 $RR = \exp[\beta(X\text{-}X0)]$

Where:

X-X0 = the change in particulate matter concentration to which the population is exposed (µg/m^3)

β = regression/slope coefficient, or the slope of the exposure-response function which can also be expressed as the per cent change in response per 1 µg/m^3 increase in particulate matter exposure

Based on this equation, where the published studies have derived relative risk values that are associated with a 10 µg/m^3 increase in exposure, the β coefficient can be calculated using the following equation:

Equation 5 $$\beta = \frac{\ln(RR)}{10}$$

Where:
RR = relative risk for the relevant health endpoint as published (µg/m^3)
10 = increase in particulate matter concentration or noise level associated with the RR (where the RR is associated with a 10 µg/m^3 increase in concentration

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14 Some reviews have identified that a log-linear exposure response function may be more relevant for some of the health endpoints considered in this assessment. Review of outcomes where a log-linear exposure-response function has been adopted (Ostro 2004) for $PM_{2.5}$ identified that the log-linear relationship calculated slightly higher relative risks compared with the linear relationship within the range 10–30 micrograms per cubic metre, (relevant for evaluating potential impacts associated with air quality goals or guidelines) but lower relative risks below and above this range. For this assessment (where impacts from a particular project are being evaluated) the impacts assessed relate to concentrations of $PM_{2.5}$ that are well below 10 micrograms per cubic metre and hence use of the linear relationship is expected to provide a more conservative estimate of relative risk.

The total number of cases attributable to exposure to the change in exposure (where a linear dose-response is assumed) can be calculated as:

Equation 6 ***E = AF x B x P***

Where:
B = baseline incidence of a given health effect (e.g. mortality rate per person per year)
P = relevant exposed population

The above approach (while presented slightly differently) is consistent with that presented in Australia (Burgers & Walsh 2002), US (OEHHA 2002; USEPA 2005a, 2010) and Europe (Martuzzi et al. 2002; Sjoberg et al. 2009).

The calculation of an increased incidence (i.e. number of cases) of a particular health endpoint is not relevant to a specific individual, rather this is relevant to a statistically relevant population. This calculation has been undertaken for populations within the suburbs surrounding the proposed project.

The above approach can be simplified (mathematically, where the incremental change in particulate concentration is low, in the order of one microgram per cubic metre or less) as follows:

Equation 7 **E = β x B x ΔX x P**

Where:
β = slope coefficient relevant to the per cent change in response to a 1 μg/m³ change in exposure concentration
B = baseline incidence of a given health effect per person (e.g. annual mortality rate)
ΔX = change (increment) in exposure concentration in μg/m³ as an average within a small area or suburb
P = population (residential – based on data from the ABS) within each small area or suburb

An additional risk is calculated as:

Equation 8 **Risk=β x ΔX x B**

Where:
β = slope coefficient relevant to the per cent change in response to a 1 μg/m³ change in exposure
ΔX = change (increment) in exposure concentration in μg/m³ relevant to the project at the point of exposure
B = baseline incidence of a given health effect per person (e.g. annual mortality rate)

This calculation provides an annual risk for individuals exposed to changes in air quality from the project at specific locations (such as the maximum, or at specific sensitive receiver locations). The calculated risk does not take into account the duration of exposure at any one location and so is considered to be representative of a population risk.

The above calculation of additional risk can also be undertaken for changes in noise levels in the community

B3 Quantification of short and long-term effects

The concentration-response functions adopted for the assessment of exposure are derived from long and short-term studies and relate to short or long-term effects endpoints (e.g. change in incidence from daily changes in nitrogen dioxide or particulate matter, or chronic incidence from long-term exposures to particulate matter).

Long-term or chronic effects are assessed on the basis of the identified exposure-response function and annual average concentrations. These then allow the calculation of a chronic incidence of the assessed health endpoint.

Short-term effects are also assessed on the basis of an exposure-response function that is expressed as a percentage change in endpoint per microgram per cubic metre change in concentration. For short-term effects, the calculations relate to daily changes in nitrogen dioxide and particulate matter exposures to calculate changes in daily effects endpoints. While it may be possible to measure daily incidence of the evaluated health endpoints in a large population study specifically designed to include such data, it is not common to collect such data in hospitals nor are effects measurable in smaller communities. Instead, these calculations relate to a parameter that is measurable, such as annual incidence of hospitalisations, mortality or lung cancer risks. The calculation of an annual incidence or additional risk can be undertaken using 2 approaches (Ostro 2004; USEPA 2010):

- calculate the daily incidence or risk at each receiver location over every 24-hour period of the year (based on the modelled incremental 24-hour average concentration for each day of the year and daily baseline incidence data) and then sum the daily incidence/risk to get the annual risk
- calculate the annual incidence/risk based on the incremental annual average concentration at each receiver (and using annual baseline incidence data).

In the absence of a threshold, and assuming a linear concentration-response function (as is the case in this assessment), these 2 approaches result in the same outcome mathematically (calculated incidence or risk). Given that it is much simpler computationally to calculate the incidence (for each receiver) based on the incremental annual average, compared with calculating effects on each day of the year and then summing, this is the preferred calculation method. It is the recommended method outlined by the WHO (Ostro 2004).

The use of the simpler approach, based on annual average concentrations should not be taken as implying or suggesting that the calculation is quantifying the effects of long-term exposure.

For the calculations presented in this technical working paper that relate to the expected use of the project tunnel − for long-term and short-term effects – annual average concentrations of nitrogen dioxide and particulate matter have thus been utilised.

Where short-term worst-case exposures are assessed (such as those related to a breakdown in the tunnel) short-term, daily, calculations have been undertaken to assessed short-term health endpoints. This has been undertaken as the exposure being assessed relates to an infrequent short-duration event. It would not occur each day of the year and so it is not appropriate to assess on the basis of an annual average.

Appendix C

Calculation of health impacts – $PM_{2.5}$

Assessment of Change in Population Incidence - $PM_{2.5}$
2033-S1

	Primary Indicators			Secondary Indicators			
Health Endpoint:	**Mortality PM2.5 - All Causes, Long-term**	**Hospitalisations PM2.5 - Cardiovascular, Short-term**	**Hospitalisations PM2.5 - Respiratory, Short-term**	**Mortality PM2.5 - All Causes, Short-term**	**Mortality PM2.5 - Cardiovascular, Short-term**	**Mortality PM2.5 - Respiratory, Short-term**	**Morbidity PM2.5 - Asthma ED Admissions - Short-term**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	All ages	1-14 years
β (change in effect per 1 μg/m^3 PM) (as per Table 5.3)	0.0058	0.0008	0.00041	0.00094	0.00097	0.0019	0.0015
Baseline incidence (per 100,000) (as per Table 4.5)	500	6829	4955	500	122.1	43.3	1206
Austral							
Total Population in study area:	6847	6847	6847	6847	6847	6847	6847
% population in assessment age-group:	54%	10%	10%	100%	100%	100%	23%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
Relative Risk:	1.000007	1.000001	1.000001	1.000001	1.000001	1.000002	1.000002
Attributable fraction (AF):	7.4E-06	1.0E-06	5.3E-07	1.2E-06	1.2E-06	2.4E-06	1.9E-06
Increased number of cases in population:	0.00014	0.000047	0.000017	0.000041	0.000010	0.0000072	0.000036
Risk:	3.7E-08	7.0E-08	2.6E-08	6.0E-09	1.5E-09	1.1E-09	2.3E-08
Badgerys Creek							
Total Population in study area:	168	168	168	168	168	168	168
% population in assessment age-group:	62%	24%	24%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0081	0.0081	0.0081	0.0081	0.0081	0.0081	0.0081
Relative Risk:	1.000047	1.000006	1.000003	1.000008	1.000008	1.000015	1.000012
Attributable fraction (AF):	4.7E-05	6.5E-06	3.3E-06	7.6E-06	7.9E-06	1.5E-05	1.2E-05
Increased number of cases in population:	0.000024	0.000018	0.0000067	0.0000064	0.0000016	0.0000011	0.0000041
Risk:	2.3E-07	4.4E-07	1.6E-07	3.8E-08	9.6E-09	6.7E-09	1.4E-07
Bringelly							
Total Population in study area:	2433	2433	2433	2433	2433	2433	2433
% population in assessment age-group:	63%	19%	19%	100%	100%	100%	15%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0193	0.0193	0.0193	0.0193	0.0193	0.0193	0.0193
Relative Risk:	1.000112	1.000015	1.000008	1.000018	1.000019	1.000037	1.000029
Attributable fraction (AF):	1.1E-04	1.5E-05	7.9E-06	1.8E-05	1.9E-05	3.7E-05	2.9E-05
Increased number of cases in population:	0.00086	0.00048	0.00018	0.00022	0.000056	0.000039	0.00013
Risk:	5.6E-07	1.1E-06	3.9E-07	9.1E-08	2.3E-08	1.6E-08	3.4E-07
Cecil Park							
Total Population in study area:	815	815	815	815	815	815	815
% population in assessment age-group:	62%	20%	20%	100%	100%	100%	14%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Relative Risk:	1.000007	1.000001	1.000000	1.000001	1.000001	1.000002	1.000002
Attributable fraction (AF):	7.0E-06	9.6E-07	4.9E-07	1.1E-06	1.2E-06	2.3E-06	1.8E-06
Increased number of cases in population:	0.000018	0.000011	0.0000040	0.0000046	0.0000012	0.00000080	0.0000024
Risk:	3.5E-08	6.6E-08	2.4E-08	5.6E-09	1.4E-09	9.9E-10	2.1E-08
Cobbitty							
Total Population in study area:	4206	4206	4206	4206	4206	4206	4206
% population in assessment age-group:	58%	15%	15%	100%	100%	100%	20%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068	0.0068
Relative Risk:	1.000039	1.000005	1.000003	1.000006	1.000007	1.000013	1.000010
Attributable fraction (AF):	3.9E-05	5.4E-06	2.8E-06	6.4E-06	6.6E-06	1.3E-05	1.0E-05
Increased number of cases in population:	0.00048	0.00024	0.000089	0.00013	0.000034	0.000023	0.00010
Risk:	2.0E-07	3.7E-07	1.4E-07	3.2E-08	8.0E-09	5.6E-09	1.2E-07
Greendale							
Total Population in study area:	314	314	314	314	314	314	314
% population in assessment age-group:	62%	18%	18%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.015	0.015	0.015	0.015	0.015	0.015	0.015
Relative Risk:	1.000084	1.000012	1.000006	1.000014	1.000014	1.000028	1.000021
Attributable fraction (AF):	8.4E-05	1.2E-05	5.9E-06	1.4E-05	1.4E-05	2.8E-05	2.1E-05
Increased number of cases in population:	0.000082	0.000044	0.000016	0.000021	0.0000054	0.0000037	0.000014
Risk:	4.2E-07	7.9E-07	2.9E-07	6.8E-08	1.7E-08	1.2E-08	2.6E-07

Kemps Creek							
Total Population in study area:	2121	2121	2121	2121	2121	2121	2121
% population in assessment age-group:	65%	21%	21%	100%	100%	100%	15%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048	0.0048
Relative Risk:	1.000028	1.000004	1.000002	1.000004	1.000005	1.000009	1.000007
Attributable fraction (AF):	2.8E-05	3.8E-06	2.0E-06	4.5E-06	4.6E-06	9.1E-06	7.1E-06
Increased number of cases in population:	0.00019	0.00012	0.000044	0.000048	0.000012	0.0000083	0.000027
Risk:	1.4E-07	2.6E-07	9.7E-08	2.2E-08	5.6E-09	3.9E-09	8.5E-08
Luddenham							
Total Population in study area:	1927	1927	1927	1927	1927	1927	1927
% population in assessment age-group:	57%	12%	12%	100%	100%	100%	21%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.14	0.14	0.14	0.14	0.14	0.14	0.14
Relative Risk:	1.000792	1.000109	1.000056	1.000128	1.000132	1.000259	1.000202
Attributable fraction (AF):	7.9E-04	1.1E-04	5.6E-05	1.3E-04	1.3E-04	2.6E-04	2.0E-04
Increased number of cases in population:	0.0044	0.0017	0.00063	0.0012	0.00031	0.00022	0.00098
Risk:	4.0E-06	7.5E-06	2.8E-06	6.4E-07	1.6E-07	1.1E-07	2.4E-06
Mount Vernon							
Total Population in study area:	1235	1235	1235	1235	1235	1235	1235
% population in assessment age-group:	59%	15%	15%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020
Relative Risk:	1.000012	1.000002	1.000001	1.000002	1.000002	1.000004	1.000003
Attributable fraction (AF):	1.2E-05	1.6E-06	8.4E-07	1.9E-06	2.0E-06	3.9E-06	3.0E-06
Increased number of cases in population:	0.000043	0.000021	0.0000079	0.000012	0.0000030	0.0000021	0.0000077
Risk:	5.9E-08	1.1E-07	4.2E-08	9.6E-09	2.4E-09	1.7E-09	3.7E-08
Mulgoa							
Total Population in study area:	2044	2044	2044	2044	2044	2044	2044
% population in assessment age-group:	62%	18%	18%	100%	100%	100%	18%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044
Relative Risk:	1.000025	1.000004	1.000002	1.000004	1.000004	1.000008	1.000006
Attributable fraction (AF):	2.5E-05	3.5E-06	1.8E-06	4.1E-06	4.2E-06	8.3E-06	6.5E-06
Increased number of cases in population:	0.00016	0.000085	0.000032	0.000042	0.000011	0.0000074	0.000029
Risk:	1.3E-07	2.4E-07	8.9E-08	2.1E-08	5.2E-09	3.6E-09	7.8E-08
Rossmore							
Total Population in study area:	2241	2241	2241	2241	2241	2241	2241
% population in assessment age-group:	60%	19%	19%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037
Relative Risk:	1.000022	1.000003	1.000002	1.000003	1.000004	1.000007	1.000005
Attributable fraction (AF):	2.2E-05	3.0E-06	1.5E-06	3.5E-06	3.6E-06	7.1E-06	5.5E-06
Increased number of cases in population:	0.00015	0.000087	0.000032	0.000039	0.0000099	0.0000069	0.000025
Risk:	1.1E-07	2.0E-07	7.5E-08	1.7E-08	4.4E-09	3.1E-09	6.6E-08
Wallacia							
Total Population in study area:	1711	1711	1711	1711	1711	1711	1711
% population in assessment age-group:	61%	17%	17%	100%	100%	100%	19%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065	0.0065
Relative Risk:	1.000038	1.000005	1.000003	1.000006	1.000006	1.000012	1.000010
Attributable fraction (AF):	3.8E-05	5.2E-06	2.7E-06	6.1E-06	6.3E-06	1.2E-05	9.6E-06
Increased number of cases in population:	0.00020	0.00011	0.000039	0.000052	0.000013	0.0000091	0.000038
Risk:	1.9E-07	3.5E-07	1.3E-07	3.0E-08	7.7E-09	5.3E-09	1.2E-07
Total population incidence - All Suburbs	**0.007**	**0.003**	**0.001**	**0.002**	**0.0005**	**0.0003**	**0.001**

Assessment of Change in Population Incidence - $PM_{2.5}$ 2033-S3

	Primary Indicators			Secondary Indicators			
Health Endpoint:	**Mortality PM2.5 - All Causes, Long-term**	**Hospitalisations PM2.5 - Cardiovascular, Short-term**	**Hospitalisations PM2.5 - Respiratory, Short-term**	**Mortality PM2.5 - All Causes, Short-term**	**Mortality PM2.5 - Cardiovascular, Short-term**	**Mortality PM2.5 - Respiratory, Short-term**	**Morbidity PM2.5 - Asthma ED Admissions - Short-term**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	All ages	1-14 years
β (change in effect per 1 μg/m³ PM) (as per Table 5.3)	0.0058	0.0008	0.00041	0.00094	0.00097	0.0019	0.0015
Baseline incidence (per 100,000) (as per Table 4.5)	500	6829	4955	500	122.1	43.3	1206
Austral							
Total Population in study area:	6847	6847	6847	6847	6847	6847	6847
% population in assessment age-group:	54%	10%	10%	100%	100%	100%	23%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m³):	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016	0.0016
Relative Risk:	1.000009	1.000001	1.000001	1.000002	1.000002	1.000003	1.000002
Attributable fraction (AF):	9.3E-06	1.3E-06	6.6E-07	1.5E-06	1.6E-06	3.0E-06	2.4E-06
Increased number of cases in population:	0.00017	0.000058	0.000022	0.000051	0.000013	0.0000090	0.000045
Risk:	4.6E-08	8.7E-08	3.3E-08	7.5E-09	1.9E-09	1.3E-09	2.9E-08
Badgerys Creek							
Total Population in study area:	168	168	168	168	168	168	168
% population in assessment age-group:	62%	24%	24%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m³):	0.0076	0.0076	0.0076	0.0076	0.0076	0.0076	0.0076
Relative Risk:	1.000044	1.000006	1.000003	1.000007	1.000007	1.000015	1.000011
Attributable fraction (AF):	4.4E-05	6.1E-06	3.1E-06	7.2E-06	7.4E-06	1.5E-05	1.1E-05
Increased number of cases in population:	0.000023	0.000017	0.0000064	0.0000060	0.0000015	0.0000011	0.0000038
Risk:	2.2E-07	4.2E-07	1.6E-07	3.6E-08	9.0E-09	6.3E-09	1.4E-07
Bringelly							
Total Population in study area:	2433	2433	2433	2433	2433	2433	2433
% population in assessment age-group:	63%	19%	19%	100%	100%	100%	15%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m³):	0.0199	0.0199	0.0199	0.0199	0.0199	0.0199	0.0199
Relative Risk:	1.000115	1.000016	1.000008	1.000019	1.000019	1.000038	1.000029
Attributable fraction (AF):	1.2E-04	1.6E-05	8.2E-06	1.9E-05	1.9E-05	3.8E-05	2.9E-05
Increased number of cases in population:	0.00088	0.00050	0.00019	0.00023	0.000057	0.000040	0.00013
Risk:	5.8E-07	1.1E-06	4.0E-07	9.4E-08	2.4E-08	1.6E-08	3.6E-07
Cecil Park							
Total Population in study area:	815	815	815	815	815	815	815
% population in assessment age-group:	62%	20%	20%	100%	100%	100%	14%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m³):	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012	0.0012
Relative Risk:	1.000007	1.000001	1.000000	1.000001	1.000001	1.000002	1.000002
Attributable fraction (AF):	7.0E-06	9.6E-07	4.9E-07	1.1E-06	1.2E-06	2.3E-06	1.8E-06
Increased number of cases in population:	0.000018	0.000011	0.0000040	0.0000046	0.0000012	0.00000080	0.0000024
Risk:	3.5E-08	6.6E-08	2.4E-08	5.6E-09	1.4E-09	9.9E-10	2.1E-08
Cobbitty							
Total Population in study area:	4206	4206	4206	4206	4206	4206	4206
% population in assessment age-group:	58%	15%	15%	100%	100%	100%	20%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m³):	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064	0.0064
Relative Risk:	1.000037	1.000005	1.000003	1.000006	1.000006	1.000012	1.000009
Attributable fraction (AF):	3.7E-05	5.1E-06	2.6E-06	6.0E-06	6.2E-06	1.2E-05	9.5E-06
Increased number of cases in population:	0.00045	0.00023	0.000084	0.00013	0.000032	0.000022	0.00010
Risk:	1.9E-07	3.5E-07	1.3E-07	3.0E-08	7.6E-09	5.3E-09	1.1E-07
Greendale							
Total Population in study area:	314	314	314	314	314	314	314
% population in assessment age-group:	62%	18%	18%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m³):	0.013	0.013	0.013	0.013	0.013	0.013	0.013
Relative Risk:	1.000073	1.000010	1.000005	1.000012	1.000012	1.000024	1.000019
Attributable fraction (AF):	7.3E-05	1.0E-05	5.2E-06	1.2E-05	1.2E-05	2.4E-05	1.9E-05
Increased number of cases in population:	0.000071	0.000039	0.000014	0.000019	0.0000047	0.0000033	0.000012
Risk:	3.7E-07	6.9E-07	2.6E-07	5.9E-08	1.5E-08	1.0E-08	2.3E-07

Kemps Creek							
Total Population in study area:	2121	2121	2121	2121	2121	2121	2121
% population in assessment age-group:	65%	21%	21%	100%	100%	100%	15%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046
Relative Risk:	1.000027	1.000004	1.000002	1.000004	1.000004	1.000009	1.000007
Attributable fraction (AF):	2.7E-05	3.7E-06	1.9E-06	4.3E-06	4.5E-06	8.8E-06	6.8E-06
Increased number of cases in population:	0.00018	0.00011	0.000042	0.000046	0.000012	0.0000080	0.000027
Risk:	1.3E-07	2.5E-07	9.4E-08	2.2E-08	5.5E-09	3.8E-09	8.2E-08
Luddenham							
Total Population in study area:	1927	1927	1927	1927	1927	1927	1927
% population in assessment age-group:	57%	12%	12%	100%	100%	100%	21%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Relative Risk:	1.000739	1.000102	1.000052	1.000120	1.000124	1.000242	1.000188
Attributable fraction (AF):	7.4E-04	1.0E-04	5.2E-05	1.2E-04	1.2E-04	2.4E-04	1.9E-04
Increased number of cases in population:	0.0041	0.0016	0.00058	0.0012	0.00029	0.00020	0.00091
Risk:	3.7E-06	7.0E-06	2.6E-06	6.0E-07	1.5E-07	1.0E-07	2.3E-06
Mount Vernon							
Total Population in study area:	1235	1235	1235	1235	1235	1235	1235
% population in assessment age-group:	59%	15%	15%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020
Relative Risk:	1.000012	1.000002	1.000001	1.000002	1.000002	1.000004	1.000003
Attributable fraction (AF):	1.2E-05	1.6E-06	8.4E-07	1.9E-06	2.0E-06	3.9E-06	3.0E-06
Increased number of cases in population:	0.000043	0.000021	0.0000078	0.000012	0.0000030	0.0000021	0.0000077
Risk:	5.9E-08	1.1E-07	4.1E-08	9.6E-09	2.4E-09	1.7E-09	3.6E-08
Mulgoa							
Total Population in study area:	2044	2044	2044	2044	2044	2044	2044
% population in assessment age-group:	62%	18%	18%	100%	100%	100%	18%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045
Relative Risk:	1.000026	1.000004	1.000002	1.000004	1.000004	1.000009	1.000007
Attributable fraction (AF):	2.6E-05	3.6E-06	1.8E-06	4.2E-06	4.4E-06	8.5E-06	6.6E-06
Increased number of cases in population:	0.00017	0.000088	0.000033	0.000043	0.000011	0.0000075	0.000030
Risk:	1.3E-07	2.5E-07	9.1E-08	2.1E-08	5.3E-09	3.7E-09	8.0E-08
Rossmore							
Total Population in study area:	2241	2241	2241	2241	2241	2241	2241
% population in assessment age-group:	60%	19%	19%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040	0.0040
Relative Risk:	1.000023	1.000003	1.000002	1.000004	1.000004	1.000008	1.000006
Attributable fraction (AF):	2.3E-05	3.2E-06	1.6E-06	3.7E-06	3.9E-06	7.6E-06	5.9E-06
Increased number of cases in population:	0.00016	0.000094	0.000035	0.000042	0.0000106	0.0000073	0.000027
Risk:	1.2E-07	2.2E-07	8.1E-08	1.9E-08	4.7E-09	3.3E-09	7.1E-08
Wallacia							
Total Population in study area:	1711	1711	1711	1711	1711	1711	1711
% population in assessment age-group:	61%	17%	17%	100%	100%	100%	19%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060	0.0060
Relative Risk:	1.000035	1.000005	1.000002	1.000006	1.000006	1.000011	1.000009
Attributable fraction (AF):	3.5E-05	4.8E-06	2.4E-06	5.6E-06	5.8E-06	1.1E-05	8.8E-06
Increased number of cases in population:	0.00018	0.00010	0.000036	0.000048	0.000012	0.0000084	0.000035
Risk:	1.7E-07	3.3E-07	1.2E-07	2.8E-08	7.1E-09	4.9E-09	1.1E-07
Total population incidence - All Suburbs	**0.006**	**0.003**	**0.001**	**0.002**	**0.0004**	**0.0003**	**0.001**

Assessment of Change in Population Incidence - $PM_{2.5}$
2033-S4

	Primary Indicators			Secondary Indicators			
Health Endpoint:	**Mortality PM2.5 - All Causes, Long-term**	**Hospitalisations PM2.5 - Cardiovascular, Short-term**	**Hospitalisations PM2.5 - Respiratory, Short-term**	**Mortality PM2.5 - All Causes, Short-term**	**Mortality PM2.5 - Cardiovascular, Short-term**	**Mortality PM2.5 - Respiratory, Short-term**	**Morbidity PM2.5 - Asthma ED Admissions - Short-term**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	All ages	1-14 years
β (change in effect per 1 μg/m³ PM) (as per Table 5.3)	0.0058	0.0008	0.00041	0.00094	0.00097	0.0019	0.0015
Baseline incidence (per 100,000) (as per Table 4.5)	500	6829	4955	500	122.1	43.3	1206
Austral							
Total Population in study area:	6847	6847	6847	6847	6847	6847	6847
% population in assessment age-group:	54%	10%	10%	100%	100%	100%	23%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m³):	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017
Relative Risk:	1.000010	1.000001	1.000001	1.000002	1.000002	1.000003	1.000003
Attributable fraction (AF):	1.0E-05	1.4E-06	7.0E-07	1.6E-06	1.7E-06	3.3E-06	2.5E-06
Increased number of cases in population:	0.00018	0.000062	0.000023	0.000055	0.000014	0.0000097	0.000048
Risk:	5.0E-08	9.4E-08	3.5E-08	8.1E-09	2.0E-09	1.4E-09	3.1E-08
Badgerys Creek							
Total Population in study area:	168	168	168	168	168	168	168
% population in assessment age-group:	62%	24%	24%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m³):	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095	0.0095
Relative Risk:	1.000055	1.000008	1.000004	1.000009	1.000009	1.000018	1.000014
Attributable fraction (AF):	5.5E-05	7.6E-06	3.9E-06	8.9E-06	9.2E-06	1.8E-05	1.4E-05
Increased number of cases in population:	0.000029	0.000021	0.0000079	0.0000075	0.0000019	0.0000013	0.0000048
Risk:	2.8E-07	5.2E-07	1.9E-07	4.5E-08	1.1E-08	7.8E-09	1.7E-07
Bringelly							
Total Population in study area:	2433	2433	2433	2433	2433	2433	2433
% population in assessment age-group:	63%	19%	19%	100%	100%	100%	15%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m³):	0.0199	0.0199	0.0199	0.0199	0.0199	0.0199	0.0199
Relative Risk:	1.000116	1.000016	1.000008	1.000019	1.000019	1.000038	1.000029
Attributable fraction (AF):	1.2E-04	1.6E-05	8.2E-06	1.9E-05	1.9E-05	3.8E-05	2.9E-05
Increased number of cases in population:	0.00089	0.00050	0.00019	0.00023	0.000057	0.000040	0.00013
Risk:	5.8E-07	1.1E-06	4.0E-07	9.4E-08	2.4E-08	1.6E-08	3.6E-07
Cecil Park							
Total Population in study area:	815	815	815	815	815	815	815
% population in assessment age-group:	62%	20%	20%	100%	100%	100%	14%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m³):	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
Relative Risk:	1.000007	1.000001	1.000001	1.000001	1.000001	1.000002	1.000002
Attributable fraction (AF):	7.4E-06	1.0E-06	5.3E-07	1.2E-06	1.2E-06	2.4E-06	1.9E-06
Increased number of cases in population:	0.000019	0.000011	0.0000043	0.0000049	0.0000012	0.00000086	0.0000025
Risk:	3.7E-08	7.0E-08	2.6E-08	6.0E-09	1.5E-09	1.1E-09	2.3E-08
Cobbitty							
Total Population in study area:	4206	4206	4206	4206	4206	4206	4206
% population in assessment age-group:	58%	15%	15%	100%	100%	100%	20%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m³):	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057
Relative Risk:	1.000033	1.000005	1.000002	1.000005	1.000006	1.000011	1.000008
Attributable fraction (AF):	3.3E-05	4.5E-06	2.3E-06	5.3E-06	5.5E-06	1.1E-05	8.4E-06
Increased number of cases in population:	0.00040	0.00020	0.000075	0.00011	0.000028	0.000020	0.00009
Risk:	1.6E-07	3.1E-07	1.2E-07	2.7E-08	6.7E-09	4.7E-09	1.0E-07
Greendale							
Total Population in study area:	314	314	314	314	314	314	314
% population in assessment age-group:	62%	18%	18%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m³):	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Relative Risk:	1.000058	1.000008	1.000004	1.000009	1.000010	1.000019	1.000015
Attributable fraction (AF):	5.8E-05	7.9E-06	4.1E-06	9.3E-06	9.6E-06	1.9E-05	1.5E-05
Increased number of cases in population:	0.000056	0.000030	0.000011	0.000015	0.0000037	0.0000026	0.000010
Risk:	2.9E-07	5.4E-07	2.0E-07	4.7E-08	1.2E-08	8.2E-09	1.8E-07

Kemps Creek							
Total Population in study area:	2121	2121	2121	2121	2121	2121	2121
% population in assessment age-group:	65%	21%	21%	100%	100%	100%	15%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054
Relative Risk:	1.000031	1.000004	1.000002	1.000005	1.000005	1.000010	1.000008
Attributable fraction (AF):	3.1E-05	4.3E-06	2.2E-06	5.1E-06	5.2E-06	1.0E-05	8.0E-06
Increased number of cases in population:	0.00021	0.00013	0.000049	0.000054	0.000014	0.0000094	0.000031
Risk:	1.6E-07	3.0E-07	1.1E-07	2.5E-08	6.4E-09	4.4E-09	9.6E-08
Luddenham							
Total Population in study area:	1927	1927	1927	1927	1927	1927	1927
% population in assessment age-group:	57%	12%	12%	100%	100%	100%	21%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Relative Risk:	1.000852	1.000117	1.000060	1.000138	1.000142	1.000279	1.000217
Attributable fraction (AF):	8.5E-04	1.2E-04	6.0E-05	1.4E-04	1.4E-04	2.8E-04	2.2E-04
Increased number of cases in population:	0.0047	0.0018	0.00067	0.0013	0.00033	0.00023	0.00105
Risk:	4.3E-06	8.0E-06	3.0E-06	6.9E-07	1.7E-07	1.2E-07	2.6E-06
Mount Vernon							
Total Population in study area:	1235	1235	1235	1235	1235	1235	1235
% population in assessment age-group:	59%	15%	15%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022	0.0022
Relative Risk:	1.000013	1.000002	1.000001	1.000002	1.000002	1.000004	1.000003
Attributable fraction (AF):	1.3E-05	1.8E-06	9.0E-07	2.1E-06	2.1E-06	4.2E-06	3.2E-06
Increased number of cases in population:	0.000046	0.000023	0.0000084	0.000013	0.0000032	0.0000022	0.0000083
Risk:	6.4E-08	1.2E-07	4.5E-08	1.0E-08	2.6E-09	1.8E-09	3.9E-08
Mulgoa							
Total Population in study area:	2044	2044	2044	2044	2044	2044	2044
% population in assessment age-group:	62%	18%	18%	100%	100%	100%	18%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043
Relative Risk:	1.000025	1.000003	1.000002	1.000004	1.000004	1.000008	1.000006
Attributable fraction (AF):	2.5E-05	3.4E-06	1.8E-06	4.0E-06	4.1E-06	8.1E-06	6.3E-06
Increased number of cases in population:	0.00016	0.000083	0.000031	0.000041	0.000010	0.0000072	0.000029
Risk:	1.2E-07	2.3E-07	8.7E-08	2.0E-08	5.1E-09	3.5E-09	7.6E-08
Rossmore							
Total Population in study area:	2241	2241	2241	2241	2241	2241	2241
% population in assessment age-group:	60%	19%	19%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044
Relative Risk:	1.000026	1.000004	1.000002	1.000004	1.000004	1.000008	1.000007
Attributable fraction (AF):	2.6E-05	3.6E-06	1.8E-06	4.2E-06	4.3E-06	8.4E-06	6.6E-06
Increased number of cases in population:	0.00017	0.000105	0.000039	0.000047	0.0000118	0.0000082	0.000030
Risk:	1.3E-07	2.4E-07	9.0E-08	2.1E-08	5.3E-09	3.7E-09	7.9E-08
Wallacia							
Total Population in study area:	1711	1711	1711	1711	1711	1711	1711
% population in assessment age-group:	61%	17%	17%	100%	100%	100%	19%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050	0.0050
Relative Risk:	1.000029	1.000004	1.000002	1.000005	1.000005	1.000010	1.000007
Attributable fraction (AF):	2.9E-05	4.0E-06	2.0E-06	4.7E-06	4.8E-06	9.5E-06	7.4E-06
Increased number of cases in population:	0.00015	0.00008	0.000030	0.000040	0.000010	0.0000070	0.000029
Risk:	1.5E-07	2.7E-07	1.0E-07	2.4E-08	5.9E-09	4.1E-09	8.9E-08
Total population incidence - All Suburbs	**0.007**	**0.003**	**0.001**	**0.002**	**0.0005**	**0.0003**	**0.001**

Assessment of Change in Population Incidence - $PM_{2.5}$
2055-S3

	Primary Indicators			Secondary Indicators			
Health Endpoint:	**Mortality PM2.5 - All Causes, Long-term**	**Hospitalisations PM2.5 - Cardiovascular, Short-term**	**Hospitalisations PM2.5 - Respiratory, Short-term**	**Mortality PM2.5 - All Causes, Short-term**	**Mortality PM2.5 - Cardiovascular, Short-term**	**Mortality PM2.5 - Respiratory, Short-term**	**Morbidity PM2.5 - Asthma ED Admissions - Short-term**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	All ages	1-14 years
β (change in effect per 1 μg/m^3 PM) (as per Table 5.3)	0.0058	0.0008	0.00041	0.00094	0.00097	0.0019	0.0015
Baseline incidence (per 100,000) (as per Table 4.5)	500	6829	4955	500	122.1	43.3	1206
Austral							
Total Population in study area:	6847	6847	6847	6847	6847	6847	6847
% population in assessment age-group:	54%	10%	10%	100%	100%	100%	23%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043	0.0043
Relative Risk:	1.000025	1.000003	1.000002	1.000004	1.000004	1.000008	1.000006
Attributable fraction (AF):	2.5E-05	3.4E-06	1.8E-06	4.0E-06	4.2E-06	8.2E-06	6.4E-06
Increased number of cases in population:	0.00046	0.000156	0.000058	0.000138	0.000035	0.0000242	0.000120
Risk:	1.2E-07	2.3E-07	8.7E-08	2.0E-08	5.1E-09	3.5E-09	7.7E-08
Badgerys Creek							
Total Population in study area:	168	168	168	168	168	168	168
% population in assessment age-group:	62%	24%	24%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0212	0.0212	0.0212	0.0212	0.0212	0.0212	0.0212
Relative Risk:	1.000123	1.000017	1.000009	1.000020	1.000021	1.000040	1.000031
Attributable fraction (AF):	1.2E-04	1.7E-05	8.7E-06	2.0E-05	2.1E-05	4.0E-05	3.1E-05
Increased number of cases in population:	0.000064	0.000047	0.0000176	0.0000167	0.0000042	0.0000029	0.0000106
Risk:	6.1E-07	1.2E-06	4.3E-07	1.0E-07	2.5E-08	1.7E-08	3.8E-07
Bringelly							
Total Population in study area:	2433	2433	2433	2433	2433	2433	2433
% population in assessment age-group:	63%	19%	19%	100%	100%	100%	15%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523	0.0523
Relative Risk:	1.000303	1.000042	1.000021	1.000049	1.000051	1.000099	1.000077
Attributable fraction (AF):	3.0E-04	4.2E-05	2.1E-05	4.9E-05	5.1E-05	9.9E-05	7.7E-05
Increased number of cases in population:	0.00232	0.00131	0.00049	0.00060	0.000151	0.000105	0.00035
Risk:	1.5E-06	2.9E-06	1.1E-06	2.5E-07	6.2E-08	4.3E-08	9.3E-07
Cecil Park							
Total Population in study area:	815	815	815	815	815	815	815
% population in assessment age-group:	62%	20%	20%	100%	100%	100%	14%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032
Relative Risk:	1.000019	1.000003	1.000001	1.000003	1.000003	1.000006	1.000005
Attributable fraction (AF):	1.9E-05	2.6E-06	1.3E-06	3.0E-06	3.1E-06	6.1E-06	4.7E-06
Increased number of cases in population:	0.000047	0.000029	0.0000107	0.0000123	0.0000031	0.00000215	0.0000063
Risk:	9.3E-08	1.8E-07	6.5E-08	1.5E-08	3.8E-09	2.6E-09	5.7E-08
Cobbitty							
Total Population in study area:	4206	4206	4206	4206	4206	4206	4206
% population in assessment age-group:	58%	15%	15%	100%	100%	100%	20%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0171	0.0171	0.0171	0.0171	0.0171	0.0171	0.0171
Relative Risk:	1.000099	1.000014	1.000007	1.000016	1.000017	1.000032	1.000025
Attributable fraction (AF):	9.9E-05	1.4E-05	7.0E-06	1.6E-05	1.7E-05	3.2E-05	2.5E-05
Increased number of cases in population:	0.00121	0.00060	0.000225	0.00034	0.000085	0.000059	0.00026
Risk:	5.0E-07	9.3E-07	3.5E-07	8.0E-08	2.0E-08	1.4E-08	3.0E-07
Greendale							
Total Population in study area:	314	314	314	314	314	314	314
% population in assessment age-group:	62%	18%	18%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.032	0.032	0.032	0.032	0.032	0.032	0.032
Relative Risk:	1.000187	1.000026	1.000013	1.000030	1.000031	1.000061	1.000048
Attributable fraction (AF):	1.9E-04	2.6E-05	1.3E-05	3.0E-05	3.1E-05	6.1E-05	4.8E-05
Increased number of cases in population:	0.000182	0.000099	0.000037	0.000048	0.0000120	0.0000083	0.000031
Risk:	9.4E-07	1.8E-06	6.6E-07	1.5E-07	3.8E-08	2.7E-08	5.8E-07

Kemps Creek							
Total Population in study area:	2121	2121	2121	2121	2121	2121	2121
% population in assessment age-group:	65%	21%	21%	100%	100%	100%	15%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126	0.0126
Relative Risk:	1.000073	1.000010	1.000005	1.000012	1.000012	1.000024	1.000019
Attributable fraction (AF):	7.3E-05	1.0E-05	5.2E-06	1.2E-05	1.2E-05	2.4E-05	1.9E-05
Increased number of cases in population:	0.00050	0.00031	0.000115	0.000126	0.000032	0.0000220	0.000073
Risk:	3.7E-07	6.9E-07	2.6E-07	5.9E-08	1.5E-08	1.0E-08	2.2E-07
Luddenham							
Total Population in study area:	1927	1927	1927	1927	1927	1927	1927
% population in assessment age-group:	57%	12%	12%	100%	100%	100%	21%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.31	0.31	0.31	0.31	0.31	0.31	0.31
Relative Risk:	1.001810	1.000249	1.000128	1.000293	1.000302	1.000592	1.000461
Attributable fraction (AF):	1.8E-03	2.5E-04	1.3E-04	2.9E-04	3.0E-04	5.9E-04	4.6E-04
Increased number of cases in population:	0.0099	0.0038	0.00143	0.0028	0.00071	0.00049	0.00223
Risk:	9.0E-06	1.7E-05	6.3E-06	1.5E-06	3.7E-07	2.6E-07	5.6E-06
Mount Vernon							
Total Population in study area:	1235	1235	1235	1235	1235	1235	1235
% population in assessment age-group:	59%	15%	15%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056	0.0056
Relative Risk:	1.000032	1.000004	1.000002	1.000005	1.000005	1.000011	1.000008
Attributable fraction (AF):	3.2E-05	4.5E-06	2.3E-06	5.2E-06	5.4E-06	1.1E-05	8.3E-06
Increased number of cases in population:	0.000118	0.000058	0.0000214	0.000032	0.0000082	0.0000057	0.0000210
Risk:	1.6E-07	3.0E-07	1.1E-07	2.6E-08	6.6E-09	4.6E-09	1.0E-07
Mulgoa							
Total Population in study area:	2044	2044	2044	2044	2044	2044	2044
% population in assessment age-group:	62%	18%	18%	100%	100%	100%	18%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0117	0.0117	0.0117	0.0117	0.0117	0.0117	0.0117
Relative Risk:	1.000068	1.000009	1.000005	1.000011	1.000011	1.000022	1.000017
Attributable fraction (AF):	6.8E-05	9.3E-06	4.8E-06	1.1E-05	1.1E-05	2.2E-05	1.7E-05
Increased number of cases in population:	0.00043	0.000228	0.000085	0.000112	0.000028	0.0000197	0.000078
Risk:	3.4E-07	6.4E-07	2.4E-07	5.5E-08	1.4E-08	9.6E-09	2.1E-07
Rossmore							
Total Population in study area:	2241	2241	2241	2241	2241	2241	2241
% population in assessment age-group:	60%	19%	19%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0109	0.0109	0.0109	0.0109	0.0109	0.0109	0.0109
Relative Risk:	1.000063	1.000009	1.000004	1.000010	1.000011	1.000021	1.000016
Attributable fraction (AF):	6.3E-05	8.7E-06	4.5E-06	1.0E-05	1.1E-05	2.1E-05	1.6E-05
Increased number of cases in population:	0.00043	0.000256	0.000095	0.000115	0.0000289	0.0000200	0.000073
Risk:	3.2E-07	5.9E-07	2.2E-07	5.1E-08	1.3E-08	8.9E-09	1.9E-07
Wallacia							
Total Population in study area:	1711	1711	1711	1711	1711	1711	1711
% population in assessment age-group:	61%	17%	17%	100%	100%	100%	19%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (μg/m^3):	0.0152	0.0152	0.0152	0.0152	0.0152	0.0152	0.0152
Relative Risk:	1.000088	1.000012	1.000006	1.000014	1.000015	1.000029	1.000022
Attributable fraction (AF):	8.8E-05	1.2E-05	6.2E-06	1.4E-05	1.5E-05	2.9E-05	2.2E-05
Increased number of cases in population:	0.00046	0.00025	0.000092	0.000122	0.000031	0.0000214	0.000089
Risk:	4.4E-07	8.3E-07	3.1E-07	7.1E-08	1.8E-08	1.2E-08	2.7E-07
Total population incidence - All Suburbs	**0.016**	**0.007**	**0.003**	**0.004**	**0.0011**	**0.0008**	**0.003**

