MOOREBANK INTERMODAL COMPANY

Moorebank Intermodal Terminal Project Environmental Impact Statement

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Technical Paper 15
Human Health Risk Assessment

Technical Paper 15 – Human Health Risk Assessment

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Technical Working Paper: Human Health Risk Assessment – Moorebank Intermodal Terminal

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Limitations

Environmental Risk Sciences has prepared this technical working paper for the use of Parsons Brinckerhoff in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this technical working paper.

It is prepared in accordance with the scope of work and for the purpose outlined in the Section 1 of this technical working paper.

The methodology adopted and sources of information used are outlined in this technical working paper. Environmental Risk Sciences has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions. No indications were found that information contained in the reports for use in this assessment was false.

This report was prepared from May to September 2014 and is based on the information provided and reviewed at that time. Environmental Risk Sciences disclaims responsibility for any changes that may have occurred after this time.

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Glossary of Terms

Acute exposure	Contact with a substance that occurs once or for only a short time (up to 14 days).
Adverse health effect	A change in body function or cell structure that might lead to disease or health problems.
ANZECC	Australia and New Zealand Environment and Conservation Council
AT	Averaging Time
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.
BTX	Benzene, toluene and total xylenes
BW	Body weight
Carcinogen	A substance that causes cancer.
Chronic exposure	Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure].
CF	Unit Conversion Factor
COPD	Chronic Obstructive Pulmonary Disease
DECCW	Department of Environment, Climate Change and Water
Detection limit	The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.
DoD	Department of Defence
DoE	Commonwealth Department of the Environment
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 milligram (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 got into the body through the eyes, skin, stomach, intestines, or lungs.
DoFD	Commonwealth Department of Finance and Deregulation
DP&E	Department of Planning and Environment
DP&I	NSW Department of Planning and Infrastructure
EC	European Commission
ED	Exposure Duration
EF	Exposure Frequency
EIS	Environmental Impact Statement
EP&A Act	Environmental Planning and Assessment Act 1979
EPA	Environment Protection Authority
ET	Exposure time

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 five 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 receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.
Guideline value	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)), that 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 and the environment. Dependent on the source, guidelines will have different names, such as investigation level, trigger value, ambient guideline etc.
HIA	Health Impact Assessment
HHRA	Human Health Risk Assessment
IMEX	Import-Export
IMT	Moorebank Intermodal Terminal
Inhalation	The act of breathing. A hazardous substance can enter the body this way [see route of exposure].
Intermediate exposure duration	Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].
LAQIA	Local Air Quality Impact Assessment
LCC	Liverpool City Council
LGA	Local Government Area
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.
LOR	Limit of Reporting
Metabolism	The conversion or breakdown of a substance from one form to another by a living organism.
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council

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.
NSW	New South Wales
OEH	Office of Environment and Heritage
OEHHA	Office of Environmental Health Hazard Assessment, California Environment Protection Agency (Cal EPA)
PAH	Polycyclic aromatic hydrocarbon
PM	Particulate matter
$PM_{2.5}$	Particulate matter of aerodynamic diameter 2.5 µm and less
PM_{10}	Particulate matter of aerodynamic diameter 10 µm and less
Point of exposure	The place where someone can come into contact with a substance present in the environment [see exposure pathway].
Population	A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).
Receptor population	People who could come into contact with hazardous substances [see exposure pathway].
Risk	The probability that something will cause injury or harm.
Risk reduction	Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.
RME	Reasonable maximum exposure – The RME represents exposure scenario based on a set of exposure parameters that is representative of expected maximum exposure for that receptor and activity. The RME would not be expected to be exceeded except under highly specific and exceptional circumstances.
Route of exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact]
SEARs	Secretary for the NSW DP&E's Environmental Assessment Requirements
SEWPaC	Commonwealth Department of Sustainability, Environment, Water, Population and Communities
SIMTA	Sydney Intermodal Terminal Alliance
SME	School of Military Engineering
SSFL	Southern Sydney Freight Line
SSWAHS	Sydney South West Area Heath Service
Synergistic Effect	A biologic response to multiple substances where one substance worsens the effect of another substance. The combined effect of the substances acting together is greater than the sum of the effects of the substances acting by themselves [see additive effect and antagonistic effect].
TEU	Twenty-foot equivalent unit
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 are based on 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.
TSP	Total suspended particulate
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 will cause harm to people [also sometimes called a safety factor].
USEPA	United States Environmental Protection Agency
VOC	Volatile Organic Compound
WHO	World Health Organisation

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Executive Summary

The Moorebank Intermodal Terminal Project ('the Project' or 'the Moorebank IMT'), proposed on approximately 220 hectares (ha) in the Moorebank area, involves the development of freight terminal facilities linked to Port Botany and the interstate freight rail network by rail. It also includes associated commercial infrastructure (including warehousing), a rail spur connecting the site to the Southern Sydney Freight Line (SSFL) and road entry and exit points from Moorebank Avenue.

Three separate rail access options for the Project were assessed, as follows:

- *northern rail access option* — with rail access from the north-western corner of the IMT site, passing through the former Casula Powerhouse Golf Course (which is currently owned by Liverpool City Council (LCC)) and crossing the Georges River and floodplain;
- *central rail access option* — with rail access from the centre of the western boundary of the IMT site, passing through Commonwealth land on the western bank of the Georges River (referred to as the 'hourglass land'); and
- *southern rail access option* — rail access from the south-western corner of the IMT site, passing through the Glenfield Landfill site (owned by Glenfield Waste Services) and crossing the Georges River and floodplain.

For each rail access option, four scenarios capturing key periods in the progressive development (involving construction and operational phases) of the Project Site and increase in IMT operations were configured and assessed. In addition three cumulative scenarios (that include the operation of both the Moorebank and SIMTA IMTs) have been considered.

This report, prepared by Environmental Risk Sciences Pty Ltd (enRiskS), presents a Human Health Risk Assessment (HHRA) associated with local air quality impacts of combustion emissions from the proposed Project, as required to address environmental impact assessment requirements of both the Commonwealth Government under the EPBC Act (the 'Final EIS Guidelines'); and the NSW Government under the EP&A Act (Secretary for the NSW Department of Planning and Environment's [NSW DP&E's] Environmental Assessment Requirements [NSW SEARs]).

Local air quality impacts have been evaluated in detail in the report "Proposed Moorebank Intermodal Terminal – Local Air Quality Impact Assessment" prepared by Environ (2014, referred to as the LAQIA). The HHRA draws on the LAQIA and as such should be read in conjunction with that report.

The HHRA has been conducted in accordance with guidance available from Australian (from enHealth and the National Environment Protection Council [NEPC]), local (from NSW Office of Environment and Heritage [OEH]) and International (specifically from the World Health Organisation and the United States Environment Protection Agency) sources. The assessment has considered both short-term/acute and long-term/chronic exposures and risks to workers within the IMT facility and surrounding communities (including sensitive receptor locations such as local schools, aged care facilities and residential areas), based on predicted impacts presented in the LAQIA report.

Emissions to air considered in the HHRA included those derived from construction and major earthworks as well as combustion emissions from construction and operations, in particular diesel emissions from trucks and locomotives. More specifically this included an assessment of potential exposures to nitrogen dioxide, carbon monoxide, sulfur dioxide, volatile organic compounds (associated with diesel emissions), polycyclic aromatic hydrocarbons (associated with diesel emissions) and particulate matter (as PM_{10} [primarily from construction/earthworks] and $PM_{2.5}$ [primarily from diesel emissions]). The assessment conducted has considered both cumulative impacts (from the Project and other local and regional sources) and incremental (from the Project only) impacts.

Exposures to nitrogen dioxide, carbon monoxide, sulfur dioxide, volatile organic compounds (associated with diesel emissions) and polycyclic aromatic hydrocarbons were evaluated on the basis of available guidelines that are protective of adverse health effects for all members of the population including sensitive groups (such as young children and the elderly). The assessment concluded that exposures to these emissions were considered to be negligible.