Assessment of Change in Population Incidence - $PM_{2.5}$ 2055-S4

	Primary Indicators			Secondary Indicators			
Health Endpoint:	**Mortality PM2.5 - All Causes, Long-term**	**Hospitalisations PM2.5 - Cardiovascular, Short-term**	**Hospitalisations PM2.5 - Respiratory, Short-term**	**Mortality PM2.5 - All Causes, Short-term**	**Mortality PM2.5 - Cardiovascular, Short-term**	**Mortality PM2.5 - Respiratory, Short-term**	**Morbidity PM2.5 - Asthma ED Admissions - Short-term**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	All ages	1-14 years
β (change in effect per 1 µg/m^3 PM) (as per Table 5.3)	0.0058	0.0008	0.00041	0.00094	0.00097	0.0019	0.0015
Baseline incidence (per 100,000) (as per Table 4.5)	500	6829	4955	500	122.1	43.3	1206
Austral							
Total Population in study area:	6847	6847	6847	6847	6847	6847	6847
% population in assessment age-group:	54%	10%	10%	100%	100%	100%	23%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045
Relative Risk:	1.000026	1.000004	1.000002	1.000004	1.000004	1.000009	1.000007
Attributable fraction (AF):	2.6E-05	3.6E-06	1.9E-06	4.3E-06	4.4E-06	8.6E-06	6.7E-06
Increased number of cases in population:	0.00048	0.000164	0.000061	0.000146	0.000037	0.0000255	0.000126
Risk:	1.3E-07	2.5E-07	9.2E-08	2.1E-08	5.4E-09	3.7E-09	8.1E-08
Badgerys Creek							
Total Population in study area:	168	168	168	168	168	168	168
% population in assessment age-group:	62%	24%	24%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247
Relative Risk:	1.000143	1.000020	1.000010	1.000023	1.000024	1.000047	1.000037
Attributable fraction (AF):	1.4E-04	2.0E-05	1.0E-05	2.3E-05	2.4E-05	4.7E-05	3.7E-05
Increased number of cases in population:	0.000074	0.000055	0.0000205	0.0000195	0.0000049	0.0000034	0.0000124
Risk:	7.2E-07	1.3E-06	5.0E-07	1.2E-07	2.9E-08	2.0E-08	4.4E-07
Bringelly							
Total Population in study area:	2433	2433	2433	2433	2433	2433	2433
% population in assessment age-group:	63%	19%	19%	100%	100%	100%	15%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0529	0.0529	0.0529	0.0529	0.0529	0.0529	0.0529
Relative Risk:	1.000307	1.000042	1.000022	1.000050	1.000051	1.000101	1.000078
Attributable fraction (AF):	3.1E-04	4.2E-05	2.2E-05	5.0E-05	5.1E-05	1.0E-04	7.8E-05
Increased number of cases in population:	0.00235	0.00133	0.00049	0.00060	0.000152	0.000106	0.00035
Risk:	1.5E-06	2.9E-06	1.1E-06	2.5E-07	6.3E-08	4.4E-08	9.4E-07
Cecil Park							
Total Population in study area:	815	815	815	815	815	815	815
% population in assessment age-group:	62%	20%	20%	100%	100%	100%	14%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034	0.0034
Relative Risk:	1.000020	1.000003	1.000001	1.000003	1.000003	1.000006	1.000005
Attributable fraction (AF):	2.0E-05	2.7E-06	1.4E-06	3.2E-06	3.3E-06	6.4E-06	5.0E-06
Increased number of cases in population:	0.000049	0.000030	0.0000112	0.0000129	0.0000032	0.00000226	0.0000067
Risk:	9.8E-08	1.8E-07	6.8E-08	1.6E-08	4.0E-09	2.8E-09	6.0E-08
Cobbitty							
Total Population in study area:	4206	4206	4206	4206	4206	4206	4206
% population in assessment age-group:	58%	15%	15%	100%	100%	100%	20%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0152	0.0152	0.0152	0.0152	0.0152	0.0152	0.0152
Relative Risk:	1.000088	1.000012	1.000006	1.000014	1.000015	1.000029	1.000022
Attributable fraction (AF):	8.8E-05	1.2E-05	6.2E-06	1.4E-05	1.5E-05	2.9E-05	2.2E-05
Increased number of cases in population:	0.00108	0.00054	0.000200	0.00030	0.000076	0.000053	0.00023
Risk:	4.4E-07	8.3E-07	3.1E-07	7.1E-08	1.8E-08	1.3E-08	2.7E-07
Greendale							
Total Population in study area:	314	314	314	314	314	314	314
% population in assessment age-group:	62%	18%	18%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.026	0.026	0.026	0.026	0.026	0.026	0.026
Relative Risk:	1.000153	1.000021	1.000011	1.000025	1.000026	1.000050	1.000039
Attributable fraction (AF):	1.5E-04	2.1E-05	1.1E-05	2.5E-05	2.6E-05	5.0E-05	3.9E-05
Increased number of cases in population:	0.000148	0.000080	0.000030	0.000039	0.0000098	0.0000068	0.000025
Risk:	7.6E-07	1.4E-06	5.3E-07	1.2E-07	3.1E-08	2.2E-08	4.7E-07

Kemps Creek							
Total Population in study area:	2121	2121	2121	2121	2121	2121	2121
% population in assessment age-group:	65%	21%	21%	100%	100%	100%	15%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0142	0.0142	0.0142	0.0142	0.0142	0.0142	0.0142
Relative Risk:	1.000082	1.000011	1.000006	1.000013	1.000014	1.000027	1.000021
Attributable fraction (AF):	8.2E-05	1.1E-05	5.8E-06	1.3E-05	1.4E-05	2.7E-05	2.1E-05
Increased number of cases in population:	0.00056	0.00035	0.000129	0.000141	0.000036	0.0000247	0.000082
Risk:	4.1E-07	7.7E-07	2.9E-07	6.7E-08	1.7E-08	1.2E-08	2.5E-07
Luddenham							
Total Population in study area:	1927	1927	1927	1927	1927	1927	1927
% population in assessment age-group:	57%	12%	12%	100%	100%	100%	21%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.37	0.37	0.37	0.37	0.37	0.37	0.37
Relative Risk:	1.002143	1.000295	1.000151	1.000347	1.000358	1.000702	1.000546
Attributable fraction (AF):	2.1E-03	3.0E-04	1.5E-04	3.5E-04	3.6E-04	7.0E-04	5.5E-04
Increased number of cases in population:	0.0118	0.0045	0.00169	0.0033	0.00084	0.00058	0.00264
Risk:	1.1E-05	2.0E-05	7.5E-06	1.7E-06	4.4E-07	3.0E-07	6.6E-06
Mount Vernon							
Total Population in study area:	1235	1235	1235	1235	1235	1235	1235
% population in assessment age-group:	59%	15%	15%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059	0.0059
Relative Risk:	1.000034	1.000005	1.000002	1.000006	1.000006	1.000011	1.000009
Attributable fraction (AF):	3.4E-05	4.7E-06	2.4E-06	5.5E-06	5.7E-06	1.1E-05	8.7E-06
Increased number of cases in population:	0.000124	0.000061	0.0000226	0.000034	0.0000086	0.0000060	0.0000222
Risk:	1.7E-07	3.2E-07	1.2E-07	2.8E-08	7.0E-09	4.8E-09	1.0E-07
Mulgoa							
Total Population in study area:	2044	2044	2044	2044	2044	2044	2044
% population in assessment age-group:	62%	18%	18%	100%	100%	100%	18%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111
Relative Risk:	1.000064	1.000009	1.000005	1.000010	1.000011	1.000021	1.000016
Attributable fraction (AF):	6.4E-05	8.9E-06	4.5E-06	1.0E-05	1.1E-05	2.1E-05	1.6E-05
Increased number of cases in population:	0.00041	0.000217	0.000081	0.000107	0.000027	0.0000186	0.000074
Risk:	3.2E-07	6.1E-07	2.3E-07	5.2E-08	1.3E-08	9.1E-09	2.0E-07
Rossmore							
Total Population in study area:	2241	2241	2241	2241	2241	2241	2241
% population in assessment age-group:	60%	19%	19%	100%	100%	100%	17%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0119	0.0119	0.0119	0.0119	0.0119	0.0119	0.0119
Relative Risk:	1.000069	1.000010	1.000005	1.000011	1.000012	1.000023	1.000018
Attributable fraction (AF):	6.9E-05	9.5E-06	4.9E-06	1.1E-05	1.2E-05	2.3E-05	1.8E-05
Increased number of cases in population:	0.00047	0.000280	0.000104	0.000125	0.0000316	0.0000219	0.000080
Risk:	3.5E-07	6.5E-07	2.4E-07	5.6E-08	1.4E-08	9.8E-09	2.1E-07
Wallacia							
Total Population in study area:	1711	1711	1711	1711	1711	1711	1711
% population in assessment age-group:	61%	17%	17%	100%	100%	100%	19%
Baseline incidence (per person)	0.005	0.06829	0.04955	0.005	0.001221	0.000433	0.01206
Incremental impact from project Δx (µg/m^3):	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131
Relative Risk:	1.000076	1.000011	1.000005	1.000012	1.000013	1.000025	1.000019
Attributable fraction (AF):	7.6E-05	1.1E-05	5.4E-06	1.2E-05	1.3E-05	2.5E-05	1.9E-05
Increased number of cases in population:	0.00040	0.00021	0.000079	0.000106	0.000027	0.0000185	0.000077
Risk:	3.8E-07	7.2E-07	2.7E-07	6.2E-08	1.6E-08	1.1E-08	2.3E-07
Total population incidence - All Suburbs	**0.018**	**0.008**	**0.003**	**0.005**	**0.0013**	**0.0009**	**0.004**

Appendix D

Calculation of health impacts – Nitrogen dioxide

Assessment of Change in Population Incidence - NO_2
2033

	S1			S3			S4		
Health Endpoint:	**Mortality - all causes**	**Mortality - respiratory**	**Asthma - ED hospital admissions**	**Mortality - all causes**	**Mortality - respiratory**	**Asthma - ED hospital admissions**	**Mortality - all causes**	**Mortality - respiratory**	**Asthma - ED hospital admissions**
Age Group:	≥ 30 years	all ages	1-14 years	≥ 30 years	all ages	1-14 years	≥ 30 years	all ages	1-14 years
β (change in effect per 1 µg/m^3 PM) (as per Table 5.4)	0.00188	0.00426	0.00115	0.00188	0.00426	0.00115	0.00188	0.00426	0.00115
Baseline incidence (per 100,000) (as per Table 4.5)	500	43.3	1228	500	43.3	1228	500	43.3	1228
Austral									
Total Population in study area:	6847	6847	6847	6847	6847	6847	6847	6847	6847
% population in assessment age-group:	54%	100%	23%	54%	100%	23%	54%	100%	23%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (µg/m^3):	0.198	0.198	0.198	0.202	0.202	0.202	0.214	0.214	0.214
Relative Risk:	1.000372	1.000844	1.000228	1.000380	1.000861	1.000232	1.000402	1.000912	1.000246
Attributable fraction (AF):	3.7E-04	8.4E-04	2.3E-04	3.8E-04	8.6E-04	2.3E-04	4.0E-04	9.1E-04	2.5E-04
Increased number of cases in population:	0.0069	0.0025	0.0044	0.0070	0.0026	0.0045	0.0074	0.0027	0.0047
Risk:	1.9E-06	3.7E-07	2.8E-06	1.9E-06	3.7E-07	2.9E-06	2.0E-06	3.9E-07	3.0E-06
Badgerys Creek									
Total Population in study area:	168	168	168	168	168	168	168	168	168
% population in assessment age-group:	62%	100%	17%	62%	100%	17%	62%	100%	17%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (µg/m^3):	0.75	0.75	0.75	0.75	0.75	0.75	0.87	0.87	0.87
Relative Risk:	1.001411	1.003200	1.000863	1.001411	1.003200	1.000863	1.001637	1.003713	1.001001
Attributable fraction (AF):	1.4E-03	3.2E-03	8.6E-04	1.4E-03	3.2E-03	8.6E-04	1.6E-03	3.7E-03	1.0E-03
Increased number of cases in population:	0.00073	0.00023	0.00030	0.00073	0.00023	0.00030	0.00085	0.00027	0.00034
Risk:	7.1E-06	1.4E-06	1.1E-05	7.1E-06	1.4E-06	1.1E-05	8.2E-06	1.6E-06	1.2E-05
Bringelly									
Total Population in study area:	2433	2433	2433	2433	2433	2433	2433	2433	2433
% population in assessment age-group:	63%	100%	15%	63%	100%	15%	63%	100%	15%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (µg/m^3):	1.3	1.3	1.3	1.42	1.42	1.42	1.5	1.5	1.5
Relative Risk:	1.002447	1.005553	1.001496	1.002673	1.006068	1.001634	1.002824	1.006410	1.001726
Attributable fraction (AF):	2.4E-03	5.5E-03	1.5E-03	2.7E-03	6.0E-03	1.6E-03	2.8E-03	6.4E-03	1.7E-03
Increased number of cases in population:	0.019	0.0058	0.0068	0.020	0.0064	0.0075	0.022	0.0067	0.0079
Risk:	1.2E-05	2.4E-06	1.8E-05	1.3E-05	2.6E-06	2.0E-05	1.4E-05	2.8E-06	2.1E-05
Cecil Park									
Total Population in study area:	815	815	815	815	815	815	815	815	815
% population in assessment age-group:	62%	100%	14%	62%	100%	14%	62%	100%	14%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (µg/m^3):	0.16	0.16	0.16	0.16	0.16	0.16	0.17	0.17	0.17
Relative Risk:	1.000301	1.000682	1.000184	1.000301	1.000682	1.000184	1.000320	1.000724	1.000196
Attributable fraction (AF):	3.0E-04	6.8E-04	1.8E-04	3.0E-04	6.8E-04	1.8E-04	3.2E-04	7.2E-04	2.0E-04
Increased number of cases in population:	0.00076	0.00024	0.00025	0.00076	0.00024	0.00025	0.00080	0.00026	0.00027
Risk:	1.5E-06	3.0E-07	2.3E-06	1.5E-06	3.0E-07	2.3E-06	1.6E-06	3.1E-07	2.4E-06
Cobbitty									
Total Population in study area:	4206	4206	4206	4206	4206	4206	4206	4206	4206
% population in assessment age-group:	58%	100%	20%	58%	100%	20%	58%	100%	20%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (µg/m^3):	0.71	0.71	0.71	0.68	0.68	0.68	0.63	0.63	0.63
Relative Risk:	1.001336	1.003029	1.000817	1.001279	1.002901	1.000782	1.001185	1.002687	1.000725
Attributable fraction (AF):	1.3E-03	3.0E-03	8.2E-04	1.3E-03	2.9E-03	7.8E-04	1.2E-03	2.7E-03	7.2E-04
Increased number of cases in population:	0.016	0.0055	0.0085	0.016	0.0053	0.0081	0.014	0.0049	0.0075
Risk:	6.7E-06	1.3E-06	1.0E-05	6.4E-06	1.3E-06	9.6E-06	5.9E-06	1.2E-06	8.9E-06
Greendale									
Total Population in study area:	314	314	314	314	314	314	314	314	314
% population in assessment age-group:	62%	100%	17%	62%	100%	17%	62%	100%	17%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (µg/m^3):	1.28	1.28	1.28	1.16	1.16	1.16	0.954	0.954	0.954
Relative Risk:	1.002409	1.005468	1.001473	1.002183	1.004954	1.001335	1.001795	1.004072	1.001098
Attributable fraction (AF):	2.4E-03	5.4E-03	1.5E-03	2.2E-03	4.9E-03	1.3E-03	1.8E-03	4.1E-03	1.1E-03
Increased number of cases in population:	0.0023	0.00074	0.0010	0.0021	0.00067	0.00088	0.0017	0.00055	0.00073
Risk:	1.2E-05	2.4E-06	1.8E-05	1.1E-05	2.1E-06	1.6E-05	9.0E-06	1.8E-06	1.3E-05
Kemps Creek									
Total Population in study area:	2121	2121	2121	2121	2121	2121	2121	2121	2121
% population in assessment age-group:	65%	100%	15%	65%	100%	15%	65%	100%	15%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (µg/m^3):	0.53	0.53	0.53	0.52	0.52	0.52	0.577	0.577	0.577
Relative Risk:	1.000997	1.002260	1.000610	1.000978	1.002218	1.000598	1.001085	1.002461	1.000664
Attributable fraction (AF):	1.0E-03	2.3E-03	6.1E-04	9.8E-04	2.2E-03	6.0E-04	1.1E-03	2.5E-03	6.6E-04
Increased number of cases in population:	0.0068	0.0021	0.0024	0.0067	0.0020	0.0024	0.0074	0.0023	0.0026
Risk:	5.0E-06	9.8E-07	7.5E-06	4.9E-06	9.6E-07	7.3E-06	5.4E-06	1.1E-06	8.1E-06

Luddenham									
Total Population in study area:	1927	1927	1927	1927	1927	1927	1927	1927	1927
% population in assessment age-group:	57%	100%	21%	57%	100%	21%	57%	100%	21%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx ($\mu g/m^3$):	6.2	6.2	6.2	6.67	6.67	6.67	8.4	8.4	8.4
Relative Risk:	1.011724	1.026764	1.007155	1.012619	1.028822	1.007700	1.015917	1.036432	1.009707
Attributable fraction (AF):	1.2E-02	2.6E-02	7.1E-03	1.2E-02	2.8E-02	7.6E-03	1.6E-02	3.5E-02	9.6E-03
Increased number of cases in population:	0.064	0.022	0.035	0.069	0.023	0.038	0.086	0.029	0.047
Risk:	5.8E-05	1.1E-05	8.8E-05	6.3E-05	1.2E-05	9.4E-05	7.9E-05	1.5E-05	1.2E-04
Mount Vernon									
Total Population in study area:	1235	1235	1235	1235	1235	1235	1235	1235	1235
% population in assessment age-group:	59%	100%	17%	59%	100%	17%	59%	100%	17%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx ($\mu g/m^3$):	0.258	0.258	0.258	0.259	0.259	0.259	0.274	0.274	0.274
Relative Risk:	1.000485	1.001100	1.000297	1.000487	1.001104	1.000298	1.000515	1.001168	1.000315
Attributable fraction (AF):	4.8E-04	1.1E-03	3.0E-04	4.9E-04	1.1E-03	3.0E-04	5.1E-04	1.2E-03	3.2E-04
Increased number of cases in population:	0.0018	0.00059	0.00077	0.0018	0.00059	0.00077	0.0019	0.00062	0.00082
Risk:	2.4E-06	4.8E-07	3.6E-06	2.4E-06	4.8E-07	3.7E-06	2.6E-06	5.1E-07	3.9E-06
Mulgoa									
Total Population in study area:	2044	2044	2044	2044	2044	2044	2044	2044	2044
% population in assessment age-group:	62%	100%	18%	62%	100%	18%	62%	100%	18%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx ($\mu g/m^3$):	0.56	0.56	0.56	0.58	0.58	0.58	0.553	0.553	0.553
Relative Risk:	1.001053	1.002388	1.000644	1.001091	1.002474	1.000667	1.001040	1.002359	1.000636
Attributable fraction (AF):	1.1E-03	2.4E-03	6.4E-04	1.1E-03	2.5E-03	6.7E-04	1.0E-03	2.4E-03	6.4E-04
Increased number of cases in population:	0.0067	0.0021	0.0030	0.0069	0.0022	0.0031	0.0066	0.0021	0.0029
Risk:	5.3E-06	1.0E-06	7.9E-06	5.5E-06	1.1E-06	8.2E-06	5.2E-06	1.0E-06	7.8E-06
Rossmore									
Total Population in study area:	2241	2241	2241	2241	2241	2241	2241	2241	2241
% population in assessment age-group:	60%	100%	17%	60%	100%	17%	60%	100%	17%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx ($\mu g/m^3$):	0.41	0.41	0.41	0.43	0.43	0.43	0.475	0.475	0.475
Relative Risk:	1.000771	1.001748	1.000472	1.000809	1.001833	1.000495	1.000893	1.002026	1.000546
Attributable fraction (AF):	7.7E-04	1.7E-03	4.7E-04	8.1E-04	1.8E-03	4.9E-04	8.9E-04	2.0E-03	5.5E-04
Increased number of cases in population:	0.0052	0.0017	0.0022	0.0055	0.0018	0.0023	0.0060	0.0020	0.0025
Risk:	3.9E-06	7.6E-07	5.8E-06	4.0E-06	7.9E-07	6.1E-06	4.5E-06	8.8E-07	6.7E-06
Wallacia									
Total Population in study area:	1711	1711	1711	1711	1711	1711	1711	1711	1711
% population in assessment age-group:	61%	100%	19%	61%	100%	19%	61%	100%	19%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx ($\mu g/m^3$):	0.78	0.78	0.78	0.74	0.74	0.74	0.617	0.617	0.617
Relative Risk:	1.001467	1.003328	1.000897	1.001392	1.003157	1.000851	1.001161	1.002632	1.000710
Attributable fraction (AF):	1.5E-03	3.3E-03	9.0E-04	1.4E-03	3.1E-03	8.5E-04	1.2E-03	2.6E-03	7.1E-04
Increased number of cases in population:	0.0077	0.0025	0.0036	0.0073	0.0023	0.0034	0.0061	0.0019	0.0029
Risk:	7.3E-06	1.4E-06	1.1E-05	7.0E-06	1.4E-06	1.0E-05	5.8E-06	1.1E-06	8.7E-06
Total population incidence - All Suburbs	**0.14**	**0.05**	**0.07**	**0.14**	**0.05**	**0.07**	**0.16**	**0.05**	**0.08**

Assessment of Change in Population Incidence - NO_2 2055

	S3			S4		
Health Endpoint:	**Mortality - all causes**	**Mortality - respiratory**	**Asthma - ED hospital admissions**	**Mortality - all causes**	**Mortality - respiratory**	**Asthma - ED hospital admissions**
Age Group:	≥ 30 years	all ages	1-14 years	≥ 30 years	all ages	1-14 years
β (change in effect per 1 µg/m³ PM) (as per Table 5.4)	0.00188	0.00426	0.00115	0.00188	0.00426	0.00115
Baseline incidence (per 100,000) (as per Table 4.5)	500	43.3	1228	500	43.3	1228
Austral						
Total Population in study area:	6847	6847	6847	6847	6847	6847
% population in assessment age-group:	54%	100%	23%	54%	100%	23%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (µg/m³):	0.578	0.578	0.578	0.603	0.603	0.603
Relative Risk:	1.001087	1.002465	1.000665	1.001134	1.002572	1.000694
Attributable fraction (AF):	1.1E-03	2.5E-03	6.6E-04	1.1E-03	2.6E-03	6.9E-04
Increased number of cases in population:	0.020	0.0073	0.013	0.021	0.0076	0.013
Risk:	5.4E-06	1.1E-06	8.2E-06	5.7E-06	1.1E-06	8.5E-06
Badgerys Creek						
Total Population in study area:	168	168	168	168	168	168
% population in assessment age-group:	62%	100%	17%	62%	100%	17%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (µg/m³):	2	2	2	2.26	2.26	2.26
Relative Risk:	1.003767	1.008556	1.002303	1.004258	1.009674	1.002602
Attributable fraction (AF):	3.8E-03	8.5E-03	2.3E-03	4.2E-03	9.6E-03	2.6E-03
Increased number of cases in population:	0.0020	0.00062	0.00079	0.0022	0.00070	0.00089
Risk:	1.9E-05	3.7E-06	2.8E-05	2.1E-05	4.2E-06	3.2E-05
Bringelly						
Total Population in study area:	2433	2433	2433	2433	2433	2433
% population in assessment age-group:	63%	100%	15%	63%	100%	15%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (µg/m³):	3.52	3.52	3.52	3.71	3.71	3.71
Relative Risk:	1.006640	1.015108	1.004056	1.006999	1.015930	1.004276
Attributable fraction (AF):	6.6E-03	1.5E-02	4.0E-03	7.0E-03	1.6E-02	4.3E-03
Increased number of cases in population:	0.051	0.016	0.018	0.053	0.017	0.019
Risk:	3.3E-05	6.5E-06	5.0E-05	3.5E-05	6.8E-06	5.2E-05
Cecil Park						
Total Population in study area:	815	815	815	815	815	815
% population in assessment age-group:	62%	100%	14%	62%	100%	14%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (µg/m³):	0.471	0.471	0.471	0.49	0.49	0.49
Relative Risk:	1.000886	1.002008	1.000542	1.000922	1.002090	1.000564
Attributable fraction (AF):	8.9E-04	2.0E-03	5.4E-04	9.2E-04	2.1E-03	5.6E-04
Increased number of cases in population:	0.0022	0.00071	0.00074	0.0023	0.00074	0.00077
Risk:	4.4E-06	8.7E-07	6.7E-06	4.6E-06	9.0E-07	6.9E-06
Cobbitty						
Total Population in study area:	4206	4206	4206	4206	4206	4206
% population in assessment age-group:	58%	100%	20%	58%	100%	20%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (µg/m³):	1.87	1.87	1.87	1.7	1.7	1.7
Relative Risk:	1.003522	1.007998	1.002153	1.003201	1.007268	1.001957
Attributable fraction (AF):	3.5E-03	7.9E-03	2.1E-03	3.2E-03	7.2E-03	2.0E-03
Increased number of cases in population:	0.043	0.014	0.022	0.039	0.013	0.020
Risk:	1.8E-05	3.4E-06	2.6E-05	1.6E-05	3.1E-06	2.4E-05
Greendale						
Total Population in study area:	314	314	314	314	314	314
% population in assessment age-group:	62%	100%	17%	62%	100%	17%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (µg/m³):	2.8	2.8	2.8	2.4	2.4	2.4
Relative Risk:	1.005278	1.011999	1.003225	1.004522	1.010276	1.002764
Attributable fraction (AF):	5.3E-03	1.2E-02	3.2E-03	4.5E-03	1.0E-02	2.8E-03
Increased number of cases in population:	0.0051	0.0016	0.0021	0.0044	0.0014	0.0018
Risk:	2.6E-05	5.2E-06	4.0E-05	2.3E-05	4.4E-06	3.4E-05
Kemps Creek						
Total Population in study area:	2121	2121	2121	2121	2121	2121
% population in assessment age-group:	65%	100%	15%	65%	100%	15%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (µg/m³):	1.49	1.49	1.49	1.57	1.57	1.57
Relative Risk:	1.002805	1.006368	1.001715	1.002956	1.006711	1.001807
Attributable fraction (AF):	2.8E-03	6.3E-03	1.7E-03	2.9E-03	6.7E-03	1.8E-03
Increased number of cases in population:	0.019	0.0058	0.0068	0.020	0.0061	0.0071
Risk:	1.4E-05	2.7E-06	2.1E-05	1.5E-05	2.9E-06	2.2E-05

Luddenham						
Total Population in study area:	1927	1927	1927	1927	1927	1927
% population in assessment age-group:	57%	100%	21%	57%	100%	21%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (μg/m^3):	14.8	14.8	14.8	7.8	7.8	7.8
Relative Risk:	1.028215	1.065078	1.017166	1.014772	1.033786	1.009010
Attributable fraction (AF):	2.7E-02	6.1E-02	1.7E-02	1.5E-02	3.3E-02	8.9E-03
Increased number of cases in population:	0.15	0.051	0.083	0.08	0.027	0.04
Risk:	1.4E-04	2.7E-05	2.1E-04	7.3E-05	1.4E-05	1.1E-04
Mount Vernon						
Total Population in study area:	1235	1235	1235	1235	1235	1235
% population in assessment age-group:	59%	100%	17%	59%	100%	17%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (μg/m^3):	0.78	0.78	0.78	0.811	0.811	0.811
Relative Risk:	1.001467	1.003328	1.000897	1.001526	1.003461	1.000933
Attributable fraction (AF):	1.5E-03	3.3E-03	9.0E-04	1.5E-03	3.4E-03	9.3E-04
Increased number of cases in population:	0.0053	0.0018	0.0023	0.0055	0.0018	0.0024
Risk:	7.3E-06	1.4E-06	1.1E-05	7.6E-06	1.5E-06	1.1E-05
Mulgoa						
Total Population in study area:	2044	2044	2044	2044	2044	2044
% population in assessment age-group:	62%	100%	18%	62%	100%	18%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (μg/m^3):	1.59	1.59	1.59	1.48	1.48	1.48
Relative Risk:	1.002994	1.006796	1.001830	1.002786	1.006325	1.001703
Attributable fraction (AF):	3.0E-03	6.8E-03	1.8E-03	2.8E-03	6.3E-03	1.7E-03
Increased number of cases in population:	0.019	0.0060	0.0084	0.018	0.0056	0.0079
Risk:	1.5E-05	2.9E-06	2.2E-05	1.4E-05	2.7E-06	2.1E-05
Rossmore						
Total Population in study area:	2241	2241	2241	2241	2241	2241
% population in assessment age-group:	60%	100%	17%	60%	100%	17%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (μg/m^3):	1.19	1.19	1.19	1.29	1.29	1.29
Relative Risk:	1.002240	1.005082	1.001369	1.002428	1.005511	1.001485
Attributable fraction (AF):	2.2E-03	5.1E-03	1.4E-03	2.4E-03	5.5E-03	1.5E-03
Increased number of cases in population:	0.015	0.0049	0.0064	0.016	0.0053	0.0069
Risk:	1.1E-05	2.2E-06	1.7E-05	1.2E-05	2.4E-06	1.8E-05
Wallacia						
Total Population in study area:	1711	1711	1711	1711	1711	1711
% population in assessment age-group:	61%	100%	19%	61%	100%	19%
Baseline incidence (per person)	0.005	0.000433	0.01228	0.005	0.000433	0.01228
Incremental impact from project Δx (μg/m^3):	1.94	1.94	1.94	1.65	1.65	1.65
Relative Risk:	1.003654	1.008299	1.002233	1.003107	1.007054	1.001899
Attributable fraction (AF):	3.6E-03	8.2E-03	2.2E-03	3.1E-03	7.0E-03	1.9E-03
Increased number of cases in population:	0.019	0.0061	0.0090	0.016	0.0052	0.0076
Risk:	1.8E-05	3.6E-06	2.7E-05	1.6E-05	3.0E-06	2.3E-05
Total population incidence - All Suburbs	**0.35**	**0.12**	**0.17**	**0.28**	**0.09**	**0.13**

Appendix E

Calculation of health impacts from noise – Sleep disturbance

Calculated %HSD - 2033

				LAeq Night				Sleep disturbance as %HSD			
ID	Type	Area	Suburb	Background	S1	S3	S4	Background	S1	S3	S4
M01	Noise Monitoring Terminal	South West Departure (Wallacia)	Wallacia	43.0	51.8	51.2	51.2	13	22	21	21
M02	Noise Monitoring Terminal	North East Departure	Kemps Creek	44.0	49.3	45.2	45.4	14	19	15	15
M03	Noise Monitoring Terminal	North East Runway	Orchard Hills	53.0	38.3	28.1	27.6	23	10	0	0
M04	Noise Monitoring Terminal	Twin Creeks	Luddenham	45.0	48.4	37.3	36.5	15	18	10	9
M06	Noise Monitoring Terminal	Mount Vernon	Mount Vernon	50.0	30.6	26.6	26.6	20	0	0	0
M07	Noise Monitoring Terminal	Kemps Creek Nature Reserve	Kemps Creek	45.0	25.6	24.9	24.9	15	0	0	0
M08	Noise Monitoring Terminal	Luddenham	Luddenham	58.0	38.6	34.1	34.0	29	10	0	0
M09	Noise Monitoring Terminal	Penrith	Penrith	42.0	22.6	18.4	18.3	13	0	0	0
M10	Noise Monitoring Terminal	Glenmore Park	Glenmore Park	46.0	30.5	23.8	23.6	16	0	0	0
M11	Noise Monitoring Terminal	Oxley Park	Oxley Park	44.0	30.6	21.1	20.7	14	0	0	0
M12	Noise Monitoring Terminal	St. Marys	St. Marys	44.0	38.7	27.4	26.7	14	10	0	0
M13	Noise Monitoring Terminal	Rooty Hill	Rooty Hill	46.0	35.1	31.1	31.3	16	9	0	0
M14	Noise Monitoring Terminal	St. Clair	St. Clair	49.0	37.6	26.9	26.4	19	10	0	0
M15	Noise Monitoring Terminal	Erskine Park	Erskine Park	43.0	31.2	23.6	23.5	13	0	0	0
M16	Noise Monitoring Terminal	Sydney International Equestrian Centre	Horsley Park	50.0	22.8	19.9	20.0	20	0	0	0
M17	Noise Monitoring Terminal	Wallacia	Wallacia	45.0	32.3	43.2	43.2	15	0	14	14
M18	Noise Monitoring Terminal	Warragamba	Warragamba	46.0	30.4	35.6	35.6	16	0	9	9
M19	Noise Monitoring Terminal	Greendale	Greendale	45.0	51.1	50.8	50.8	15	21	21	21
M20	Noise Monitoring Terminal	Bringelly	Bringelly	44.0	31.6	33.4	33.4	14	0	0	0
M21	Noise Monitoring Terminal	Bents Basin	Greendale	47.0	49.9	48.8	48.8	17	20	19	19
M22	Noise Monitoring Terminal	Silverdale	Silverdale	44.0	51.9	51.5	51.6	14	22	21	21
M23	Noise Monitoring Terminal	Werombi	Werombi	45.0	31.3	29.6	29.6	15	0	0	0
M24	Noise Monitoring Terminal	Blaxland	Blaxland	42.0	23.5	23.6	23.6	13	0	0	0
M25	Noise Monitoring Terminal	Linden	Linden	43.0	33.0	36.6	36.6	13	0	9	9
M26	Noise Monitoring Terminal	North Richmond	North Richmond	41.0	18.4	10.2	10.0	12	0	0	0
M27	Noise Monitoring Terminal	Kurrajong	Kurrajong	44.0	15.7	8.5	8.2	14	0	0	0
M28	Noise Monitoring Terminal	The Oaks	The Oaks	44.0	24.4	28.7	28.7	14	0	0	0
M29	Noise Monitoring Terminal	Lake Burragorang (Natai, Brownlow Hill)	Nattai	44.0	29.3	25.2	25.4	14	0	0	0
M30	Noise Monitoring Terminal	Tahmoor	Tahmoor	48.0	19.0	27.6	27.6	18	0	0	0
R1	Residential	Bringelly	Bringelly		26.8	28.0	28.0		0	0	0
R2	Residential	Luddenham	Luddenham		39.0	38.3	38.3		11	10	10
R3	Residential	Greendale, Greendale Road	Greendale		45.3	52.4	52.4		15	22	22
R6	Residential	Kemps Creek	Kemps Creek		40.6	33.1	32.8		12	0	0
R7	Residential	Wallacia	Wallacia		32.3	43.9	43.9		0	14	14
R8	Residential	Twin Creeks, Cnr Twin Ck Drie & Humewood Place	Luddenham		50.9	39.9	39.2		21	11	11
R14	Residential	Lawson Road, Badgerys Creek	Badgerys Creek		43.5	36.8	36.7		14	9	9
R15	Residential	Mersey Rd, Greendale	Greendale		34.6	35.5	35.5		0	9	9
R17	Residential	Luddenham Road	Luddenham		44.5	40.1	40.0		15	11	11
R18	Residential	Cnr Adams & Elizabeth Drive	Luddenham		47.6	47.4	47.4		17	17	17
R19	Residential	Cnr Adams & Anton Road	Luddenham		46.0	46.1	46.1		16	16	16
R21	Residential	Cnr Willowdene Ave and Vicar Park Lane	Luddenham		57.4	60.6	60.6		29	33	33
R22	Residential	Rossmore, Victor Ave	Rossmore		30.9	30.6	30.6		0	0	0
R23	Residential	Wallacia, Greendale Road	Wallacia		36.6	49.9	49.9		9	20	20
R24	On-Site	Badgerys Creek 1 NE			47.7	44.3	44.3		18	15	14
R25	On-Site	Badgerys Creek 2 SW			49.0	50.0	50.0		19	20	20
R27	Residential	Greendale, Dwyer Rd	Greendale		34.4	37.9	37.9		0	10	10
R30	Residential	Rossmore residential	Rossmore		22.7	23.4	23.4		0	0	0
R31	Residential	Mt Vernon residential	Mount Vernon		29.7	25.9	25.9		0	0	0
R34	Aged Care	Emmaus Residential Aged Care	Kemps Creek		35.0	29.8	29.9		0	0	0
R35	Childcare	Mamre After School and Vacation Care	Kemps Creek		36.8	30.8	30.9		9	0	0
R37	Childcare	Schoolies at Mulgoa	Luddenham		44.9	45.0	45.0		15	15	15
R38	Childcare	Do-re-mi Day Care Centre	Mount Vernon		28.5	25.1	25.1		0	0	0
R39	Childcare	Little Amigos Austral Early Learning Centre	Austral		20.3	20.8	20.8		0	0	0
R40	Childcare	Little Smarties Childcare Centre	Kemps Creek		36.9	30.9	31.0		9	0	0
R41	Childcare	The Grove Academy	Kemps Creek		27.0	26.2	26.2		0	0	0
R42	Childcare	Horsley Kids	Horsley Park		28.1	24.5	24.6		0	0	0
R44	Childcare	Bringelly Child Care Centre	Bringelly		33.0	35.3	35.3		0	9	9
R46	Childcare	Chementson Drive Early Educational Centre	Rossmore		27.7	27.9	27.9		0	0	0
R48	Childcare	Kids Korner West Hoxton Early Learning Centre	Austral		19.8	20.0	20.0		0	0	0
R49	Childcare	Luddenham Child Care Centre	Luddenham		42.8	42.2	42.2		13	13	13
R52	Childcare	The Frogs Lodge	Austral		20.3	20.6	20.6		0	0	0
R54	Childcare	Mulgoa Preschool	Mulgoa		42.7	33.1	32.6		13	0	0
R55	Childcare	Jillys Educational Childcare Centre	Rossmore		25.6	26.2	26.2		0	0	0
R59	Community Centre	Bringelly Community Centre	Bringelly		27.4	28.6	28.6		0	0	0
R63	Community Centre	Luddenham Progress Hall	Luddenham		46.0	45.7	45.7		16	16	16
R64	Community Centre	Mulgoa Hall	Mulgoa		42.1	33.1	32.6		13	0	0
R65	School	Emmaus Catholic College	Kemps Creek		37.0	32.1	32.2		9	0	0
R66	School	University of Sydney Farms	Greendale		33.3	46.8	46.8		0	17	17
R68	School	Christadelphian Heritage College Sydney	Kemps Creek		29.3	27.2	27.1		0	0	0
R69	School	Mamre Anglican School	Kemps Creek		36.9	30.9	30.9		9	0	0
R72	School	Irfan College	Cecil Park		23.2	21.5	21.5		0	0	0
R73	School	Luddenham Public School	Luddenham		46.9	46.4	46.4		17	16	16
R74	School	Kemps Creek Public School	Kemps Creek		29.5	27.3	27.3		0	0	0
R75	School	Trinity Catholic Primary School	Kemps Creek		35.8	30.1	30.2		9	0	0
R76	School	Bringelly Public School	Bringelly		27.0	28.2	28.2		0	0	0
R78	School	Mulgoa Public School	Mulgoa		42.1	33.2	32.7		13	0	0
R79	School	Rossmore Public School	Rossmore		22.7	23.4	23.4		0	0	0
R80	School	Wallacia Public School	Wallacia		32.4	42.8	42.8		0	13	13
R82	School	Bellfield College - Junior Campus	Rossmore		23.6	24.3	24.3		0	0	0
R84	Park	Bringelly Park	Bringelly		27.6	28.8	28.8		0	0	0
R85	Park	Bents Basin State Conservation Reserve and Gulgue	Greendale		38.6	37.1	37.2		10	10	10
R86	Park	Blaxland Crossing Reserve	Wallacia		32.5	42.8	42.8		0	13	13
R87	Park	Bill Anderson Reserve	Kemps Creek		30.3	27.6	27.6		0	0	0
R91	Park	Western Sydney Parklands	Eastern Creek		39.4	35.5	35.7		11	9	9
R93	Park	Rossmore Grange	Rossmore		26.1	26.6	26.6		0	0	0
R94	Park	Freeburn Park	Luddenham		44.8	44.4	44.4		15	15	15
R95	Park	Overett Reserve	Kemps Creek		37.8	33.4	33.3		10	0	0
R97	Park	Mulgoa Park	Mulgoa		42.1	33.1	32.6		13	0	0
R98	Recreation	Wallacia Bowling and Recreation Club	Wallacia		32.3	45.8	45.8		0	16	16
R99	Recreation	Hubertus Country Club	Luddenham		49.2	49.1	49.1		19	19	19
R100	Recreation	Sugarloaf Cobbitty Equestrian Club	Cobbitty		29.1	45.1	45.1		0	15	15
R102	Recreation	Panthers Wallacia (country club)	Wallacia		32.2	43.8	43.8		0	14	14
R103	Recreation	Twin Creeks Gold and Country Club	Luddenham		47.9	36.8	35.9		18	9	9
R104	Recreation	Sydney International Shooting Centre	Cecil Park		23.5	22.4	22.4		0	0	0

Calculated %HSD - 2033

					LAeq Night				Sleep disturbance as %HSD		
ID	Type	Area	Suburb	Background	S1	S3	S4	Background	S1	S3	S4
R108	Recreation	Luddenham Showground	Luddenham		41.0	40.7	40.6		12	12	12
R109	Recreation	Kemps Creek Sporting and Bowling Club	Cecil Park		26.4	24.5	24.4		0	0	0
R110	Religious Facility	St James Luddenham	Luddenham		48.4	47.9	47.9		18	18	18
R111	Religious Facility	Lin Ying Temple	Rossmore		26.7	26.9	26.9		0	0	0
R112	Religious Facility	Vat Ketanak Khmer Kampuchea Krom	Rossmore		25.7	26.3	26.3		0	0	0
R114	Religious Facility	Anglican Church Sydney Diocese	Rossmore		23.6	24.3	24.3		0	0	0
R115	Religious Facility	Anglican Parish of Mulgoa	Mulgoa		43.0	33.0	32.3		13	0	0
R117	Religious Facility	Bringelly Vineyard Church	Bringelly		25.9	26.8	26.8		0	0	0
R120	Religious Facility	Our Lady Queen of Peace	Greystanes		10.9	10.2	10.3		0	0	0
R122	Religious Facility	St Anthony	Austral		20.4	20.8	20.8		0	0	0
R123	Religious Facility	St Marys Church	Mulgoa		39.2	33.1	32.9		11	0	0
R124	Religious Facility	Wallacia Christian Church	Wallacia		32.3	43.9	43.9		0	14	14
R126	Religious Facility	St Francis Xavier Church	Greendale		55.3	55.3	55.3		26	26	26
R127	Religious Facility	Luddenham Uniting Church	Luddenham		46.3	46.0	46.0		16	16	16
R131	Religious Facility	Science of the Soul Study Centre	Cecil Park		27.2	25.1	25.1		0	0	0
R132	Shopping Centre	Bringelly shops	Bringelly		26.8	28.0	28.0		0	0	0
R134	Shopping Centre	Kemps Creek shops	Kemps Creek		30.5	27.6	27.6		0	0	0
R135	Shopping Centre	Luddenham shops	Luddenham		50.0	49.5	49.5		20	19	19
R136	Shopping Centre	Mulgoa shops	Mulgoa		40.6	33.1	32.8		12	0	0
R137	Shopping Centre	Rossmore shops	Rossmore		22.7	23.4	23.4		0	0	0
R138	Shopping Centre	Wallacia Shops	Wallacia		32.1	44.4	44.4		0	15	15
R140	School	Holy Family Catholic Primary and Church	Luddenham		44.7	45.1	45.1		15	15	15
R141	Religious Facility	Edmund Rice Retreat and Conference Centre	Mulgoa		35.3	36.8	36.8		9	9	9
N1	Aged Care	CATHOLIC HEALTHCARE EMMAUS VILLAGE	Kemps Creek		35.0	29.8	29.9		0	0	0
N2	Aged Care	JOHN EDMONDSON VC GARDENS	Austral		20.3	20.8	20.8		0	0	0
N3	Aged Care	REGAL OAKS VILLAGE	Wallacia		32.1	45.0	45.0		0	15	15
N4	Aged Care	SCALABRINI VILLAGE AUSTRAL	Austral		19.2	19.7	19.7		0	0	0
N5	Aged Care	TOBRUK VILLAGE	Austral		20.2	20.7	20.7		0	0	0
N6	Childcare	BLAXLAND PRE-SCHOOL	Blaxland		22.2	21.3	21.3		0	0	0
N7	Childcare	GLENBROOK PRE-SCHOOL	Glenbrook		24.1	23.3	23.3		0	0	0
N8	Childcare	KEMPS CREEK CHILDRENS COTTAGE	Kemps Creek		27.0	26.3	26.3		0	0	0
N9	Childcare	LAPSTONE PRE-SCHOOL	Lapstone		25.0	22.1	22.0		0	0	0
N10	Childcare	MindChamps Early Learning & Preschool @ Kemps	Kemps Creek		27.0	26.3	26.3		0	0	0
N11	Childcare	MY FIRST SCHOOL CHILDCARE CENTRE	St Marys		37.9	26.6	26.0		10	0	0
N12	Childcare	SILVERDALE CHILD CARE CENTRE	Silverdale		40.9	39.1	39.1		12	11	11
N13	Childcare	WARRAGAMBA PRE-SCHOOL	Warragamba		31.1	34.9	34.9		0	0	0
N14	Hospital	MINCHINBURY COMMUNITY HOSPITAL	Rooty Hill		26.2	22.2	22.3		0	0	0
N15	Hospital	MOUNT DRUITT HOSPITAL	Mount Druit		26.4	22.3	22.5		0	0	0
N16	Hospital	NEPEAN HOSPITAL	Kingswood		24.2	19.1	19.0		0	0	0
N17	Hospital	NEPEAN PRIVATE HOSPITAL	Kingswood		24.0	19.0	18.9		0	0	0
N18	Religious Facility	AUSTRAL CHURCH OF CHRIST	Austral		20.1	20.6	20.6		0	0	0
N19	Religious Facility	GOOD SHEPHERD CATHOLIC CHURCH	Hoxten Park		16.0	16.2	16.2		0	0	0
N20	Religious Facility	Grace West Anglican Church - Glenmore Park	Glenmore Park		28.1	22.6	22.5		0	0	0
N21	Religious Facility	Holy Family Church	Luddenham		44.5	45.0	45.0		15	15	15
N22	Religious Facility	HOLY SPIRIT CATHOLIC CHURCH	Horningsea Park		17.0	17.4	17.4		0	0	0
N23	Religious Facility	Holy Spirit Parish	St Clair		33.7	23.8	23.4		0	0	0
N24	Religious Facility	HOXTON PARK ANGLICAN CHURCH	West Hoxton		17.2	17.6	17.6		0	0	0
N25	Religious Facility	Imagine Nations Church	Orchard Hills		28.1	22.1	21.9		0	0	0
N26	Religious Facility	INSPIRE CHURCH	Hoxten Park		15.7	15.9	15.9		0	0	0
N27	Religious Facility	Mt Hope Uniting Church Orchard Hills	Orchard Hills		28.0	21.7	21.6		0	0	0
N28	Religious Facility	Orchard Hills Kingdom Hall of Jehovah's Witnesses	Orchard Hills		29.1	22.8	22.6		0	0	0
N29	Religious Facility	Samoan Methodist Church	Leppington		18.4	19.1	19.1		0	0	0
N30	Religious Facility	SIKH MISSION CENTRE	Austral		20.9	21.3	21.3		0	0	0
N31	Religious Facility	St Clair Anglican Church	St Clair		28.0	21.6	21.5		0	0	0
N32	Religious Facility	St Mary Mother of the Church	Leppington		19.3	19.9	19.9		0	0	0
N33	Religious Facility	ST ZAIA CATHEDRAL	Middleton Grange		18.6	18.7	18.7		0	0	0
N34	Religious Facility	Uniting Church St Clair	St Clair		30.5	22.1	21.9		0	0	0
N35	Religious Facility	WEST HOXTON COMMUNITY CHURCH	West Hoxton		18.9	19.2	19.2		0	0	0
N36	School	AL-FAISAL COLLEGE LIVERPOOL CAMPUS	Austral		22.3	22.4	22.4		0	0	0
N37	School	AUSTRAL PUBLIC SCHOOL	Austral		20.0	20.5	20.5		0	0	0
N38	School	AUSTRALIAN ISLAMIC COLLEGE OF SYDNEY SENIOR	Mount Druit		27.3	23.2	23.4		0	0	0
N39	School	BANKS PUBLIC SCHOOL	St Clair		37.3	26.4	25.9		10	0	0
N40	School	BENNETT ROAD PUBLIC SCHOOL	Colyton		29.2	20.9	20.6		0	0	0
N41	School	BETHANY CATHOLIC PRIMARY SCHOOL	Glenmore Park		28.8	23.0	22.8		0	0	0
N42	School	BIDWILL PUBLIC SCHOOL	Bidwill		33.8	29.7	29.9		0	0	0
N43	School	BLACKETT PUBLIC SCHOOL	Blackett		27.4	22.7	22.9		0	0	0
N44	School	BLACKTOWN NORTH PUBLIC SCHOOL	Blacktown		15.7	13.1	13.2		0	0	0
N45	School	BLACKTOWN SOUTH PUBLIC SCHOOL	Blacktown		19.2	16.2	16.4		0	0	0
N46	School	BLACKTOWN TAFE COLLEGE	Blacktown		17.3	14.5	14.6		0	0	0
N47	School	BLACKTOWN WEST PUBLIC SCHOOL	Blacktown		23.1	19.6	19.9		0	0	0
N48	School	BLACKWELL PUBLIC SCHOOL	St Clair		33.6	24.5	24.1		0	0	0
N49	School	BLAXLAND EAST PUBLIC SCHOOL	Blaxland		22.0	20.6	20.6		0	0	0
N50	School	BLAXLAND HIGH SCHOOL	Warrimoo		24.6	23.1	23.2		0	0	0
N51	School	BLAXLAND PUBLIC SCHOOL	Blaxland		24.0	22.9	23.0		0	0	0
N52	School	CAMBRIDGE GARDENS PUBLIC SCHOOL	Cambridge Gardens		24.9	18.6	18.5		0	0	0
N53	School	CAMBRIDGE PARK PUBLIC SCHOOL	Ceambridge Park		25.4	18.7	18.6		0	0	0
N54	School	CATHWEST INNOVATION COLLEGE MCCARTHY CAM	Emu Plains		21.7	18.4	18.4		0	0	0
N55	School	CECIL HILLS PUBLIC SCHOOL	Cecil Hills		18.9	18.2	18.3		0	0	0
N56	School	CHIFLEY COLLEGE BIDWILL CAMPUS	Bidwill		33.4	29.4	29.6		0	0	0
N57	School	CHIFLEY COLLEGE DUNHEVED CAMPUS	North St Marys		33.4	22.7	22.2		0	0	0
N58	School	CHIFLEY COLLEGE MOUNT DRUITT CAMPUS	Dharruk		26.1	20.9	21.0		0	0	0
N59	School	CHIFLEY COLLEGE SENIOR CAMPUS	Rooty Hill		26.3	22.2	22.4		0	0	0
N60	School	CHIFLEY COLLEGE SHALVEY CAMPUS	Shalvey		28.3	23.3	23.4		0	0	0
N61	School	CHRISTADELPHIAN HERITAGE COLLEGE SYDNEY	Kemps Creek		29.3	27.1	27.1		0	0	0
N62	School	CLAIRGATE PUBLIC SCHOOL	St Clair		27.8	21.2	21.1		0	0	0
N63	School	CLAREMONT MEADOWS PUBLIC SCHOOL	Claremont		32.8	23.0	22.6		0	0	0
N64	School	COLYTON HIGH SCHOOL	Colyton		27.7	20.0	19.9		0	0	0
N65	School	COLYTON PUBLIC SCHOOL	Mount Druit		24.8	19.5	19.5		0	0	0
N66	School	DAWSON PUBLIC SCHOOL	Dharruk		26.3	21.3	21.4		0	0	0
N67	School	EASTERN CREEK PUBLIC SCHOOL	Eastern Creek		39.1	35.0	35.2		11	9	9
N68	School	EASTERN CREEK PUBLIC SCHOOL PRESCHOOL	Eastern Creek		39.1	35.0	35.2		11	9	9
N69	School	EMERTON PUBLIC SCHOOL	Emerton		26.4	19.9	19.9		0	0	0
N70	School	EMU HEIGHTS PUBLIC SCHOOL	Emu Heights		21.9	19.3	19.3		0	0	0
N71	School	EMU PLAINS PUBLIC SCHOOL	Emu Plains		22.5	19.6	19.5		0	0	0

Calculated %HSD - 2033

				LAeq Night				Sleep disturbance as %HSD			
ID	Type	Area	Suburb	Background	S1	S3	S4	Background	S1	S3	S4
N72	School	ERSKINE PARK HIGH SCHOOL	Erskine Park		28.7	23.4	23.4		0	0	0
N73	School	GLENBROOK PUBLIC SCHOOL	Glenbrook		23.9	23.0	23.0		0	0	0
N74	School	GLENDENNING PUBLIC SCHOOL	Glendenning		35.9	31.9	32.1		9	0	0
N75	School	GLENMORE PARK PUBLIC SCHOOL	Glenmore Park		27.9	22.3	22.2		0	0	0
N76	School	GOOD SHEPHERD CATHOLIC PRIMARY SCHOOL	Hoxten Park		16.0	16.2	16.2		0	0	0
N77	School	GOOD SHEPHERD PRIMARY SCHOOL	Plumpton		32.6	28.5	28.8		0	0	0
N78	School	GREENWAY PARK PUBLIC SCHOOL	West Hoxton		17.5	17.9	17.9		0	0	0
N79	School	HASSALL GROVE PUBLIC SCHOOL	Hassall Grove		37.2	33.2	33.4		10	0	0
N80	School	HEBERSHAM PUBLIC SCHOOL	Hebersham		28.1	23.9	24.1		0	0	0
N81	School	HOLY FAMILY PRIMARY SCHOOL	Lethbridge Park		27.0	19.8	19.8		0	0	0
N82	School	HOLY SPIRIT PRIMARY SCHOOL	St Clair		33.8	23.9	23.5		0	0	0
N83	School	HOLY SPIRIT PRIMARY SCHOOL	Carnes Hill		17.0	17.4	17.4		0	0	0
N84	School	HORSLEY PARK PUBLIC SCHOOL	Horsley Park		27.7	24.0	24.2		0	0	0
N85	School	HOXTON PARK PUBLIC SCHOOL	Hoxten Park		17.0	17.3	17.3		0	0	0
N86	School	JAMES ERSKINE PUBLIC SCHOOL	Erskine Park		28.2	22.8	22.8		0	0	0
N87	School	JAMISON HIGH SCHOOL	South Penrith		25.7	20.8	20.7		0	0	0
N88	School	JAMISONTOWN PUBLIC SCHOOL	Jamisontown		25.1	20.7	20.6		0	0	0
N89	School	JORDAN SPRINGS PUBLIC SCHOOL	Jordan Springs		27.0	20.6	20.6		0	0	0
N90	School	KINGSWOOD PARK PUBLIC SCHOOL	Kingswood		26.1	19.7	19.5		0	0	0
N91	School	KINGSWOOD PUBLIC SCHOOL	Kingswood		26.2	19.8	19.6		0	0	0
N92	School	KINGSWOOD SOUTH PUBLIC SCHOOL	Kingswood		24.9	19.9	19.8		0	0	0
N93	School	LAPSTONE PUBLIC SCHOOL	Glenbrook		24.6	22.0	22.0		0	0	0
N94	School	LEONAY PUBLIC SCHOOL	Leonay		24.0	20.8	20.8		0	0	0
N95	School	LEPPINGTON PUBLIC SCHOOL	Leppington		18.3	18.9	18.9		0	0	0
N96	School	LETHBRIDGE PARK PUBLIC SCHOOL	Blackett		27.4	22.7	22.9		0	0	0
N97	School	LLANDILO PUBLIC SCHOOL	Llandilo		35.8	28.9	28.9		9	0	0
N98	School	LYNWOOD PARK PUBLIC SCHOOL	Blacktown		13.0	11.1	11.1		0	0	0
N99	School	MACARTHUR BUILDING INDUSTRY SKILLS CENTRE	Ingleburn		13.8	14.0	14.0		0	0	0
N100	School	MACQUARIE FIELDS TAFE COLLEGE	Macquarie Fields		12.8	13.1	13.1		0	0	0
N101	School	MADANG AVENUE PUBLIC SCHOOL	Whalan		26.0	19.1	19.0		0	0	0
N102	School	MALEK FAHD ISLAMIC SCHOOL HOXTON PARK	Hoxten Park		16.7	16.9	16.9		0	0	0
N103	School	MARAYONG HEIGHTS PUBLIC SCHOOL	Marayong		17.5	14.4	14.5		0	0	0
N104	School	MARAYONG PUBLIC SCHOOL	Marayong		20.4	17.0	17.2		0	0	0
N105	School	MIDDLETON GRANGE PUBLIC SCHOOL	Middleton Grange		17.7	17.8	17.8		0	0	0
N106	School	MINCHINBURY PUBLIC SCHOOL	Minchinbury		28.3	24.3	24.4		0	0	0
N107	School	MONTGROVE COLLEGE	Orchard Hills		26.1	20.6	20.5		0	0	0
N108	School	MOUNT DRUITT PUBLIC SCHOOL	Mount Druit		24.9	19.2	19.2		0	0	0
N109	School	MOUNT DRUITT PUBLIC SCHOOL PRESCHOOL	Mount Druit		25.0	19.2	19.3		0	0	0
N110	School	MOUNT DRUITT TAFE COLLEGE	Mount Druit		25.3	21.1	21.2		0	0	0
N111	School	MOUNT RIVERVIEW PUBLIC SCHOOL	Mount Riverview		23.3	20.7	20.7		0	0	0
N112	School	NEPEAN CHRISTIAN SCHOOL	Mulgoa		35.5	27.1	26.8		9	0	0
N113	School	NEPEAN CREATIVE AND PERFORMING ARTS HIGH S	Emu Plains		21.9	18.8	18.8		0	0	0
N114	School	NEPEAN TAFE COLLEGE KINGSWOOD CAMPUS	Kingswood		28.9	20.6	20.3		0	0	0
N115	School	NEPEAN TAFE COLLEGE PENRITH CAMPUS	Penrith		22.6	18.6	18.5		0	0	0
N116	School	NOUMEA PUBLIC SCHOOL	Lethbridge Park		28.2	23.3	23.4		0	0	0
N117	School	ORCHARD HILLS PUBLIC SCHOOL	Orchard Hills		28.1	21.8	21.6		0	0	0
N118	School	OUR LADY OF THE ROSARY PRIMARY SCHOOL	St Marys		37.2	26.0	25.4		10	0	0
N119	School	OUR LADY OF THE WAY PRIMARY SCHOOL	Emu Plains		22.8	19.8	19.8		0	0	0
N120	School	OXLEY PARK PUBLIC SCHOOL	Oxley Park		30.8	21.2	20.9		0	0	0
N121	School	PENOLA CATHOLIC COLLEGE EMU PLAINS	Emu Plains		21.7	18.4	18.4		0	0	0
N122	School	PENRITH ANGLICAN COLLEGE	Orchard Hills		31.5	24.1	23.9		0	0	0
N123	School	PENRITH CHRISTIAN SCHOOL	Orchard Hills		28.1	22.1	21.9		0	0	0
N124	School	PENRITH HIGH SCHOOL	Penrith		23.3	18.9	18.8		0	0	0
N125	School	PENRITH PUBLIC SCHOOL	Penrith		23.2	18.8	18.8		0	0	0
N126	School	PENRITH SOUTH PUBLIC SCHOOL	South Penrith		23.8	19.5	19.4		0	0	0
N127	School	PLUMPTON HIGH SCHOOL	Plumpton		32.7	28.7	28.9		0	0	0
N128	School	PLUMPTON PUBLIC SCHOOL	Plumpton		34.2	30.2	30.4		0	0	0
N129	School	REGENTVILLE PUBLIC SCHOOL	Regentville		26.1	21.6	21.5		0	0	0
N130	School	ROOTY HILL HIGH SCHOOL	Rooty Hill		29.4	25.4	25.6		0	0	0
N131	School	ROOTY HILL PUBLIC SCHOOL	Rooty Hill		30.8	26.8	27.0		0	0	0
N132	School	ROPES CROSSING PUBLIC SCHOOL	Ropes Crossing		32.5	22.8	22.5		0	0	0
N133	School	SACRED HEART PRIMARY SCHOOL	Mount Druit		24.8	19.5	19.5		0	0	0
N134	School	SHALVEY PUBLIC SCHOOL	Shalvey		30.3	25.8	26.0		0	0	0
N135	School	SHELLEY PUBLIC SCHOOL	Blacktown		16.2	13.8	13.9		0	0	0
N136	School	ST AIDAN'S PRIMARY SCHOOL	Rooty Hill		29.5	25.6	25.8		0	0	0
N137	School	ST ANDREWS PRIMARY SCHOOL	Quakers Hill		19.4	16.0	16.2		0	0	0
N138	School	ST ANTHONY OF PADUA CATHOLIC COLLEGE	Austral		20.7	21.1	21.1		0	0	0
N139	School	ST CLAIR HIGH SCHOOL	St Clair		31.8	22.5	22.2		0	0	0
N140	School	ST CLAIR PUBLIC SCHOOL	St Clair		31.7	22.8	22.5		0	0	0
N141	School	ST FINBAR'S PRIMARY SCHOOL	Glenbrook		23.2	22.2	22.2		0	0	0
N142	School	ST FRANCIS OF ASSISI PRIMARY SCHOOL	Glendenning		34.3	30.3	30.5		0	0	0
N143	School	ST JOSEPH'S PRIMARY SCHOOL	Kingswood		25.1	19.0	18.9		0	0	0
N144	School	ST MARY MACKILLOP PRIMARY SCHOOL	South Penrith		26.7	21.3	21.1		0	0	0
N145	School	ST MARYS NORTH PUBLIC SCHOOL	North St Marys		34.0	23.1	22.6		0	0	0
N146	School	ST MARYS PUBLIC SCHOOL	St Marys		37.6	26.2	25.6		10	0	0
N147	School	ST MARYS SENIOR HIGH SCHOOL	St Marys		37.4	26.1	25.4		10	0	0
N148	School	ST MARYS SOUTH PUBLIC SCHOOL	St Marys		36.0	25.1	24.5		9	0	0
N149	School	ST NICHOLAS OF MYRA PRIMARY SCHOOL	Penrith		23.0	18.8	18.8		0	0	0
N150	School	SURVEYORS CREEK PUBLIC SCHOOL	Glenmore Park		28.8	22.7	22.6		0	0	0
N151	School	THOMAS HASSALL ANGLICAN COLLEGE	Middleton Grange		18.4	18.6	18.6		0	0	0
N152	School	TREGEAR PUBLIC SCHOOL	Tregear		28.8	20.0	19.8		0	0	0
N153	School	UNITY GRAMMAR COLLEGE	Austral		20.0	20.5	20.5		0	0	0
N154	School	UNIVERSITY OF WESTERN SYDNEY PENRITH CAMPU	Kingswood		26.9	20.1	19.9		0	0	0
N155	School	UNIVERSITY OF WESTERN SYDNEY WERRINGTON N	Werrington		31.9	21.9	21.5		0	0	0
N156	School	UNIVERSITY OF WESTERN SYDNEY WERRINGTON ST	Kingswood		30.4	21.4	21.0		0	0	0
N157	School	WALTERS ROAD PUBLIC SCHOOL	Blacktown		25.4	22.0	22.2		0	0	0
N158	School	WARRAGAMBA PUBLIC SCHOOL	Warragamba		31.2	34.7	34.8		0	0	0
N159	School	WARRIMOO PUBLIC SCHOOL	Warrimoo		26.7	24.4	24.5		0	0	0
N160	School	WERRINGTON COUNTY PUBLIC SCHOOL	Werrington County		31.9	21.6	21.2		0	0	0
N161	School	WERRINGTON PUBLIC SCHOOL	Werrington		31.5	21.5	21.1		0	0	0
N162	School	WETHERILL PARK TAFE COLLEGE	Wetherill Park		14.2	13.1	13.2		0	0	0
N163	School	WHALAN PUBLIC SCHOOL	Whalan		25.5	19.4	19.5		0	0	0
N164	School	WILLIAM DEAN PUBLIC SCHOOL	Dean Park		29.6	25.7	25.9		0	0	0
N165	School	WILLMOT PUBLIC SCHOOL	Willmot		30.6	24.3	24.4		0	0	0

Calculated %HSD - 2033

				LAeq Night				Sleep disturbance as %HSD			
ID	Type	Area	Suburb	Background	S1	S3	S4	Background	S1	S3	S4
N166	School	YORK PUBLIC SCHOOL	South Penrith		26.1	21.0	20.9		0	0	0
N167	Aged Care	AQUINAS COURT	Springwood		22.9	23.5	23.5		0	0	0
N168	Aged Care	BAPTISTCARE MORVEN GARDENS CENTRE	Leura		22.3	23.5	23.5		0	0	0
N169	Aged Care	BLUE MOUNTAINS RETIREMENT VILLAGE	Leura		22.3	23.0	23.0		0	0	0
N170	Aged Care	BUCKLAND	Springwood		22.1	21.8	21.8		0	0	0
N171	Aged Care	MARTYN CLAVER AGED CARE	Leura		22.6	23.8	23.8		0	0	0
N172	Aged Care	WINGARA HAMLET	Springwood		24.1	25.4	25.5		0	0	0
N173	Childcare	CHILDRENS HOUSE MONTESSORI CHILD CARE	Faulconbridge		28.1	29.7	29.7		0	0	0
N174	Childcare	KATOOMBA LEURA PRE-SCHOOL	Katoomba		24.2	24.9	24.9		0	0	0
N175	Childcare	KEMPS CREEK CHILDRENS COTTAGE	Kemps Creek		27.0	26.3	26.3		0	0	0
N176	Childcare	LAPSTONE PRE-SCHOOL	Lapstone		25.0	22.1	22.0		0	0	0
N177	Hospital	BLUE MOUNTAINS DISTRICT ANZAC MEMORIAL HO	Katoomba		22.2	22.8	22.8		0	0	0
N178	Hospital	SPRINGWOOD HOSPITAL	Springwood		22.1	22.5	22.6		0	0	0
N179	Recreation	ECHO POINT LOOKOUT	Katoomba		27.5	28.5	28.5		0	0	0
N180	Religious Facility	ANGLICAN	Leura		23.0	24.0	24.0		0	0	0
N181	Religious Facility	ANGLICAN	Katoomba		23.8	24.4	24.4		0	0	0
N182	Religious Facility	BAPTIST	Katoomba		24.6	25.2	25.2		0	0	0
N183	Religious Facility	BAPTIST	Leura		22.5	23.4	23.4		0	0	0
N184	Religious Facility	UNITING	Springwood		24.6	26.2	26.3		0	0	0
N185	School	BLUE MOUNTAINS STEINER SCHOOL	Hazelbrook		25.6	27.3	27.3		0	0	0
N186	School	ELLISON PUBLIC SCHOOL	Springwood		21.4	20.7	20.8		0	0	0
N187	School	FAULCONBRIDGE PUBLIC SCHOOL	Faulconbridge		25.8	27.1	27.1		0	0	0
N188	School	HAZELBROOK PUBLIC SCHOOL	Hazelbrook		24.3	25.8	25.8		0	0	0
N189	School	KATOOMBA HIGH SCHOOL	Katoomba		26.4	27.3	27.3		0	0	0
N190	School	KATOOMBA NORTH PUBLIC SCHOOL	Katoomba		21.4	21.8	21.8		0	0	0
N191	School	KATOOMBA PUBLIC SCHOOL	Katoomba		24.8	25.5	25.5		0	0	0
N192	School	KINGSWOOD PARK PUBLIC SCHOOL	Kingswood		26.1	19.7	19.5		0	0	0
N193	School	KINGSWOOD PUBLIC SCHOOL	Kingswood		26.2	19.8	19.6		0	0	0
N194	School	KINGSWOOD SOUTH PUBLIC SCHOOL	Kingswood		24.9	19.9	19.8		0	0	0
N195	School	LAPSTONE PUBLIC SCHOOL	Glenbrook		24.5	22.0	22.0		0	0	0
N196	School	LAWSON PUBLIC SCHOOL	Lawson		21.5	23.6	23.6		0	0	0
N197	School	LEURA PUBLIC SCHOOL	Leura		22.4	23.4	23.4		0	0	0
N198	School	OUR LADY OF THE NATIVITY PRIMARY SCHOOL	Lawson		22.0	24.1	24.1		0	0	0
N199	School	SPRINGWOOD HIGH SCHOOL	Faulconbridge		24.7	25.6	25.6		0	0	0
N200	School	SPRINGWOOD PUBLIC SCHOOL	Springwood		24.0	24.0	24.0		0	0	0
N201	School	ST CANICES PRIMARY SCHOOL	Katoomba		24.2	24.9	24.9		0	0	0
N202	School	ST THOMAS AQUINAS PRIMARY SCHOOL	Springwood		20.5	19.5	19.5		0	0	0
N203	School	WENTWORTH FALLS PUBLIC SCHOOL	Wentworth Falls		21.1	22.8	22.8		0	0	0

Calculated %HSD - 2055

				LAeq Night			Sleep disturbance as %HSD		
ID	**Type**	**Area**	**Suburb**	**S1**	**S3**	**S4**	**S1**	**S3**	**S4**
M01	Noise Monitoring Terminal	South West Departure (Wallacia)	Wallacia	56.6	56.1	56.1	28	27	27
M02	Noise Monitoring Terminal	North East Departure	Kemps Creek	54.3	50.2	50.4	25	20	20
M03	Noise Monitoring Terminal	North East Runway	Orchard Hills	44.5	33.7	33.2	15	0	0
M04	Noise Monitoring Terminal	Twin Creeks	Luddenham	54.2	42.7	42.0	25	13	13
M06	Noise Monitoring Terminal	Mount Vernon	Mount Vernon	35.5	31.4	31.4	9	0	0
M07	Noise Monitoring Terminal	Kemps Creek Nature Reserve	Kemps Creek	30.1	29.4	29.4	0	0	0
M08	Noise Monitoring Terminal	Luddenham	Luddenham	42.3	38.4	38.3	13	10	10
M09	Noise Monitoring Terminal	Penrith	Penrith	28.1	23.4	23.4	0	0	0
M10	Noise Monitoring Terminal	Glenmore Park	Glenmore Park	34.2	28.1	27.9	0	0	0
M11	Noise Monitoring Terminal	Oxley Park	Oxley Park	37.1	26.7	26.5	10	0	0
M12	Noise Monitoring Terminal	St. Marys	St. Marys	45.7	33.8	33.3	16	0	0
M13	Noise Monitoring Terminal	Rooty Hill	Rooty Hill	39.6	35.5	35.7	11	9	9
M14	Noise Monitoring Terminal	St. Clair	St. Clair	44.3	33.0	32.5	14	0	0
M15	Noise Monitoring Terminal	Erskine Park	Erskine Park	37.2	28.8	28.6	10	0	0
M16	Noise Monitoring Terminal	Sydney International Equestrian Centre	Horsley Park	28.3	25.0	25.1	0	0	0
M17	Noise Monitoring Terminal	Wallacia	Wallacia	36.2	47.5	47.5	9	17	17
M18	Noise Monitoring Terminal	Warragamba	Warragamba	34.6	40.3	40.3	0	12	12
M19	Noise Monitoring Terminal	Greendale	Greendale	56.0	55.7	55.8	27	26	27
M20	Noise Monitoring Terminal	Bringelly	Bringelly	35.9	37.5	37.5	9	10	10
M21	Noise Monitoring Terminal	Bents Basin	Greendale	54.6	53.6	53.7	25	24	24
M22	Noise Monitoring Terminal	Silverdale	Silverdale	56.7	56.5	56.5	28	27	27
M23	Noise Monitoring Terminal	Werombi	Werombi	35.7	33.9	33.9	9	0	0
M24	Noise Monitoring Terminal	Blaxland	Blaxland	29.1	29.5	29.5	0	0	0
M25	Noise Monitoring Terminal	Linden	Linden	38.3	43.1	43.1	10	14	14
M26	Noise Monitoring Terminal	North Richmond	North Richmond	25.2	16.4	16.2	0	0	0
M27	Noise Monitoring Terminal	Kurrajong	Kurrajong	22.1	14.6	14.5	0	0	0
M28	Noise Monitoring Terminal	The Oaks	The Oaks	29.3	32.5	32.5	0	0	0
M29	Noise Monitoring Terminal	Lake Burragorang (Natai, Brownlow Hill)	Nattai	34.6	31.1	31.2	0	0	0
M30	Noise Monitoring Terminal	Tahmoor	Tahmoor	23.7	30.9	30.9	0	0	0
R1	Residential	Bringelly	Bringelly	31.1	32.1	32.1	0	0	0
R2	Residential	Luddenham	Luddenham	43.2	42.5	42.5	14	13	13
R3	Residential	Greendale, Greendale Road	Greendale	49.8	57.0	57.0	20	28	28
R6	Residential	Kemps Creek	Kemps Creek	44.1	37.3	37.0	14	10	10
R7	Residential	Wallacia	Wallacia	36.2	48.3	48.3	9	18	18
R8	Residential	Twin Creeks, Cnr Twin Ck Drie & Humewood Place	Luddenham	56.3	45.1	44.4	27	15	15
R14	Residential	Lawson Road, Badgerys Creek	Badgerys Creek	47.9	41.4	41.3	18	12	12
R15	Residential	Mersey Rd, Greendale	Greendale	38.9	39.4	39.4	11	11	11
R17	Residential	Luddenham Road	Luddenham	48.4	44.5	44.5	18	15	15
R18	Residential	Cnr Adams & Elizabeth Drive	Luddenham	51.6	51.8	51.8	22	22	22
R19	Residential	Cnr Adams & Anton Road	Luddenham	50.3	50.6	50.6	20	20	20
R21	Residential	Cnr Willowdene Ave and Vicar Park Lane	Luddenham	62.0	65.1	65.1	35	40	40
R22	Residential	Rossmore, Victor Ave	Rossmore	35.2	35.1	35.1	9	9	9
R23	Residential	Wallacia, Greendale Road	Wallacia	41.0	55.5	55.5	12	26	26
R24	On-Site	Badgerys Creek 1 NE		51.8	48.8	48.7	22	19	19
R25	On-Site	Badgerys Creek 2 SW		53.0	53.6	53.6	23	24	24
R27	Residential	Greendale, Dwyer Rd	Greendale	38.7	41.9	41.9	10	13	13
R30	Residential	Rossmore residential	Rossmore	26.9	27.6	27.6	0	0	0
R31	Residential	Mt Vernon residential	Mount Vernon	34.7	30.7	30.8	0	0	0
R34	Aged Care	Emmaus Residential Aged Care	Kemps Creek	40.4	34.8	34.9	12	0	0
R35	Childcare	Mamre After School and Vacation Care	Kemps Creek	42.3	35.9	35.9	13	9	9
R37	Childcare	Schoolies at Mulgoa	Luddenham	48.9	48.7	48.7	19	19	19
R38	Childcare	Do-re-mi Day Care Centre	Mount Vernon	33.4	29.8	29.8	0	0	0
R39	Childcare	Little Amigos Austral Early Learning Centre	Austral	24.7	25.1	25.1	0	0	0
R40	Childcare	Little Smarties Childcare Centre	Kemps Creek	42.3	36.0	36.0	13	9	9
R41	Childcare	The Grove Academy	Kemps Creek	31.4	30.7	30.7	0	0	0
R42	Childcare	Horsley Kids	Horsley Park	33.5	29.7	29.8	0	0	0
R44	Childcare	Bringelly Child Care Centre	Bringelly	37.3	39.3	39.3	10	11	11
R46	Childcare	Chementson Drive Early Educational Centre	Rossmore	32.0	32.4	32.4	0	0	0
R48	Childcare	Kids Korner West Hoxton Early Learning Centre	Austral	24.2	24.4	24.4	0	0	0
R49	Childcare	Luddenham Child Care Centre	Luddenham	46.9	46.0	46.0	17	16	16
R52	Childcare	The Frogs Lodge	Austral	24.6	25.0	25.0	0	0	0
R54	Childcare	Mulgoa Preschool	Mulgoa	46.3	37.2	36.6	16	10	9
R55	Childcare	Jillys Educational Childcare Centre	Rossmore	29.9	30.5	30.5	0	0	0
R59	Community Centre	Bringelly Community Centre	Bringelly	31.7	32.8	32.8	0	0	0
R63	Community Centre	Luddenham Progress Hall	Luddenham	50.1	49.3	49.3	20	19	19
R64	Community Centre	Mulgoa Hall	Mulgoa	45.6	37.1	36.6	16	10	9
R65	School	Emmaus Catholic College	Kemps Creek	42.3	37.1	37.2	13	10	10
R66	School	University of Sydney Farms	Greendale	37.7	50.8	50.8	10	21	21
R68	School	Christadelphian Heritage College Sydney	Kemps Creek	33.9	31.7	31.7	0	0	0
R69	School	Mamre Anglican School	Kemps Creek	42.3	35.9	36.0	13	9	9
R72	School	Irfan College	Cecil Park	28.1	26.1	26.1	0	0	0
R73	School	Luddenham Public School	Luddenham	51.0	50.0	50.0	21	20	20
R74	School	Kemps Creek Public School	Kemps Creek	34.0	31.8	31.8	0	0	0
R75	School	Trinity Catholic Primary School	Kemps Creek	41.3	35.2	35.2	12	9	9
R76	School	Bringelly Public School	Bringelly	31.3	32.4	32.4	0	0	0
R78	School	Mulgoa Public School	Mulgoa	45.7	37.2	36.8	16	10	9
R79	School	Rossmore Public School	Rossmore	26.9	27.5	27.5	0	0	0
R80	School	Wallacia Public School	Wallacia	36.2	47.1	47.1	9	17	17
R82	School	Bellfield College - Junior Campus	Rossmore	27.8	28.5	28.5	0	0	0
R84	Park	Bringelly Park	Bringelly	31.9	33.0	33.0	0	0	0
R85	Park	Bents Basin State Conservation Reserve and Gulguer	Greendale	42.9	41.6	41.7	13	12	12
R86	Park	Blaxland Crossing Reserve	Wallacia	36.3	47.1	47.1	9	17	17