The more detailed assessment of potential exposures to particulate matter concluded the following:

- Cumulative impacts of $PM_{2.5}$ and PM_{10} were shown to meet goals established by OEH and NEPC that are based on the protection of community health and wellbeing. On this basis, cumulative impacts meet these goals and are not considered to be of concern.
- Incremental impacts associated with $PM_{2.5}$ and PM_{10} have also been evaluated. The evaluation has calculated increased lifetime risks and the increase in the number of cases for a range of key health effects. The health effects included premature mortality (from all causes and from specific causes such as cardiovascular, respiratory disease or lung cancer and increased risks of cancer) as well as increased hospitalisations for pre-existing illnesses such as cardiovascular disease and respiratory disease. These calculations have been undertaken on the basis of established exposure-effects relationships for exposure to $PM_{2.5}$, PM_{10} and diesel particulate matter (DPM, where 100% of the $PM_{2.5}$ from the site is assumed to be DPM) that are relevant to all members of the population including sensitive groups such as the elderly, young children and individuals with pre-existing illness.
- For the assessment of potential impacts of $PM_{2.5}$ and PM_{10} from the Project over all phases of operation, and rail access options considered, potential health impacts are low (not significant) in the surrounding community. Regardless of this assessment, where possible the best available technology and mitigation measures should be implemented to minimise exposures to particulates in the community.
- In relation to the assessment of cumulative impacts from the operation of both the Moorebank and SIMTA IMTs, the predicted health impacts are generally considered to be low (not significant); however there is the potential for risks in adjacent commercial/industrial areas to be at a level that is considered unacceptable. Mitigation measures need to be implemented to minimise exposure to particulates in the adjacent workplaces.

Overall, on the basis of the assessment conducted, cumulative and incremental impacts from the operation of the Project overall years associated with construction/development and operation, on the health of the adjacent community (including sensitive groups) are generally considered to be low and acceptable. Regardless of this assessment, where possible the best available technology and

mitigation measures should be implemented to minimise exposures to particulates in the community,

Section 1. Introduction

1.1 Project overview

The Moorebank Intermodal Terminal (IMT) Project (the Project) involves the development of approximately 220 hectares (ha) of land at the Project site (refer to **Figure 1.1**) for the construction and operation of an IMT and associated infrastructure, facilities and warehousing. The Project includes a rail link connecting the Project site to the Southern Sydney Freight Line (SSFL) and road entry and exit points from Moorebank Avenue.

The primary function of the IMT is to be a transfer point in the logistics chain for shipping containers and to handle both international IMEX cargo, and domestic interstate and intrastate (regional) cargo. The key aims of the Project are to increase Sydney's rail freight mode share including: promoting the movement of container freight by rail between Port Botany and western and south-western Sydney; and reducing road freight on Sydney's congested road network.

The Project proponent is Moorebank Intermodal Company (MIC), a Government Business Enterprise set up to facilitate the development of the Project.

The Project site is currently largely occupied by the Department of Defence's (Defence) School of Military Engineering (SME). Under the approved Moorebank Units Relocation (MUR) Project, the SME is planned to be relocated to Holsworthy Barracks by mid-2015, which would enable the construction of the Project to commence.

The key features/components of the Project comprise:

- *an IMEX freight terminal* – designed to handle up to 1.05 million TEU per annum (525,000 TEU inbound and 525,000 TEU outbound) of IMEX containerised freight to service 'port shuttle' train services between Port Botany and the Project;
- *an Interstate freight terminal* – designed to handle up to 500,000 TEU per annum (250,000 TEU inbound and 250,000 TEU outbound) of interstate containerised freight to service freight trains travelling to and from regional and interstate destinations; and
- *warehousing facilities* – with capacity for up to 300,000 square metres (m^2) of warehousing to provide an interface between the IMT and commercial users of the facilities such as freight forwarders, logistics facilities and retail distribution centres.

The proposal concept described in the main EIS (refer Chapters 7 and 8) provides an indicative layout and operational concept for the Project, while retaining flexibility for future developers and operators of the Project. The proposal concept is indicative only and subject to further refinement during detailed design.

1.2 Project location

The Project is situated on land in the Sydney suburb of Moorebank, NSW (refer **Figure 1.1**). The Project Site is approximately 220 hectares (ha) in area, and is located within a locality that includes the residential suburbs of Casula, Wattle Grove and North Glenfield, as well as industrial, commercial and Department of Defence (DoD) land. The Project would provide connectivity to Port Botany by rail, and would connect to major regional and interstate roads and highways via the M5 and M7 Motorways.

1.3 Rail access options and layouts

The Project is intended to connect to the SSFL, which was commissioned in January 2013 within the Main South Railway Line corridor. The SSFL connects Port Botany to west and south-western Sydney, and would provide a direct route for freight trains from Port Botany to the Project site.

Three separate rail access options are included as part of the proposal concept as detailed herein and shown in **Figure 1.1**. These options comprise:

- *northern rail access option* — with rail access from the north-western corner of the IMT site, passing through the former Casula Powerhouse Golf Course (which is currently owned by Liverpool City Council (LCC)) and crossing the Georges River and floodplain;
- *central rail access option* — with rail access from the centre of the western boundary of the IMT site, passing through Commonwealth land on the western bank of the Georges River (referred to as the 'hourglass land'); and
- *southern rail access option* — rail access from the south-western corner of the IMT site, passing through the Glenfield Landfill site (owned by Glenfield Waste Services) and crossing the Georges River and floodplain.

In order to maintain flexibility for future developers and operators of the Project, the proposal concept, as presented in the EIS, provides three indicative IMT internal layouts; one for each of three proposed rail access options. Once the selected developer/operator has been appointed, the Project would progress to the detailed design phase and one of the three rail access options identified above would be selected.

1.4 Indicative Project development phasing

The Project is proposed to be phased (staged) in its development, as summarised in **Figure 1.2**. The proposed indicative phasing includes both construction and operational phases, which are likely to overlap at certain times. For the purposes of assessment of the Project, five project development phases have been identified and detailed in the EIS. These are indicative only, but illustrate the type of construction and operation activities that would occur over time at the Project site.

The Project would likely commence in 2015 with the Early Works development phase and would progress with concurrent construction and operation through to the Project Full Build Phase (operation of full IMEX terminal, warehousing and interstate terminal) by approximately 2030.

The development phasing is proposed in line with the forecast market demand for processing of containers through the Project.

1.5 Road access to the site

Freight trucks would access the Project site from Moorebank Avenue, via the M5 Motorway. Trucks would then access the M7 Motorway and Hume Highway by the M5 Motorway. An upgrade to Moorebank Avenue would be included as part of the first phase of Project development (Project Phase A) to enable safe and efficient access to the Project site.

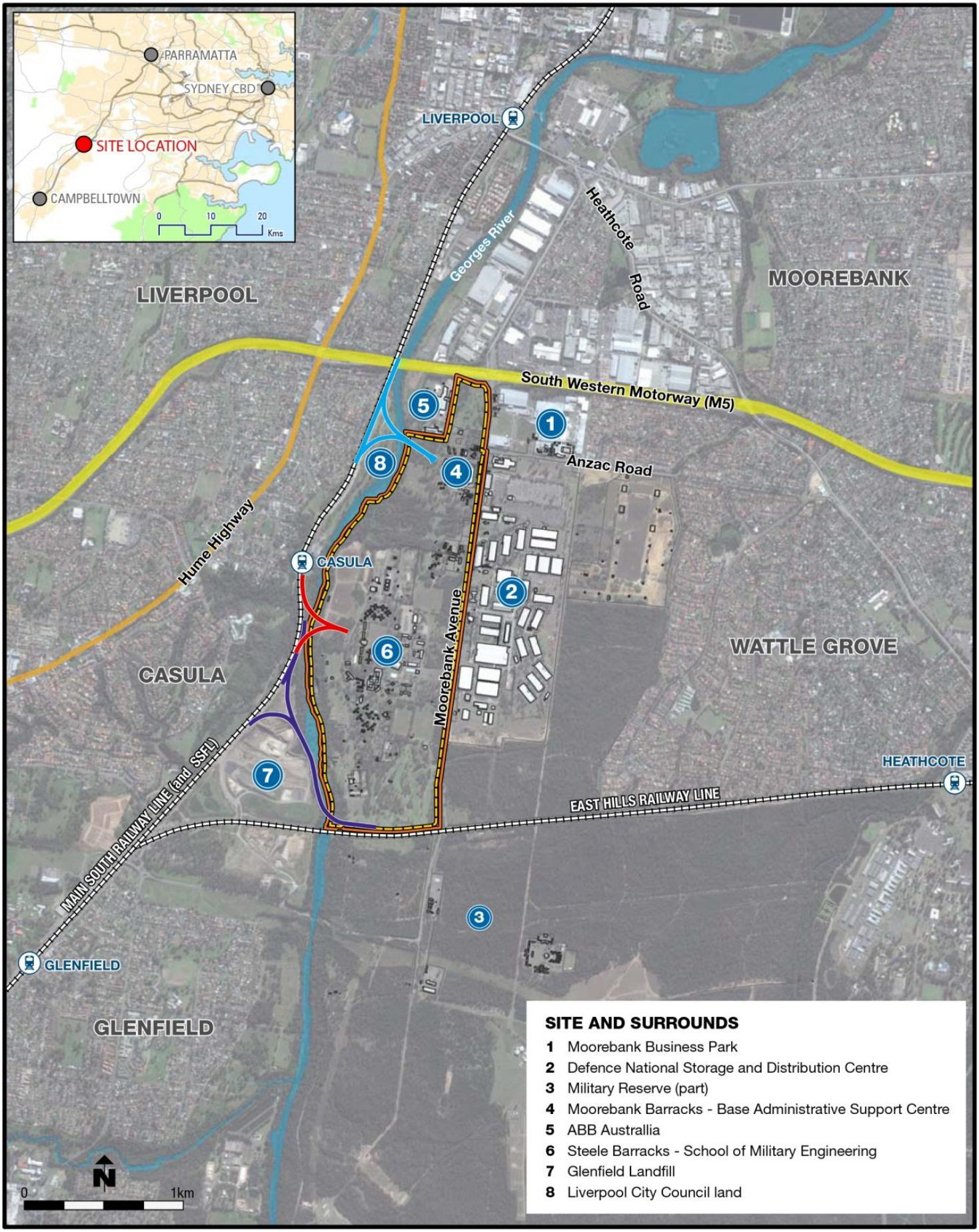

Figure 1.1 Project Site and context

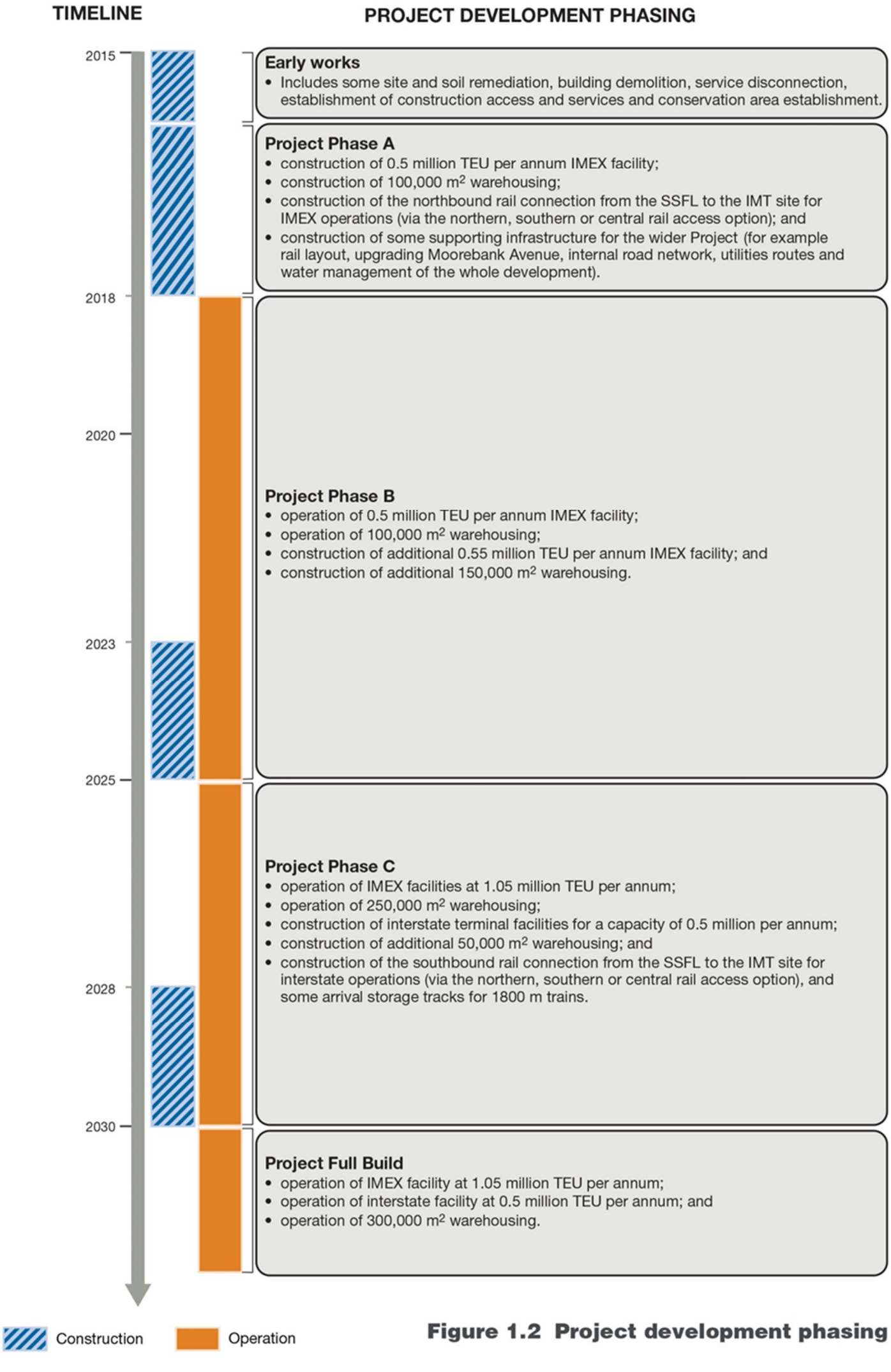

Figure 1.2 Project development phasing

1.6 Planning and environmental approvals

The Project is subject to both Commonwealth and NSW State Government approvals, and the EIS has been prepared to support applications for both approvals (EPBC number 2011/6086 and SSD-5066). The Project is a 'controlled action' under the (Commonwealth) *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). Therefore, MIC is seeking approval for the construction and operation of the Project from the (Commonwealth) Department of the Environment (DoE) under Part 9 of the EPBC Act.

Under the (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act), MIC is seeking a staged development approval for the Project as State significant development (SSD). At this stage, MIC is seeking Stage 1 SSD approval for the proposal concept (as described in the EIS) from NSW Planning and Infrastructure (NSW P&I) under Part 4, Division 4.1 of the EP&A Act (hereafter referred to as the Stage 1 SSD approval). The Stage 1 SSD approval application also includes a package of 'early works' that comprises remediation, clean-up and demolition or relocation of existing buildings, and establishment of a conservation area. The EIS is seeking approval for these early works without the need for any further approvals. Subject to Stage 1 SSD approval being received, the Project (with the exclusion of the early works) will be subject to further development applications and environmental assessment under the EP&A Act (hereafter referred to as the Stage 2 SSD approvals).

This technical working paper presents a Human Health Risk Assessment (HHRA) associated with local air quality impacts associated with Stage 1 SSD approval (including early works). Both construction and operation phase impacts have been assessed and are presented. Further details of the Project would be the subject of future development applications as those details are developed, with environmental impact assessments to be conducted in detail at that time.

1.7 Environmental impact assessment requirements

This Technical Paper has been prepared by Environmental Risk Sciences Pty Ltd (enRiskS) to address environmental impact assessment requirements of both the Commonwealth Government under the EPBC Act (the 'Final EIS Guidelines'); and the Secretary for the NSW Department of Planning and Environment's (NSW DP&E's) Environmental Assessment Requirements (NSW SEARs). More specifically this Technical Paper presents a Human Health Risk Assessment (HHRA) associated with local air quality impacts associated with Stage 1 SSD approval (including early works).

The requirement to conduct a HHRA in relation to potential impacts on local air quality is outlined in the NSW SEARs for Air Quality. The conduct of the HHRA associated with local air quality impacts is also required to address a key aspect of the Health Impact Assessment (HIA) required within the NSW SEARs and Commonwealth Guidelines for the content of a Draft EIS .The HIA is presented in a separate document.