Calculated %HSD - 2055

				LAeq Night			Sleep disturbance as %HSD		
ID	Type	Area	Suburb	S1	S3	S4	S1	S3	S4
R87	Park	Bill Anderson Reserve	Kemps Creek	34.9	32.2	32.1	0	0	0
R91	Park	Western Sydney Parklands	Eastern Creek	44.9	40.8	41.0	15	12	12
R93	Park	Rossmore Grange	Rossmore	30.3	30.9	30.9	0	0	0
R94	Park	Freeburn Park	Luddenham	48.9	48.1	48.1	19	18	18
R95	Park	Overett Reserve	Kemps Creek	42.3	38.0	37.9	13	10	10
R97	Park	Mulgoa Park	Mulgoa	45.7	37.2	36.7	16	10	9
R98	Recreation	Wallacia Bowling and Recreation Club	Wallacia	36.4	50.2	50.2	9	20	20
R99	Recreation	Hubertus Country Club	Luddenham	53.3	53.6	53.6	24	24	24
R100	Recreation	Sugarloaf Cobbitty Equestrian Club	Cobbitty	33.6	48.9	48.9	0	19	19
R102	Recreation	Panthers Wallacia (country club)	Wallacia	36.1	48.2	48.2	9	18	18
R103	Recreation	Twin Creeks Gold and Country Club	Luddenham	53.8	42.2	41.6	24	13	12
R104	Recreation	Sydney International Shooting Centre	Cecil Park	28.1	26.9	26.9	0	0	0
R108	Recreation	Luddenham Showground	Luddenham	45.1	44.5	44.5	15	15	15
R109	Recreation	Kemps Creek Sporting and Bowling Club	Cecil Park	31.1	29.0	29.0	0	0	0
R110	Religious Facility	St James Luddenham	Luddenham	52.4	51.5	51.5	22	21	21
R111	Religious Facility	Lin Ying Temple	Rossmore	31.1	31.3	31.3	0	0	0
R112	Religious Facility	Vat Ketanak Khmer Kampuchea Krom	Rossmore	29.9	30.6	30.6	0	0	0
R114	Religious Facility	Anglican Church Sydney Diocese	Rossmore	27.8	28.5	28.5	0	0	0
R115	Religious Facility	Anglican Parish of Mulgoa	Mulgoa	46.8	37.1	36.4	17	10	9
R117	Religious Facility	Bringelly Vineyard Church	Bringelly	30.1	31.0	31.0	0	0	0
R120	Religious Facility	Our Lady Queen of Peace	Greystanes	16.7	15.1	15.2	0	0	0
R122	Religious Facility	St Anthony	Austral	24.7	25.1	25.1	0	0	0
R123	Religious Facility	St Marys Church	Mulgoa	42.7	37.4	37.2	13	10	10
R124	Religious Facility	Wallacia Christian Church	Wallacia	36.2	48.3	48.3	9	18	18
R126	Religious Facility	St Francis Xavier Church	Greendale	60.2	60.3	60.3	33	33	33
R127	Religious Facility	Luddenham Uniting Church	Luddenham	50.4	49.6	49.6	20	19	19
R131	Religious Facility	Science of the Soul Study Centre	Cecil Park	31.9	29.6	29.6	0	0	0
R132	Shopping Centre	Bringelly shops	Bringelly	31.1	32.1	32.1	0	0	0
R134	Shopping Centre	Kemps Creek shops	Kemps Creek	35.1	32.2	32.1	9	0	0
R135	Shopping Centre	Luddenham shops	Luddenham	54.0	53.1	53.1	24	23	23
R136	Shopping Centre	Mulgoa shops	Mulgoa	44.1	37.3	37.0	14	10	10
R137	Shopping Centre	Rossmore shops	Rossmore	26.9	27.6	27.6	0	0	0
R138	Shopping Centre	Wallacia Shops	Wallacia	36.0	48.7	48.7	9	19	19
R140	School	Holy Family Catholic Primary and Church	Luddenham	48.7	48.8	48.8	18	19	19
R141	Religious Facility	Edmund Rice Retreat and Conference Centre	Mulgoa	38.8	41.2	41.1	11	12	12
N1	Aged Care	CATHOLIC HEALTHCARE EMMAUS VILLAGE	Kemps Creek	40.4	34.8	34.9	12	0	0
N2	Aged Care	JOHN EDMONDSON VC GARDENS	Austral	24.7	25.1	25.1	0	0	0
N3	Aged Care	REGAL OAKS VILLAGE	Wallacia	36.0	49.4	49.4	9	19	19
N4	Aged Care	SCALABRINI VILLAGE AUSTRAL	Austral	23.5	24.0	24.0	0	0	0
N5	Aged Care	TOBRUK VILLAGE	Austral	24.6	25.0	25.0	0	0	0
N6	Childcare	BLAXLAND PRE-SCHOOL	Blaxland	27.5	26.9	27.0	0	0	0
N7	Childcare	GLENBROOK PRE-SCHOOL	Glenbrook	28.1	28.7	28.7	0	0	0
N8	Childcare	KEMPS CREEK CHILDRENS COTTAGE	Kemps Creek	31.5	30.7	30.7	0	0	0
N9	Childcare	LAPSTONE PRE-SCHOOL	Lapstone	28.8	27.0	27.0	0	0	0
N10	Childcare	MindChamps Early Learning & Preschool @ Kemps C	Kemps Creek	31.5	30.7	30.7	0	0	0
N11	Childcare	MY FIRST SCHOOL CHILDCARE CENTRE	St Marys	44.9	33.0	32.6	15	0	0
N12	Childcare	SILVERDALE CHILD CARE CENTRE	Silverdale	45.3	43.7	43.8	15	14	14
N13	Childcare	WARRAGAMBA PRE-SCHOOL	Warragamba	35.3	39.7	39.7	9	11	11
N14	Hospital	MINCHINBURY COMMUNITY HOSPITAL	Rooty Hill	31.6	27.2	27.3	0	0	0
N15	Hospital	MOUNT DRUITT HOSPITAL	Mount Druit	32.3	27.9	28.0	0	0	0
N16	Hospital	NEPEAN HOSPITAL	Kingswood	29.6	23.9	23.8	0	0	0
N17	Hospital	NEPEAN PRIVATE HOSPITAL	Kingswood	29.4	23.8	23.7	0	0	0
N18	Religious Facility	AUSTRAL CHURCH OF CHRIST	Austral	24.5	24.9	24.9	0	0	0
N19	Religious Facility	GOOD SHEPHERD CATHOLIC CHURCH	Hoxten Park	20.5	20.6	20.6	0	0	0
N20	Religious Facility	Grace West Anglican Church - Glenmore Park	Glenmore Park	31.9	27.0	26.8	0	0	0
N21	Religious Facility	Holy Family Church	Luddenham	48.5	48.7	48.7	18	18	18
N22	Religious Facility	HOLY SPIRIT CATHOLIC CHURCH	Horningsea Park	21.4	21.7	21.7	0	0	0
N23	Religious Facility	Holy Spirit Parish	St Clair	40.2	29.6	29.2	11	0	0
N24	Religious Facility	HOXTON PARK ANGLICAN CHURCH	West Hoxton	21.7	21.9	21.9	0	0	0
N25	Religious Facility	Imagine Nations Church	Orchard Hills	32.4	26.5	26.3	0	0	0
N26	Religious Facility	INSPIRE CHURCH	Hoxten Park	20.3	20.3	20.3	0	0	0
N27	Religious Facility	Mt Hope Uniting Church Orchard Hills	Orchard Hills	32.8	26.2	26.1	0	0	0
N28	Religious Facility	Orchard Hills Kingdom Hall of Jehovah's Witnesses	Orchard Hills	33.1	27.1	26.9	0	0	0
N29	Religious Facility	Samoan Methodist Church	Leppington	22.5	23.2	23.2	0	0	0
N30	Religious Facility	SIKH MISSION CENTRE	Austral	25.2	25.6	25.6	0	0	0
N31	Religious Facility	St Clair Anglican Church	St Clair	34.0	26.7	26.7	0	0	0
N32	Religious Facility	St Mary Mother of the Church	Leppington	23.5	24.1	24.1	0	0	0
N33	Religious Facility	ST ZAIA CATHEDRAL	Middleton Grange	23.2	23.1	23.1	0	0	0
N34	Religious Facility	Uniting Church St Clair	St Clair	36.8	27.5	27.3	9	0	0
N35	Religious Facility	WEST HOXTON COMMUNITY CHURCH	West Hoxton	23.3	23.6	23.6	0	0	0
N36	School	AL-FAISAL COLLEGE LIVERPOOL CAMPUS	Austral	26.8	26.8	26.8	0	0	0
N37	School	AUSTRAL PUBLIC SCHOOL	Austral	24.3	24.8	24.8	0	0	0
N38	School	AUSTRALIAN ISLAMIC COLLEGE OF SYDNEY SENIOR S	Mount Druit	33.3	28.9	29.1	0	0	0
N39	School	BANKS PUBLIC SCHOOL	St Clair	44.1	32.6	32.2	14	0	0
N40	School	BENNETT ROAD PUBLIC SCHOOL	Colyton	35.6	26.3	26.1	9	0	0
N41	School	BETHANY CATHOLIC PRIMARY SCHOOL	Glenmore Park	32.5	27.3	27.1	0	0	0
N42	School	BIDWILL PUBLIC SCHOOL	Bidwill	39.3	35.2	35.3	11	9	9
N43	School	BLACKETT PUBLIC SCHOOL	Blackett	33.6	28.6	28.7	0	0	0
N44	School	BLACKTOWN NORTH PUBLIC SCHOOL	Blacktown	22.6	19.2	19.3	0	0	0
N45	School	BLACKTOWN SOUTH PUBLIC SCHOOL	Blacktown	26.6	22.9	23.0	0	0	0
N46	School	BLACKTOWN TAFE COLLEGE	Blacktown	24.3	20.8	20.9	0	0	0
N47	School	BLACKTOWN WEST PUBLIC SCHOOL	Blacktown	30.4	26.4	26.6	0	0	0

Calculated %HSD - 2055

				LAeq Night			Sleep disturbance as %HSD		
ID	Type	Area	Suburb	S1	S3	S4	S1	S3	S4
N48	School	BLACKWELL PUBLIC SCHOOL	St Clair	39.9	29.9	29.6	11	0	0
N49	School	BLAXLAND EAST PUBLIC SCHOOL	Blaxland	27.1	26.2	26.2	0	0	0
N50	School	BLAXLAND HIGH SCHOOL	Warrimoo	30.4	29.1	29.1	0	0	0
N51	School	BLAXLAND PUBLIC SCHOOL	Blaxland	29.7	28.8	28.9	0	0	0
N52	School	CAMBRIDGE GARDENS PUBLIC SCHOOL	Cambridge Garden	31.1	24.1	24.1	0	0	0
N53	School	CAMBRIDGE PARK PUBLIC SCHOOL	Ceambridge Park	31.5	23.9	23.8	0	0	0
N54	School	CATHWEST INNOVATION COLLEGE MCCARTHY CAMI	Emu Plains	27.1	23.6	23.6	0	0	0
N55	School	CECIL HILLS PUBLIC SCHOOL	Cecil Hills	23.8	22.8	22.8	0	0	0
N56	School	CHIFLEY COLLEGE BIDWILL CAMPUS	Bidwill	39.0	34.8	35.0	11	0	0
N57	School	CHIFLEY COLLEGE DUNHEVED CAMPUS	North St Marys	40.0	28.7	28.3	11	0	0
N58	School	CHIFLEY COLLEGE MOUNT DRUITT CAMPUS	Dharruk	32.4	26.8	26.9	0	0	0
N59	School	CHIFLEY COLLEGE SENIOR CAMPUS	Rooty Hill	32.1	27.7	27.8	0	0	0
N60	School	CHIFLEY COLLEGE SHALVEY CAMPUS	Shalvey	34.6	29.3	29.4	0	0	0
N61	School	CHRISTADELPHIAN HERITAGE COLLEGE SYDNEY	Kemps Creek	33.8	31.7	31.7	0	0	0
N62	School	CLAIRGATE PUBLIC SCHOOL	St Clair	34.0	26.4	26.3	0	0	0
N63	School	CLAREMONT MEADOWS PUBLIC SCHOOL	Claremont	38.9	28.4	28.0	11	0	0
N64	School	COLYTON HIGH SCHOOL	Colyton	34.0	25.4	25.3	0	0	0
N65	School	COLYTON PUBLIC SCHOOL	Mount Druit	30.9	24.8	24.9	0	0	0
N66	School	DAWSON PUBLIC SCHOOL	Dharruk	32.5	27.2	27.3	0	0	0
N67	School	EASTERN CREEK PUBLIC SCHOOL	Eastern Creek	43.0	38.9	39.1	13	11	11
N68	School	EASTERN CREEK PUBLIC SCHOOL PRESCHOOL	Eastern Creek	43.0	38.9	39.1	13	11	11
N69	School	EMERTON PUBLIC SCHOOL	Emerton	32.8	25.8	25.8	0	0	0
N70	School	EMU HEIGHTS PUBLIC SCHOOL	Emu Heights	27.4	24.9	24.9	0	0	0
N71	School	EMU PLAINS PUBLIC SCHOOL	Emu Plains	27.1	24.6	24.5	0	0	0
N72	School	ERSKINE PARK HIGH SCHOOL	Erskine Park	34.3	28.4	28.4	0	0	0
N73	School	GLENBROOK PUBLIC SCHOOL	Glenbrook	28.0	28.3	28.3	0	0	0
N74	School	GLENDENNING PUBLIC SCHOOL	Glendenning	41.3	37.3	37.4	12	10	10
N75	School	GLENMORE PARK PUBLIC SCHOOL	Glenmore Park	31.7	26.7	26.5	0	0	0
N76	School	GOOD SHEPHERD CATHOLIC PRIMARY SCHOOL	Hoxten Park	20.5	20.6	20.6	0	0	0
N77	School	GOOD SHEPHERD PRIMARY SCHOOL	Plumpton	38.2	34.1	34.2	10	0	0
N78	School	GREENWAY PARK PUBLIC SCHOOL	West Hoxton	21.9	22.2	22.2	0	0	0
N79	School	HASSALL GROVE PUBLIC SCHOOL	Hassall Grove	42.6	38.5	38.6	13	10	10
N80	School	HEBERSHAM PUBLIC SCHOOL	Hebersham	34.1	29.6	29.8	0	0	0
N81	School	HOLY FAMILY PRIMARY SCHOOL	Lethbridge Park	33.3	25.7	25.7	0	0	0
N82	School	HOLY SPIRIT PRIMARY SCHOOL	St Clair	40.4	29.7	29.3	12	0	0
N83	School	HOLY SPIRIT PRIMARY SCHOOL	Carnes Hill	21.4	21.8	21.8	0	0	0
N84	School	HORSLEY PARK PUBLIC SCHOOL	Horsley Park	33.2	29.3	29.4	0	0	0
N85	School	HOXTON PARK PUBLIC SCHOOL	Hoxten Park	21.4	21.6	21.6	0	0	0
N86	School	JAMES ERSKINE PUBLIC SCHOOL	Erskine Park	33.9	27.8	27.8	0	0	0
N87	School	JAMISON HIGH SCHOOL	South Penrith	30.0	25.3	25.2	0	0	0
N88	School	JAMISONTOWN PUBLIC SCHOOL	Jamisontown	29.2	25.2	25.1	0	0	0
N89	School	JORDAN SPRINGS PUBLIC SCHOOL	Jordan Springs	33.5	26.6	26.7	0	0	0
N90	School	KINGSWOOD PARK PUBLIC SCHOOL	Kingswood	31.8	24.6	24.5	0	0	0
N91	School	KINGSWOOD PUBLIC SCHOOL	Kingswood	31.9	24.7	24.5	0	0	0
N92	School	KINGSWOOD SOUTH PUBLIC SCHOOL	Kingswood	30.0	24.5	24.4	0	0	0
N93	School	LAPSTONE PUBLIC SCHOOL	Glenbrook	28.4	27.0	27.0	0	0	0
N94	School	LEONAY PUBLIC SCHOOL	Leonay	28.1	25.7	25.6	0	0	0
N95	School	LEPPINGTON PUBLIC SCHOOL	Leppington	22.5	23.1	23.1	0	0	0
N96	School	LETHBRIDGE PARK PUBLIC SCHOOL	Blackett	33.6	28.6	28.7	0	0	0
N97	School	LLANDILO PUBLIC SCHOOL	Llandilo	42.3	34.8	34.9	13	0	0
N98	School	LYNWOOD PARK PUBLIC SCHOOL	Blacktown	19.8	16.8	16.9	0	0	0
N99	School	MACARTHUR BUILDING INDUSTRY SKILLS CENTRE	Ingleburn	18.0	18.2	18.2	0	0	0
N100	School	MACQUARIE FIELDS TAFE COLLEGE	Macquarie Fields	17.1	17.2	17.2	0	0	0
N101	School	MADANG AVENUE PUBLIC SCHOOL	Whalan	32.3	24.7	24.7	0	0	0
N102	School	MALEK FAHD ISLAMIC SCHOOL HOXTON PARK	Hoxten Park	21.2	21.3	21.3	0	0	0
N103	School	MARAYONG HEIGHTS PUBLIC SCHOOL	Marayong	24.3	20.6	20.7	0	0	0
N104	School	MARAYONG PUBLIC SCHOOL	Marayong	27.2	23.4	23.5	0	0	0
N105	School	MIDDLETON GRANGE PUBLIC SCHOOL	Middleton Grange	22.2	22.2	22.2	0	0	0
N106	School	MINCHINBURY PUBLIC SCHOOL	Minchinbury	33.1	28.9	29.0	0	0	0
N107	School	MONTGROVE COLLEGE	Orchard Hills	30.9	25.2	25.1	0	0	0
N108	School	MOUNT DRUITT PUBLIC SCHOOL	Mount Druit	31.1	24.8	24.8	0	0	0
N109	School	MOUNT DRUITT PUBLIC SCHOOL PRESCHOOL	Mount Druit	31.2	24.8	24.8	0	0	0
N110	School	MOUNT DRUITT TAFE COLLEGE	Mount Druit	31.2	26.5	26.6	0	0	0
N111	School	MOUNT RIVERVIEW PUBLIC SCHOOL	Mount Riverview	29.2	26.5	26.5	0	0	0
N112	School	NEPEAN CHRISTIAN SCHOOL	Mulgoa	39.0	31.3	30.9	11	0	0
N113	School	NEPEAN CREATIVE AND PERFORMING ARTS HIGH SC	Emu Plains	26.9	23.9	23.9	0	0	0
N114	School	NEPEAN TAFE COLLEGE KINGSWOOD CAMPUS	Kingswood	34.8	25.7	25.5	0	0	0
N115	School	NEPEAN TAFE COLLEGE PENRITH CAMPUS	Penrith	27.8	23.5	23.5	0	0	0
N116	School	NOUMEA PUBLIC SCHOOL	Lethbridge Park	34.5	29.3	29.4	0	0	0
N117	School	ORCHARD HILLS PUBLIC SCHOOL	Orchard Hills	32.8	26.3	26.1	0	0	0
N118	School	OUR LADY OF THE ROSARY PRIMARY SCHOOL	St Marys	44.2	32.4	31.9	14	0	0
N119	School	OUR LADY OF THE WAY PRIMARY SCHOOL	Emu Plains	27.2	24.8	24.8	0	0	0
N120	School	OXLEY PARK PUBLIC SCHOOL	Oxley Park	37.3	26.9	26.6	10	0	0
N121	School	PENOLA CATHOLIC COLLEGE EMU PLAINS	Emu Plains	27.1	23.6	23.6	0	0	0
N122	School	PENRITH ANGLICAN COLLEGE	Orchard Hills	35.4	28.4	28.1	9	0	0
N123	School	PENRITH CHRISTIAN SCHOOL	Orchard Hills	32.3	26.5	26.3	0	0	0
N124	School	PENRITH HIGH SCHOOL	Penrith	28.6	23.7	23.6	0	0	0
N125	School	PENRITH PUBLIC SCHOOL	Penrith	28.5	23.7	23.6	0	0	0
N126	School	PENRITH SOUTH PUBLIC SCHOOL	South Penrith	28.7	24.2	24.1	0	0	0
N127	School	PLUMPTON HIGH SCHOOL	Plumpton	38.3	34.2	34.3	10	0	0
N128	School	PLUMPTON PUBLIC SCHOOL	Plumpton	39.7	35.6	35.8	11	9	9
N129	School	REGENTVILLE PUBLIC SCHOOL	Regentville	30.0	26.1	26.0	0	0	0

Calculated %HSD - 2055

				LAeq Night			Sleep disturbance as %HSD		
ID	Type	Area	Suburb	S1	S3	S4	S1	S3	S4
N130	School	ROOTY HILL HIGH SCHOOL	Rooty Hill	34.8	30.6	30.8	0	0	0
N131	School	ROOTY HILL PUBLIC SCHOOL	Rooty Hill	36.1	32.0	32.2	9	0	0
N132	School	ROPES CROSSING PUBLIC SCHOOL	Ropes Crossing	39.1	28.9	28.7	11	0	0
N133	School	SACRED HEART PRIMARY SCHOOL	Mount Druit	30.9	24.8	24.9	0	0	0
N134	School	SHALVEY PUBLIC SCHOOL	Shalvey	36.5	31.7	31.8	9	0	0
N135	School	SHELLEY PUBLIC SCHOOL	Blacktown	23.4	20.0	20.1	0	0	0
N136	School	ST AIDAN'S PRIMARY SCHOOL	Rooty Hill	35.2	31.0	31.2	9	0	0
N137	School	ST ANDREWS PRIMARY SCHOOL	Quakers Hill	26.1	22.2	22.4	0	0	0
N138	School	ST ANTHONY OF PADUA CATHOLIC COLLEGE	Austral	25.0	25.4	25.4	0	0	0
N139	School	ST CLAIR HIGH SCHOOL	St Clair	38.3	28.1	27.8	10	0	0
N140	School	ST CLAIR PUBLIC SCHOOL	St Clair	38.1	28.3	28.0	10	0	0
N141	School	ST FINBAR'S PRIMARY SCHOOL	Glenbrook	27.5	27.6	27.6	0	0	0
N142	School	ST FRANCIS OF ASSISI PRIMARY SCHOOL	Glendenning	39.8	35.7	35.9	11	9	9
N143	School	ST JOSEPH'S PRIMARY SCHOOL	Kingswood	30.9	24.0	23.9	0	0	0
N144	School	ST MARY MACKILLOP PRIMARY SCHOOL	South Penrith	31.1	25.7	25.6	0	0	0
N145	School	ST MARYS NORTH PUBLIC SCHOOL	North St Marys	40.6	29.1	28.8	12	0	0
N146	School	ST MARYS PUBLIC SCHOOL	St Marys	44.5	32.6	32.2	15	0	0
N147	School	ST MARYS SENIOR HIGH SCHOOL	St Marys	44.3	32.4	32.0	14	0	0
N148	School	ST MARYS SOUTH PUBLIC SCHOOL	St Marys	42.8	31.2	30.8	13	0	0
N149	School	ST NICHOLAS OF MYRA PRIMARY SCHOOL	Penrith	28.1	23.7	23.6	0	0	0
N150	School	SURVEYORS CREEK PUBLIC SCHOOL	Glenmore Park	32.7	27.1	26.9	0	0	0
N151	School	THOMAS HASSALL ANGLICAN COLLEGE	Middleton Grange	23.0	23.0	23.0	0	0	0
N152	School	TREGEAR PUBLIC SCHOOL	Tregear	35.1	25.9	25.7	9	0	0
N153	School	UNITY GRAMMAR COLLEGE	Austral	24.3	24.8	24.8	0	0	0
N154	School	UNIVERSITY OF WESTERN SYDNEY PENRITH CAMPUS	Kingswood	32.6	24.9	24.8	0	0	0
N155	School	UNIVERSITY OF WESTERN SYDNEY WERRINGTON NT	Werrington	38.1	27.4	27.1	10	0	0
N156	School	UNIVERSITY OF WESTERN SYDNEY WERRINGTON STH	Kingswood	36.4	26.6	26.3	9	0	0
N157	School	WALTERS ROAD PUBLIC SCHOOL	Blacktown	33.5	29.5	29.6	0	0	0
N158	School	WARRAGAMBA PUBLIC SCHOOL	Warragamba	35.5	39.5	39.5	9	11	11
N159	School	WARRIMOO PUBLIC SCHOOL	Warrimoo	32.6	30.4	30.5	0	0	0
N160	School	WERRINGTON COUNTY PUBLIC SCHOOL	Werrington County	38.3	27.4	27.1	10	0	0
N161	School	WERRINGTON PUBLIC SCHOOL	Werrington	37.8	27.1	26.8	10	0	0
N162	School	WETHERILL PARK TAFE COLLEGE	Wetherill Park	20.0	18.1	18.1	0	0	0
N163	School	WHALAN PUBLIC SCHOOL	Whalan	31.8	25.2	25.2	0	0	0
N164	School	WILLIAM DEAN PUBLIC SCHOOL	Dean Park	35.6	31.5	31.7	9	0	0
N165	School	WILLMOT PUBLIC SCHOOL	Willmot	37.0	30.4	30.5	9	0	0
N166	School	YORK PUBLIC SCHOOL	South Penrith	30.3	25.5	25.4	0	0	0
N167	Aged Care	AQUINAS COURT	Springwood	29.2	29.8	29.8	0	0	0
N168	Aged Care	BAPTISTCARE MORVEN GARDENS CENTRE	Leura	25.2	26.5	26.5	0	0	0
N169	Aged Care	BLUE MOUNTAINS RETIREMENT VILLAGE	Leura	25.1	25.9	25.9	0	0	0
N170	Aged Care	BUCKLAND	Springwood	28.4	28.1	28.1	0	0	0
N171	Aged Care	MARTYN CLAVER AGED CARE	Leura	25.5	26.7	26.7	0	0	0
N172	Aged Care	WINGARA HAMLET	Springwood	30.2	31.7	31.8	0	0	0
N173	Childcare	CHILDRENS HOUSE MONTESSORI CHILD CARE	Faulconbridge	33.9	36.0	36.1	0	9	9
N174	Childcare	KATOOMBA LEURA PRE-SCHOOL	Katoomba	27.0	27.6	27.6	0	0	0
N175	Childcare	KEMPS CREEK CHILDRENS COTTAGE	Kemps Creek	31.5	30.7	30.7	0	0	0
N176	Childcare	LAPSTONE PRE-SCHOOL	Lapstone	28.8	27.0	27.0	0	0	0
N177	Hospital	BLUE MOUNTAINS DISTRICT ANZAC MEMORIAL HOS	Katoomba	25.0	25.7	25.7	0	0	0
N178	Hospital	SPRINGWOOD HOSPITAL	Springwood	28.4	28.9	28.9	0	0	0
N179	Recreation	ECHO POINT LOOKOUT	Katoomba	30.2	31.2	31.2	0	0	0
N180	Religious Facility	ANGLICAN	Leura	25.8	26.9	26.9	0	0	0
N181	Religious Facility	ANGLICAN	Katoomba	26.6	27.2	27.2	0	0	0
N182	Religious Facility	BAPTIST	Katoomba	27.3	27.9	27.9	0	0	0
N183	Religious Facility	BAPTIST	Leura	25.3	26.3	26.3	0	0	0
N184	Religious Facility	UNITING	Springwood	30.8	32.6	32.6	0	0	0
N185	School	BLUE MOUNTAINS STEINER SCHOOL	Hazelbrook	31.5	33.2	33.2	0	0	0
N186	School	ELLISON PUBLIC SCHOOL	Springwood	27.7	27.0	27.1	0	0	0
N187	School	FAULCONBRIDGE PUBLIC SCHOOL	Faulconbridge	31.8	33.4	33.4	0	0	0
N188	School	HAZELBROOK PUBLIC SCHOOL	Hazelbrook	30.1	31.4	31.4	0	0	0
N189	School	KATOOMBA HIGH SCHOOL	Katoomba	29.1	30.0	30.0	0	0	0
N190	School	KATOOMBA NORTH PUBLIC SCHOOL	Katoomba	24.2	24.9	24.9	0	0	0
N191	School	KATOOMBA PUBLIC SCHOOL	Katoomba	27.5	28.2	28.2	0	0	0
N192	School	KINGSWOOD PARK PUBLIC SCHOOL	Kingswood	31.8	24.6	24.5	0	0	0
N193	School	KINGSWOOD PUBLIC SCHOOL	Kingswood	31.9	24.7	24.5	0	0	0
N194	School	KINGSWOOD SOUTH PUBLIC SCHOOL	Kingswood	30.0	24.5	24.4	0	0	0
N195	School	LAPSTONE PUBLIC SCHOOL	Glenbrook	28.4	27.0	27.0	0	0	0
N196	School	LAWSON PUBLIC SCHOOL	Lawson	26.4	28.3	28.3	0	0	0
N197	School	LEURA PUBLIC SCHOOL	Leura	25.3	26.4	26.4	0	0	0
N198	School	OUR LADY OF THE NATIVITY PRIMARY SCHOOL	Lawson	27.4	29.2	29.2	0	0	0
N199	School	SPRINGWOOD HIGH SCHOOL	Faulconbridge	30.8	31.9	31.9	0	0	0
N200	School	SPRINGWOOD PUBLIC SCHOOL	Springwood	30.2	30.3	30.3	0	0	0
N201	School	ST CANICES PRIMARY SCHOOL	Katoomba	27.0	27.6	27.6	0	0	0
N202	School	ST THOMAS AQUINAS PRIMARY SCHOOL	Springwood	26.9	25.8	25.8	0	0	0
N203	School	WENTWORTH FALLS PUBLIC SCHOOL	Wentworth Falls	24.5	26.2	26.2	0	0	0

Appendix F

Calculation of health impacts from noise – Annoyance

Calculation of %HA - 2033

				L_{den}				Annoyance as %HA				Annoyance as %HA (sensitivity)			
ID	Type	Area	Suburb	Background	S1	S3	S4	Background	S1	S3	S4	Background	S1	S3	S4
M01	Noise Monitoring Termi	South West Departure (Wallacia)	Wallacia	56.3	58.7	58.3	58.4	29	34	33	33	12	16	15	15
M02	Noise Monitoring Termi	North East Departure	Kemps Creek	60.4	57.0	54.2	56.6	37	30	25	30	18	13	9	12
M03	Noise Monitoring Termi	North East Runway	Orchard Hills	65.2	49.3	49.9	43.3	46	17	18	6	27	4	5	0
M04	Noise Monitoring Termi	Twin Creeks	Luddenham	52.3	54.1	47.3	44.0	22	25	13	8	7	9	3	1
M06	Noise Monitoring Termi	Mount Vernon	Mount Vernon	57.0	40.7	40.9	37.9	30	2	3	0	13	0	0	0
M07	Noise Monitoring Termi	Kemps Creek Nature Reserve	Kemps Creek	56.4	35.0	35.4	33.8	29	0	0	0	12	0	0	0
M08	Noise Monitoring Termi	Luddenham	Luddenham	65.2	44.8	41.5	41.5	46	9	4	4	27	1	0	0
M09	Noise Monitoring Termi	Penrith	Penrith	51.8	39.3	40.5	35.4	21	0	2	0	7	0	0	0
M10	Noise Monitoring Termi	Glenmore Park	Glenmore Park	56.5	38.4	35.2	36.9	30	0	0	0	12	0	0	0
M11	Noise Monitoring Termi	Oxley Park	Oxley Park	69.0	39.9	39.6	34.8	54	1	1	0	35	0	0	0
M12	Noise Monitoring Termi	St. Marys	St. Marys	55.9	47.2	46.5	40.4	28	13	12	2	11	3	2	0
M13	Noise Monitoring Termi	Rooty Hill	Rooty Hill	54.5	42.5	39.6	41.8	26	5	1	4	10	0	0	0
M14	Noise Monitoring Termi	St. Clair	St. Clair	57.3	48.1	48.5	41.9	31	15	15	4	13	3	4	0
M15	Noise Monitoring Termi	Erskine Park	Erskine Park	57.2	44.5	45.6	39.5	31	9	10	0	13	1	2	0
M16	Noise Monitoring Termi	Sydney International Equestrian Centre	Horsley Park	57.5	32.3	31.9	31.0	31	0	0	0	14	0	0	0
M17	Noise Monitoring Termi	Wallacia	Wallacia	53.9	39.9	48.6	48.7	25	1	15	16	9	0	4	4
M18	Noise Monitoring Termi	Warragamba	Warragamba	53.4	37.8	41.3	41.9	24	0	3	4	8	0	0	0
M19	Noise Monitoring Termi	Greendale	Greendale	53.0	58.0	57.3	58.3	23	32	31	33	8	14	13	15
M20	Noise Monitoring Termi	Bringelly	Bringelly	52.9	39.3	40.3	40.5	23	0	2	2	8	0	0	0
M21	Noise Monitoring Termi	Bents Basin	Greendale	60.9	56.8	55.9	56.3	38	30	28	29	19	13	11	12
M22	Noise Monitoring Termi	Silverdale	Silverdale	52.6	58.8	58.7	58.4	22	34	33	33	7	16	15	15
M23	Noise Monitoring Termi	Werombi	Werombi	56.5	38.0	36.8	37.0	29	0	0	0	12	0	0	0
M24	Noise Monitoring Termi	Blaxland	Blaxland	50.5	37.5	38.5	35.1	19	0	0	0	5	0	0	0
M25	Noise Monitoring Termi	Linden	Linden	51.6	41.1	42.8	43.9	21	3	6	8	6	0	0	1
M26	Noise Monitoring Termi	North Richmond	North Richmond	52.3	28.6	27.8	26.5	22	0	0	0	7	0	0	0
M27	Noise Monitoring Termi	Kurrajong	Kurrajong	52.0	25.7	24.5	24.1	21	0	0	0	7	0	0	0
M28	Noise Monitoring Termi	The Oaks	The Oaks	55.0	35.0	36.6	37.0	27	0	0	0	10	0	0	0
M29	Noise Monitoring Termi	Lake Burragorang (Natai, Brownlow Hill)	Nattai	50.5	37.4	34.1	37.4	19	0	0	0	5	0	0	0
M30	Noise Monitoring Termi	Tahmoor	Tahmoor		29.7	33.5	34.8		0	0	0		0	0	0
R1	Residential	Bringelly	Bringelly		35.1	35.7	35.7		0	0	0		0	0	0
R2	Residential	Luddenham	Luddenham		46.4	46.0	46.0		12	11	11		2	2	2
R3	Residential	Greendale, Greendale Road	Greendale		52.3	57.9	58.2		22	32	33		7	14	15
R6	Residential	Kemps Creek	Kemps Creek		46.1	39.5	39.5		11	0	0		2	0	0
R7	Residential	Wallacia	Wallacia		40.0	49.3	49.4		1	17	17		0	4	4
R8	Residential	Twin Creeks, Cnr Twin Ck Drie & Humewood Place	Luddenham		56.7	50.7	47.4		30	19	13		13	5	3
R14	Residential	Lawson Road, Badgerys Creek	Badgerys Creek		51.5	50.5	46.5		21	19	12		6	5	2
R15	Residential	Mersey Rd, Greendale	Greendale		42.1	42.6	42.7		5	5	6		0	0	0
R17	Residential	Luddenham Road	Luddenham		51.0	48.6	47.5		20	15	14		6	4	3
R18	Residential	Cnr Adams & Elizabeth Drive	Luddenham		54.8	54.7	54.7		26	26	26		10	10	10
R19	Residential	Cnr Adams & Anton Road	Luddenham		53.4	53.5	53.5		24	24	24		8	8	8
R21	Residential	Cnr Willowdene Ave and Vicar Park Lane	Luddenham		64.4	66.4	67.1		44	48	50		25	29	31
R22	Residential	Rossmore, Victor Ave	Rossmore		39.0	39.2	38.4		0	0	0		0	0	0
R23	Residential	Wallacia, Greendale Road	Wallacia		44.0	55.2	55.3		8	27	27		1	11	11
R24	On-Site	Badgerys Creek 1 NE			55.1	54.0	52.2		27	25	22		10	9	7
R25	On-Site	Badgerys Creek 2 SW			56.2	56.7	57.1		29	30	30		12	13	13
R27	Residential	Greendale, Dwyer Rd	Greendale		41.9	44.1	44.4		4	8	8		0	1	1
R30	Residential	Rossmore residential	Rossmore		32.4	32.8	32.5		0	0	0		0	0	0
R31	Residential	Mt Vernon residential	Mount Vernon		39.8	39.9	37.2		1	1	0		0	0	0
R34	Aged Care	Emmaus Residential Aged Care	Kemps Creek		48.0	49.0	44.0		14	16	8		3	4	1
R35	Childcare	Mamre After School and Vacation Care	Kemps Creek		51.0	52.3	46.3		20	22	12		6	7	2
R37	Childcare	Schoolies at Mulgoa	Luddenham		52.3	52.3	52.6		22	22	22		7	7	7
R38	Childcare	Do-re-mi Day Care Centre	Mount Vernon		38.7	38.9	35.9		0	0	0		0	0	0
R39	Childcare	Little Amigos Austral Early Learning Centre	Austral		31.3	31.9	30.9		0	0	0		0	0	0
R40	Childcare	Little Smarties Childcare Centre	Kemps Creek		51.0	52.2	46.4		20	22	12		6	7	2
R41	Childcare	The Grove Academy	Kemps Creek		36.0	36.4	34.9		0	0	0		0	0	0
R42	Childcare	Horsley Kids	Horsley Park		36.6	35.0	35.8		0	0	0		0	0	0
R44	Childcare	Bringelly Child Care Centre	Bringelly		40.6	41.9	42.2		2	4	5		0	0	0
R46	Childcare	Chementson Drive Early Educational Centre	Rossmore		36.1	36.5	35.9		0	0	0		0	0	0
R48	Childcare	Kids Korner West Hoxton Early Learning Centre	Austral		31.1	31.8	30.3		0	0	0		0	0	0
R49	Childcare	Luddenham Child Care Centre	Luddenham		50.2	49.9	49.9		18	18	18		5	5	5
R52	Childcare	The Frogs Lodge	Austral		31.2	31.9	30.7		0	0	0		0	0	0
R54	Childcare	Mulgoa Preschool	Mulgoa		48.1	39.4	39.2		15	0	0		3	0	0
R55	Childcare	Jillys Educational Childcare Centre	Rossmore		34.3	34.7	34.3		0	0	0		0	0	0
R59	Community Centre	Bringelly Community Centre	Bringelly		35.6	36.2	36.2		0	0	0		0	0	0
R63	Community Centre	Luddenham Progress Hall	Luddenham		53.5	53.2	53.2		24	23	24		8	8	8
R64	Community Centre	Mulgoa Hall	Mulgoa		47.5	39.4	39.3		14	0	0		3	0	0
R65	School	Emmaus Catholic College	Kemps Creek		49.4	50.3	45.8		17	18	11		4	5	2
R66	School	University of Sydney Farms	Greendale		40.5	52.1	52.2		2	22	22		0	7	7
R68	School	Christadelphian Heritage College Sydney	Kemps Creek		38.6	38.8	36.2		0	0	0		0	0	0
R69	School	Mamre Anglican School	Kemps Creek		51.0	52.3	46.4		20	22	12		6	7	2
R72	School	Irfan College	Cecil Park		33.7	34.2	31.8		0	0	0		0	0	0
R73	School	Luddenham Public School	Luddenham		54.3	54.0	53.9		25	25	25		9	9	9
R74	School	Kemps Creek Public School	Kemps Creek		38.7	38.9	36.4		0	0	0		0	0	0
R75	School	Trinity Catholic Primary School	Kemps Creek		49.7	50.9	45.2		17	19	10		5	6	1
R76	School	Bringelly Public School	Bringelly		35.2	35.8	35.9		0	0	0		0	0	0
R78	School	Mulgoa Public School	Mulgoa		47.5	39.5	39.3		14	0	0		3	0	0
R79	School	Rossmore Public School	Rossmore		32.4	32.7	32.6		0	0	0		0	0	0
R80	School	Wallacia Public School	Wallacia		39.9	48.2	48.3		1	15	15		0	3	3
R82	School	Bellfield College - Junior Campus	Rossmore		32.9	33.3	33.0		0	0	0		0	0	0
R84	Park	Bringelly Park	Bringelly		35.7	36.3	36.4		0	0	0		0	0	0
R85	Park	Bents Basin State Conservation Reserve and Gulgue	Greendale		45.5	44.1	45.2		10	8	10		2	1	1
R86	Park	Blaxland Crossing Reserve	Wallacia		39.8	48.2	48.3		1	15	15		0	3	3
R87	Park	Bill Anderson Reserve	Kemps Creek		39.6	39.7	36.9		1	1	0		0	0	0
R91	Park	Western Sydney Parklands	Eastern Creek		47.0	43.6	46.9		13	7	13		2	1	2
R93	Park	Rossmore Grange	Rossmore		34.5	35.0	34.7		0	0	0		0	0	0
R94	Park	Freeburn Park	Luddenham		52.3	52.0	52.0		22	21	21		7	7	7
R95	Park	Overett Reserve	Kemps Creek		46.2	45.7	42.5		11	11	5		2	2	0
R97	Park	Mulgoa Park	Mulgoa		47.5	39.4	39.3		14	0	0		3	0	0
R98	Recreation	Wallacia Bowling and Recreation Club	Wallacia		40.3	51.1	51.2		2	20	20		0	6	6
R99	Recreation	Hubertus Country Club	Luddenham		56.6	56.6	56.5		30	30	29		12	12	12
R100	Recreation	Sugarloaf Cobbitty Equestrian Club	Cobbitty		36.6	50.4	50.4		0	19	19		0	5	5
R102	Recreation	Panthers Wallacia (country club)	Wallacia		39.9	49.2	49.4		1	17	17		0	4	4
R103	Recreation	Twin Creeks Gold and Country Club	Luddenham		53.5	46.8	43.4		24	12	7		8	2	0
R104	Recreation	Sydney International Shooting Centre	Cecil Park		33.7	34.3	32.2		0	0	0		0	0	0
R108	Recreation	Luddenham Showground	Luddenham		48.5	48.3	48.4		15	15	15		4	3	3
R109	Recreation	Kemps Creek Sporting and Bowling Club	Cecil Park		36.3	36.6	34.1		0	0	0		0	0	0
R110	Religious Facility	St James Luddenham	Luddenham		55.7	55.4	55.4		28	28	28		11	11	11
R111	Religious Facility	Lin Ying Temple	Rossmore		35.3	35.7	35.0		0	0	0		0	0	0
R112	Religious Facility	Vat Ketanak Khmer Kampuchea Krom	Rossmore		34.3	34.7	34.4		0	0	0		0	0	0
R114	Religious Facility	Anglican Church Sydney Diocese	Rossmore		32.9	33.2	33.1		0	0	0		0	0	0
R115	Religious Facility	Anglican Parish of Mulgoa	Mulgoa		48.4	39.2	39.0		15	0	0		3	0	0
R117	Religious Facility	Bringelly Vineyard Church	Bringelly		34.4	34.8	34.8		0	0	0		0	0	0
R120	Religious Facility	Our Lady Queen of Peace	Greystanes		22.3	22.7	21.4		0	0	0		0	0	0
R122	Religious Facility	St Anthony	Austral		31.3	31.9	30.8		0	0	0		0	0	0
R123	Religious Facility	St Marys Church	Mulgoa		44.8	39.5	39.7		9	0	1		1	0	0
R124	Religious Facility	Wallacia Christian Church	Wallacia		40.0	49.3	49.4		1	17	17		0	4	4
R126	Religious Facility	St Francis Xavier Church	Greendale		62.2	62.3	62.1		40	40	40		21	21	21
R127	Religious Facility	Luddenham Uniting Church	Luddenham		53.7	53.4	53.5		24	24	24		9	8	8
R131	Religious Facility	Science of the Soul Study Centre	Cecil Park		37.0	37.3	34.7		0	0	0		0	0	0
R132	Shopping Centre	Bringelly shops	Bringelly		35.1	35.7	35.7		0	0	0		0	0	0
R134	Shopping Centre	Kemps Creek shops	Kemps Creek		39.8	40.0	37.0		1	1	0		0	0	0