Local air quality impacts have been evaluated in detail in the report "Proposed Moorebank Intermodal Terminal - Air Quality Impact Assessment" prepared by Environ (2014), referred to in this document as the Local Air Quality Impact Assessment or LAQIA. This HHRA draws on the LAQIA and as such should be read in conjunction with that report.

1.8 Objectives and assessment scenarios

1.8.1 Objectives

The overall objective of the HHRA presented in this report is:

- To assess health risks posed by emissions to air of combustion products derived from the development and operation of the proposed intermodal facility.

The assessment presented has considered both short-term/acute and long-term/chronic risks to workers within the IMT facility and surrounding communities, based on outcomes presented in the LAQIA report. More specifically this HHRA has addressed impacts associated with the five Project development phases as outlined in **Figure 1.2**.

This approach allows for assessment of potential worst case impacts, by considering the cumulative impacts of simultaneous construction and operational activities. This assessment approach has also been applied to provide transparency to the community and approval agencies (DoE and NSW Planning and Infrastructure (NSW P&I)) in relation to the potential impacts over the course of development of the Project.

The assessment scenarios considered within the five development phases are outlined below:

1.8.2 Early works (2015)

The first phase of the Project would consist of site preparation activities, referred to as the Early Works Project development phase. This phase, which would commence in 2015, would include initial site preparation activities including some site remediation, building demolition, service disconnection and establishment of construction access and services. Section 8.3 provides a detailed description of the works included within the Early Works development phase.

Construction would commence in July 2015 and is likely to continue for 6 months. Construction hours would be 7.00 am to 6.00 pm Monday to Friday, 8.00 am to 1.00 pm Saturday and no work on Sunday and public holidays.

1.8.3 Project Phase A – Construction of initial IMEX terminal and warehousing (2015–2018)

Project Phase A – Construction of initial IMEX terminal and warehousing (Project Phase A) is likely commence in 2015, at which time construction of the initial IMEX freight terminal facilities and warehousing would be undertaken. In particular, this project development phase involves construction activities associated with the development of the initial IMEX terminal (catering for a capacity of 0.5 million twenty-foot equivalent units (TEUs)) and the provision of 100,000 square metres (sq. m) of warehousing. In addition, construction of some supporting infrastructure for the wider Project (for example rail layout, upgrading Moorebank Avenue, internal road network, utilities routes and water management for the whole Project site) would also be undertaken.

The rail connection between the SSFL and the Project site for IMEX operations would also be developed during Project Phase A, including construction of the bridge across the Georges River. In order to adequately assess the impacts of each of the three rail access options included within this proposal concept, separate scenarios have been developed for each option:

- **Scenario N1** assesses the impacts during Project Phase A and is based on the northern rail access option and associated IMT site layout.
- **Scenario C1** assesses the impacts during Project Phase A and is based on the central rail access option and associated IMT site layout.
- **Scenario S1** assesses the impacts during Project Phase A and is based on the southern rail access option and associated IMT site layout.

Standard construction hours would apply. These are 7.00 am to 6.00 pm Monday to Friday, 8.00 am to 1.00 pm Saturday and no work on Sunday and public holidays.

Further details of the construction activities occurring during Project Phase A are provided in section 8.4 of the EIS.

1.8.4 Project Phase B – Operation of initial IMEX and warehousing, construction of additional capacity (2018–2025)

By 2018 it is expected that the initial IMEX and warehousing component of the IMT would commence operation. This would involve operation of the IMEX terminal at a capacity of 0.5 million TEUs per annum and operation of 100,000 sq. m of warehousing. This Project development phase is referred to as Project Phase B – Operation of initial IMEX terminal and warehousing, construction of additional capacity (Project Phase B).

The IMEX terminal and trains would operate 24 hours a day, 7 days a week. Truck gates to the terminal would be open 16 hours, 5.5 days a week. Operations within the warehousing precinct could occur 24 hours a day, 7 days a week.

During Project Phase B, additional IMEX freight terminal facilities would be constructed to increase the IMT capacity to 1.05 million TEUs per annum, along with an additional 150,000 sq. m of warehousing. Construction of the additional IMEX facilities and warehousing is likely to commence in the latter part of Project Phase B, around 2023.

As with the previous scenarios, Scenarios N2, C2, S2 each represent one of the three rail access options and associated IMT layouts:

- **Scenario N2** assesses the impacts during Project Phase B using the northern rail access option.
- **Scenario C2** the central rail access option.
- **Scenario S2** the southern rail access option.

The scenarios occur at a point of time between 2023 and 2025, when both construction and operation activities are taking place on the Project site.

1.8.5 Project Phase C – Operation of IMEX and warehousing, construction of interstate terminal and additional warehousing (2025–2030)

Project Phase C – Operation of IMEX terminal and warehousing, construction of interstate terminal and additional warehousing (Project Phase C) would commence in 2025 and would involve the operation of the IMEX terminal at its maximum capacity (1.05 million TEUs per annum) along with 250,000 sq. m of warehousing.

Construction of the interstate terminal (for a capacity of 500,000 TEU per annum) and the southbound rail connection from the SSFL to the IMT for interstate operations (via either the northern, southern or central rail access option) is also likely to occur in the latter part of this phase, around 2028. An additional 50,000 sq. m of warehousing would also be constructed during this time.

As with the previous scenarios, Scenarios N3, C3, S3 each represent one of the three rail access options and associated IMT layouts:

- **Scenario N3** assesses the impacts during Project Phase C using the northern rail access option.
- **Scenario C3** the central rail access option.
- **Scenario S3** the southern rail access option.

The scenarios occur between 2028 and 2030, when both construction and operation activities are taking place on the Project site.

1.8.6 Project Phase Full Build (2030)

By 2030 it is expected that the IMT would have reached its maximum capacity (i.e. Full Build). This phase would involve operation of the IMEX and interstate terminals and 300,000 sq. m of warehousing. It is expected that there would be no construction activities occurring during this phase, as the Project would have reached its maximum capacity.

The IMEX and interstate facility would operate 24 hours a day, 7 days a week, including truck access to the IMT site.

As with the previous scenarios, Scenarios N4, C4, S4 each represent one of the three rail access options and associated IMT layouts:

- **Scenario N4** assesses the impacts of the IMT at Full Build based on using the northern rail access option.
- **Scenario C4** the central rail access option.
- **Scenario S4** the southern rail access option.

Figures 1.3, 1.4 and 1.5 present the proposed Project layout at Full Build based on using the northern rail access option (**Figure 1.3**), central rail access option (**Figure 1.4**) and the southern rail access option (**Figure 1.5**).

INDICATIVE NORTHERN RAIL CONNECTION CONCEPT LAYOUT
MOOREBANK INTERMODAL TERMINAL

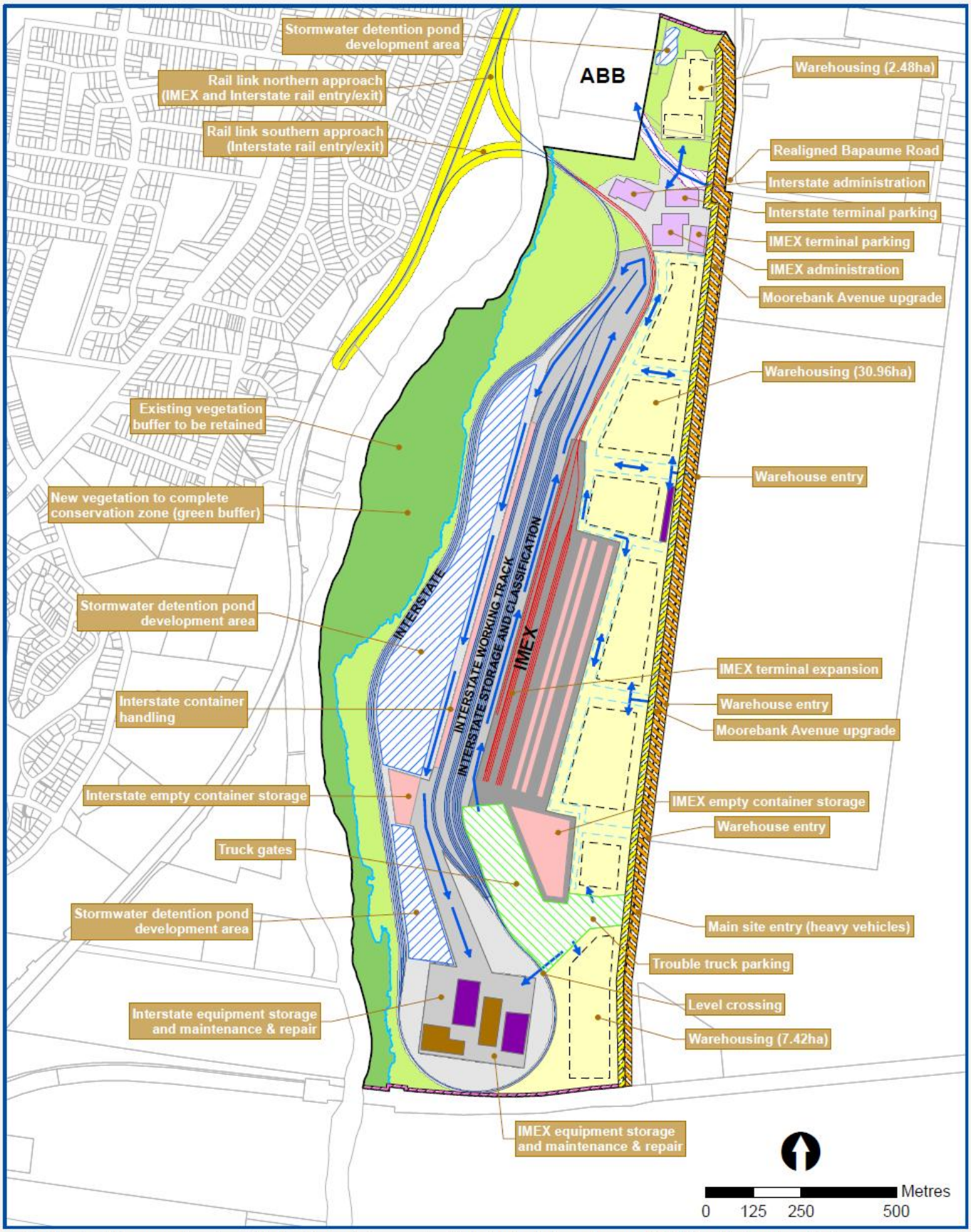

Figure 1.3: Indicative IMT layout associated with the northern rail access option at Full Build

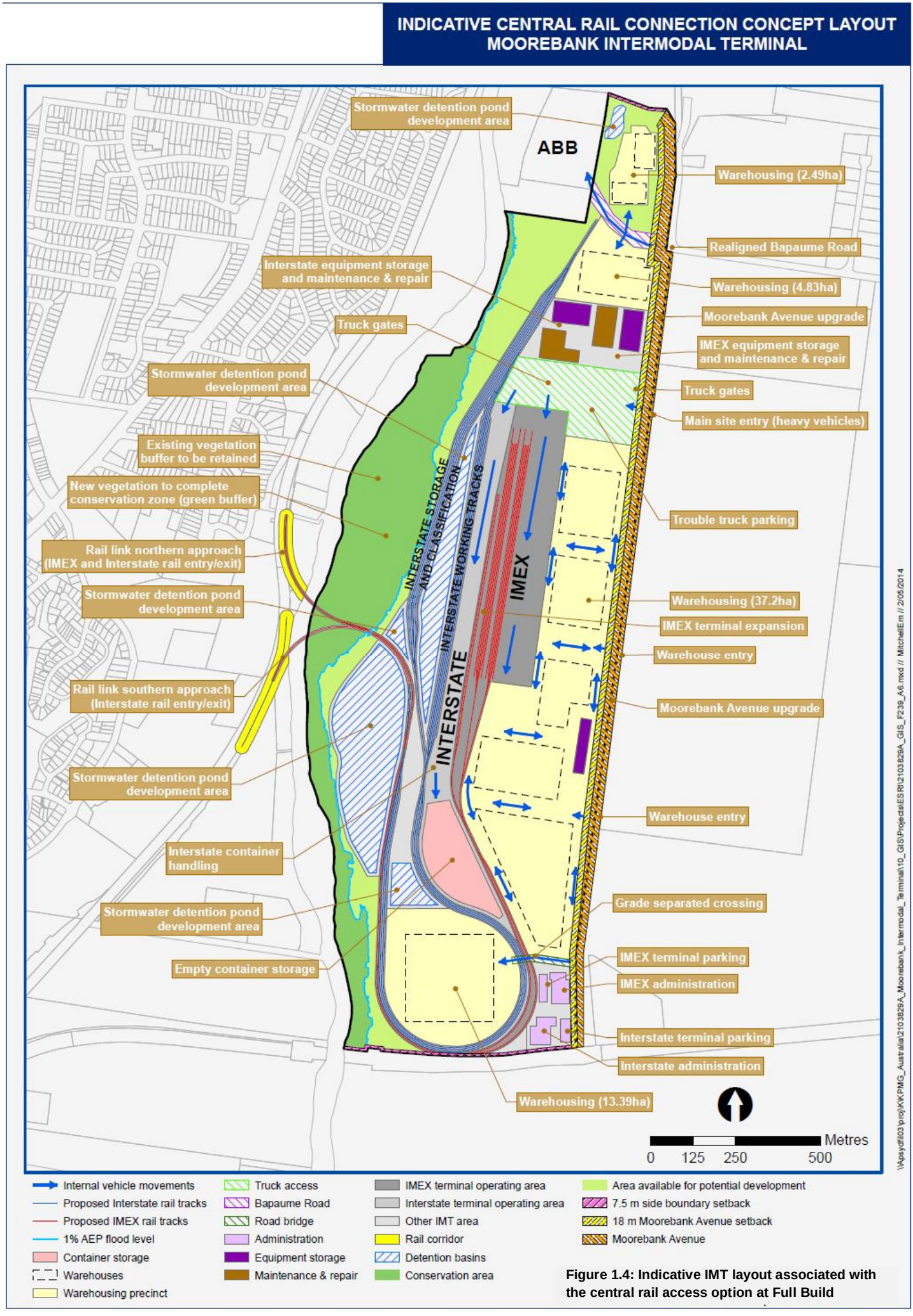

Figure 1.4: Indicative IMT layout associated with the central rail access option at Full Build