Calculation of %HA - 2033

				L_{den}				Annoyance as %HA				Annoyance as %HA (sensitivity)			
ID	Type	Area	Suburb	Background	S1	S3	S4	Background	S1	S3	S4	Background	S1	S3	S4
R135	Shopping Centre	Luddenham shops	Luddenham		57.3	57.0	57.0		31	30	30		13	13	13
R136	Shopping Centre	Mulgoa shops	Mulgoa		46.1	39.5	39.5		11	0	0		2	0	0
R137	Shopping Centre	Rossmore shops	Rossmore		32.4	32.8	32.5		0	0	0		0	0	0
R138	Shopping Centre	Wallacia Shops	Wallacia		39.8	49.7	49.8		1	17	18		0	5	5
R140	School	Holy Family Catholic Primary and Church	Luddenham		52.2	52.2	52.6		22	22	22		7	7	7
R141	Religious Facility	Edmund Rice Retreat and Conference Centre	Mulgoa		41.5	42.6	42.9		4	5	6		0	0	0
N1	Aged Care	CATHOLIC HEALTHCARE EMMAUS VILLAGE	Kemps Creek		48.0	49.0	44.0		14	16	8		3	4	1
N2	Aged Care	JOHN EDMONDSON VC GARDENS	Austral		31.3	31.9	30.8		0	0	0		0	0	0
N3	Aged Care	REGAL OAKS VILLAGE	Wallacia		39.8	50.4	50.5		1	18	19		0	5	5
N4	Aged Care	SCALABRINI VILLAGE AUSTRAL	Austral		31.0	31.5	30.8		0	0	0		0	0	0
N5	Aged Care	TOBRUK VILLAGE	Austral		31.2	31.8	30.8		0	0	0		0	0	0
N6	Childcare	BLAXLAND PRE-SCHOOL	Blaxland		36.4	37.4	33.7		0	0	0		0	0	0
N7	Childcare	GLENBROOK PRE-SCHOOL	Glenbrook		34.4	34.3	33.8		0	0	0		0	0	0
N8	Childcare	KEMPS CREEK CHILDRENS COTTAGE	Kemps Creek		36.1	36.4	34.9		0	0	0		0	0	0
N9	Childcare	LAPSTONE PRE-SCHOOL	Lapstone		34.4	33.5	33.3		0	0	0		0	0	0
N10	Childcare	MindChamps Early Learning & Preschool @ Kemps C	Kemps Creek		36.1	36.4	34.9		0	0	0		0	0	0
N11	Childcare	MY FIRST SCHOOL CHILDCARE CENTRE	St Marys		46.4	45.6	39.8		12	10	1		2	2	0
N12	Childcare	SILVERDALE CHILD CARE CENTRE	Silverdale		48.0	46.0	47.8		14	11	14		3	2	3
N13	Childcare	WARRAGAMBA PRE-SCHOOL	Warragamba		38.5	40.8	41.6		0	3	4		0	0	0
N14	Hospital	MINCHINBURY COMMUNITY HOSPITAL	Rooty Hill		35.7	35.1	34.0		0	0	0		0	0	0
N15	Hospital	MOUNT DRUITT HOSPITAL	Mount Druit		35.8	34.9	34.6		0	0	0		0	0	0
N16	Hospital	NEPEAN HOSPITAL	Kingswood		41.1	42.0	38.6		3	4	0		0	0	0
N17	Hospital	NEPEAN PRIVATE HOSPITAL	Kingswood		40.9	41.8	38.2		3	4	0		0	0	0
N18	Religious Facility	AUSTRAL CHURCH OF CHRIST	Austral		31.2	31.8	30.8		0	0	0		0	0	0
N19	Religious Facility	GOOD SHEPHERD CATHOLIC CHURCH	Hoxten Park		28.8	29.4	28.4		0	0	0		0	0	0
N20	Religious Facility	Grace West Anglican Church - Glenmore Park	Glenmore Park		37.6	35.2	37.3		0	0	0		0	0	0
N21	Religious Facility	Holy Family Church	Luddenham		52.0	52.1	52.4		21	21	22		7	7	7
N22	Religious Facility	HOLY SPIRIT CATHOLIC CHURCH	Horningsea Park		30.0	30.6	29.5		0	0	0		0	0	0
N23	Religious Facility	Holy Spirit Parish	St Clair		44.8	45.4	39.1		9	10	0		1	1	0
N24	Religious Facility	HOXTON PARK ANGLICAN CHURCH	West Hoxton		29.8	30.5	29.2		0	0	0		0	0	0
N25	Religious Facility	Imagine Nations Church	Orchard Hills		38.2	37.4	36.5		0	0	0		0	0	0
N26	Religious Facility	INSPIRE CHURCH	Hoxten Park		28.5	29.0	28.1		0	0	0		0	0	0
N27	Religious Facility	Mt Hope Uniting Church Orchard Hills	Orchard Hills		39.3	39.4	36.4		0	0	0		0	0	0
N28	Religious Facility	Orchard Hills Kingdom Hall of Jehovah's Witnesses	Orchard Hills		37.9	36.2	36.1		0	0	0		0	0	0
N29	Religious Facility	Samoan Methodist Church	Leppington		31.1	31.2	31.3		0	0	0		0	0	0
N30	Religious Facility	SIKH MISSION CENTRE	Austral		31.5	32.0	31.2		0	0	0		0	0	0
N31	Religious Facility	St Clair Anglican Church	St Clair		39.8	40.5	35.3		1	2	0		0	0	0
N32	Religious Facility	St Mary Mother of the Church	Leppington		31.3	31.6	31.3		0	0	0		0	0	0
N33	Religious Facility	ST ZAIA CATHEDRAL	Middleton Grange		30.2	30.9	29.4		0	0	0		0	0	0
N34	Religious Facility	Uniting Church St Clair	St Clair		42.1	42.9	37.0		5	6	0		0	0	0
N35	Religious Facility	WEST HOXTON COMMUNITY CHURCH	West Hoxton		30.6	31.3	29.8		0	0	0		0	0	0
N36	School	AL-FAISAL COLLEGE LIVERPOOL CAMPUS	Austral		32.5	33.1	31.7		0	0	0		0	0	0
N37	School	AUSTRAL PUBLIC SCHOOL	Austral		31.1	31.8	30.7		0	0	0		0	0	0
N38	School	AUSTRALIAN ISLAMIC COLLEGE OF SYDNEY SENIOR S	Mount Druit		36.5	35.2	35.6		0	0	0		0	0	0
N39	School	BANKS PUBLIC SCHOOL	St Clair		47.2	47.3	40.9		13	13	3		3	3	0
N40	School	BENNETT ROAD PUBLIC SCHOOL	Colyton		39.7	40.0	34.7		1	1	0		0	0	0
N41	School	BETHANY CATHOLIC PRIMARY SCHOOL	Glenmore Park		37.8	35.3	37.4		0	0	0		0	0	0
N42	School	BIDWILL PUBLIC SCHOOL	Bidwill		42.1	39.2	42.0		5	0	4		0	0	0
N43	School	BLACKETT PUBLIC SCHOOL	Blackett		37.4	36.0	37.0		0	0	0		0	0	0
N44	School	BLACKTOWN NORTH PUBLIC SCHOOL	Blacktown		27.6	28.1	26.2		0	0	0		0	0	0
N45	School	BLACKTOWN SOUTH PUBLIC SCHOOL	Blacktown		29.7	29.2	29.2		0	0	0		0	0	0
N46	School	BLACKTOWN TAFE COLLEGE	Blacktown		28.4	28.4	27.4		0	0	0		0	0	0
N47	School	BLACKTOWN WEST PUBLIC SCHOOL	Blacktown		32.8	31.4	32.7		0	0	0		0	0	0
N48	School	BLACKWELL PUBLIC SCHOOL	St Clair		46.4	47.5	41.0		12	14	3		2	3	0
N49	School	BLAXLAND EAST PUBLIC SCHOOL	Blaxland		36.2	37.2	33.4		0	0	0		0	0	0
N50	School	BLAXLAND HIGH SCHOOL	Warrimoo		38.0	39.0	35.0		0	0	0		0	0	0
N51	School	BLAXLAND PUBLIC SCHOOL	Blaxland		37.7	38.8	34.9		0	0	0		0	0	0
N52	School	CAMBRIDGE GARDENS PUBLIC SCHOOL	Cambridge Gardens		37.4	38.0	34.0		0	0	0		0	0	0
N53	School	CAMBRIDGE PARK PUBLIC SCHOOL	Ceambridge Park		39.6	40.2	37.0		1	2	0		0	0	0
N54	School	CATHWEST INNOVATION COLLEGE MCCARTHY CAM	Emu Plains		38.4	39.7	34.1		0	1	0		0	0	0
N55	School	CECIL HILLS PUBLIC SCHOOL	Cecil Hills		30.0	30.6	29.0		0	0	0		0	0	0
N56	School	CHIFLEY COLLEGE BIDWILL CAMPUS	Bidwill		41.8	39.0	41.8		4	0	4		0	0	0
N57	School	CHIFLEY COLLEGE DUNHEVED CAMPUS	North St Marys		42.5	41.6	38.6		5	4	0		0	0	0
N58	School	CHIFLEY COLLEGE MOUNT DRUITT CAMPUS	Dharruk		36.4	35.5	35.3		0	0	0		0	0	0
N59	School	CHIFLEY COLLEGE SENIOR CAMPUS	Rooty Hill		35.7	34.9	34.4		0	0	0		0	0	0
N60	School	CHIFLEY COLLEGE SHALVEY CAMPUS	Shalvey		40.1	38.1	40.8		1	0	3		0	0	0
N61	School	CHRISTADELPHIAN HERITAGE COLLEGE SYDNEY	Kemps Creek		38.5	38.7	36.2		0	0	0		0	0	0
N62	School	CLAIRGATE PUBLIC SCHOOL	St Clair		39.4	40.1	34.9		0	1	0		0	0	0
N63	School	CLAREMONT MEADOWS PUBLIC SCHOOL	Claremont		44.1	44.7	38.9		8	9	0		1	1	0
N64	School	COLYTON HIGH SCHOOL	Colyton		38.1	38.3	33.5		0	0	0		0	0	0
N65	School	COLYTON PUBLIC SCHOOL	Mount Druit		35.3	35.4	32.3		0	0	0		0	0	0
N66	School	DAWSON PUBLIC SCHOOL	Dharruk		36.3	35.4	35.3		0	0	0		0	0	0
N67	School	EASTERN CREEK PUBLIC SCHOOL	Eastern Creek		46.1	42.8	45.4		11	6	10		2	0	1
N68	School	EASTERN CREEK PUBLIC SCHOOL PRESCHOOL	Eastern Creek		46.2	42.8	45.4		11	6	10		2	0	1
N69	School	EMERTON PUBLIC SCHOOL	Emerton		37.0	36.2	35.5		0	0	0		0	0	0
N70	School	EMU HEIGHTS PUBLIC SCHOOL	Emu Heights		37.7	39.0	33.7		0	0	0		0	0	0
N71	School	EMU PLAINS PUBLIC SCHOOL	Emu Plains		36.5	37.4	33.4		0	0	0		0	0	0
N72	School	ERSKINE PARK HIGH SCHOOL	Erskine Park		40.2	40.9	36.5		2	3	0		0	0	0
N73	School	GLENBROOK PUBLIC SCHOOL	Glenbrook		34.4	34.4	33.7		0	0	0		0	0	0
N74	School	GLENDENNING PUBLIC SCHOOL	Glendenning		43.6	40.4	43.4		7	2	7		1	0	0
N75	School	GLENMORE PARK PUBLIC SCHOOL	Glenmore Park		37.8	35.7	37.6		0	0	0		0	0	0
N76	School	GOOD SHEPHERD CATHOLIC PRIMARY SCHOOL	Hoxten Park		28.8	29.4	28.4		0	0	0		0	0	0
N77	School	GOOD SHEPHERD PRIMARY SCHOOL	Plumpton		40.6	38.0	40.3		2	0	2		0	0	0
N78	School	GREENWAY PARK PUBLIC SCHOOL	West Hoxton		30.2	30.9	29.7		0	0	0		0	0	0
N79	School	HASSALL GROVE PUBLIC SCHOOL	Hassall Grove		44.8	41.6	44.6		9	4	9		1	0	1
N80	School	HEBERSHAM PUBLIC SCHOOL	Hebersham		37.1	35.6	36.5		0	0	0		0	0	0
N81	School	HOLY FAMILY PRIMARY SCHOOL	Lethbridge Park		37.6	36.9	36.1		0	0	0		0	0	0
N82	School	HOLY SPIRIT PRIMARY SCHOOL	St Clair		44.9	45.6	39.3		9	10	0		1	2	0
N83	School	HOLY SPIRIT PRIMARY SCHOOL	Carnes Hill		30.0	30.6	29.5		0	0	0		0	0	0
N84	School	HORSLEY PARK PUBLIC SCHOOL	Horsley Park		36.2	34.6	35.4		0	0	0		0	0	0
N85	School	HOXTON PARK PUBLIC SCHOOL	Hoxten Park		29.6	30.3	29.1		0	0	0		0	0	0
N86	School	JAMES ERSKINE PUBLIC SCHOOL	Erskine Park		39.7	40.3	35.8		1	2	0		0	0	0
N87	School	JAMISON HIGH SCHOOL	South Penrith		38.6	38.1	38.1		0	0	0		0	0	0
N88	School	JAMISONTOWN PUBLIC SCHOOL	Jamisontown		37.2	36.7	36.6		0	0	0		0	0	0
N89	School	JORDAN SPRINGS PUBLIC SCHOOL	Jordan Springs		37.2	37.3	33.2		0	0	0		0	0	0
N90	School	KINGSWOOD PARK PUBLIC SCHOOL	Kingswood		42.0	42.7	39.8		5	6	1		0	0	0
N91	School	KINGSWOOD PUBLIC SCHOOL	Kingswood		42.2	42.9	39.9		5	6	1		0	0	0
N92	School	KINGSWOOD SOUTH PUBLIC SCHOOL	Kingswood		40.8	41.3	39.1		2	3	0		0	0	0
N93	School	LAPSTONE PUBLIC SCHOOL	Glenbrook		34.3	33.7	33.2		0	0	0		0	0	0
N94	School	LEONAY PUBLIC SCHOOL	Leonay		34.9	34.7	33.2		0	0	0		0	0	0
N95	School	LEPPINGTON PUBLIC SCHOOL	Leppington		31.0	31.4	30.9		0	0	0		0	0	0
N96	School	LETHBRIDGE PARK PUBLIC SCHOOL	Blackett		37.4	36.0	37.0		0	0	0		0	0	0
N97	School	LLANDILO PUBLIC SCHOOL	Llandilo		43.5	42.3	37.8		7	5	0		1	0	0
N98	School	LYNWOOD PARK PUBLIC SCHOOL	Blacktown		26.1	27.0	24.3		0	0	0		0	0	0
N99	School	MACARTHUR BUILDING INDUSTRY SKILLS CENTRE	Ingleburn		28.5	28.9	28.2		0	0	0		0	0	0
N100	School	MACQUARIE FIELDS TAFE COLLEGE	Macquarie Fields		27.8	28.1	27.8		0	0	0		0	0	0
N101	School	MADANG AVENUE PUBLIC SCHOOL	Whalan		36.1	35.9	32.9		0	0	0		0	0	0
N102	School	MALEK FAHD ISLAMIC SCHOOL HOXTON PARK	Hoxten Park		29.3	29.9	28.7		0	0	0		0	0	0
N103	School	MARAYONG HEIGHTS PUBLIC SCHOOL	Marayong		29.1	29.4	27.6		0	0	0		0	0	0
N104	School	MARAYONG PUBLIC SCHOOL	Marayong		30.7	30.1	29.9		0	0	0		0	0	0
N105	School	MIDDLETON GRANGE PUBLIC SCHOOL	Middleton Grange		29.6	30.3	28.9		0	0	0		0	0	0

Calculation of %HA - 2033

				L_{den}				Annoyance as %HA				Annoyance as %HA (sensitivity)			
ID	Type	Area	Suburb	Background	S1	S3	S4	Background	S1	S3	S4	Background	S1	S3	S4
N106	School	MINCHINBURY PUBLIC SCHOOL	Minchinbury		37.0	35.9	35.6		0	0	0		0	0	0
N107	School	MONTGROVE COLLEGE	Orchard Hills		40.0	40.2	38.6		1	1	0		0	0	0
N108	School	MOUNT DRUITT PUBLIC SCHOOL	Mount Druit		35.2	35.1	32.5		0	0	0		0	0	0
N109	School	MOUNT DRUITT PUBLIC SCHOOL PRESCHOOL	Mount Druit		35.2	35.1	32.5		0	0	0		0	0	0
N110	School	MOUNT DRUITT TAFE COLLEGE	Mount Druit		35.1	34.7	33.5		0	0	0		0	0	0
N111	School	MOUNT RIVERVIEW PUBLIC SCHOOL	Mount Riverview		38.4	39.6	34.2		0	1	0		0	0	0
N112	School	NEPEAN CHRISTIAN SCHOOL	Mulgoa		41.5	35.6	36.9		4	0	0		0	0	0
N113	School	NEPEAN CREATIVE AND PERFORMING ARTS HIGH SC	Emu Plains		38.1	39.4	34.1		0	0	0		0	0	0
N114	School	NEPEAN TAFE COLLEGE KINGSWOOD CAMPUS	Kingswood		42.7	43.4	39.9		6	7	1		0	0	0
N115	School	NEPEAN TAFE COLLEGE PENRITH CAMPUS	Penrith		39.5	40.8	35.6		0	2	0		0	0	0
N116	School	NOUMEA PUBLIC SCHOOL	Lethbridge Park		39.7	37.8	40.3		1	0	2		0	0	0
N117	School	ORCHARD HILLS PUBLIC SCHOOL	Orchard Hills		39.4	39.5	36.4		0	0	0		0	0	0
N118	School	OUR LADY OF THE ROSARY PRIMARY SCHOOL	St Marys		45.9	45.2	39.3		11	10	0		2	1	0
N119	School	OUR LADY OF THE WAY PRIMARY SCHOOL	Emu Plains		36.0	36.7	33.3		0	0	0		0	0	0
N120	School	OXLEY PARK PUBLIC SCHOOL	Oxley Park		40.2	40.0	34.9		2	1	0		0	0	0
N121	School	PENOLA CATHOLIC COLLEGE EMU PLAINS	Emu Plains		38.5	39.8	34.1		0	1	0		0	0	0
N122	School	PENRITH ANGLICAN COLLEGE	Orchard Hills		38.6	35.8	34.8		0	0	0		0	0	0
N123	School	PENRITH CHRISTIAN SCHOOL	Orchard Hills		38.2	37.3	36.6		0	0	0		0	0	0
N124	School	PENRITH HIGH SCHOOL	Penrith		40.4	41.5	37.2		2	4	0		0	0	0
N125	School	PENRITH PUBLIC SCHOOL	Penrith		40.3	41.4	37.0		2	3	0		0	0	0
N126	School	PENRITH SOUTH PUBLIC SCHOOL	South Penrith		39.8	40.5	37.6		1	2	0		0	0	0
N127	School	PLUMPTON HIGH SCHOOL	Plumpton		40.7	38.1	40.4		2	0	2		0	0	0
N128	School	PLUMPTON PUBLIC SCHOOL	Plumpton		42.1	39.2	41.8		5	0	4		0	0	0
N129	School	REGENTVILLE PUBLIC SCHOOL	Regentville		36.4	35.0	35.9		0	0	0		0	0	0
N130	School	ROOTY HILL HIGH SCHOOL	Rooty Hill		37.8	36.0	37.0		0	0	0		0	0	0
N131	School	ROOTY HILL PUBLIC SCHOOL	Rooty Hill		38.9	36.8	38.3		0	0	0		0	0	0
N132	School	ROPES CROSSING PUBLIC SCHOOL	Ropes Crossing		42.7	41.5	41.1		6	4	3		0	0	0
N133	School	SACRED HEART PRIMARY SCHOOL	Mount Druit		35.3	35.4	32.3		0	0	0		0	0	0
N134	School	SHALVEY PUBLIC SCHOOL	Shalvey		41.3	39.0	42.1		3	0	5		0	0	0
N135	School	SHELLEY PUBLIC SCHOOL	Blacktown		27.4	27.4	26.5		0	0	0		0	0	0
N136	School	ST AIDAN'S PRIMARY SCHOOL	Rooty Hill		38.0	36.1	37.4		0	0	0		0	0	0
N137	School	ST ANDREWS PRIMARY SCHOOL	Quakers Hill		30.2	30.2	29.0		0	0	0		0	0	0
N138	School	ST ANTHONY OF PADUA CATHOLIC COLLEGE	Austral		31.4	32.0	30.9		0	0	0		0	0	0
N139	School	ST CLAIR HIGH SCHOOL	St Clair		42.6	43.1	37.2		5	6	0		0	0	0
N140	School	ST CLAIR PUBLIC SCHOOL	St Clair		43.4	44.2	38.1		7	8	0		0	1	0
N141	School	ST FINBAR'S PRIMARY SCHOOL	Glenbrook		34.5	34.7	33.5		0	0	0		0	0	0
N142	School	ST FRANCIS OF ASSISI PRIMARY SCHOOL	Glendenning		42.1	39.1	41.9		5	0	4		0	0	0
N143	School	ST JOSEPH'S PRIMARY SCHOOL	Kingswood		41.1	41.8	38.8		3	4	0		0	0	0
N144	School	ST MARY MACKILLOP PRIMARY SCHOOL	South Penrith		38.7	38.2	37.9		0	0	0		0	0	0
N145	School	ST MARYS NORTH PUBLIC SCHOOL	North St Marys		42.8	41.9	37.9		6	4	0		0	0	0
N146	School	ST MARYS PUBLIC SCHOOL	St Marys		46.0	45.1	39.4		11	10	0		2	1	0
N147	School	ST MARYS SENIOR HIGH SCHOOL	St Marys		45.8	44.8	39.4		11	9	0		2	1	0
N148	School	ST MARYS SOUTH PUBLIC SCHOOL	St Marys		45.2	44.9	38.9		10	9	0		1	1	0
N149	School	ST NICHOLAS OF MYRA PRIMARY SCHOOL	Penrith		39.9	41.0	36.4		1	3	0		0	0	0
N150	School	SURVEYORS CREEK PUBLIC SCHOOL	Glenmore Park		37.9	35.7	37.1		0	0	0		0	0	0
N151	School	THOMAS HASSALL ANGLICAN COLLEGE	Middleton Grange		30.2	30.9	29.4		0	0	0		0	0	0
N152	School	TREGEAR PUBLIC SCHOOL	Tregear		39.0	38.3	36.9		0	0	0		0	0	0
N153	School	UNITY GRAMMAR COLLEGE	Austral		31.3	31.7	31.1		0	0	0		0	0	0
N154	School	UNIVERSITY OF WESTERN SYDNEY PENRITH CAMPUS	Kingswood		42.4	43.2	39.9		5	6	1		0	0	0
N155	School	UNIVERSITY OF WESTERN SYDNEY WERRINGTON NT	Werrington		43.4	43.5	40.1		7	7	1		0	1	0
N156	School	UNIVERSITY OF WESTERN SYDNEY WERRINGTON ST	Kingswood		43.2	43.8	39.4		6	7	0		0	1	0
N157	School	WALTERS ROAD PUBLIC SCHOOL	Blacktown		35.1	33.0	35.6		0	0	0		0	0	0
N158	School	WARRAGAMBA PUBLIC SCHOOL	Warragamba		38.6	40.7	41.5		0	2	4		0	0	0
N159	School	WARRIMOO PUBLIC SCHOOL	Warrimoo		38.1	38.7	35.2		0	0	0		0	0	0
N160	School	WERRINGTON COUNTY PUBLIC SCHOOL	Werrington County		42.4	42.0	39.6		5	4	1		0	0	0
N161	School	WERRINGTON PUBLIC SCHOOL	Werrington		42.8	42.6	40.4		6	5	2		0	0	0
N162	School	WETHERILL PARK TAFE COLLEGE	Wetherill Park		24.7	24.9	24.0		0	0	0		0	0	0
N163	School	WHALAN PUBLIC SCHOOL	Whalan		35.8	35.4	33.5		0	0	0		0	0	0
N164	School	WILLIAM DEAN PUBLIC SCHOOL	Dean Park		38.0	35.7	37.7		0	0	0		0	0	0
N165	School	WILLMOT PUBLIC SCHOOL	Willmot		41.0	39.5	40.7		3	0	2		0	0	0
N166	School	YORK PUBLIC SCHOOL	South Penrith		38.4	37.6	38.1		0	0	0		0	0	0
N167	Aged Care	AQUINAS COURT	Springwood		34.5	34.4	34.8		0	0	0		0	0	0
N168	Aged Care	BAPTISTCARE MORVEN GARDENS CENTRE	Leura		29.7	30.8	30.2		0	0	0		0	0	0
N169	Aged Care	BLUE MOUNTAINS RETIREMENT VILLAGE	Leura		30.1	31.0	29.9		0	0	0		0	0	0
N170	Aged Care	BUCKLAND	Springwood		34.2	34.1	34.0		0	0	0		0	0	0
N171	Aged Care	MARTYN CLAVER AGED CARE	Leura		29.9	30.9	30.4		0	0	0		0	0	0
N172	Aged Care	WINGARA HAMLET	Springwood		35.0	35.0	35.8		0	0	0		0	0	0
N173	Childcare	CHILDRENS HOUSE MONTESSORI CHILD CARE	Faulconbridge		37.5	37.4	39.0		0	0	0		0	0	0
N174	Childcare	KATOOMBA LEURA PRE-SCHOOL	Katoomba		31.0	31.7	31.1		0	0	0		0	0	0
N175	Childcare	KEMPS CREEK CHILDRENS COTTAGE	Kemps Creek		36.1	36.4	34.9		0	0	0		0	0	0
N176	Childcare	LAPSTONE PRE-SCHOOL	Lapstone		34.4	33.5	33.3		0	0	0		0	0	0
N177	Hospital	BLUE MOUNTAINS DISTRICT ANZAC MEMORIAL HOS	Katoomba		30.2	31.1	29.8		0	0	0		0	0	0
N178	Hospital	SPRINGWOOD HOSPITAL	Springwood		34.2	34.1	34.4		0	0	0		0	0	0
N179	Recreation	ECHO POINT LOOKOUT	Katoomba		33.4	34.2	34.2		0	0	0		0	0	0
N180	Religious Facility	ANGLICAN	Leura		30.2	31.1	30.5		0	0	0		0	0	0
N181	Religious Facility	ANGLICAN	Katoomba		30.8	31.5	30.8		0	0	0		0	0	0
N182	Religious Facility	BAPTIST	Katoomba		31.2	31.9	31.4		0	0	0		0	0	0
N183	Religious Facility	BAPTIST	Leura		30.0	30.9	30.1		0	0	0		0	0	0
N184	Religious Facility	UNITING	Springwood		35.3	35.2	36.4		0	0	0		0	0	0
N185	School	BLUE MOUNTAINS STEINER SCHOOL	Hazelbrook		34.8	34.9	36.3		0	0	0		0	0	0
N186	School	ELLISON PUBLIC SCHOOL	Springwood		34.0	34.0	33.6		0	0	0		0	0	0
N187	School	FAULCONBRIDGE PUBLIC SCHOOL	Faulconbridge		35.9	35.7	37.1		0	0	0		0	0	0
N188	School	HAZELBROOK PUBLIC SCHOOL	Hazelbrook		33.5	33.6	34.8		0	0	0		0	0	0
N189	School	KATOOMBA HIGH SCHOOL	Katoomba		32.5	33.2	33.2		0	0	0		0	0	0
N190	School	KATOOMBA NORTH PUBLIC SCHOOL	Katoomba		30.4	31.5	29.5		0	0	0		0	0	0
N191	School	KATOOMBA PUBLIC SCHOOL	Katoomba		31.3	32.0	31.6		0	0	0		0	0	0
N192	School	KINGSWOOD PARK PUBLIC SCHOOL	Kingswood		42.0	42.7	39.8		5	6	1		0	0	0
N193	School	KINGSWOOD PUBLIC SCHOOL	Kingswood		42.2	42.9	39.9		5	6	1		0	0	0
N194	School	KINGSWOOD SOUTH PUBLIC SCHOOL	Kingswood		40.8	41.3	39.1		2	3	0		0	0	0
N195	School	LAPSTONE PUBLIC SCHOOL	Glenbrook		34.3	33.7	33.2		0	0	0		0	0	0
N196	School	LAWSON PUBLIC SCHOOL	Lawson		30.5	31.3	31.8		0	0	0		0	0	0
N197	School	LEURA PUBLIC SCHOOL	Leura		29.9	30.8	30.1		0	0	0		0	0	0
N198	School	OUR LADY OF THE NATIVITY PRIMARY SCHOOL	Lawson		31.3	31.9	32.6		0	0	0		0	0	0
N199	School	SPRINGWOOD HIGH SCHOOL	Faulconbridge		35.4	35.1	36.2		0	0	0		0	0	0
N200	School	SPRINGWOOD PUBLIC SCHOOL	Springwood		35.1	35.0	34.9		0	0	0		0	0	0
N201	School	ST CANICES PRIMARY SCHOOL	Katoomba		31.0	31.7	31.1		0	0	0		0	0	0
N202	School	ST THOMAS AQUINAS PRIMARY SCHOOL	Springwood		34.2	34.4	33.4		0	0	0		0	0	0
N203	School	WENTWORTH FALLS PUBLIC SCHOOL	Wentworth Falls		29.2	30.3	30.0		0	0	0		0	0	0

Calculation of %HA - 2055

				L_{den}			Annoyance as %HA				Annoyance as %HA (sensitivity)		
ID	Type	Area	Suburb	S1	S3	S4	Background	S1	S3	S4	S1	S3	S4
M01	Noise Monitoring Termi	South West Departure (Wallacia)	Wallacia	63.4	63.1	63.0	29	43	42	42	23	23	23
M02	Noise Monitoring Termi	North East Departure	Kemps Creek	61.9	58.7	61.3	37	39	34	38	21	16	20
M03	Noise Monitoring Termi	North East Runway	Orchard Hills	53.9	53.8	47.6	46	25	25	14	9	9	3
M04	Noise Monitoring Termi	Twin Creeks	Luddenham	59.7	51.3	48.8	22	35	20	16	17	6	4
M06	Noise Monitoring Termi	Mount Vernon	Mount Vernon	44.6	44.1	42.1	30	9	8	5	1	1	0
M07	Noise Monitoring Termi	Kemps Creek Nature Reserve	Kemps Creek	38.7	38.8	38.0	29	0	0	0	0	0	0
M08	Noise Monitoring Termi	Luddenham	Luddenham	48.3	45.3	45.2	46	15	10	10	3	1	1
M09	Noise Monitoring Termi	Penrith	Penrith	43.1	44.2	39.4	21	6	8	0	0	1	0
M10	Noise Monitoring Termi	Glenmore Park	Glenmore Park	42.5	39.3	41.6	30	5	0	4	0	0	0
M11	Noise Monitoring Termi	Oxley Park	Oxley Park	44.3	42.0	38.2	54	8	4	0	1	0	0
M12	Noise Monitoring Termi	St. Marys	St. Marys	52.6	49.9	44.6	28	22	18	9	7	5	1
M13	Noise Monitoring Termi	Rooty Hill	Rooty Hill	47.1	43.7	46.7	26	13	7	12	2	1	2
M14	Noise Monitoring Termi	St. Clair	St. Clair	52.9	52.3	46.2	31	23	22	11	8	7	2
M15	Noise Monitoring Termi	Erskine Park	Erskine Park	48.2	48.8	43.2	31	15	16	6	3	4	0
M16	Noise Monitoring Termi	Sydney International Equestrian Centre	Horsley Park	36.7	35.4	35.7	31	0	0	0	0	0	0
M17	Noise Monitoring Termi	Wallacia	Wallacia	43.1	52.9	52.9	25	6	23	23	0	8	8
M18	Noise Monitoring Termi	Warragamba	Warragamba	41.4	45.9	46.2	24	4	11	11	0	2	2
M19	Noise Monitoring Termi	Greendale	Greendale	62.6	62.2	62.8	23	41	40	41	22	21	22
M20	Noise Monitoring Termi	Bringelly	Bringelly	42.9	44.0	44.0	23	6	8	8	0	1	1
M21	Noise Monitoring Termi	Bents Basin	Greendale	61.4	60.6	60.8	38	39	37	37	20	18	19
M22	Noise Monitoring Termi	Silverdale	Silverdale	63.5	63.5	63.1	22	43	43	42	24	24	23
M23	Noise Monitoring Termi	Werombi	Werombi	42.3	41.1	41.0	29	5	3	3	0	0	0
M24	Noise Monitoring Termi	Blaxland	Blaxland	41.0	42.2	38.6	19	3	5	0	0	0	0
M25	Noise Monitoring Termi	Linden	Linden	45.0	48.7	49.1	21	9	16	16	1	4	4
M26	Noise Monitoring Termi	North Richmond	North Richmond	32.4	29.6	28.1	22	0	0	0	0	0	0
M27	Noise Monitoring Termi	Kurrajong	Kurrajong	29.3	26.5	25.7	21	0	0	0	0	0	0
M28	Noise Monitoring Termi	The Oaks	The Oaks	38.1	39.7	40.0	27	0	1	1	0	0	0
M29	Noise Monitoring Termi	Lake Burragorang (Natai, Brownlow Hill)	Nattai	41.9	38.8	41.3	19	4	0	3	0	0	0
M30	Noise Monitoring Termi	Tahmoor	Tahmoor	32.7	36.9	37.5		0	0	0	0	0	0
R1	Residential	Bringelly	Bringelly	39.0	39.6	39.6		0	1	1	0	0	0
R2	Residential	Luddenham	Luddenham	49.9	49.4	49.4		18	17	17	5	4	4
R3	Residential	Greendale, Greendale Road	Greendale	56.4	62.4	62.7		29	41	41	12	22	22
R6	Residential	Kemps Creek	Kemps Creek	49.5	43.6	43.3		17	7	6	4	1	0
R7	Residential	Wallacia	Wallacia	43.2	53.6	53.6		6	24	24	0	9	9
R8	Residential	Twin Creeks, Cnr Twin Ck Drie & Humewood Place	Luddenham	61.9	54.5	52.0		40	26	21	21	10	7
R14	Residential	Lawson Road, Badgerys Creek	Badgerys Creek	55.2	53.5	50.3		27	24	18	11	8	5
R15	Residential	Mersey Rd, Greendale	Greendale	45.7	46.0	46.0		10	11	11	2	2	2
R17	Residential	Luddenham Road	Luddenham	54.4	51.9	51.2		26	21	20	10	7	6
R18	Residential	Cnr Adams & Elizabeth Drive	Luddenham	58.3	58.4	58.5		33	33	33	15	15	15
R19	Residential	Cnr Adams & Anton Road	Luddenham	57.1	57.3	57.3		31	31	31	13	13	13
R21	Residential	Cnr Willowdene Ave and Vicar Park Lane	Luddenham	68.7	70.9	71.3		53	57	58	34	39	40
R22	Residential	Rossmore, Victor Ave	Rossmore	42.6	42.7	42.3		5	6	5	0	0	0
R23	Residential	Wallacia, Greendale Road	Wallacia	47.8	60.7	60.8		14	37	37	3	19	19
R24	On-Site	Badgerys Creek 1 NE		58.6	57.2	55.9		33	31	28	15	13	11
R25	On-Site	Badgerys Creek 2 SW		59.6	60.0	60.1		35	36	36	17	18	18
R27	Residential	Greendale, Dwyer Rd	Greendale	45.5	47.8	48.1		10	14	15	1	3	3
R30	Residential	Rossmore residential	Rossmore	36.8	37.1	37.0		0	0	0	0	0	0
R31	Residential	Mt Vernon residential	Mount Vernon	43.6	43.1	41.5		7	6	4	1	0	0
R34	Aged Care	Emmaus Residential Aged Care	Kemps Creek	51.9	52.6	48.3		21	22	15	7	7	3
R35	Childcare	Mamre After School and Vacation Care	Kemps Creek	55.2	56.2	50.8		27	29	19	10	12	6
R37	Childcare	Schoolies at Mulgoa	Luddenham	55.7	55.5	55.5		28	28	28	11	11	11
R38	Childcare	Do-re-mi Day Care Centre	Mount Vernon	42.4	42.1	40.1		5	5	1	0	0	0
R39	Childcare	Little Amigos Austral Early Learning Centre	Austral	35.8	36.0	35.7		0	0	0	0	0	0
R40	Childcare	Little Smarties Childcare Centre	Kemps Creek	55.1	56.2	50.9		27	29	19	10	12	6
R41	Childcare	The Grove Academy	Kemps Creek	39.8	39.8	39.0		1	1	0	0	0	0
R42	Childcare	Horsley Kids	Horsley Park	41.3	38.9	40.6		3	0	2	0	0	0
R44	Childcare	Bringelly Child Care Centre	Bringelly	44.2	45.6	45.7		8	10	11	1	2	2
R46	Childcare	Chementson Drive Early Educational Centre	Rossmore	39.7	40.0	39.8		1	1	1	0	0	0
R48	Childcare	Kids Korner West Hoxton Early Learning Centre	Austral	35.2	35.5	35.0		0	0	0	0	0	0
R49	Childcare	Luddenham Child Care Centre	Luddenham	53.6	53.1	52.9		24	23	23	9	8	8
R52	Childcare	The Frogs Lodge	Austral	35.6	35.9	35.4		0	0	0	0	0	0
R54	Childcare	Mulgoa Preschool	Mulgoa	51.7	43.5	42.9		21	7	6	6	1	0
R55	Childcare	Jillys Educational Childcare Centre	Rossmore	38.1	38.5	38.4		0	0	0	0	0	0
R59	Community Centre	Bringelly Community Centre	Bringelly	39.4	40.0	40.0		0	1	1	0	0	0
R63	Community Centre	Luddenham Progress Hall	Luddenham	56.9	56.4	56.2		30	29	29	13	12	12
R64	Community Centre	Mulgoa Hall	Mulgoa	51.0	43.5	43.0		20	7	6	6	1	0
R65	School	Emmaus Catholic College	Kemps Creek	53.5	54.0	50.2		24	25	18	8	9	5
R66	School	University of Sydney Farms	Greendale	44.5	56.1	56.2		9	29	29	1	12	12
R68	School	Christadelphian Heritage College Sydney	Kemps Creek	42.2	42.0	40.3		5	4	2	0	0	0
R69	School	Mamre Anglican School	Kemps Creek	55.2	56.3	50.9		27	29	19	11	12	6
R72	School	Irfan College	Cecil Park	37.6	37.5	36.2		0	0	0	0	0	0
R73	School	Luddenham Public School	Luddenham	57.7	57.1	57.0		32	31	30	14	13	13
R74	School	Kemps Creek Public School	Kemps Creek	42.4	42.2	40.4		5	5	2	0	0	0
R75	School	Trinity Catholic Primary School	Kemps Creek	53.8	54.8	49.7		25	26	17	9	10	5
R76	School	Bringelly Public School	Bringelly	39.1	39.7	39.7		0	1	1	0	0	0
R78	School	Mulgoa Public School	Mulgoa	51.0	43.6	43.1		20	7	6	6	1	0
R79	School	Rossmore Public School	Rossmore	36.8	37.1	37.0		0	0	0	0	0	0
R80	School	Wallacia Public School	Wallacia	43.1	52.5	52.5		6	22	22	0	7	7
R82	School	Bellfield College - Junior Campus	Rossmore	37.1	37.4	37.4		0	0	0	0	0	0
R84	Park	Bringelly Park	Bringelly	39.5	40.2	40.2		0	2	2	0	0	0
R85	Park	Bents Basin State Conservation Reserve and Gulgue	Greendale	49.6	48.4	49.1		17	15	16	4	3	4
R86	Park	Blaxland Crossing Reserve	Wallacia	43.0	52.5	52.5		6	22	22	0	7	7
R87	Park	Bill Anderson Reserve	Kemps Creek	43.3	43.0	40.9		6	6	3	0	0	0
R91	Park	Western Sydney Parklands	Eastern Creek	52.2	48.5	51.7		22	15	21	7	4	6
R93	Park	Rossmore Grange	Rossmore	38.4	38.8	38.6		0	0	0	0	0	0
R94	Park	Freeburn Park	Luddenham	55.7	55.2	55.0		28	27	27	11	10	10
R95	Park	Overett Reserve	Kemps Creek	49.8	48.7	46.3		17	16	12	5	4	2
R97	Park	Mulgoa Park	Mulgoa	51.1	43.5	43.0		20	7	6	6	1	0
R98	Recreation	Wallacia Bowling and Recreation Club	Wallacia	43.5	55.5	55.5		7	28	28	1	11	11
R99	Recreation	Hubertus Country Club	Luddenham	60.2	60.3	60.4		36	37	37	18	18	18
R100	Recreation	Sugarloaf Cobbitty Equestrian Club	Cobbitty	40.9	54.2	54.2		3	25	25	0	9	9
R102	Recreation	Panthers Wallacia (country club)	Wallacia	43.1	53.5	53.6		6	24	24	0	8	9
R103	Recreation	Twin Creeks Gold and Country Club	Luddenham	59.2	50.8	48.3		35	19	15	16	6	3
R104	Recreation	Sydney International Shooting Centre	Cecil Park	37.6	37.6	36.6		0	0	0	0	0	0
R108	Recreation	Luddenham Showground	Luddenham	51.9	51.5	51.4		21	20	20	7	6	6
R109	Recreation	Kemps Creek Sporting and Bowling Club	Cecil Park	40.0	39.9	38.3		1	1	0	0	0	0
R110	Religious Facility	St James Luddenham	Luddenham	59.2	58.6	58.4		34	33	33	16	15	15
R111	Religious Facility	Lin Ying Temple	Rossmore	39.0	39.3	39.0		0	0	0	0	0	0
R112	Religious Facility	Vat Ketanak Khmer Kampuchea Krom	Rossmore	38.2	38.5	38.4		0	0	0	0	0	0