INDICATIVE SOUTHERN RAIL CONNECTION CONCEPT LAYOUT
MOOREBANK INTERMODAL TERMINAL

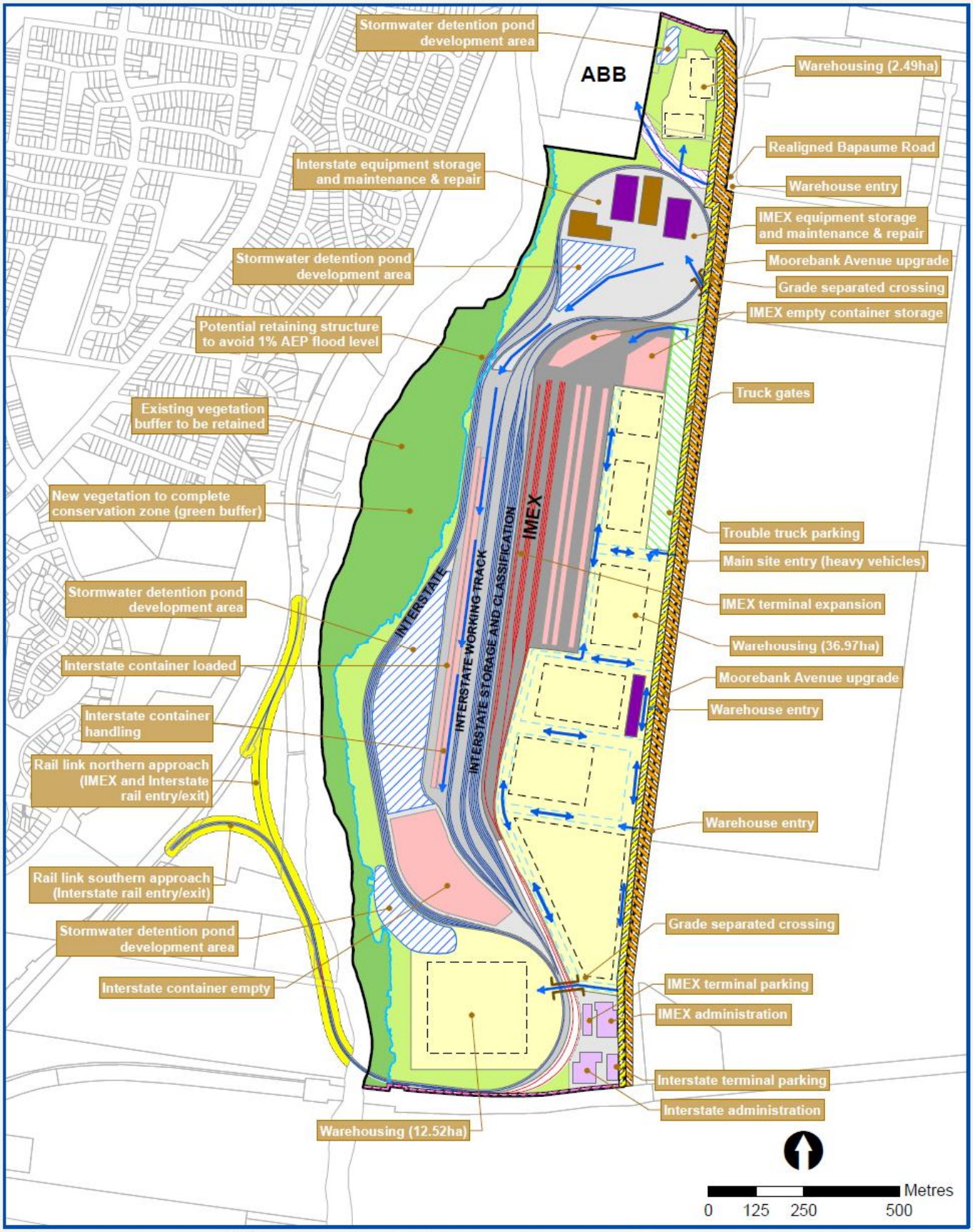

Figure 1.4: Indicative IMT layout associated with the southern rail access option at Full Build

1.8.7 SIMTA cumulative scenarios

Sydney Intermodal Terminal Alliance (SIMTA) is proposing to develop an IMT facility on the site currently occupied by the DNSDC on Moorebank Avenue, Moorebank. In light of this, the NSW SEARs require a cumulative assessment of the impacts that would occur in the event that both projects were developed.

The site for the SIMTA development is to the immediate east of the Moorebank IMT Project Site and the two projects would, if both approved, operate simultaneously. The line capacity of the SSFL is likely to constrain the development and operational capacity of the two IMTs. Even assuming future upgrades are made to the line, including additional passing loops and intermediate signalling, the SSFL is likely to be capacity-constrained above a throughput of 1.7 million TEUs. At full operation the two proposed IMT developments provide would involve:

- Moorebank IMT Project - 1.05 million TEUs (IMEX facility) and 0.5 million TEUs (interstate facility) throughput capacity; and
- SIMTA IMT – 1 million TEUs throughput capacity.

In response to this constraint, potentially more realistic scenarios have been developed. The development of these scenarios has considered the SSFL capacity constraints, the need for an IMT in the area, the existing zoning of the SIMTA site (IN1 – General Industrial which permits warehouse or distribution centres) as well as the existing concept approval for an IMT on the SIMTA site.

It is noted that these scenarios have been developed by DoFD and its Moorebank Advisor Project Team purely for the purposes of an indicative cumulative impact assessment should these types of developments operate adjacent to each other in this location. No consultation with SIMTA has occurred in relation to these scenarios.

The cumulative scenarios considered are as follows:

- Cumulative Scenario 1: Development of the Moorebank IMT site as described in the EIS with additional development of 300,000m^2 warehousing on the SIMTA site.
- Cumulative Scenario 2: Development of both sites to include IMEX, each handing 500,000 TEU throughput, with the Interstate freight terminal on the Moorebank IMT site and 300,000m^2 warehousing on each site.
- Cumulative Scenario 3: Development of an Interstate freight terminal and 300,000m^2 warehousing on the Moorebank IMT site, and development of the SIMTA development as proposed (Hyder Consulting 2013).

For these cumulative scenarios it is assumed that:

- the Moorebank IMT Project operates in accordance with how it is defined in the Moorebank IMT Project EIS (and as described in this Technical Paper) – with operations considered on the basis of the northern rail access option for scenario 1 and the southern rail access option for scenarios 2 and 3;
- both sites are assumed to be operational 24 hours a day, seven days a week; and

- the assessment would consider cumulative operations of the two developments at year 2030 – when both are at full build operational levels. This allows for an assessment of potential 'worst case' impacts resulting from the two developments.

1.9 Approach to Human Health Risk Assessment

1.9.1 What is a risk assessment?

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 in the environment and evaluation of projects with 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 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, tornados, etc., and exposures to environmental contaminants are examples of involuntary risks.

Defining risk

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 from a range of facilities (e.g. industrial or infrastructure) are usually assessed through qualitative and/or quantitative risk assessment techniques. In general, risk 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, including those beyond the perimeter boundary of a facility.

1.9.2 Overall approach

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

- EnHealth Environmental Health Risk Assessment: Guidelines for Assessing Human Health Risks from Environmental Hazards: 2012 (enHealth 2012a);
- EnHealth Health Impact Assessment Guidelines: September 2001 (enHealth 2001);
- EnHealth Exposure Factors Guide, EnHealth Council, 2012 (enHealth 2012b);
- National Environment Protection Council (NEPC) Schedule B(8) Guideline on Community Consultation and Risk Communication, National Environment Protection (Assessment of Site Contamination) Measure, 1999 (NEPC 1999 amended 2013);

- NEPC National Environmental Protection (Air Toxics) Measure, Impact Statement for the National Environment Protection (Air Toxics) Measure, 2003 (NEPC 2003); and
- United States Environment Protection Agency (USEPA) Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual (Part F, Supplemental Guidance for Inhalation Risk Assessment), EPA-540-R-070-002, January 2009 (USEPA 2009a).

More specifically in relation to the assessment of health impacts associated with exposure to particulates, guidelines available from the NEPC ((Burgers & Walsh 2002; NEPC 1998, 2002, 2003, 2009, 2010), World Health Organisation (Ostro 2004; WHO 2003, 2006a, 2006b, 2013) and the USEPA (USEPA 2005, 2009b) have been used as required.

In following this guidance, the following tasks have been completed and are presented in this technical working paper.

Data evaluation and issue identification

This task involves a review of all available information that relates to the operation of the proposed facility and the LAQIA completed for the proposed IMT Project. Specifically the predicted ground level concentrations of pollutants considered in the LAQIA have been further reviewed in relation to the following:

- Existing air quality; and
- Short-term (acute) and long-term (chronic) impacts associated with the proposed IMT Project.

This aspect of the assessment also considers the available guidelines for air quality, whether these guidelines are based on the protection of community health, and if a more detailed evaluation of specific impacts is required. The HHRA has considered a more detailed evaluation of exposures to particulate emissions within the surrounding community.

Exposure assessment

This involves the identification of populations located in the vicinity of the Project who may be exposed to key air pollutants considered in this assessment. The health of the existing population will be further considered in relation to the key health endpoints that require further detailed consideration in this assessment. The assessment of potential exposure has considered both short-term (acute) and long-term (chronic) inhalation exposures relevant to the Project.

Toxicity assessment

The objective of the toxicity assessment is to identify the adverse health effects and quantitative toxicity values or exposure-response relationships that are associated with the key pollutants that have been identified and evaluated as part of this assessment. This has been applied to the assessment of exposures to particulate matter where the following has been undertaken:

1. Identify the adverse health effects associated with exposure to particulate matter. Based on the available information, the most robust health end-points (effects or outcomes) for the assessment of inhalation exposure to particulate matter (assessed over different size fractions) have been identified. The most robust health end-points are where a relationship

has been established between exposure to particulate matter and a specific health end-point (effect/outcome).

2. Identify the most relevant and robust exposure-response relationship for the quantitative assessment of exposure to particulate matter. The exposure-response relationships are derived from published peer reviewed sources and relate to the identified health end-points (effects/outcomes).

The health-endpoints and associated exposure-response relationships adopted for the assessment of particulate matter, particularly derived from combustion sources (such as petrol and diesel vehicles) have been discussed with NSW Health prior to the completion of this assessment.

For other air pollutants national guidelines based on the protection of health have been adopted.