Calculation of %HA - 2055

				L_{den}				Annoyance as %HA			Annoyance as %HA (sensitivity)		
ID	Type	Area	Suburb	S1	S3	S4	Background	S1	S3	S4	S1	S3	S4
R114	Religious Facility	Anglican Church Sydney Diocese	Rossmore	37.1	37.4	37.4		0	0	0	0	0	0
R115	Religious Facility	Anglican Parish of Mulgoa	Mulgoa	52.2	43.3	42.8		22	7	6	7	0	0
R117	Religious Facility	Bringelly Vineyard Church	Bringelly	38.4	38.8	38.8		0	0	0	0	0	0
R120	Religious Facility	Our Lady Queen of Peace	Greystanes	26.6	26.3	26.2		0	0	0	0	0	0
R122	Religious Facility	St Anthony	Austral	35.6	35.9	35.5		0	0	0	0	0	0
R123	Religious Facility	St Marys Church	Mulgoa	48.2	43.7	43.4		15	7	7	3	1	0
R124	Religious Facility	Wallacia Christian Church	Wallacia	43.2	53.6	53.6		6	24	24	0	9	9
R126	Religious Facility	St Francis Xavier Church	Greendale	67.1	67.2	66.9		50	50	49	31	31	30
R127	Religious Facility	Luddenham Uniting Church	Luddenham	57.1	56.6	56.5		31	30	29	13	12	12
R131	Religious Facility	Science of the Soul Study Centre	Cecil Park	40.7	40.5	38.8		2	2	0	0	0	0
R132	Shopping Centre	Bringelly shops	Bringelly	39.0	39.6	39.6		0	1	1	0	0	0
R134	Shopping Centre	Kemps Creek shops	Kemps Creek	43.5	43.2	41.0		7	6	3	1	0	0
R135	Shopping Centre	Luddenham shops	Luddenham	60.7	60.2	60.0		37	36	36	19	18	17
R136	Shopping Centre	Mulgoa shops	Mulgoa	49.5	43.6	43.3		17	7	6	4	1	0
R137	Shopping Centre	Rossmore shops	Rossmore	36.8	37.1	37.0		0	0	0	0	0	0
R138	Shopping Centre	Wallacia Shops	Wallacia	43.0	54.0	54.1		6	25	25	0	9	9
R140	School	Holy Family Catholic Primary and Church	Luddenham	55.5	55.5	55.6		28	28	28	11	11	11
R141	Religious Facility	Edmund Rice Retreat and Conference Centre	Mulgoa	44.8	46.8	46.9		9	12	13	1	2	2
N1	Aged Care	CATHOLIC HEALTHCARE EMMAUS VILLAGE	Kemps Creek	51.9	52.6	48.3		21	22	15	7	7	3
N2	Aged Care	JOHN EDMONDSON VC GARDENS	Austral	35.7	36.0	35.6		0	0	0	0	0	0
N3	Aged Care	REGAL OAKS VILLAGE	Wallacia	43.0	54.7	54.8		6	26	26	0	10	10
N4	Aged Care	SCALABRINI VILLAGE AUSTRAL	Austral	35.9	36.0	35.9		0	0	0	0	0	0
N5	Aged Care	TOBRUK VILLAGE	Austral	35.7	36.0	35.6		0	0	0	0	0	0
N6	Childcare	BLAXLAND PRE-SCHOOL	Blaxland	39.6	40.7	36.9		1	2	0	0	0	0
N7	Childcare	GLENBROOK PRE-SCHOOL	Glenbrook	37.4	37.9	37.0		0	0	0	0	0	0
N8	Childcare	KEMPS CREEK CHILDRENS COTTAGE	Kemps Creek	39.8	39.8	39.0		1	1	0	0	0	0
N9	Childcare	LAPSTONE PRE-SCHOOL	Lapstone	37.5	37.0	36.5		0	0	0	0	0	0
N10	Childcare	MindChamps Early Learning & Preschool @ Kemps C	Kemps Creek	39.8	39.8	39.0		1	1	0	0	0	0
N11	Childcare	MY FIRST SCHOOL CHILDCARE CENTRE	St Marys	51.7	48.9	43.9		21	16	7	7	4	1
N12	Childcare	SILVERDALE CHILD CARE CENTRE	Silverdale	52.0	50.4	51.6		21	19	21	7	5	6
N13	Childcare	WARRAGAMBA PRE-SCHOOL	Warragamba	42.2	45.4	45.8		5	10	11	0	1	2
N14	Hospital	MINCHINBURY COMMUNITY HOSPITAL	Rooty Hill	39.8	37.9	38.5		1	0	0	0	0	0
N15	Hospital	MOUNT DRUITT HOSPITAL	Mount Druit	40.3	38.0	39.3		2	0	0	0	0	0
N16	Hospital	NEPEAN HOSPITAL	Kingswood	45.3	45.9	43.3		10	11	7	1	2	0
N17	Hospital	NEPEAN PRIVATE HOSPITAL	Kingswood	45.0	45.7	42.9		9	11	6	1	2	0
N18	Religious Facility	AUSTRAL CHURCH OF CHRIST	Austral	35.6	35.9	35.6		0	0	0	0	0	0
N19	Religious Facility	GOOD SHEPHERD CATHOLIC CHURCH	Hoxten Park	34.2	34.3	34.2		0	0	0	0	0	0
N20	Religious Facility	Grace West Anglican Church - Glenmore Park	Glenmore Park	41.8	39.4	42.0		4	0	5	0	0	0
N21	Religious Facility	Holy Family Church	Luddenham	55.3	55.3	55.4		27	27	28	11	11	11
N22	Religious Facility	HOLY SPIRIT CATHOLIC CHURCH	Horningsea Park	35.1	35.2	35.0		0	0	0	0	0	0
N23	Religious Facility	Holy Spirit Parish	St Clair	48.9	48.4	42.7		16	15	6	4	3	0
N24	Religious Facility	HOXTON PARK ANGLICAN CHURCH	West Hoxton	34.7	34.9	34.6		0	0	0	0	0	0
N25	Religious Facility	Imagine Nations Church	Orchard Hills	42.1	40.8	41.0		5	2	3	0	0	0
N26	Religious Facility	INSPIRE CHURCH	Hoxten Park	34.0	34.1	34.0		0	0	0	0	0	0
N27	Religious Facility	Mt Hope Uniting Church Orchard Hills	Orchard Hills	43.0	42.6	40.6		6	5	2	0	0	0
N28	Religious Facility	Orchard Hills Kingdom Hall of Jehovah's Witnesses	Orchard Hills	41.9	39.8	40.6		4	1	2	0	0	0
N29	Religious Facility	Samoan Methodist Church	Leppington	36.4	36.4	36.6		0	0	0	0	0	0
N30	Religious Facility	SIKH MISSION CENTRE	Austral	35.9	36.2	35.9		0	0	0	0	0	0
N31	Religious Facility	St Clair Anglican Church	St Clair	43.4	43.2	38.9		7	6	0	0	0	0
N32	Religious Facility	St Mary Mother of the Church	Leppington	36.3	36.4	36.4		0	0	0	0	0	0
N33	Religious Facility	ST ZAIA CATHEDRAL	Middleton Grange	34.6	34.8	34.4		0	0	0	0	0	0
N34	Religious Facility	Uniting Church St Clair	St Clair	45.9	45.7	40.4		11	11	2	2	2	0
N35	Religious Facility	WEST HOXTON COMMUNITY CHURCH	West Hoxton	35.0	35.2	34.7		0	0	0	0	0	0
N36	School	AL-FAISAL COLLEGE LIVERPOOL CAMPUS	Austral	36.4	36.6	36.1		0	0	0	0	0	0
N37	School	AUSTRAL PUBLIC SCHOOL	Austral	35.6	35.9	35.5		0	0	0	0	0	0
N38	School	AUSTRALIAN ISLAMIC COLLEGE OF SYDNEY SENIOR S	Mount Druit	41.2	38.6	40.4		3	0	2	0	0	0
N39	School	BANKS PUBLIC SCHOOL	St Clair	52.0	50.8	45.0		21	19	9	7	6	1
N40	School	BENNETT ROAD PUBLIC SCHOOL	Colyton	43.6	42.5	38.0		7	5	0	1	0	0
N41	School	BETHANY CATHOLIC PRIMARY SCHOOL	Glenmore Park	42.1	39.4	42.2		5	0	5	0	0	0
N42	School	BIDWILL PUBLIC SCHOOL	Bidwill	47.2	43.8	47.0		13	7	13	3	1	2
N43	School	BLACKETT PUBLIC SCHOOL	Blackett	42.2	39.5	41.8		5	0	4	0	0	0
N44	School	BLACKTOWN NORTH PUBLIC SCHOOL	Blacktown	31.4	30.3	30.3		0	0	0	0	0	0
N45	School	BLACKTOWN SOUTH PUBLIC SCHOOL	Blacktown	34.6	32.5	33.9		0	0	0	0	0	0
N46	School	BLACKTOWN TAFE COLLEGE	Blacktown	32.7	31.2	31.8		0	0	0	0	0	0
N47	School	BLACKTOWN WEST PUBLIC SCHOOL	Blacktown	38.1	35.4	37.5		0	0	0	0	0	0
N48	School	BLACKWELL PUBLIC SCHOOL	St Clair	50.5	51.0	44.9		19	20	9	5	6	1
N49	School	BLAXLAND EAST PUBLIC SCHOOL	Blaxland	39.4	40.5	36.5		0	2	0	0	0	0
N50	School	BLAXLAND HIGH SCHOOL	Warrimoo	41.7	42.7	38.6		4	6	0	0	0	0
N51	School	BLAXLAND PUBLIC SCHOOL	Blaxland	41.4	42.5	38.4		3	5	0	0	0	0
N52	School	CAMBRIDGE GARDENS PUBLIC SCHOOL	Cambridge Garden	41.1	40.9	37.7		3	3	0	0	0	0
N53	School	CAMBRIDGE PARK PUBLIC SCHOOL	Ceambridge Park	43.5	43.5	41.3		7	7	3	1	1	0
N54	School	CATHWEST INNOVATION COLLEGE MCCARTHY CAM	Emu Plains	42.2	43.5	37.9		5	7	0	0	1	0
N55	School	CECIL HILLS PUBLIC SCHOOL	Cecil Hills	34.6	34.5	34.1		0	0	0	0	0	0
N56	School	CHIFLEY COLLEGE BIDWILL CAMPUS	Bidwill	46.9	43.6	46.8		13	7	12	2	1	2
N57	School	CHIFLEY COLLEGE DUNHEVED CAMPUS	North St Marys	47.3	44.5	42.9		13	8	6	3	1	0
N58	School	CHIFLEY COLLEGE MOUNT DRUITT CAMPUS	Dharruk	40.9	38.6	40.0		3	0	1	0	0	0
N59	School	CHIFLEY COLLEGE SENIOR CAMPUS	Rooty Hill	40.1	37.9	39.0		1	0	0	0	0	0
N60	School	CHIFLEY COLLEGE SHALVEY CAMPUS	Shalvey	45.0	42.2	45.8		9	5	11	1	0	2
N61	School	CHRISTADELPHIAN HERITAGE COLLEGE SYDNEY	Kemps Creek	42.2	42.0	40.3		5	4	2	0	0	0
N62	School	CLAIRGATE PUBLIC SCHOOL	St Clair	43.0	42.7	38.4		6	6	0	0	0	0
N63	School	CLAREMONT MEADOWS PUBLIC SCHOOL	Claremont	48.4	48.2	43.0		15	15	6	3	3	0
N64	School	COLYTON HIGH SCHOOL	Colyton	42.0	40.7	36.9		4	2	0	0	0	0
N65	School	COLYTON PUBLIC SCHOOL	Mount Druit	39.1	37.8	36.2		0	0	0	0	0	0
N66	School	DAWSON PUBLIC SCHOOL	Dharruk	40.9	38.6	40.0		3	0	1	0	0	0
N67	School	EASTERN CREEK PUBLIC SCHOOL	Eastern Creek	50.3	46.8	49.9		18	12	18	5	2	5
N68	School	EASTERN CREEK PUBLIC SCHOOL PRESCHOOL	Eastern Creek	50.3	46.8	49.9		18	12	18	5	2	5
N69	School	EMERTON PUBLIC SCHOOL	Emerton	41.4	39.2	40.1		3	0	1	0	0	0
N70	School	EMU HEIGHTS PUBLIC SCHOOL	Emu Heights	41.3	42.6	37.3		3	5	0	0	0	0
N71	School	EMU PLAINS PUBLIC SCHOOL	Emu Plains	39.8	40.7	36.8		1	2	0	0	0	0
N72	School	ERSKINE PARK HIGH SCHOOL	Erskine Park	43.8	43.7	40.3		7	7	2	1	1	0
N73	School	GLENBROOK PUBLIC SCHOOL	Glenbrook	37.4	37.9	36.8		0	0	0	0	0	0
N74	School	GLENDENNING PUBLIC SCHOOL	Glendenning	48.8	45.2	48.4		16	10	15	4	1	3
N75	School	GLENMORE PARK PUBLIC SCHOOL	Glenmore Park	42.1	39.8	42.4		5	1	5	0	0	0
N76	School	GOOD SHEPHERD CATHOLIC PRIMARY SCHOOL	Hoxten Park	34.2	34.3	34.2		0	0	0	0	0	0
N77	School	GOOD SHEPHERD PRIMARY SCHOOL	Plumpton	45.8	42.5	45.4		11	5	10	2	0	1
N78	School	GREENWAY PARK PUBLIC SCHOOL	West Hoxton	35.1	35.3	35.0		0	0	0	0	0	0
N79	School	HASSALL GROVE PUBLIC SCHOOL	Hassall Grove	50.0	46.4	49.7		18	12	17	5	2	5
N80	School	HEBERSHAM PUBLIC SCHOOL	Hebersham	42.0	39.3	41.3		4	0	3	0	0	0
N81	School	HOLY FAMILY PRIMARY SCHOOL	Lethbridge Park	42.0	39.8	40.6		5	1	2	0	0	0

Calculation of %HA - 2055

				L_{den}				Annoyance as %HA			Annoyance as %HA (sensitivity)		
ID	Type	Area	Suburb	S1	S3	S4	Background	S1	S3	S4	S1	S3	S4
N82	School	HOLY SPIRIT PRIMARY SCHOOL	St Clair	49.1	48.6	42.9		16	16	6	4	4	0
N83	School	HOLY SPIRIT PRIMARY SCHOOL	Carnes Hill	35.0	35.2	35.0		0	0	0	0	0	0
N84	School	HORSLEY PARK PUBLIC SCHOOL	Horsley Park	40.9	38.5	40.2		3	0	2	0	0	0
N85	School	HOXTON PARK PUBLIC SCHOOL	Hoxten Park	34.7	34.8	34.5		0	0	0	0	0	0
N86	School	JAMES ERSKINE PUBLIC SCHOOL	Erskine Park	43.3	43.1	39.7		7	6	1	0	0	0
N87	School	JAMISON HIGH SCHOOL	South Penrith	42.8	41.7	43.0		6	4	6	0	0	0
N88	School	JAMISONTOWN PUBLIC SCHOOL	Jamisontown	41.2	40.3	41.2		3	2	3	0	0	0
N89	School	JORDAN SPRINGS PUBLIC SCHOOL	Jordan Springs	41.3	40.0	36.9		3	1	0	0	0	0
N90	School	KINGSWOOD PARK PUBLIC SCHOOL	Kingswood	46.3	46.6	44.7		12	12	9	2	2	1
N91	School	KINGSWOOD PUBLIC SCHOOL	Kingswood	46.5	46.8	44.8		12	12	9	2	2	1
N92	School	KINGSWOOD SOUTH PUBLIC SCHOOL	Kingswood	44.9	45.0	44.0		9	9	8	1	1	1
N93	School	LAPSTONE PUBLIC SCHOOL	Glenbrook	37.4	37.1	36.3		0	0	0	0	0	0
N94	School	LEONAY PUBLIC SCHOOL	Leonay	38.1	38.0	36.5		0	0	0	0	0	0
N95	School	LEPPINGTON PUBLIC SCHOOL	Leppington	36.1	36.2	36.2		0	0	0	0	0	0
N96	School	LETHBRIDGE PARK PUBLIC SCHOOL	Blackett	42.2	39.6	41.8		5	1	4	0	0	0
N97	School	LLANDILO PUBLIC SCHOOL	Llandilo	48.6	45.6	42.3		16	10	5	4	2	0
N98	School	LYNWOOD PARK PUBLIC SCHOOL	Blacktown	29.3	28.9	27.9		0	0	0	0	0	0
N99	School	MACARTHUR BUILDING INDUSTRY SKILLS CENTRE	Ingleburn	34.3	34.3	34.3		0	0	0	0	0	0
N100	School	MACQUARIE FIELDS TAFE COLLEGE	Macquarie Fields	34.1	34.0	34.2		0	0	0	0	0	0
N101	School	MADANG AVENUE PUBLIC SCHOOL	Whalan	40.2	38.3	36.9		2	0	0	0	0	0
N102	School	MALEK FAHD ISLAMIC SCHOOL HOXTON PARK	Hoxten Park	34.4	34.5	34.3		0	0	0	0	0	0
N103	School	MARAYONG HEIGHTS PUBLIC SCHOOL	Marayong	32.9	31.6	31.8		0	0	0	0	0	0
N104	School	MARAYONG PUBLIC SCHOOL	Marayong	35.3	33.1	34.5		0	0	0	0	0	0
N105	School	MIDDLETON GRANGE PUBLIC SCHOOL	Middleton Grange	34.3	34.5	34.1		0	0	0	0	0	0
N106	School	MINCHINBURY PUBLIC SCHOOL	Minchinbury	41.0	38.9	40.0		3	0	1	0	0	0
N107	School	MONTGROVE COLLEGE	Orchard Hills	44.0	43.7	43.4		8	7	7	1	1	0
N108	School	MOUNT DRUITT PUBLIC SCHOOL	Mount Druit	39.2	37.6	36.5		0	0	0	0	0	0
N109	School	MOUNT DRUITT PUBLIC SCHOOL PRESCHOOL	Mount Druit	39.3	37.6	36.6		0	0	0	0	0	0
N110	School	MOUNT DRUITT TAFE COLLEGE	Mount Druit	39.3	37.5	38.0		0	0	0	0	0	0
N111	School	MOUNT RIVERVIEW PUBLIC SCHOOL	Mount Riverview	42.2	43.4	38.0		5	7	0	0	0	0
N112	School	NEPEAN CHRISTIAN SCHOOL	Mulgoa	45.2	39.7	41.2		10	1	3	1	0	0
N113	School	NEPEAN CREATIVE AND PERFORMING ARTS HIGH S	Emu Plains	41.7	43.0	37.8		4	6	0	0	0	0
N114	School	NEPEAN TAFE COLLEGE KINGSWOOD CAMPUS	Kingswood	46.9	47.0	44.5		13	13	9	2	2	1
N115	School	NEPEAN TAFE COLLEGE PENRITH CAMPUS	Penrith	43.4	44.6	39.8		7	9	1	0	1	0
N116	School	NOUMEA PUBLIC SCHOOL	Lethbridge Park	44.6	41.8	45.3		9	4	10	1	0	1
N117	School	ORCHARD HILLS PUBLIC SCHOOL	Orchard Hills	43.1	42.7	40.6		6	6	2	0	0	0
N118	School	OUR LADY OF THE ROSARY PRIMARY SCHOOL	St Marys	51.1	48.3	43.2		20	15	6	6	3	0
N119	School	OUR LADY OF THE WAY PRIMARY SCHOOL	Emu Plains	39.2	40.0	36.5		0	1	0	0	0	0
N120	School	OXLEY PARK PUBLIC SCHOOL	Oxley Park	44.6	42.4	38.3		9	5	0	1	0	0
N121	School	PENOLA CATHOLIC COLLEGE EMU PLAINS	Emu Plains	42.2	43.6	38.0		5	7	0	0	1	0
N122	School	PENRITH ANGLICAN COLLEGE	Orchard Hills	42.3	39.2	38.7		5	0	0	0	0	0
N123	School	PENRITH CHRISTIAN SCHOOL	Orchard Hills	42.1	40.7	41.1		5	2	3	0	0	0
N124	School	PENRITH HIGH SCHOOL	Penrith	44.4	45.3	41.7		8	10	4	1	1	0
N125	School	PENRITH PUBLIC SCHOOL	Penrith	44.3	45.2	41.4		8	10	3	1	1	0
N126	School	PENRITH SOUTH PUBLIC SCHOOL	South Penrith	43.7	44.2	42.1		7	8	5	1	1	0
N127	School	PLUMPTON HIGH SCHOOL	Plumpton	45.9	42.6	45.5		11	5	10	2	0	1
N128	School	PLUMPTON PUBLIC SCHOOL	Plumpton	47.2	43.8	46.8		13	7	12	3	1	2
N129	School	REGENTVILLE PUBLIC SCHOOL	Regentville	40.3	38.7	40.3		2	0	2	0	0	0
N130	School	ROOTY HILL HIGH SCHOOL	Rooty Hill	42.5	39.7	41.9		5	1	4	0	0	0
N131	School	ROOTY HILL PUBLIC SCHOOL	Rooty Hill	43.8	40.7	43.3		7	2	7	1	0	0
N132	School	ROPES CROSSING PUBLIC SCHOOL	Ropes Crossing	47.6	44.8	46.0		14	9	11	3	1	2
N133	School	SACRED HEART PRIMARY SCHOOL	Mount Druit	39.1	37.8	36.2		0	0	0	0	0	0
N134	School	SHALVEY PUBLIC SCHOOL	Shalvey	46.4	43.3	47.2		12	7	13	2	0	3
N135	School	SHELLEY PUBLIC SCHOOL	Blacktown	31.9	30.5	31.0		0	0	0	0	0	0
N136	School	ST AIDAN'S PRIMARY SCHOOL	Rooty Hill	42.9	40.0	42.4		6	1	5	0	0	0
N137	School	ST ANDREWS PRIMARY SCHOOL	Quakers Hill	34.4	32.7	33.4		0	0	0	0	0	0
N138	School	ST ANTHONY OF PADUA CATHOLIC COLLEGE	Austral	35.7	36.0	35.6		0	0	0	0	0	0
N139	School	ST CLAIR HIGH SCHOOL	St Clair	46.6	45.8	40.5		12	11	2	2	2	0
N140	School	ST CLAIR PUBLIC SCHOOL	St Clair	47.3	47.1	41.5		13	13	4	3	2	0
N141	School	ST FINBAR'S PRIMARY SCHOOL	Glenbrook	37.5	38.1	36.4		0	0	0	0	0	0
N142	School	ST FRANCIS OF ASSISI PRIMARY SCHOOL	Glendenning	47.3	43.8	46.9		13	7	13	3	1	2
N143	School	ST JOSEPH'S PRIMARY SCHOOL	Kingswood	45.2	45.6	43.5		10	10	7	1	2	1
N144	School	ST MARY MACKILLOP PRIMARY SCHOOL	South Penrith	42.9	41.8	42.7		6	4	6	0	0	0
N145	School	ST MARYS NORTH PUBLIC SCHOOL	North St Marys	47.6	44.7	41.9		14	9	4	3	1	0
N146	School	ST MARYS PUBLIC SCHOOL	St Marys	51.3	48.3	43.5		20	15	7	6	3	1
N147	School	ST MARYS SENIOR HIGH SCHOOL	St Marys	51.1	48.0	43.5		20	14	7	6	3	1
N148	School	ST MARYS SOUTH PUBLIC SCHOOL	St Marys	50.0	47.9	42.6		18	14	5	5	3	0
N149	School	ST NICHOLAS OF MYRA PRIMARY SCHOOL	Penrith	43.8	44.9	40.7		7	9	2	1	1	0
N150	School	SURVEYORS CREEK PUBLIC SCHOOL	Glenmore Park	42.1	39.7	41.9		5	1	4	0	0	0
N151	School	THOMAS HASSALL ANGLICAN COLLEGE	Middleton Grange	34.6	34.9	34.4		0	0	0	0	0	0
N152	School	TREGEAR PUBLIC SCHOOL	Tregear	43.5	41.1	41.3		7	3	3	1	0	0
N153	School	UNITY GRAMMAR COLLEGE	Austral	36.0	36.2	36.0		0	0	0	0	0	0
N154	School	UNIVERSITY OF WESTERN SYDNEY PENRITH CAMPU	Kingswood	46.7	47.1	44.7		12	13	9	2	2	1
N155	School	UNIVERSITY OF WESTERN SYDNEY WERRINGTON NT	Werrington	47.6	46.7	44.6		14	12	9	3	2	1
N156	School	UNIVERSITY OF WESTERN SYDNEY WERRINGTON ST	Kingswood	47.3	47.4	43.9		13	13	7	3	3	1
N157	School	WALTERS ROAD PUBLIC SCHOOL	Blacktown	41.1	37.9	40.5		3	0	2	0	0	0
N158	School	WARRAGAMBA PUBLIC SCHOOL	Warragamba	42.4	45.2	45.7		5	10	11	0	1	2
N159	School	WARRIMOO PUBLIC SCHOOL	Warrimoo	42.1	42.6	39.0		5	5	0	0	0	0
N160	School	WERRINGTON COUNTY PUBLIC SCHOOL	Werrington County	46.9	45.0	44.1		13	9	8	2	1	1
N161	School	WERRINGTON PUBLIC SCHOOL	Werrington	47.2	45.7	45.1		13	11	10	3	2	1
N162	School	WETHERILL PARK TAFE COLLEGE	Wetherill Park	29.7	29.1	29.3		0	0	0	0	0	0
N163	School	WHALAN PUBLIC SCHOOL	Whalan	40.0	38.0	37.8		1	0	0	0	0	0
N164	School	WILLIAM DEAN PUBLIC SCHOOL	Dean Park	43.2	40.0	42.7		6	1	6	0	0	0
N165	School	WILLMOT PUBLIC SCHOOL	Willmot	46.0	43.2	45.7		11	6	10	2	0	2
N166	School	YORK PUBLIC SCHOOL	South Penrith	42.6	41.4	42.9		5	3	6	0	0	0
N167	Aged Care	AQUINAS COURT	Springwood	37.8	38.1	37.8		0	0	0	0	0	0
N168	Aged Care	BAPTISTCARE MORVEN GARDENS CENTRE	Leura	32.2	33.1	32.9		0	0	0	0	0	0
N169	Aged Care	BLUE MOUNTAINS RETIREMENT VILLAGE	Leura	32.2	33.0	32.4		0	0	0	0	0	0
N170	Aged Care	BUCKLAND	Springwood	37.3	37.4	36.8		0	0	0	0	0	0
N171	Aged Care	MARTYN CLAVER AGED CARE	Leura	32.3	33.2	33.1		0	0	0	0	0	0
N172	Aged Care	WINGARA HAMLET	Springwood	38.4	39.2	39.2		0	0	0	0	0	0
N173	Childcare	CHILDRENS HOUSE MONTESSORI CHILD CARE	Faulconbridge	41.2	42.3	43.0		3	5	6	0	0	0
N174	Childcare	KATOOMBA LEURA PRE-SCHOOL	Katoomba	33.4	33.9	33.7		0	0	0	0	0	0
N175	Childcare	KEMPS CREEK CHILDRENS COTTAGE	Kemps Creek	39.8	39.8	39.0		1	1	0	0	0	0
N176	Childcare	LAPSTONE PRE-SCHOOL	Lapstone	37.5	37.0	36.5		0	0	0	0	0	0
N177	Hospital	BLUE MOUNTAINS DISTRICT ANZAC MEMORIAL HO	Katoomba	32.2	32.9	32.3		0	0	0	0	0	0
N178	Hospital	SPRINGWOOD HOSPITAL	Springwood	37.2	37.5	37.3		0	0	0	0	0	0
N179	Recreation	ECHO POINT LOOKOUT	Katoomba	36.0	36.8	37.0		0	0	0	0	0	0
N180	Religious Facility	ANGLICAN	Leura	32.6	33.4	33.2		0	0	0	0	0	0

Calculation of %HA - 2055

				L_{den}				Annoyance as %HA			Annoyance as %HA (sensitivity)		
ID	Type	Area	Suburb	S1	S3	S4	Background	S1	S3	S4	S1	S3	S4
N181	Religious Facility	ANGLICAN	Katoomba	33.1	33.7	33.4		0	0	0	0	0	0
N182	Religious Facility	BAPTIST	Katoomba	33.6	34.2	34.0		0	0	0	0	0	0
N183	Religious Facility	BAPTIST	Leura	32.3	33.1	32.7		0	0	0	0	0	0
N184	Religious Facility	UNITING	Springwood	38.7	39.6	39.9		0	1	1	0	0	0
N185	School	BLUE MOUNTAINS STEINER SCHOOL	Hazelbrook	38.7	39.6	40.2		0	1	2	0	0	0
N186	School	ELLISON PUBLIC SCHOOL	Springwood	37.0	37.1	36.2		0	0	0	0	0	0
N187	School	FAULCONBRIDGE PUBLIC SCHOOL	Faulconbridge	39.5	40.2	40.7		0	1	2	0	0	0
N188	School	HAZELBROOK PUBLIC SCHOOL	Hazelbrook	37.4	38.0	38.5		0	0	0	0	0	0
N189	School	KATOOMBA HIGH SCHOOL	Katoomba	35.1	35.8	35.9		0	0	0	0	0	0
N190	School	KATOOMBA NORTH PUBLIC SCHOOL	Katoomba	32.2	33.0	31.8		0	0	0	0	0	0
N191	School	KATOOMBA PUBLIC SCHOOL	Katoomba	33.7	34.4	34.3		0	0	0	0	0	0
N192	School	KINGSWOOD PARK PUBLIC SCHOOL	Kingswood	46.3	46.6	44.7		12	12	9	2	2	1
N193	School	KINGSWOOD PUBLIC SCHOOL	Kingswood	46.5	46.8	44.8		12	12	9	2	2	1
N194	School	KINGSWOOD SOUTH PUBLIC SCHOOL	Kingswood	44.9	45.0	44.0		9	9	8	1	1	1
N195	School	LAPSTONE PUBLIC SCHOOL	Glenbrook	37.4	37.1	36.3		0	0	0	0	0	0
N196	School	LAWSON PUBLIC SCHOOL	Lawson	34.0	35.1	35.3		0	0	0	0	0	0
N197	School	LEURA PUBLIC SCHOOL	Leura	32.2	33.1	32.8		0	0	0	0	0	0
N198	School	OUR LADY OF THE NATIVITY PRIMARY SCHOOL	Lawson	35.0	35.9	36.3		0	0	0	0	0	0
N199	School	SPRINGWOOD HIGH SCHOOL	Faulconbridge	38.7	39.2	39.6		0	0	1	0	0	0
N200	School	SPRINGWOOD PUBLIC SCHOOL	Springwood	38.6	38.8	38.1		0	0	0	0	0	0
N201	School	ST CANICES PRIMARY SCHOOL	Katoomba	33.4	33.9	33.7		0	0	0	0	0	0
N202	School	ST THOMAS AQUINAS PRIMARY SCHOOL	Springwood	36.9	37.0	35.7		0	0	0	0	0	0
N203	School	WENTWORTH FALLS PUBLIC SCHOOL	Wentworth Falls	31.9	33.0	32.9		0	0	0	0	0	0

Appendix G

Calculation of health impacts from noise – Cognitive impairment

Calculation of cognitive impairment (children) - 2033

				L_{den}				Cognitive impairment (days of delay)			
ID	Type	Area	Suburb	Background	S1	S3	S4	Background	S1	S3	S4
M01	Noise Monitoring Termi	South West Departure (Wallacia)	Wallacia	56.3	58.7	58.3	58.4	11	34	30	30
M02	Noise Monitoring Termi	North East Departure	Kemps Creek	60.4	57.0	54.2	56.6	49	18	0	14
M03	Noise Monitoring Termi	North East Runway	Orchard Hills	65.2	49.3	49.9	43.3	91	0	0	0
M04	Noise Monitoring Termi	Twin Creeks	Luddenham	52.3	54.1	47.3	44.0	0	0	0	0
M06	Noise Monitoring Termi	Mount Vernon	Mount Vernon	57.0	40.7	40.9	37.9	18	0	0	0
M07	Noise Monitoring Termi	Kemps Creek Nature Reserve	Kemps Creek	56.4	35.0	35.4	33.8	13	0	0	0
M08	Noise Monitoring Termi	Luddenham	Luddenham	65.2	44.8	41.5	41.5	92	0	0	0
M09	Noise Monitoring Termi	Penrith	Penrith	51.8	39.3	40.5	35.4	0	0	0	0
M10	Noise Monitoring Termi	Glenmore Park	Glenmore Park	56.5	38.4	35.2	36.9	14	0	0	0
M11	Noise Monitoring Termi	Oxley Park	Oxley Park	69.0	39.9	39.6	34.8	126	0	0	0
M12	Noise Monitoring Termi	St. Marys	St. Marys	55.9	47.2	46.5	40.4	8	0	0	0
M13	Noise Monitoring Termi	Rooty Hill	Rooty Hill	54.5	42.5	39.6	41.8	0	0	0	0
M14	Noise Monitoring Termi	St. Clair	St. Clair	57.3	48.1	48.5	41.9	20	0	0	0
M15	Noise Monitoring Termi	Erskine Park	Erskine Park	57.2	44.5	45.6	39.5	20	0	0	0
M16	Noise Monitoring Termi	Sydney International Equestrian Centre	Horsley Park	57.5	32.3	31.9	31.0	22	0	0	0
M17	Noise Monitoring Termi	Wallacia	Wallacia	53.9	39.9	48.6	48.7	0	0	0	0
M18	Noise Monitoring Termi	Warragamba	Warragamba	53.4	37.8	41.3	41.9	0	0	0	0
M19	Noise Monitoring Termi	Greendale	Greendale	53.0	58.0	57.3	58.3	0	27	21	29
M20	Noise Monitoring Termi	Bringelly	Bringelly	52.9	39.3	40.3	40.5	0	0	0	0
M21	Noise Monitoring Termi	Bents Basin	Greendale	60.9	56.8	55.9	56.3	53	16	8	12
M22	Noise Monitoring Termi	Silverdale	Silverdale	52.6	58.8	58.7	58.4	0	34	33	31
M23	Noise Monitoring Termi	Werombi	Werombi	56.5	38.0	36.8	37.0	14	0	0	0
M24	Noise Monitoring Termi	Blaxland	Blaxland	50.5	37.5	38.5	35.1	0	0	0	0
M25	Noise Monitoring Termi	Linden	Linden	51.6	41.1	42.8	43.9	0	0	0	0
M26	Noise Monitoring Termi	North Richmond	North Richmond	52.3	28.6	27.8	26.5	0	0	0	0
M27	Noise Monitoring Termi	Kurrajong	Kurrajong	52.0	25.7	24.5	24.1	0	0	0	0
M28	Noise Monitoring Termi	The Oaks	The Oaks	55.0	35.0	36.6	37.0	0	0	0	0
M29	Noise Monitoring Termi	Lake Burragorang (Natai, Brownlow Hill)	Nattai	50.5	37.4	34.1	37.4	0	0	0	0
M30	Noise Monitoring Termi	Tahmoor	Tahmoor	0.0	29.7	33.5	34.8		0	0	0
R1	Residential	Bringelly	Bringelly		35.1	35.7	35.7		0	0	0
R2	Residential	Luddenham	Luddenham		46.4	46.0	46.0		0	0	0
R3	Residential	Greendale, Greendale Road	Greendale		52.3	57.9	58.2		0	26	29
R6	Residential	Kemps Creek	Kemps Creek		46.1	39.5	39.5		0	0	0
R7	Residential	Wallacia	Wallacia		40.0	49.3	49.4		0	0	0
R8	Residential	Twin Creeks, Cnr Twin Ck Drie & Humewood Place	Luddenham		56.7	50.7	47.4		15	0	0
R14	Residential	Lawson Road, Badgerys Creek	Badgerys Creek		51.5	50.5	46.5		0	0	0
R15	Residential	Mersey Rd, Greendale	Greendale		42.1	42.6	42.7		0	0	0
R17	Residential	Luddenham Road	Luddenham		51.0	48.6	47.5		0	0	0
R18	Residential	Cnr Adams & Elizabeth Drive	Luddenham		54.8	54.7	54.7		0	0	0
R19	Residential	Cnr Adams & Anton Road	Luddenham		53.4	53.5	53.5		0	0	0
R21	Residential	Cnr Willowdene Ave and Vicar Park Lane	Luddenham		64.4	66.4	67.1		85	103	109
R22	Residential	Rossmore, Victor Ave	Rossmore		39.0	39.2	38.4		0	0	0
R23	Residential	Wallacia, Greendale Road	Wallacia		44.0	55.2	55.3		0	2	3
R24	On-Site	Badgerys Creek 1 NE			55.1	54.0	52.2		1	0	0
R25	On-Site	Badgerys Creek 2 SW			56.2	56.7	57.1		11	15	18
R27	Residential	Greendale, Dwyer Rd	Greendale		41.9	44.1	44.4		0	0	0
R30	Residential	Rossmore residential	Rossmore		32.4	32.8	32.5		0	0	0
R31	Residential	Mt Vernon residential	Mount Vernon		39.8	39.9	37.2		0	0	0
R34	Aged Care	Emmaus Residential Aged Care	Kemps Creek		48.0	49.0	44.0		0	0	0
R35	Childcare	Mamre After School and Vacation Care	Kemps Creek		51.0	52.3	46.3		0	0	0
R37	Childcare	Schoolies at Mulgoa	Luddenham		52.3	52.3	52.6		0	0	0
R38	Childcare	Do-re-mi Day Care Centre	Mount Vernon		38.7	38.9	35.9		0	0	0
R39	Childcare	Little Amigos Austral Early Learning Centre	Austral		31.3	31.9	30.9		0	0	0
R40	Childcare	Little Smarties Childcare Centre	Kemps Creek		51.0	52.2	46.4		0	0	0
R41	Childcare	The Grove Academy	Kemps Creek		36.0	36.4	34.9		0	0	0
R42	Childcare	Horsley Kids	Horsley Park		36.6	35.0	35.8		0	0	0
R44	Childcare	Bringelly Child Care Centre	Bringelly		40.6	41.9	42.2		0	0	0
R46	Childcare	Chementson Drive Early Educational Centre	Rossmore		36.1	36.5	35.9		0	0	0
R48	Childcare	Kids Korner West Hoxton Early Learning Centre	Austral		31.1	31.8	30.3		0	0	0
R49	Childcare	Luddenham Child Care Centre	Luddenham		50.2	49.9	49.9		0	0	0
R52	Childcare	The Frogs Lodge	Austral		31.2	31.9	30.7		0	0	0
R54	Childcare	Mulgoa Preschool	Mulgoa		48.1	39.4	39.2		0	0	0
R55	Childcare	Jillys Educational Childcare Centre	Rossmore		34.3	34.7	34.3		0	0	0
R59	Community Centre	Bringelly Community Centre	Bringelly		35.6	36.2	36.2		0	0	0
R63	Community Centre	Luddenham Progress Hall	Luddenham		53.5	53.2	53.2		0	0	0
R64	Community Centre	Mulgoa Hall	Mulgoa		47.5	39.4	39.3		0	0	0
R65	School	Emmaus Catholic College	Kemps Creek		49.4	50.3	45.8		0	0	0
R66	School	University of Sydney Farms	Greendale		40.5	52.1	52.2		0	0	0
R68	School	Christadelphian Heritage College Sydney	Kemps Creek		38.6	38.8	36.2		0	0	0
R69	School	Mamre Anglican School	Kemps Creek		51.0	52.3	46.4		0	0	0
R72	School	Irfan College	Cecil Park		33.7	34.2	31.8		0	0	0
R73	School	Luddenham Public School	Luddenham		54.3	54.0	53.9		0	0	0
R74	School	Kemps Creek Public School	Kemps Creek		38.7	38.9	36.4		0	0	0
R75	School	Trinity Catholic Primary School	Kemps Creek		49.7	50.9	45.2		0	0	0
R76	School	Bringelly Public School	Bringelly		35.2	35.8	35.9		0	0	0
R78	School	Mulgoa Public School	Mulgoa		47.5	39.5	39.3		0	0	0
R79	School	Rossmore Public School	Rossmore		32.4	32.7	32.6		0	0	0
R80	School	Wallacia Public School	Wallacia		39.9	48.2	48.3		0	0	0
R82	School	Bellfield College - Junior Campus	Rossmore		32.9	33.3	33.0		0	0	0
R84	Park	Bringelly Park	Bringelly		35.7	36.3	36.4		0	0	0
R85	Park	Bents Basin State Conservation Reserve and Gulguer	Greendale		45.5	44.1	45.2		0	0	0
R86	Park	Blaxland Crossing Reserve	Wallacia		39.8	48.2	48.3		0	0	0
R87	Park	Bill Anderson Reserve	Kemps Creek		39.6	39.7	36.9		0	0	0
R91	Park	Western Sydney Parklands	Eastern Creek		47.0	43.6	46.9		0	0	0
R93	Park	Rossmore Grange	Rossmore		34.5	35.0	34.7		0	0	0
R94	Park	Freeburn Park	Luddenham		52.3	52.0	52.0		0	0	0

Calculation of cognitive impairment (children) - 2033

				L_{den}				Cognitive impairment (days of delay)			
ID	Type	Area	Suburb	Background	S1	S3	S4	Background	S1	S3	S4
R95	Park	Overett Reserve	Kemps Creek		46.2	45.7	42.5		0	0	0
R97	Park	Mulgoa Park	Mulgoa		47.5	39.4	39.3		0	0	0
R98	Recreation	Wallacia Bowling and Recreation Club	Wallacia		40.3	51.1	51.2		0	0	0
R99	Recreation	Hubertus Country Club	Luddenham		56.6	56.6	56.5		14	14	13
R100	Recreation	Sugarloaf Cobbitty Equestrian Club	Cobbitty		36.6	50.4	50.4		0	0	0
R102	Recreation	Panthers Wallacia (country club)	Wallacia		39.9	49.2	49.4		0	0	0
R103	Recreation	Twin Creeks Gold and Country Club	Luddenham		53.5	46.8	43.4		0	0	0
R104	Recreation	Sydney International Shooting Centre	Cecil Park		33.7	34.3	32.2		0	0	0
R108	Recreation	Luddenham Showground	Luddenham		48.5	48.3	48.4		0	0	0
R109	Recreation	Kemps Creek Sporting and Bowling Club	Cecil Park		36.3	36.6	34.1		0	0	0
R110	Religious Facility	St James Luddenham	Luddenham		55.7	55.4	55.4		7	4	4
R111	Religious Facility	Lin Ying Temple	Rossmore		35.3	35.7	35.0		0	0	0
R112	Religious Facility	Vat Ketanak Khmer Kampuchea Krom	Rossmore		34.3	34.7	34.4		0	0	0
R114	Religious Facility	Anglican Church Sydney Diocese	Rossmore		32.9	33.2	33.1		0	0	0
R115	Religious Facility	Anglican Parish of Mulgoa	Mulgoa		48.4	39.2	39.0		0	0	0
R117	Religious Facility	Bringelly Vineyard Church	Bringelly		34.4	34.8	34.8		0	0	0
R120	Religious Facility	Our Lady Queen of Peace	Greystanes		22.3	22.7	21.4		0	0	0
R122	Religious Facility	St Anthony	Austral		31.3	31.9	30.8		0	0	0
R123	Religious Facility	St Marys Church	Mulgoa		44.8	39.5	39.7		0	0	0
R124	Religious Facility	Wallacia Christian Church	Wallacia		40.0	49.3	49.4		0	0	0
R126	Religious Facility	St Francis Xavier Church	Greendale		62.2	62.3	62.1		65	66	64
R127	Religious Facility	Luddenham Uniting Church	Luddenham		53.7	53.4	53.5		0	0	0
R131	Religious Facility	Science of the Soul Study Centre	Cecil Park		37.0	37.3	34.7		0	0	0
R132	Shopping Centre	Bringelly shops	Bringelly		35.1	35.7	35.7		0	0	0
R134	Shopping Centre	Kemps Creek shops	Kemps Creek		39.8	40.0	37.0		0	0	0
R135	Shopping Centre	Luddenham shops	Luddenham		57.3	57.0	57.0		21	18	18
R136	Shopping Centre	Mulgoa shops	Mulgoa		46.1	39.5	39.5		0	0	0
R137	Shopping Centre	Rossmore shops	Rossmore		32.4	32.8	32.5		0	0	0
R138	Shopping Centre	Wallacia Shops	Wallacia		39.8	49.7	49.8		0	0	0
R140	School	Holy Family Catholic Primary and Church	Luddenham		52.2	52.2	52.6		0	0	0
R141	Religious Facility	Edmund Rice Retreat and Conference Centre	Mulgoa		41.5	42.6	42.9		0	0	0
N1	Aged Care	CATHOLIC HEALTHCARE EMMAUS VILLAGE	Kemps Creek		48.0	49.0	44.0		0	0	0
N2	Aged Care	JOHN EDMONDSON VC GARDENS	Austral		31.3	31.9	30.8		0	0	0
N3	Aged Care	REGAL OAKS VILLAGE	Wallacia		39.8	50.4	50.5		0	0	0
N4	Aged Care	SCALABRINI VILLAGE AUSTRAL	Austral		31.0	31.5	30.8		0	0	0
N5	Aged Care	TOBRUK VILLAGE	Austral		31.2	31.8	30.8		0	0	0
N6	Childcare	BLAXLAND PRE-SCHOOL	Blaxland		36.4	37.4	33.7		0	0	0
N7	Childcare	GLENBROOK PRE-SCHOOL	Glenbrook		34.4	34.3	33.8		0	0	0
N8	Childcare	KEMPS CREEK CHILDRENS COTTAGE	Kemps Creek		36.1	36.4	34.9		0	0	0
N9	Childcare	LAPSTONE PRE-SCHOOL	Lapstone		34.4	33.5	33.3		0	0	0
N10	Childcare	MindChamps Early Learning & Preschool @ Kemps C	Kemps Creek		36.1	36.4	34.9		0	0	0
N11	Childcare	MY FIRST SCHOOL CHILDCARE CENTRE	St Marys		46.4	45.6	39.8		0	0	0
N12	Childcare	SILVERDALE CHILD CARE CENTRE	Silverdale		48.0	46.0	47.8		0	0	0
N13	Childcare	WARRAGAMBA PRE-SCHOOL	Warragamba		38.5	40.8	41.6		0	0	0
N14	Hospital	MINCHINBURY COMMUNITY HOSPITAL	Rooty Hill		35.7	35.1	34.0		0	0	0
N15	Hospital	MOUNT DRUITT HOSPITAL	Mount Druit		35.8	34.9	34.6		0	0	0
N16	Hospital	NEPEAN HOSPITAL	Kingswood		41.1	42.0	38.6		0	0	0
N17	Hospital	NEPEAN PRIVATE HOSPITAL	Kingswood		40.9	41.8	38.2		0	0	0
N18	Religious Facility	AUSTRAL CHURCH OF CHRIST	Austral		31.2	31.8	30.8		0	0	0
N19	Religious Facility	GOOD SHEPHERD CATHOLIC CHURCH	Hoxten Park		28.8	29.4	28.4		0	0	0
N20	Religious Facility	Grace West Anglican Church - Glenmore Park	Glenmore Park		37.6	35.2	37.3		0	0	0
N21	Religious Facility	Holy Family Church	Luddenham		52.0	52.1	52.4		0	0	0
N22	Religious Facility	HOLY SPIRIT CATHOLIC CHURCH	Horningsea Park		30.0	30.6	29.5		0	0	0
N23	Religious Facility	Holy Spirit Parish	St Clair		44.8	45.4	39.1		0	0	0
N24	Religious Facility	HOXTON PARK ANGLICAN CHURCH	West Hoxton		29.8	30.5	29.2		0	0	0
N25	Religious Facility	Imagine Nations Church	Orchard Hills		38.2	37.4	36.5		0	0	0
N26	Religious Facility	INSPIRE CHURCH	Hoxten Park		28.5	29.0	28.1		0	0	0
N27	Religious Facility	Mt Hope Uniting Church Orchard Hills	Orchard Hills		39.3	39.4	36.4		0	0	0
N28	Religious Facility	Orchard Hills Kingdom Hall of Jehovah's Witnesses	Orchard Hills		37.9	36.2	36.1		0	0	0
N29	Religious Facility	Samoan Methodist Church	Leppington		31.1	31.2	31.3		0	0	0
N30	Religious Facility	SIKH MISSION CENTRE	Austral		31.5	32.0	31.2		0	0	0
N31	Religious Facility	St Clair Anglican Church	St Clair		39.8	40.5	35.3		0	0	0
N32	Religious Facility	St Mary Mother of the Church	Leppington		31.3	31.6	31.3		0	0	0
N33	Religious Facility	ST ZAIA CATHEDRAL	Middleton Grange		30.2	30.9	29.4		0	0	0
N34	Religious Facility	Uniting Church St Clair	St Clair		42.1	42.9	37.0		0	0	0
N35	Religious Facility	WEST HOXTON COMMUNITY CHURCH	West Hoxton		30.6	31.3	29.8		0	0	0
N36	School	AL-FAISAL COLLEGE LIVERPOOL CAMPUS	Austral		32.5	33.1	31.7		0	0	0
N37	School	AUSTRAL PUBLIC SCHOOL	Austral		31.1	31.8	30.7		0	0	0
N38	School	AUSTRALIAN ISLAMIC COLLEGE OF SYDNEY SENIOR S	Mount Druit		36.5	35.2	35.6		0	0	0
N39	School	BANKS PUBLIC SCHOOL	St Clair		47.2	47.3	40.9		0	0	0
N40	School	BENNETT ROAD PUBLIC SCHOOL	Colyton		39.7	40.0	34.7		0	0	0
N41	School	BETHANY CATHOLIC PRIMARY SCHOOL	Glenmore Park		37.8	35.3	37.4		0	0	0
N42	School	BIDWILL PUBLIC SCHOOL	Bidwill		42.1	39.2	42.0		0	0	0
N43	School	BLACKETT PUBLIC SCHOOL	Blackett		37.4	36.0	37.0		0	0	0
N44	School	BLACKTOWN NORTH PUBLIC SCHOOL	Blacktown		27.6	28.1	26.2		0	0	0
N45	School	BLACKTOWN SOUTH PUBLIC SCHOOL	Blacktown		29.7	29.2	29.2		0	0	0
N46	School	BLACKTOWN TAFE COLLEGE	Blacktown		28.4	28.4	27.4		0	0	0
N47	School	BLACKTOWN WEST PUBLIC SCHOOL	Blacktown		32.8	31.4	32.7		0	0	0
N48	School	BLACKWELL PUBLIC SCHOOL	St Clair		46.4	47.5	41.0		0	0	0
N49	School	BLAXLAND EAST PUBLIC SCHOOL	Blaxland		36.2	37.2	33.4		0	0	0
N50	School	BLAXLAND HIGH SCHOOL	Warrimoo		38.0	39.0	35.0		0	0	0
N51	School	BLAXLAND PUBLIC SCHOOL	Blaxland		37.7	38.8	34.9		0	0	0
N52	School	CAMBRIDGE GARDENS PUBLIC SCHOOL	Cambridge Gardens		37.4	38.0	34.0		0	0	0
N53	School	CAMBRIDGE PARK PUBLIC SCHOOL	Ceambridge Park		39.6	40.2	37.0		0	0	0
N54	School	CATHWEST INNOVATION COLLEGE MCCARTHY CAMI	Emu Plains		38.4	39.7	34.1		0	0	0
N55	School	CECIL HILLS PUBLIC SCHOOL	Cecil Hills		30.0	30.6	29.0		0	0	0

Calculation of cognitive impairment (children) - 2033

				L_{den}				Cognitive impairment (days of delay)			
ID	Type	Area	Suburb	Background	S1	S3	S4	Background	S1	S3	S4
N56	School	CHIFLEY COLLEGE BIDWILL CAMPUS	Bidwill		41.8	39.0	41.8		0	0	0
N57	School	CHIFLEY COLLEGE DUNHEVED CAMPUS	North St Marys		42.5	41.6	38.6		0	0	0
N58	School	CHIFLEY COLLEGE MOUNT DRUITT CAMPUS	Dharruk		36.4	35.5	35.3		0	0	0
N59	School	CHIFLEY COLLEGE SENIOR CAMPUS	Rooty Hill		35.7	34.9	34.4		0	0	0
N60	School	CHIFLEY COLLEGE SHALVEY CAMPUS	Shalvey		40.1	38.1	40.8		0	0	0
N61	School	CHRISTADELPHIAN HERITAGE COLLEGE SYDNEY	Kemps Creek		38.5	38.7	36.2		0	0	0
N62	School	CLAIRGATE PUBLIC SCHOOL	St Clair		39.4	40.1	34.9		0	0	0
N63	School	CLAREMONT MEADOWS PUBLIC SCHOOL	Claremont		44.1	44.7	38.9		0	0	0
N64	School	COLYTON HIGH SCHOOL	Colyton		38.1	38.3	33.5		0	0	0
N65	School	COLYTON PUBLIC SCHOOL	Mount Druit		35.3	35.4	32.3		0	0	0
N66	School	DAWSON PUBLIC SCHOOL	Dharruk		36.3	35.4	35.3		0	0	0
N67	School	EASTERN CREEK PUBLIC SCHOOL	Eastern Creek		46.1	42.8	45.4		0	0	0
N68	School	EASTERN CREEK PUBLIC SCHOOL PRESCHOOL	Eastern Creek		46.2	42.8	45.4		0	0	0
N69	School	EMERTON PUBLIC SCHOOL	Emerton		37.0	36.2	35.5		0	0	0
N70	School	EMU HEIGHTS PUBLIC SCHOOL	Emu Heights		37.7	39.0	33.7		0	0	0
N71	School	EMU PLAINS PUBLIC SCHOOL	Emu Plains		36.5	37.4	33.4		0	0	0
N72	School	ERSKINE PARK HIGH SCHOOL	Erskine Park		40.2	40.9	36.5		0	0	0
N73	School	GLENBROOK PUBLIC SCHOOL	Glenbrook		34.4	34.4	33.7		0	0	0
N74	School	GLENDENNING PUBLIC SCHOOL	Glendenning		43.6	40.4	43.4		0	0	0
N75	School	GLENMORE PARK PUBLIC SCHOOL	Glenmore Park		37.8	35.7	37.6		0	0	0
N76	School	GOOD SHEPHERD CATHOLIC PRIMARY SCHOOL	Hoxten Park		28.8	29.4	28.4		0	0	0
N77	School	GOOD SHEPHERD PRIMARY SCHOOL	Plumpton		40.6	38.0	40.3		0	0	0
N78	School	GREENWAY PARK PUBLIC SCHOOL	West Hoxton		30.2	30.9	29.7		0	0	0
N79	School	HASSALL GROVE PUBLIC SCHOOL	Hassall Grove		44.8	41.6	44.6		0	0	0
N80	School	HEBERSHAM PUBLIC SCHOOL	Hebersham		37.1	35.6	36.5		0	0	0
N81	School	HOLY FAMILY PRIMARY SCHOOL	Lethbridge Park		37.6	36.9	36.1		0	0	0
N82	School	HOLY SPIRIT PRIMARY SCHOOL	St Clair		44.9	45.6	39.3		0	0	0
N83	School	HOLY SPIRIT PRIMARY SCHOOL	Carnes Hill		30.0	30.6	29.5		0	0	0
N84	School	HORSLEY PARK PUBLIC SCHOOL	Horsley Park		36.2	34.6	35.4		0	0	0
N85	School	HOXTON PARK PUBLIC SCHOOL	Hoxten Park		29.6	30.3	29.1		0	0	0
N86	School	JAMES ERSKINE PUBLIC SCHOOL	Erskine Park		39.7	40.3	35.8		0	0	0
N87	School	JAMISON HIGH SCHOOL	South Penrith		38.6	38.1	38.1		0	0	0
N88	School	JAMISONTOWN PUBLIC SCHOOL	Jamisontown		37.2	36.7	36.6		0	0	0
N89	School	JORDAN SPRINGS PUBLIC SCHOOL	Jordan Springs		37.2	37.3	33.2		0	0	0
N90	School	KINGSWOOD PARK PUBLIC SCHOOL	Kingswood		42.0	42.7	39.8		0	0	0
N91	School	KINGSWOOD PUBLIC SCHOOL	Kingswood		42.2	42.9	39.9		0	0	0
N92	School	KINGSWOOD SOUTH PUBLIC SCHOOL	Kingswood		40.8	41.3	39.1		0	0	0
N93	School	LAPSTONE PUBLIC SCHOOL	Glenbrook		34.3	33.7	33.2		0	0	0
N94	School	LEONAY PUBLIC SCHOOL	Leonay		34.9	34.7	33.2		0	0	0
N95	School	LEPPINGTON PUBLIC SCHOOL	Leppington		31.0	31.4	30.9		0	0	0
N96	School	LETHBRIDGE PARK PUBLIC SCHOOL	Blackett		37.4	36.0	37.0		0	0	0
N97	School	LLANDILO PUBLIC SCHOOL	Llandilo		43.5	42.3	37.8		0	0	0
N98	School	LYNWOOD PARK PUBLIC SCHOOL	Blacktown		26.1	27.0	24.3		0	0	0
N99	School	MACARTHUR BUILDING INDUSTRY SKILLS CENTRE	Ingleburn		28.5	28.9	28.2		0	0	0
N100	School	MACQUARIE FIELDS TAFE COLLEGE	Macquarie Fields		27.8	28.1	27.8		0	0	0
N101	School	MADANG AVENUE PUBLIC SCHOOL	Whalan		36.1	35.9	32.9		0	0	0
N102	School	MALEK FAHD ISLAMIC SCHOOL HOXTON PARK	Hoxten Park		29.3	29.9	28.7		0	0	0
N103	School	MARAYONG HEIGHTS PUBLIC SCHOOL	Marayong		29.1	29.4	27.6		0	0	0
N104	School	MARAYONG PUBLIC SCHOOL	Marayong		30.7	30.1	29.9		0	0	0
N105	School	MIDDLETON GRANGE PUBLIC SCHOOL	Middleton Grange		29.6	30.3	28.9		0	0	0
N106	School	MINCHINBURY PUBLIC SCHOOL	Minchinbury		37.0	35.9	35.6		0	0	0
N107	School	MONTGROVE COLLEGE	Orchard Hills		40.0	40.2	38.6		0	0	0
N108	School	MOUNT DRUITT PUBLIC SCHOOL	Mount Druit		35.2	35.1	32.5		0	0	0
N109	School	MOUNT DRUITT PUBLIC SCHOOL PRESCHOOL	Mount Druit		35.2	35.1	32.5		0	0	0
N110	School	MOUNT DRUITT TAFE COLLEGE	Mount Druit		35.1	34.7	33.5		0	0	0
N111	School	MOUNT RIVERVIEW PUBLIC SCHOOL	Mount Riverview		38.4	39.6	34.2		0	0	0
N112	School	NEPEAN CHRISTIAN SCHOOL	Mulgoa		41.5	35.6	36.9		0	0	0
N113	School	NEPEAN CREATIVE AND PERFORMING ARTS HIGH SC	Emu Plains		38.1	39.4	34.1		0	0	0
N114	School	NEPEAN TAFE COLLEGE KINGSWOOD CAMPUS	Kingswood		42.7	43.4	39.9		0	0	0
N115	School	NEPEAN TAFE COLLEGE PENRITH CAMPUS	Penrith		39.5	40.8	35.6		0	0	0
N116	School	NOUMEA PUBLIC SCHOOL	Lethbridge Park		39.7	37.8	40.3		0	0	0
N117	School	ORCHARD HILLS PUBLIC SCHOOL	Orchard Hills		39.4	39.5	36.4		0	0	0
N118	School	OUR LADY OF THE ROSARY PRIMARY SCHOOL	St Marys		45.9	45.2	39.3		0	0	0
N119	School	OUR LADY OF THE WAY PRIMARY SCHOOL	Emu Plains		36.0	36.7	33.3		0	0	0
N120	School	OXLEY PARK PUBLIC SCHOOL	Oxley Park		40.2	40.0	34.9		0	0	0
N121	School	PENOLA CATHOLIC COLLEGE EMU PLAINS	Emu Plains		38.5	39.8	34.1		0	0	0
N122	School	PENRITH ANGLICAN COLLEGE	Orchard Hills		38.6	35.8	34.8		0	0	0
N123	School	PENRITH CHRISTIAN SCHOOL	Orchard Hills		38.2	37.3	36.6		0	0	0
N124	School	PENRITH HIGH SCHOOL	Penrith		40.4	41.5	37.2		0	0	0
N125	School	PENRITH PUBLIC SCHOOL	Penrith		40.3	41.4	37.0		0	0	0
N126	School	PENRITH SOUTH PUBLIC SCHOOL	South Penrith		39.8	40.5	37.6		0	0	0
N127	School	PLUMPTON HIGH SCHOOL	Plumpton		40.7	38.1	40.4		0	0	0
N128	School	PLUMPTON PUBLIC SCHOOL	Plumpton		42.1	39.2	41.8		0	0	0
N129	School	REGENTVILLE PUBLIC SCHOOL	Regentville		36.4	35.0	35.9		0	0	0
N130	School	ROOTY HILL HIGH SCHOOL	Rooty Hill		37.8	36.0	37.0		0	0	0
N131	School	ROOTY HILL PUBLIC SCHOOL	Rooty Hill		38.9	36.8	38.3		0	0	0
N132	School	ROPES CROSSING PUBLIC SCHOOL	Ropes Crossing		42.7	41.5	41.1		0	0	0
N133	School	SACRED HEART PRIMARY SCHOOL	Mount Druit		35.3	35.4	32.3		0	0	0
N134	School	SHALVEY PUBLIC SCHOOL	Shalvey		41.3	39.0	42.1		0	0	0
N135	School	SHELLEY PUBLIC SCHOOL	Blacktown		27.4	27.4	26.5		0	0	0
N136	School	ST AIDAN'S PRIMARY SCHOOL	Rooty Hill		38.0	36.1	37.4		0	0	0
N137	School	ST ANDREWS PRIMARY SCHOOL	Quakers Hill		30.2	30.2	29.0		0	0	0
N138	School	ST ANTHONY OF PADUA CATHOLIC COLLEGE	Austral		31.4	32.0	30.9		0	0	0
N139	School	ST CLAIR HIGH SCHOOL	St Clair		42.6	43.1	37.2		0	0	0
N140	School	ST CLAIR PUBLIC SCHOOL	St Clair		43.4	44.2	38.1		0	0	0
N141	School	ST FINBAR'S PRIMARY SCHOOL	Glenbrook		34.5	34.7	33.5		0	0	0

Calculation of cognitive impairment (children) - 2033

				L_{den}				Cognitive impairment (days of delay)			
ID	Type	Area	Suburb	Background	S1	S3	S4	Background	S1	S3	S4
N142	School	ST FRANCIS OF ASSISI PRIMARY SCHOOL	Glendenning		42.1	39.1	41.9		0	0	0
N143	School	ST JOSEPH'S PRIMARY SCHOOL	Kingswood		41.1	41.8	38.8		0	0	0
N144	School	ST MARY MACKILLOP PRIMARY SCHOOL	South Penrith		38.7	38.2	37.9		0	0	0
N145	School	ST MARYS NORTH PUBLIC SCHOOL	North St Marys		42.8	41.9	37.9		0	0	0
N146	School	ST MARYS PUBLIC SCHOOL	St Marys		46.0	45.1	39.4		0	0	0
N147	School	ST MARYS SENIOR HIGH SCHOOL	St Marys		45.8	44.8	39.4		0	0	0
N148	School	ST MARYS SOUTH PUBLIC SCHOOL	St Marys		45.2	44.9	38.9		0	0	0
N149	School	ST NICHOLAS OF MYRA PRIMARY SCHOOL	Penrith		39.9	41.0	36.4		0	0	0
N150	School	SURVEYORS CREEK PUBLIC SCHOOL	Glenmore Park		37.9	35.7	37.1		0	0	0
N151	School	THOMAS HASSALL ANGLICAN COLLEGE	Middleton Grange		30.2	30.9	29.4		0	0	0
N152	School	TREGEAR PUBLIC SCHOOL	Tregear		39.0	38.3	36.9		0	0	0
N153	School	UNITY GRAMMAR COLLEGE	Austral		31.3	31.7	31.1		0	0	0
N154	School	UNIVERSITY OF WESTERN SYDNEY PENRITH CAMPUS	Kingswood		42.4	43.2	39.9		0	0	0
N155	School	UNIVERSITY OF WESTERN SYDNEY WERRINGTON NTI	Werrington		43.4	43.5	40.1		0	0	0
N156	School	UNIVERSITY OF WESTERN SYDNEY WERRINGTON STH	Kingswood		43.2	43.8	39.4		0	0	0
N157	School	WALTERS ROAD PUBLIC SCHOOL	Blacktown		35.1	33.0	35.6		0	0	0
N158	School	WARRAGAMBA PUBLIC SCHOOL	Warragamba		38.6	40.7	41.5		0	0	0
N159	School	WARRIMOO PUBLIC SCHOOL	Warrimoo		38.1	38.7	35.2		0	0	0
N160	School	WERRINGTON COUNTY PUBLIC SCHOOL	Werrington County		42.4	42.0	39.6		0	0	0
N161	School	WERRINGTON PUBLIC SCHOOL	Werrington		42.8	42.6	40.4		0	0	0
N162	School	WETHERILL PARK TAFE COLLEGE	Wetherill Park		24.7	24.9	24.0		0	0	0
N163	School	WHALAN PUBLIC SCHOOL	Whalan		35.8	35.4	33.5		0	0	0
N164	School	WILLIAM DEAN PUBLIC SCHOOL	Dean Park		38.0	35.7	37.7		0	0	0
N165	School	WILLMOT PUBLIC SCHOOL	Willmot		41.0	39.5	40.7		0	0	0
N166	School	YORK PUBLIC SCHOOL	South Penrith		38.4	37.6	38.1		0	0	0
N167	Aged Care	AQUINAS COURT	Springwood		34.5	34.4	34.8		0	0	0
N168	Aged Care	BAPTISTCARE MORVEN GARDENS CENTRE	Leura		29.7	30.8	30.2		0	0	0
N169	Aged Care	BLUE MOUNTAINS RETIREMENT VILLAGE	Leura		30.1	31.0	29.9		0	0	0
N170	Aged Care	BUCKLAND	Springwood		34.2	34.1	34.0		0	0	0
N171	Aged Care	MARTYN CLAVER AGED CARE	Leura		29.9	30.9	30.4		0	0	0
N172	Aged Care	WINGARA HAMLET	Springwood		35.0	35.0	35.8		0	0	0
N173	Childcare	CHILDRENS HOUSE MONTESSORI CHILD CARE	Faulconbridge		37.5	37.4	39.0		0	0	0
N174	Childcare	KATOOMBA LEURA PRE-SCHOOL	Katoomba		31.0	31.7	31.1		0	0	0
N175	Childcare	KEMPS CREEK CHILDRENS COTTAGE	Kemps Creek		36.1	36.4	34.9		0	0	0
N176	Childcare	LAPSTONE PRE-SCHOOL	Lapstone		34.4	33.5	33.3		0	0	0
N177	Hospital	BLUE MOUNTAINS DISTRICT ANZAC MEMORIAL HOS	Katoomba		30.2	31.1	29.8		0	0	0
N178	Hospital	SPRINGWOOD HOSPITAL	Springwood		34.2	34.1	34.4		0	0	0
N179	Recreation	ECHO POINT LOOKOUT	Katoomba		33.4	34.2	34.2		0	0	0
N180	Religious Facility	ANGLICAN	Leura		30.2	31.1	30.5		0	0	0
N181	Religious Facility	ANGLICAN	Katoomba		30.8	31.5	30.8		0	0	0
N182	Religious Facility	BAPTIST	Katoomba		31.2	31.9	31.4		0	0	0
N183	Religious Facility	BAPTIST	Leura		30.0	30.9	30.1		0	0	0
N184	Religious Facility	UNITING	Springwood		35.3	35.2	36.4		0	0	0
N185	School	BLUE MOUNTAINS STEINER SCHOOL	Hazelbrook		34.8	34.9	36.3		0	0	0
N186	School	ELLISON PUBLIC SCHOOL	Springwood		34.0	34.0	33.6		0	0	0
N187	School	FAULCONBRIDGE PUBLIC SCHOOL	Faulconbridge		35.9	35.7	37.1		0	0	0
N188	School	HAZELBROOK PUBLIC SCHOOL	Hazelbrook		33.5	33.6	34.8		0	0	0
N189	School	KATOOMBA HIGH SCHOOL	Katoomba		32.5	33.2	33.2		0	0	0
N190	School	KATOOMBA NORTH PUBLIC SCHOOL	Katoomba		30.4	31.5	29.5		0	0	0
N191	School	KATOOMBA PUBLIC SCHOOL	Katoomba		31.3	32.0	31.6		0	0	0
N192	School	KINGSWOOD PARK PUBLIC SCHOOL	Kingswood		42.0	42.7	39.8		0	0	0
N193	School	KINGSWOOD PUBLIC SCHOOL	Kingswood		42.2	42.9	39.9		0	0	0
N194	School	KINGSWOOD SOUTH PUBLIC SCHOOL	Kingswood		40.8	41.3	39.1		0	0	0
N195	School	LAPSTONE PUBLIC SCHOOL	Glenbrook		34.3	33.7	33.2		0	0	0
N196	School	LAWSON PUBLIC SCHOOL	Lawson		30.5	31.3	31.8		0	0	0
N197	School	LEURA PUBLIC SCHOOL	Leura		29.9	30.8	30.1		0	0	0
N198	School	OUR LADY OF THE NATIVITY PRIMARY SCHOOL	Lawson		31.3	31.9	32.6		0	0	0
N199	School	SPRINGWOOD HIGH SCHOOL	Faulconbridge		35.4	35.1	36.2		0	0	0
N200	School	SPRINGWOOD PUBLIC SCHOOL	Springwood		35.1	35.0	34.9		0	0	0
N201	School	ST CANICES PRIMARY SCHOOL	Katoomba		31.0	31.7	31.1		0	0	0
N202	School	ST THOMAS AQUINAS PRIMARY SCHOOL	Springwood		34.2	34.4	33.4		0	0	0
N203	School	WENTWORTH FALLS PUBLIC SCHOOL	Wentworth Falls		29.2	30.3	30.0		0	0	0

Calculation of cognitive impairment (children) - 2055

				L_{den}			Cognitive impairment (days of delay)		
ID	**Type**	**Area**	**Suburb**	**S1**	**S3**	**S4**	**S1**	**S3**	**S4**
M01	Noise Monitoring Termi	South West Departure (Wallacia)	Wallacia	63.4	63.1	63.0	76	73	72
M02	Noise Monitoring Termi	North East Departure	Kemps Creek	61.9	58.7	61.3	62	34	57
M03	Noise Monitoring Termi	North East Runway	Orchard Hills	53.9	53.8	47.6	0	0	0
M04	Noise Monitoring Termi	Twin Creeks	Luddenham	59.7	51.3	48.8	42	0	0
M06	Noise Monitoring Termi	Mount Vernon	Mount Vernon	44.6	44.1	42.1	0	0	0
M07	Noise Monitoring Termi	Kemps Creek Nature Reserve	Kemps Creek	38.7	38.8	38.0	0	0	0
M08	Noise Monitoring Termi	Luddenham	Luddenham	48.3	45.3	45.2	0	0	0
M09	Noise Monitoring Termi	Penrith	Penrith	43.1	44.2	39.4	0	0	0
M10	Noise Monitoring Termi	Glenmore Park	Glenmore Park	42.5	39.3	41.6	0	0	0
M11	Noise Monitoring Termi	Oxley Park	Oxley Park	44.3	42.0	38.2	0	0	0
M12	Noise Monitoring Termi	St. Marys	St. Marys	52.6	49.9	44.6	0	0	0
M13	Noise Monitoring Termi	Rooty Hill	Rooty Hill	47.1	43.7	46.7	0	0	0
M14	Noise Monitoring Termi	St. Clair	St. Clair	52.9	52.3	46.2	0	0	0
M15	Noise Monitoring Termi	Erskine Park	Erskine Park	48.2	48.8	43.2	0	0	0
M16	Noise Monitoring Termi	Sydney International Equestrian Centre	Horsley Park	36.7	35.4	35.7	0	0	0
M17	Noise Monitoring Termi	Wallacia	Wallacia	43.1	52.9	52.9	0	0	0
M18	Noise Monitoring Termi	Warragamba	Warragamba	41.4	45.9	46.2	0	0	0
M19	Noise Monitoring Termi	Greendale	Greendale	62.6	62.2	62.8	69	64	71
M20	Noise Monitoring Termi	Bringelly	Bringelly	42.9	44.0	44.0	0	0	0
M21	Noise Monitoring Termi	Bents Basin	Greendale	61.4	60.6	60.8	57	50	52
M22	Noise Monitoring Termi	Silverdale	Silverdale	63.5	63.5	63.1	77	76	73
M23	Noise Monitoring Termi	Werombi	Werombi	42.3	41.1	41.0	0	0	0
M24	Noise Monitoring Termi	Blaxland	Blaxland	41.0	42.2	38.6	0	0	0
M25	Noise Monitoring Termi	Linden	Linden	45.0	48.7	49.1	0	0	0
M26	Noise Monitoring Termi	North Richmond	North Richmond	32.4	29.6	28.1	0	0	0
M27	Noise Monitoring Termi	Kurrajong	Kurrajong	29.3	26.5	25.7	0	0	0
M28	Noise Monitoring Termi	The Oaks	The Oaks	38.1	39.7	40.0	0	0	0
M29	Noise Monitoring Termi	Lake Burragorang (Natai, Brownlow Hill)	Nattai	41.9	38.8	41.3	0	0	0
M30	Noise Monitoring Termi	Tahmoor	Tahmoor	32.7	36.9	37.5	0	0	0
R1	Residential	Bringelly	Bringelly	39.0	39.6	39.6	0	0	0
R2	Residential	Luddenham	Luddenham	49.9	49.4	49.4	0	0	0
R3	Residential	Greendale, Greendale Road	Greendale	56.4	62.4	62.7	13	67	69
R6	Residential	Kemps Creek	Kemps Creek	49.5	43.6	43.3	0	0	0
R7	Residential	Wallacia	Wallacia	43.2	53.6	53.6	0	0	0
R8	Residential	Twin Creeks, Cnr Twin Ck Drie & Humewood Place	Luddenham	61.9	54.5	52.0	62	0	0
R14	Residential	Lawson Road, Badgerys Creek	Badgerys Creek	55.2	53.5	50.3	2	0	0
R15	Residential	Mersey Rd, Greendale	Greendale	45.7	46.0	46.0	0	0	0
R17	Residential	Luddenham Road	Luddenham	54.4	51.9	51.2	0	0	0
R18	Residential	Cnr Adams & Elizabeth Drive	Luddenham	58.3	58.4	58.5	30	31	31
R19	Residential	Cnr Adams & Anton Road	Luddenham	57.1	57.3	57.3	19	21	21
R21	Residential	Cnr Willowdene Ave and Vicar Park Lane	Luddenham	68.7	70.9	71.3	123	143	147
R22	Residential	Rossmore, Victor Ave	Rossmore	42.6	42.7	42.3	0	0	0
R23	Residential	Wallacia, Greendale Road	Wallacia	47.8	60.7	60.8	0	52	52
R24	On-Site	Badgerys Creek 1 NE		58.6	57.2	55.9	32	19	8
R25	On-Site	Badgerys Creek 2 SW		59.6	60.0	60.1	42	45	46
R27	Residential	Greendale, Dwyer Rd	Greendale	45.5	47.8	48.1	0	0	0
R30	Residential	Rossmore residential	Rossmore	36.8	37.1	37.0	0	0	0
R31	Residential	Mt Vernon residential	Mount Vernon	43.6	43.1	41.5	0	0	0
R34	Aged Care	Emmaus Residential Aged Care	Kemps Creek	51.9	52.6	48.3	0	0	0
R35	Childcare	Mamre After School and Vacation Care	Kemps Creek	55.2	56.2	50.8	1	11	0
R37	Childcare	Schoolies at Mulgoa	Luddenham	55.7	55.5	55.5	6	4	5
R38	Childcare	Do-re-mi Day Care Centre	Mount Vernon	42.4	42.1	40.1	0	0	0
R39	Childcare	Little Amigos Austral Early Learning Centre	Austral	35.8	36.0	35.7	0	0	0
R40	Childcare	Little Smarties Childcare Centre	Kemps Creek	55.1	56.2	50.9	1	11	0
R41	Childcare	The Grove Academy	Kemps Creek	39.8	39.8	39.0	0	0	0
R42	Childcare	Horsley Kids	Horsley Park	41.3	38.9	40.6	0	0	0
R44	Childcare	Bringelly Child Care Centre	Bringelly	44.2	45.6	45.7	0	0	0
R46	Childcare	Chementson Drive Early Educational Centre	Rossmore	39.7	40.0	39.8	0	0	0
R48	Childcare	Kids Korner West Hoxton Early Learning Centre	Austral	35.2	35.5	35.0	0	0	0
R49	Childcare	Luddenham Child Care Centre	Luddenham	53.6	53.1	52.9	0	0	0
R52	Childcare	The Frogs Lodge	Austral	35.6	35.9	35.4	0	0	0
R54	Childcare	Mulgoa Preschool	Mulgoa	51.7	43.5	42.9	0	0	0
R55	Childcare	Jillys Educational Childcare Centre	Rossmore	38.1	38.5	38.4	0	0	0
R59	Community Centre	Bringelly Community Centre	Bringelly	39.4	40.0	40.0	0	0	0
R63	Community Centre	Luddenham Progress Hall	Luddenham	56.9	56.4	56.2	17	12	11
R64	Community Centre	Mulgoa Hall	Mulgoa	51.0	43.5	43.0	0	0	0
R65	School	Emmaus Catholic College	Kemps Creek	53.5	54.0	50.2	0	0	0
R66	School	University of Sydney Farms	Greendale	44.5	56.1	56.2	0	10	11
R68	School	Christadelphian Heritage College Sydney	Kemps Creek	42.2	42.0	40.3	0	0	0
R69	School	Mamre Anglican School	Kemps Creek	55.2	56.3	50.9	2	11	0
R72	School	Irfan College	Cecil Park	37.6	37.5	36.2	0	0	0
R73	School	Luddenham Public School	Luddenham	57.7	57.1	57.0	24	19	18
R74	School	Kemps Creek Public School	Kemps Creek	42.4	42.2	40.4	0	0	0
R75	School	Trinity Catholic Primary School	Kemps Creek	53.8	54.8	49.7	0	0	0
R76	School	Bringelly Public School	Bringelly	39.1	39.7	39.7	0	0	0
R78	School	Mulgoa Public School	Mulgoa	51.0	43.6	43.1	0	0	0