Risk characterisation

Risks have been characterised using quantitative and qualitative assessment methods. The quantitative assessment of potential exposure to particulate emissions from the Project combined with information on exposure (i.e. what additional concentrations of particulate matter would be present in the community as a result of the Project) and the exposure-response relationships relevant for the health-endpoints (effect) has been used. This enables an assessment of an increased annual risk and an increased incidence of the effect occurring within the population of concern.

In some cases a qualitative assessment has been undertaken. A qualitative assessment does not specifically require the quantification of risk or exposure. Rather the assessment provides a relative or comparative evaluation of whether the exposure or impact considered is unacceptable in the local population.

The assessment presented has also considered the level of uncertainty associated with all aspects of the technical studies relied on for the conduct of the HHRA and within the HHRA. The final determination of risks to human health will be based on the quantification of risks as well as consideration of these uncertainties.

The overall approach is outlined in **Figure 1.6**.

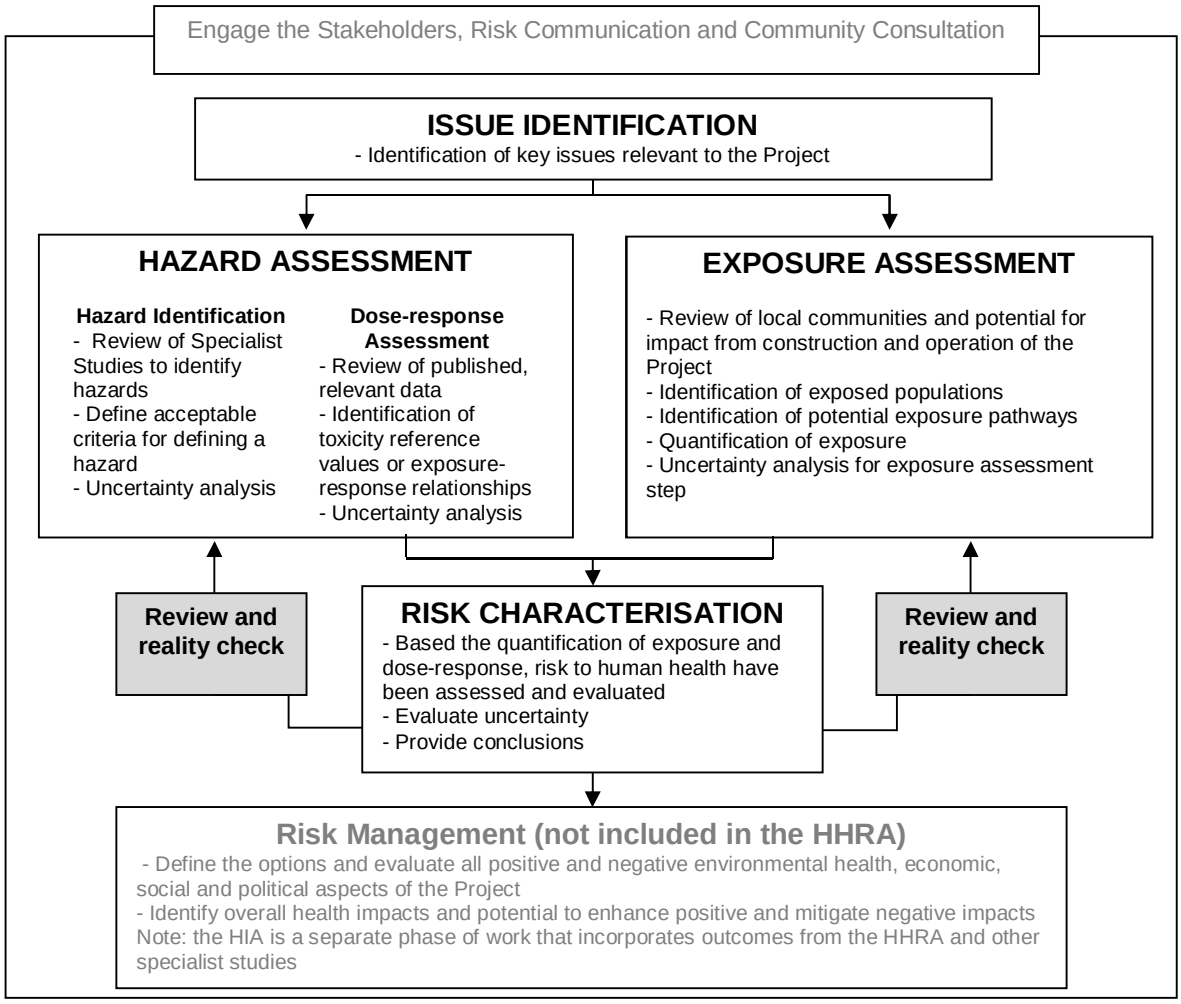

Figure 1.6 Overall human health risk assessment approach (modified from enHealth, 2012)

1.9.3 Features of the risk assessment

The HHRA has been carried out in accordance with international best practice and general principles and methodology accepted in Australia by groups such as 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 risk assessment is a tool (that is systematic) that addresses potential exposure pathways based on an understanding of the nature and extent of the impact assessed and the uses of the local area by the general public. The risk assessment is based on an estimation of maximum, or worst-case, ground level concentrations modelled in the local community and hence is expected to overestimate the actual risks.
- Conclusions can only be drawn with respect to emissions to air derived from the Project as outlined in this technical working paper.
- Available statistics in relation to the existing health status of the existing community are presented in the technical working paper; however the HHRA 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 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 risk assessment reflects the current state of knowledge regarding the potential health effects of chemicals identified and evaluated in this assessment. 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.

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Section 2. Community profile

2.1 General

This section provides an overview of the community potentially impacted by the Project. The key focus of the assessment presented is the local community, however some aspects of the assessment require consideration of statistics that are derived from larger populations, such as those within the South Western Sydney Area Health District and the greater Sydney Area. Hence, where relevant, information related to both the local community and other areas within Sydney (and NSW) have been presented.

2.2 Surrounding area and population

The study area considered within the LAQIA encompasses the local air shed in which the construction and operation of the Moorebank IMT Project would likely influence.

The Project is located within the Liverpool City Council Local Government Area (LGA), within the Sydney south-western region. The majority of the Site is located on land currently used for DoD purposes, including the SME and other minor Moorebank units. Key areas surrounding the site include (refer to **Figure 2.1**):

- East: Moorebank Avenue with existing warehouse facilities used by the DoD. It is noted that the warehouse area located east of the site is currently proposed to be redeveloped for a separate intermodal terminal (Sydney Intermodal Terminal Alliance (SIMTA)). Areas located further east comprise low density and medium density housing within the suburb of Wattle Grove. The area located northeast of the site, north of the M5 motorway lies within the suburb of Moorebank and is zoned for general industry. Within the industrial area to the northeast is a low to medium density residential area.
- South and south east: comprises land zoned for DoD purposes, within the Holsworthy area;
- West and south west: The Georges River, and land zoned for public recreation and national parks and nature reserves (Leacock Regional Park) is located adjacent to the western boundary of the Project Site. Further west comprises land that is used for low to medium density residential purposes within the suburb of Casula. To the immediate southwest of the Project Site is the Glenfield Waste Disposals landfill operation. Further southwest comprises land used for low to medium density residential purposes within the suburb of Glenfield.
- North and northwest: Areas zoned for industrial use are located to the north of the site, along with the M5 motorway. Further northwest are low to medium density residential areas within the suburbs of Casula and Lurnea.

The study area defined in the LAQIA is that which is located within a five kilometre radius of the Project Site (also shown on **Figure 2.1**) and within this area a number of representative off-site sensitive receptors have been identified and considered in the LAQIA. Sensitive receivers are locations in the local community where more sensitive members of the population, such as infants and young children, the elderly or those with existing health conditions or illnesses, may spend a significant period of time. These locations comprise hospitals, child care facilities, schools and aged care homes/facilities.

The location of the sensitive receptors are illustrated on **Figure 2.1**, and listed in **Table 2.1**.