Calculation of cognitive impairment (children) - 2055

				L_{den}			Cognitive impairment (days of delay)		
ID	Type	Area	Suburb	S1	S3	S4	S1	S3	S4
R79	School	Rossmore Public School	Rossmore	36.8	37.1	37.0	0	0	0
R80	School	Wallacia Public School	Wallacia	43.1	52.5	52.5	0	0	0
R82	School	Bellfield College - Junior Campus	Rossmore	37.1	37.4	37.4	0	0	0
R84	Park	Bringelly Park	Bringelly	39.5	40.2	40.2	0	0	0
R85	Park	Bents Basin State Conservation Reserve and Gulgue	Greendale	49.6	48.4	49.1	0	0	0
R86	Park	Blaxland Crossing Reserve	Wallacia	43.0	52.5	52.5	0	0	0
R87	Park	Bill Anderson Reserve	Kemps Creek	43.3	43.0	40.9	0	0	0
R91	Park	Western Sydney Parklands	Eastern Creek	52.2	48.5	51.7	0	0	0
R93	Park	Rossmore Grange	Rossmore	38.4	38.8	38.6	0	0	0
R94	Park	Freeburn Park	Luddenham	55.7	55.2	55.0	6	1	0
R95	Park	Overett Reserve	Kemps Creek	49.8	48.7	46.3	0	0	0
R97	Park	Mulgoa Park	Mulgoa	51.1	43.5	43.0	0	0	0
R98	Recreation	Wallacia Bowling and Recreation Club	Wallacia	43.5	55.5	55.5	0	4	5
R99	Recreation	Hubertus Country Club	Luddenham	60.2	60.3	60.4	46	48	48
R100	Recreation	Sugarloaf Cobbitty Equestrian Club	Cobbitty	40.9	54.2	54.2	0	0	0
R102	Recreation	Panthers Wallacia (country club)	Wallacia	43.1	53.5	53.6	0	0	0
R103	Recreation	Twin Creeks Gold and Country Club	Luddenham	59.2	50.8	48.3	38	0	0
R104	Recreation	Sydney International Shooting Centre	Cecil Park	37.6	37.6	36.6	0	0	0
R108	Recreation	Luddenham Showground	Luddenham	51.9	51.5	51.4	0	0	0
R109	Recreation	Kemps Creek Sporting and Bowling Club	Cecil Park	40.0	39.9	38.3	0	0	0
R110	Religious Facility	St James Luddenham	Luddenham	59.2	58.6	58.4	38	33	31
R111	Religious Facility	Lin Ying Temple	Rossmore	39.0	39.3	39.0	0	0	0
R112	Religious Facility	Vat Ketanak Khmer Kampuchea Krom	Rossmore	38.2	38.5	38.4	0	0	0
R114	Religious Facility	Anglican Church Sydney Diocese	Rossmore	37.1	37.4	37.4	0	0	0
R115	Religious Facility	Anglican Parish of Mulgoa	Mulgoa	52.2	43.3	42.8	0	0	0
R117	Religious Facility	Bringelly Vineyard Church	Bringelly	38.4	38.8	38.8	0	0	0
R120	Religious Facility	Our Lady Queen of Peace	Greystanes	26.6	26.3	26.2	0	0	0
R122	Religious Facility	St Anthony	Austral	35.6	35.9	35.5	0	0	0
R123	Religious Facility	St Marys Church	Mulgoa	48.2	43.7	43.4	0	0	0
R124	Religious Facility	Wallacia Christian Church	Wallacia	43.2	53.6	53.6	0	0	0
R126	Religious Facility	St Francis Xavier Church	Greendale	67.1	67.2	66.9	109	110	107
R127	Religious Facility	Luddenham Uniting Church	Luddenham	57.1	56.6	56.5	19	15	14
R131	Religious Facility	Science of the Soul Study Centre	Cecil Park	40.7	40.5	38.8	0	0	0
R132	Shopping Centre	Bringelly shops	Bringelly	39.0	39.6	39.6	0	0	0
R134	Shopping Centre	Kemps Creek shops	Kemps Creek	43.5	43.2	41.0	0	0	0
R135	Shopping Centre	Luddenham shops	Luddenham	60.7	60.2	60.0	52	47	45
R136	Shopping Centre	Mulgoa shops	Mulgoa	49.5	43.6	43.3	0	0	0
R137	Shopping Centre	Rossmore shops	Rossmore	36.8	37.1	37.0	0	0	0
R138	Shopping Centre	Wallacia Shops	Wallacia	43.0	54.0	54.1	0	0	0
R140	School	Holy Family Catholic Primary and Church	Luddenham	55.5	55.5	55.6	4	4	5
R141	Religious Facility	Edmund Rice Retreat and Conference Centre	Mulgoa	44.8	46.8	46.9	0	0	0
N1	Aged Care	CATHOLIC HEALTHCARE EMMAUS VILLAGE	Kemps Creek	51.9	52.6	48.3	0	0	0
N2	Aged Care	JOHN EDMONDSON VC GARDENS	Austral	35.7	36.0	35.6	0	0	0
N3	Aged Care	REGAL OAKS VILLAGE	Wallacia	43.0	54.7	54.8	0	0	0
N4	Aged Care	SCALABRINI VILLAGE AUSTRAL	Austral	35.9	36.0	35.9	0	0	0
N5	Aged Care	TOBRUK VILLAGE	Austral	35.7	36.0	35.6	0	0	0
N6	Childcare	BLAXLAND PRE-SCHOOL	Blaxland	39.6	40.7	36.9	0	0	0
N7	Childcare	GLENBROOK PRE-SCHOOL	Glenbrook	37.4	37.9	37.0	0	0	0
N8	Childcare	KEMPS CREEK CHILDRENS COTTAGE	Kemps Creek	39.8	39.8	39.0	0	0	0
N9	Childcare	LAPSTONE PRE-SCHOOL	Lapstone	37.5	37.0	36.5	0	0	0
N10	Childcare	MindChamps Early Learning & Preschool @ Kemps (	Kemps Creek	39.8	39.8	39.0	0	0	0
N11	Childcare	MY FIRST SCHOOL CHILDCARE CENTRE	St Marys	51.7	48.9	43.9	0	0	0
N12	Childcare	SILVERDALE CHILD CARE CENTRE	Silverdale	52.0	50.4	51.6	0	0	0
N13	Childcare	WARRAGAMBA PRE-SCHOOL	Warragamba	42.2	45.4	45.8	0	0	0
N14	Hospital	MINCHINBURY COMMUNITY HOSPITAL	Rooty Hill	39.8	37.9	38.5	0	0	0
N15	Hospital	MOUNT DRUITT HOSPITAL	Mount Druit	40.3	38.0	39.3	0	0	0
N16	Hospital	NEPEAN HOSPITAL	Kingswood	45.3	45.9	43.3	0	0	0
N17	Hospital	NEPEAN PRIVATE HOSPITAL	Kingswood	45.0	45.7	42.9	0	0	0
N18	Religious Facility	AUSTRAL CHURCH OF CHRIST	Austral	35.6	35.9	35.6	0	0	0
N19	Religious Facility	GOOD SHEPHERD CATHOLIC CHURCH	Hoxten Park	34.2	34.3	34.2	0	0	0
N20	Religious Facility	Grace West Anglican Church - Glenmore Park	Glenmore Park	41.8	39.4	42.0	0	0	0
N21	Religious Facility	Holy Family Church	Luddenham	55.3	55.3	55.4	3	3	4
N22	Religious Facility	HOLY SPIRIT CATHOLIC CHURCH	Horningsea Park	35.1	35.2	35.0	0	0	0
N23	Religious Facility	Holy Spirit Parish	St Clair	48.9	48.4	42.7	0	0	0
N24	Religious Facility	HOXTON PARK ANGLICAN CHURCH	West Hoxton	34.7	34.9	34.6	0	0	0
N25	Religious Facility	Imagine Nations Church	Orchard Hills	42.1	40.8	41.0	0	0	0
N26	Religious Facility	INSPIRE CHURCH	Hoxten Park	34.0	34.1	34.0	0	0	0
N27	Religious Facility	Mt Hope Uniting Church Orchard Hills	Orchard Hills	43.0	42.6	40.6	0	0	0
N28	Religious Facility	Orchard Hills Kingdom Hall of Jehovah's Witnesses	Orchard Hills	41.9	39.8	40.6	0	0	0
N29	Religious Facility	Samoan Methodist Church	Leppington	36.4	36.4	36.6	0	0	0
N30	Religious Facility	SIKH MISSION CENTRE	Austral	35.9	36.2	35.9	0	0	0
N31	Religious Facility	St Clair Anglican Church	St Clair	43.4	43.2	38.9	0	0	0
N32	Religious Facility	St Mary Mother of the Church	Leppington	36.3	36.4	36.4	0	0	0
N33	Religious Facility	ST ZAIA CATHEDRAL	Middleton Grange	34.6	34.8	34.4	0	0	0
N34	Religious Facility	Uniting Church St Clair	St Clair	45.9	45.7	40.4	0	0	0
N35	Religious Facility	WEST HOXTON COMMUNITY CHURCH	West Hoxton	35.0	35.2	34.7	0	0	0

Calculation of cognitive impairment (children) - 2055

				L_{den}			Cognitive impairment (days of delay)		
ID	Type	Area	Suburb	S1	S3	S4	S1	S3	S4
N36	School	AL-FAISAL COLLEGE LIVERPOOL CAMPUS	Austral	36.4	36.6	36.1	0	0	0
N37	School	AUSTRAL PUBLIC SCHOOL	Austral	35.6	35.9	35.5	0	0	0
N38	School	AUSTRALIAN ISLAMIC COLLEGE OF SYDNEY SENIOR	Mount Druit	41.2	38.6	40.4	0	0	0
N39	School	BANKS PUBLIC SCHOOL	St Clair	52.0	50.8	45.0	0	0	0
N40	School	BENNETT ROAD PUBLIC SCHOOL	Colyton	43.6	42.5	38.0	0	0	0
N41	School	BETHANY CATHOLIC PRIMARY SCHOOL	Glenmore Park	42.1	39.4	42.2	0	0	0
N42	School	BIDWILL PUBLIC SCHOOL	Bidwill	47.2	43.8	47.0	0	0	0
N43	School	BLACKETT PUBLIC SCHOOL	Blackett	42.2	39.5	41.8	0	0	0
N44	School	BLACKTOWN NORTH PUBLIC SCHOOL	Blacktown	31.4	30.3	30.3	0	0	0
N45	School	BLACKTOWN SOUTH PUBLIC SCHOOL	Blacktown	34.6	32.5	33.9	0	0	0
N46	School	BLACKTOWN TAFE COLLEGE	Blacktown	32.7	31.2	31.8	0	0	0
N47	School	BLACKTOWN WEST PUBLIC SCHOOL	Blacktown	38.1	35.4	37.5	0	0	0
N48	School	BLACKWELL PUBLIC SCHOOL	St Clair	50.5	51.0	44.9	0	0	0
N49	School	BLAXLAND EAST PUBLIC SCHOOL	Blaxland	39.4	40.5	36.5	0	0	0
N50	School	BLAXLAND HIGH SCHOOL	Warrimoo	41.7	42.7	38.6	0	0	0
N51	School	BLAXLAND PUBLIC SCHOOL	Blaxland	41.4	42.5	38.4	0	0	0
N52	School	CAMBRIDGE GARDENS PUBLIC SCHOOL	Cambridge Garden	41.1	40.9	37.7	0	0	0
N53	School	CAMBRIDGE PARK PUBLIC SCHOOL	Ceambridge Park	43.5	43.5	41.3	0	0	0
N54	School	CATHWEST INNOVATION COLLEGE MCCARTHY CAM	Emu Plains	42.2	43.5	37.9	0	0	0
N55	School	CECIL HILLS PUBLIC SCHOOL	Cecil Hills	34.6	34.5	34.1	0	0	0
N56	School	CHIFLEY COLLEGE BIDWILL CAMPUS	Bidwill	46.9	43.6	46.8	0	0	0
N57	School	CHIFLEY COLLEGE DUNHEVED CAMPUS	North St Marys	47.3	44.5	42.9	0	0	0
N58	School	CHIFLEY COLLEGE MOUNT DRUITT CAMPUS	Dharruk	40.9	38.6	40.0	0	0	0
N59	School	CHIFLEY COLLEGE SENIOR CAMPUS	Rooty Hill	40.1	37.9	39.0	0	0	0
N60	School	CHIFLEY COLLEGE SHALVEY CAMPUS	Shalvey	45.0	42.2	45.8	0	0	0
N61	School	CHRISTADELPHIAN HERITAGE COLLEGE SYDNEY	Kemps Creek	42.2	42.0	40.3	0	0	0
N62	School	CLAIRGATE PUBLIC SCHOOL	St Clair	43.0	42.7	38.4	0	0	0
N63	School	CLAREMONT MEADOWS PUBLIC SCHOOL	Claremont	48.4	48.2	43.0	0	0	0
N64	School	COLYTON HIGH SCHOOL	Colyton	42.0	40.7	36.9	0	0	0
N65	School	COLYTON PUBLIC SCHOOL	Mount Druit	39.1	37.8	36.2	0	0	0
N66	School	DAWSON PUBLIC SCHOOL	Dharruk	40.9	38.6	40.0	0	0	0
N67	School	EASTERN CREEK PUBLIC SCHOOL	Eastern Creek	50.3	46.8	49.9	0	0	0
N68	School	EASTERN CREEK PUBLIC SCHOOL PRESCHOOL	Eastern Creek	50.3	46.8	49.9	0	0	0
N69	School	EMERTON PUBLIC SCHOOL	Emerton	41.4	39.2	40.1	0	0	0
N70	School	EMU HEIGHTS PUBLIC SCHOOL	Emu Heights	41.3	42.6	37.3	0	0	0
N71	School	EMU PLAINS PUBLIC SCHOOL	Emu Plains	39.8	40.7	36.8	0	0	0
N72	School	ERSKINE PARK HIGH SCHOOL	Erskine Park	43.8	43.7	40.3	0	0	0
N73	School	GLENBROOK PUBLIC SCHOOL	Glenbrook	37.4	37.9	36.8	0	0	0
N74	School	GLENDENNING PUBLIC SCHOOL	Glendenning	48.8	45.2	48.4	0	0	0
N75	School	GLENMORE PARK PUBLIC SCHOOL	Glenmore Park	42.1	39.8	42.4	0	0	0
N76	School	GOOD SHEPHERD CATHOLIC PRIMARY SCHOOL	Hoxten Park	34.2	34.3	34.2	0	0	0
N77	School	GOOD SHEPHERD PRIMARY SCHOOL	Plumpton	45.8	42.5	45.4	0	0	0
N78	School	GREENWAY PARK PUBLIC SCHOOL	West Hoxton	35.1	35.3	35.0	0	0	0
N79	School	HASSALL GROVE PUBLIC SCHOOL	Hassall Grove	50.0	46.4	49.7	0	0	0
N80	School	HEBERSHAM PUBLIC SCHOOL	Hebersham	42.0	39.3	41.3	0	0	0
N81	School	HOLY FAMILY PRIMARY SCHOOL	Lethbridge Park	42.0	39.8	40.6	0	0	0
N82	School	HOLY SPIRIT PRIMARY SCHOOL	St Clair	49.1	48.6	42.9	0	0	0
N83	School	HOLY SPIRIT PRIMARY SCHOOL	Carnes Hill	35.0	35.2	35.0	0	0	0
N84	School	HORSLEY PARK PUBLIC SCHOOL	Horsley Park	40.9	38.5	40.2	0	0	0
N85	School	HOXTON PARK PUBLIC SCHOOL	Hoxten Park	34.7	34.8	34.5	0	0	0
N86	School	JAMES ERSKINE PUBLIC SCHOOL	Erskine Park	43.3	43.1	39.7	0	0	0
N87	School	JAMISON HIGH SCHOOL	South Penrith	42.8	41.7	43.0	0	0	0
N88	School	JAMISONTOWN PUBLIC SCHOOL	Jamisontown	41.2	40.3	41.2	0	0	0
N89	School	JORDAN SPRINGS PUBLIC SCHOOL	Jordan Springs	41.3	40.0	36.9	0	0	0
N90	School	KINGSWOOD PARK PUBLIC SCHOOL	Kingswood	46.3	46.6	44.7	0	0	0
N91	School	KINGSWOOD PUBLIC SCHOOL	Kingswood	46.5	46.8	44.8	0	0	0
N92	School	KINGSWOOD SOUTH PUBLIC SCHOOL	Kingswood	44.9	45.0	44.0	0	0	0
N93	School	LAPSTONE PUBLIC SCHOOL	Glenbrook	37.4	37.1	36.3	0	0	0
N94	School	LEONAY PUBLIC SCHOOL	Leonay	38.1	38.0	36.5	0	0	0
N95	School	LEPPINGTON PUBLIC SCHOOL	Leppington	36.1	36.2	36.2	0	0	0
N96	School	LETHBRIDGE PARK PUBLIC SCHOOL	Blackett	42.2	39.6	41.8	0	0	0
N97	School	LLANDILO PUBLIC SCHOOL	Llandilo	48.6	45.6	42.3	0	0	0
N98	School	LYNWOOD PARK PUBLIC SCHOOL	Blacktown	29.3	28.9	27.9	0	0	0
N99	School	MACARTHUR BUILDING INDUSTRY SKILLS CENTRE	Ingleburn	34.3	34.3	34.3	0	0	0
N100	School	MACQUARIE FIELDS TAFE COLLEGE	Macquarie Fields	34.1	34.0	34.2	0	0	0
N101	School	MADANG AVENUE PUBLIC SCHOOL	Whalan	40.2	38.3	36.9	0	0	0
N102	School	MALEK FAHD ISLAMIC SCHOOL HOXTON PARK	Hoxten Park	34.4	34.5	34.3	0	0	0
N103	School	MARAYONG HEIGHTS PUBLIC SCHOOL	Marayong	32.9	31.6	31.8	0	0	0
N104	School	MARAYONG PUBLIC SCHOOL	Marayong	35.3	33.1	34.5	0	0	0
N105	School	MIDDLETON GRANGE PUBLIC SCHOOL	Middleton Grange	34.3	34.5	34.1	0	0	0
N106	School	MINCHINBURY PUBLIC SCHOOL	Minchinbury	41.0	38.9	40.0	0	0	0
N107	School	MONTGROVE COLLEGE	Orchard Hills	44.0	43.7	43.4	0	0	0
N108	School	MOUNT DRUITT PUBLIC SCHOOL	Mount Druit	39.2	37.6	36.5	0	0	0
N109	School	MOUNT DRUITT PUBLIC SCHOOL PRESCHOOL	Mount Druit	39.3	37.6	36.6	0	0	0
N110	School	MOUNT DRUITT TAFE COLLEGE	Mount Druit	39.3	37.5	38.0	0	0	0
N111	School	MOUNT RIVERVIEW PUBLIC SCHOOL	Mount Riverview	42.2	43.4	38.0	0	0	0

Calculation of cognitive impairment (children) - 2055

				L_{den}			Cognitive impairment (days of delay)		
ID	**Type**	**Area**	**Suburb**	**S1**	**S3**	**S4**	**S1**	**S3**	**S4**
N112	School	NEPEAN CHRISTIAN SCHOOL	Mulgoa	45.2	39.7	41.2	0	0	0
N113	School	NEPEAN CREATIVE AND PERFORMING ARTS HIGH S	Emu Plains	41.7	43.0	37.8	0	0	0
N114	School	NEPEAN TAFE COLLEGE KINGSWOOD CAMPUS	Kingswood	46.9	47.0	44.5	0	0	0
N115	School	NEPEAN TAFE COLLEGE PENRITH CAMPUS	Penrith	43.4	44.6	39.8	0	0	0
N116	School	NOUMEA PUBLIC SCHOOL	Lethbridge Park	44.6	41.8	45.3	0	0	0
N117	School	ORCHARD HILLS PUBLIC SCHOOL	Orchard Hills	43.1	42.7	40.6	0	0	0
N118	School	OUR LADY OF THE ROSARY PRIMARY SCHOOL	St Marys	51.1	48.3	43.2	0	0	0
N119	School	OUR LADY OF THE WAY PRIMARY SCHOOL	Emu Plains	39.2	40.0	36.5	0	0	0
N120	School	OXLEY PARK PUBLIC SCHOOL	Oxley Park	44.6	42.4	38.3	0	0	0
N121	School	PENOLA CATHOLIC COLLEGE EMU PLAINS	Emu Plains	42.2	43.6	38.0	0	0	0
N122	School	PENRITH ANGLICAN COLLEGE	Orchard Hills	42.3	39.2	38.7	0	0	0
N123	School	PENRITH CHRISTIAN SCHOOL	Orchard Hills	42.1	40.7	41.1	0	0	0
N124	School	PENRITH HIGH SCHOOL	Penrith	44.4	45.3	41.7	0	0	0
N125	School	PENRITH PUBLIC SCHOOL	Penrith	44.3	45.2	41.4	0	0	0
N126	School	PENRITH SOUTH PUBLIC SCHOOL	South Penrith	43.7	44.2	42.1	0	0	0
N127	School	PLUMPTON HIGH SCHOOL	Plumpton	45.9	42.6	45.5	0	0	0
N128	School	PLUMPTON PUBLIC SCHOOL	Plumpton	47.2	43.8	46.8	0	0	0
N129	School	REGENTVILLE PUBLIC SCHOOL	Regentville	40.3	38.7	40.3	0	0	0
N130	School	ROOTY HILL HIGH SCHOOL	Rooty Hill	42.5	39.7	41.9	0	0	0
N131	School	ROOTY HILL PUBLIC SCHOOL	Rooty Hill	43.8	40.7	43.3	0	0	0
N132	School	ROPES CROSSING PUBLIC SCHOOL	Ropes Crossing	47.6	44.8	46.0	0	0	0
N133	School	SACRED HEART PRIMARY SCHOOL	Mount Druit	39.1	37.8	36.2	0	0	0
N134	School	SHALVEY PUBLIC SCHOOL	Shalvey	46.4	43.3	47.2	0	0	0
N135	School	SHELLEY PUBLIC SCHOOL	Blacktown	31.9	30.5	31.0	0	0	0
N136	School	ST AIDAN'S PRIMARY SCHOOL	Rooty Hill	42.9	40.0	42.4	0	0	0
N137	School	ST ANDREWS PRIMARY SCHOOL	Quakers Hill	34.4	32.7	33.4	0	0	0
N138	School	ST ANTHONY OF PADUA CATHOLIC COLLEGE	Austral	35.7	36.0	35.6	0	0	0
N139	School	ST CLAIR HIGH SCHOOL	St Clair	46.6	45.8	40.5	0	0	0
N140	School	ST CLAIR PUBLIC SCHOOL	St Clair	47.3	47.1	41.5	0	0	0
N141	School	ST FINBAR'S PRIMARY SCHOOL	Glenbrook	37.5	38.1	36.4	0	0	0
N142	School	ST FRANCIS OF ASSISI PRIMARY SCHOOL	Glendenning	47.3	43.8	46.9	0	0	0
N143	School	ST JOSEPH'S PRIMARY SCHOOL	Kingswood	45.2	45.6	43.5	0	0	0
N144	School	ST MARY MACKILLOP PRIMARY SCHOOL	South Penrith	42.9	41.8	42.7	0	0	0
N145	School	ST MARYS NORTH PUBLIC SCHOOL	North St Marys	47.6	44.7	41.9	0	0	0
N146	School	ST MARYS PUBLIC SCHOOL	St Marys	51.3	48.3	43.5	0	0	0
N147	School	ST MARYS SENIOR HIGH SCHOOL	St Marys	51.1	48.0	43.5	0	0	0
N148	School	ST MARYS SOUTH PUBLIC SCHOOL	St Marys	50.0	47.9	42.6	0	0	0
N149	School	ST NICHOLAS OF MYRA PRIMARY SCHOOL	Penrith	43.8	44.9	40.7	0	0	0
N150	School	SURVEYORS CREEK PUBLIC SCHOOL	Glenmore Park	42.1	39.7	41.9	0	0	0
N151	School	THOMAS HASSALL ANGLICAN COLLEGE	Middleton Grange	34.6	34.9	34.4	0	0	0
N152	School	TREGEAR PUBLIC SCHOOL	Tregear	43.5	41.1	41.3	0	0	0
N153	School	UNITY GRAMMAR COLLEGE	Austral	36.0	36.2	36.0	0	0	0
N154	School	UNIVERSITY OF WESTERN SYDNEY PENRITH CAMPU	Kingswood	46.7	47.1	44.7	0	0	0
N155	School	UNIVERSITY OF WESTERN SYDNEY WERRINGTON N	Werrington	47.6	46.7	44.6	0	0	0
N156	School	UNIVERSITY OF WESTERN SYDNEY WERRINGTON ST	Kingswood	47.3	47.4	43.9	0	0	0
N157	School	WALTERS ROAD PUBLIC SCHOOL	Blacktown	41.1	37.9	40.5	0	0	0
N158	School	WARRAGAMBA PUBLIC SCHOOL	Warragamba	42.4	45.2	45.7	0	0	0
N159	School	WARRIMOO PUBLIC SCHOOL	Warrimoo	42.1	42.6	39.0	0	0	0
N160	School	WERRINGTON COUNTY PUBLIC SCHOOL	Werrington County	46.9	45.0	44.1	0	0	0
N161	School	WERRINGTON PUBLIC SCHOOL	Werrington	47.2	45.7	45.1	0	0	0
N162	School	WETHERILL PARK TAFE COLLEGE	Wetherill Park	29.7	29.1	29.3	0	0	0
N163	School	WHALAN PUBLIC SCHOOL	Whalan	40.0	38.0	37.8	0	0	0
N164	School	WILLIAM DEAN PUBLIC SCHOOL	Dean Park	43.2	40.0	42.7	0	0	0
N165	School	WILLMOT PUBLIC SCHOOL	Willmot	46.0	43.2	45.7	0	0	0
N166	School	YORK PUBLIC SCHOOL	South Penrith	42.6	41.4	42.9	0	0	0
N167	Aged Care	AQUINAS COURT	Springwood	37.8	38.1	37.8	0	0	0
N168	Aged Care	BAPTISTCARE MORVEN GARDENS CENTRE	Leura	32.2	33.1	32.9	0	0	0
N169	Aged Care	BLUE MOUNTAINS RETIREMENT VILLAGE	Leura	32.2	33.0	32.4	0	0	0
N170	Aged Care	BUCKLAND	Springwood	37.3	37.4	36.8	0	0	0
N171	Aged Care	MARTYN CLAVER AGED CARE	Leura	32.3	33.2	33.1	0	0	0
N172	Aged Care	WINGARA HAMLET	Springwood	38.4	39.2	39.2	0	0	0
N173	Childcare	CHILDRENS HOUSE MONTESSORI CHILD CARE	Faulconbridge	41.2	42.3	43.0	0	0	0
N174	Childcare	KATOOMBA LEURA PRE-SCHOOL	Katoomba	33.4	33.9	33.7	0	0	0
N175	Childcare	KEMPS CREEK CHILDRENS COTTAGE	Kemps Creek	39.8	39.8	39.0	0	0	0
N176	Childcare	LAPSTONE PRE-SCHOOL	Lapstone	37.5	37.0	36.5	0	0	0
N177	Hospital	BLUE MOUNTAINS DISTRICT ANZAC MEMORIAL HO	Katoomba	32.2	32.9	32.3	0	0	0
N178	Hospital	SPRINGWOOD HOSPITAL	Springwood	37.2	37.5	37.3	0	0	0
N179	Recreation	ECHO POINT LOOKOUT	Katoomba	36.0	36.8	37.0	0	0	0
N180	Religious Facility	ANGLICAN	Leura	32.6	33.4	33.2	0	0	0
N181	Religious Facility	ANGLICAN	Katoomba	33.1	33.7	33.4	0	0	0
N182	Religious Facility	BAPTIST	Katoomba	33.6	34.2	34.0	0	0	0
N183	Religious Facility	BAPTIST	Leura	32.3	33.1	32.7	0	0	0
N184	Religious Facility	UNITING	Springwood	38.7	39.6	39.9	0	0	0
N185	School	BLUE MOUNTAINS STEINER SCHOOL	Hazelbrook	38.7	39.6	40.2	0	0	0
N186	School	ELLISON PUBLIC SCHOOL	Springwood	37.0	37.1	36.2	0	0	0
N187	School	FAULCONBRIDGE PUBLIC SCHOOL	Faulconbridge	39.5	40.2	40.7	0	0	0

Calculation of cognitive impairment (children) - 2055

				L_{den}			Cognitive impairment (days of delay)		
ID	Type	Area	Suburb	S1	S3	S4	S1	S3	S4
N188	School	HAZELBROOK PUBLIC SCHOOL	Hazelbrook	37.4	38.0	38.5	0	0	0
N189	School	KATOOMBA HIGH SCHOOL	Katoomba	35.1	35.8	35.9	0	0	0
N190	School	KATOOMBA NORTH PUBLIC SCHOOL	Katoomba	32.2	33.0	31.8	0	0	0
N191	School	KATOOMBA PUBLIC SCHOOL	Katoomba	33.7	34.4	34.3	0	0	0
N192	School	KINGSWOOD PARK PUBLIC SCHOOL	Kingswood	46.3	46.6	44.7	0	0	0
N193	School	KINGSWOOD PUBLIC SCHOOL	Kingswood	46.5	46.8	44.8	0	0	0
N194	School	KINGSWOOD SOUTH PUBLIC SCHOOL	Kingswood	44.9	45.0	44.0	0	0	0
N195	School	LAPSTONE PUBLIC SCHOOL	Glenbrook	37.4	37.1	36.3	0	0	0
N196	School	LAWSON PUBLIC SCHOOL	Lawson	34.0	35.1	35.3	0	0	0
N197	School	LEURA PUBLIC SCHOOL	Leura	32.2	33.1	32.8	0	0	0
N198	School	OUR LADY OF THE NATIVITY PRIMARY SCHOOL	Lawson	35.0	35.9	36.3	0	0	0
N199	School	SPRINGWOOD HIGH SCHOOL	Faulconbridge	38.7	39.2	39.6	0	0	0
N200	School	SPRINGWOOD PUBLIC SCHOOL	Springwood	38.6	38.8	38.1	0	0	0
N201	School	ST CANICES PRIMARY SCHOOL	Katoomba	33.4	33.9	33.7	0	0	0
N202	School	ST THOMAS AQUINAS PRIMARY SCHOOL	Springwood	36.9	37.0	35.7	0	0	0
N203	School	WENTWORTH FALLS PUBLIC SCHOOL	Wentworth Falls	31.9	33.0	32.9	0	0	0

Appendix H

Calculation of health impacts from noise – Cardiovascular effects

Assessment of Change in Population Incidence - Noise

	2033			
	Background	**S1**	**S3**	**S4**
Health Endpoint:	**IHD hospitalisations**	**IHD hospitalisations**	**IHD hospitalisations**	**IHD hospitalisations**
Age Group:	all ages	all ages	all ages	all ages
β (change in effect per 1 dB(A))	0.0086	0.0086	0.0086	0.0086
Baseline incidence (per 100,000) (as per Table 4.5)	415.8	415.8	415.8	415.8
Badgerys Creek				
Total Population in study area:	168	168	168	168
% population in assessment age-group:	100%	100%	100%	100%
Baseline incidence (per person)	0.004158	0.004158	0.004158	0.004158
Impact from project above threshold, ΔL_{den} (dB(A)):	3	5	4	
Relative Risk:	1.026190	1.044031	1.035072	1.000000
Attributable fraction (AF):	2.6E-02	4.2E-02	3.4E-02	0.0E+00
Increased number of cases in population:	0.02	0.03	0.02	0.000
Risk:	1.1E-04	1.8E-04	1.4E-04	0.0E+00
Greendale				
Total Population in study area:	314	314	314	314
% population in assessment age-group:	100%	100%	100%	100%
Baseline incidence (per person)	0.004158	0.004158	0.004158	0.004158
Impact from project above threshold, ΔL_{den} (dB(A)):	10	3	5	5
Relative Risk:	1.090000	1.026190	1.044031	1.044031
Attributable fraction (AF):	8.3E-02	2.6E-02	4.2E-02	4.2E-02
Increased number of cases in population:	0.1	0.03	0.06	0.06
Risk:	3.6E-04	1.1E-04	1.8E-04	1.8E-04
Luddenham				
Total Population in study area:	1927	1927	1927	1927
% population in assessment age-group:	100%	100%	100%	100%
Baseline incidence (per person)	0.004158	0.004158	0.004158	0.004158
Impact from project above threshold, ΔL_{den} (dB(A)):	12	6	5	5
Relative Risk:	1.108950	1.053067	1.044031	1.044031
Attributable fraction (AF):	9.8E-02	5.0E-02	4.2E-02	4.2E-02
Increased number of cases in population:	0.8	0.4	0.3	0.3
Risk:	4.3E-04	2.1E-04	1.8E-04	1.8E-04
Silverdale				
Total Population in study area:	4543	4543	4543	4543
% population in assessment age-group:	100%	100%	100%	100%
Baseline incidence (per person)	0.004158	0.004158	0.004158	0.004158
Impact from project above threshold, ΔL_{den} (dB(A)):	6	6	5	6
Relative Risk:	1.053067	1.053067	1.044031	1.053067
Attributable fraction (AF):	5.0E-02	5.0E-02	4.2E-02	5.0E-02
Increased number of cases in population:	1.0	1.0	0.8	1.0
Risk:	2.1E-04	2.1E-04	1.8E-04	2.1E-04
Wallacia				
Total Population in study area:	1711	1711	1711	1711
% population in assessment age-group:	100%	100%	100%	100%
Baseline incidence (per person)	0.004158	0.004158	0.004158	0.004158
Impact from project above threshold, ΔL_{den} (dB(A)):	7		4	4
Relative Risk:	1.062181	1.000000	1.035072	1.035072
Attributable fraction (AF):	5.9E-02	0.0E+00	3.4E-02	3.4E-02
Increased number of cases in population:	0.4	0.0	0.2	0.2
Risk:	2.5E-04	0.0E+00	1.4E-04	1.4E-04
Total population incidence - All Suburbs	**2.3**	**1.4**	**1.5**	**1.6**

Assessment of Change in Population Incidence - Noise

	2055			
	Background	**S1**	**S3**	**S4**
Health Endpoint:	**IHD hospitalisations**	**IHD hospitalisations**	**IHD hospitalisations**	**IHD hospitalisations**
Age Group:	all ages	all ages	all ages	all ages
β (change in effect per 1 dB(A))	0.0086	0.0086	0.0086	0.0086
Baseline incidence (per 100,000) (as per Table 4.5)	415.8	415.8	415.8	415.8
Badgerys Creek				
Total Population in study area:	168	168	168	168
% population in assessment age-group:	100%	100%	100%	100%
Baseline incidence (per person)	0.004158	0.004158	0.004158	0.004158
Impact from project above threshold, ΔL_{den} (dB(A)):	3	8	6	3
Relative Risk:	1.026190	1.071374	1.053067	1.026190
Attributable fraction (AF):	2.6E-02	6.7E-02	5.0E-02	2.6E-02
Increased number of cases in population:	0.02	0.05	0.04	0.02
Risk:	1.1E-04	2.9E-04	2.1E-04	1.1E-04
Greendale				
Total Population in study area:	314	314	314	314
% population in assessment age-group:	100%	100%	100%	100%
Baseline incidence (per person)	0.004158	0.004158	0.004158	0.004158
Impact from project above threshold, ΔL_{den} (dB(A)):	10	7	9	10
Relative Risk:	1.090000	1.062181	1.080647	1.090000
Attributable fraction (AF):	8.3E-02	5.9E-02	7.5E-02	8.3E-02
Increased number of cases in population:	0.1	0.08	0.10	0.1
Risk:	3.6E-04	2.5E-04	3.2E-04	3.6E-04
Luddenham				
Total Population in study area:	1927	1927	1927	1927
% population in assessment age-group:	100%	100%	100%	100%
Baseline incidence (per person)	0.004158	0.004158	0.004158	0.004158
Impact from project above threshold, ΔL_{den} (dB(A)):	12	10	8	8
Relative Risk:	1.108950	1.090000	1.071374	1.071374
Attributable fraction (AF):	9.8E-02	8.3E-02	6.7E-02	6.7E-02
Increased number of cases in population:	0.8	0.7	0.5	0.5
Risk:	4.3E-04	3.6E-04	2.9E-04	2.9E-04
Mulgoa				
Total Population in study area:	2044	2044	2044	2044
% population in assessment age-group:	100%	100%	100%	100%
Baseline incidence (per person)	0.004158	0.004158	0.004158	0.004158
Impact from project above threshold, ΔL_{den} (dB(A)):	3	2		
Relative Risk:	1.026190	1.017385	1.000000	1.000000
Attributable fraction (AF):	2.6E-02	1.7E-02	0.0E+00	0.0E+00
Increased number of cases in population:	0.2	0.1	0.0	0.0
Risk:	1.1E-04	7.2E-05	0.0E+00	0.0E+00
Silverdale				
Total Population in study area:	4543	4543	4543	4543
% population in assessment age-group:	100%	100%	100%	100%
Baseline incidence (per person)	0.004158	0.004158	0.004158	0.004158
Impact from project above threshold, ΔL_{den} (dB(A)):	6	11	10	10
Relative Risk:	1.053067	1.099434	1.090000	1.090000
Attributable fraction (AF):	5.0E-02	9.0E-02	8.3E-02	8.3E-02
Increased number of cases in population:	1.0	2	2	2
Risk:	2.1E-04	3.9E-04	3.6E-04	3.6E-04
Wallacia				
Total Population in study area:	1711	1711	1711	1711
% population in assessment age-group:	100%	100%	100%	100%
Baseline incidence (per person)	0.004158	0.004158	0.004158	0.004158
Impact from project above threshold, ΔL_{den} (dB(A)):	7		8	8
Relative Risk:	1.062181	1.000000	1.071374	1.071374
Attributable fraction (AF):	5.9E-02	0.0E+00	6.7E-02	6.7E-02
Increased number of cases in population:	0.4	0.0	0.5	0.5
Risk:	2.5E-04	0.0E+00	2.9E-04	2.9E-04
Total population incidence - All Suburbs	**2.5**	**2.6**	**2.7**	**2.7**

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