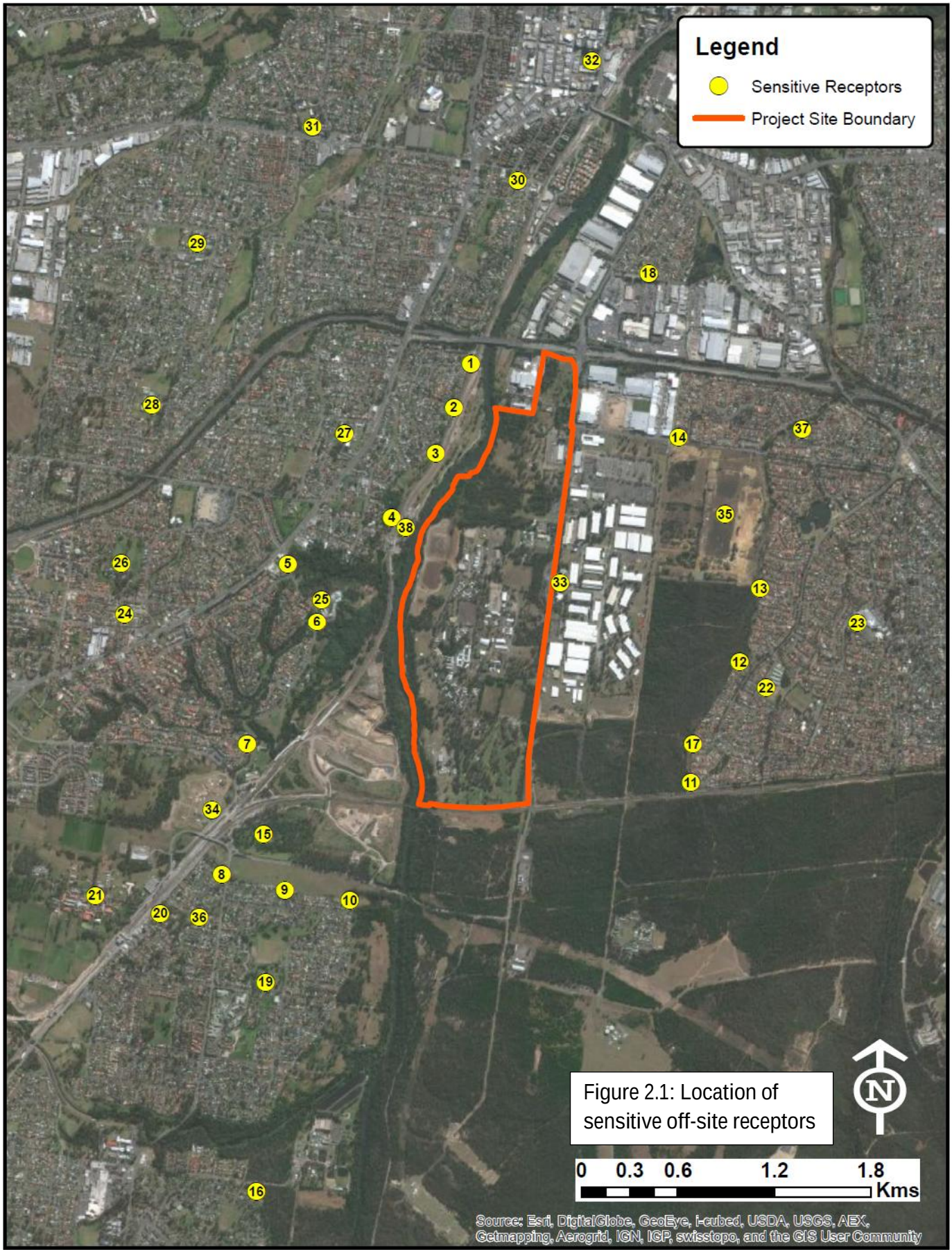


Figure 2.1: Location of sensitive off-site receptors

Table 2.1 Sensitive off-site receptors

Receiver	Receiver description	Representative Receptor Use	Distance from Site Boundary (m)
1	Lakewood Crescent	Residential	400
2	St Andrews Boulevard	Residential	275
3	Buckland Rd Receiver (Receptor 6 in SIMTA Report*)	Residential	200
4	Dunmore Cres	Residential	225
5	Leacocks Lane	Residential	800
6	Leacocks Lane_Mid (Receptor 5 in SIMTA Report*)	Residential	600
7	Slessor Road	Residential	1025
8	Canterbury Road	Residential	1275
9	Ferguson Street	Residential	1025
10	Goodenough St (Receptor 4 in SIMTA Report*)	Residential	725
11	Wallcliff Cres	Residential	1025
12	Corryton Ct	Residential	1200
13	Martindale Ct (Receptor 3 in SIMTA Report*)	Residential	1300
14	Anzac Road (Receptor 2 in SIMTA report*)	Residential and commercial/industrial	650
15	Cambridge Avenue	Commercial	975
16	Hickory Place	Residential	2625
17	Yallum Cres (Receptor 1 in SIMTA report*)	Residential	1000
18	Church Road (Receptor 7 in SIMTA report*)	Residential and commercial/industrial	675
19	Glenwood Public School	School and residential	1450
20	Glenfield Public School	School and residential	1700
21	Hurlstone Agricultural High School	School and residential	2075
22	Wattle Grove Public School	School and residential	1400
23	St Marks Coptic College, Wattle Grove	School and residential	1900
24	Maple Grove Retirement Village	Residential	1725
25	All Saints Catholic Senior College	School and residential	550
26	Casula High School	School and residential	1750
27	Casula Public School	School and residential	700
28	Lurnea High School	School and residential	1900
29	St Francis Xavier Primary School Lurnea	School and residential	2300
30	Al Amanah College Liverpool Campus Liverpool	School and residential	1050
31	Liverpool West Public School	School and residential	2025
32	Liverpool Public School	School and commercial/industrial	1850
33	Moorebank Ave (DNSDC) 2014*	Commercial/industrial	50
34	Glenfield new land release	Residential	1250
35	DNSDC proposed relocation from 2015	Commercial/industrial	1025
36	Playground Learning Centre Glenfield, Chesham Parade	Residential	1790
37	Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential and recreational	1500
38	Casula Powerhouse Arts Centre	Recreational	100

* A separate evaluation has been conducted in relation to the proposed development of the Defence National Storage and Distribution Centre (DNSDC) property, located adjacent to the eastern side of Moorebank Avenue, by the Sydney Intermodal Terminal Alliance (SIMTA) to develop an intermodal terminal. A number of sensitive receptors, representative of key off-site areas, identified and considered in the SIMTA evaluation have been included in this assessment.

In addition to the above the maximum concentration on the site boundary has also been evaluated. The maximum concentration on the site boundary is assumed to be representative of a worst-case impact that may be present in an adjacent commercial/industrial premises.

2.3 Population profile

The population within the area evaluated comprises workers and residents as well as those attending school, day care and recreational areas within the surrounding suburbs. The composition of these populations is expected to be generally consistent with population statistics for the individual suburbs. Population statistics for the surrounding suburbs of Casula, Glenfield, Macquarie Fields, Wattle Grove, Liverpool, Lurnea, Holsworthy and Moorebank are available from the Australian Bureau of Statistics for the census year 2011 and are summarised in **Table 2.2 and Figure 2.2**.

Based on this general population data, the suburbs of Moorebank, Casula, Liverpool, Lurnea and Glenfield are largely similar to Sydney Southwest and Greater Sydney. However Macquarie Fields, Wattle Grove and Holsworthy are characterised by a lower proportion of people aged 65 years and over, reflecting the presence of a higher percentage of military families in these suburbs.

Table 2.2 Summary of population statistics

Location	Total Population		% Population by Key Age Groups				
	Male	Female	0-4	5-19	20-64	65+	30+
Moorebank	3807	3788	8.4	19.5	59.3	12.8	60
Casula	7167	7529	7.9	22.1	59.6	10.3	49
Wattle Grove	4058	4134	8.7	25.1	61	5.2	45
Liverpool	11881	12214	8.6	18.7	61.6	11.1	51
Lurnea	4225	4385	8.7	23.8	55.1	12.3	70
Holsworthy	5850	5505	9	24.7	63.7	2.6	43
Glenfield	3646	3912	6.6	19.7	59.8	13.9	67
Macquarie Fields	6345	6825	7.6	24	58.9	9.5	53
Sydney South West	178129	182037	7.1	22.4	60	10.6	50
Greater Sydney	2162221	2229453	6.8	18.7	61.7	12.9	60
Rest of NSW (excluding greater Sydney)	1239007	1273942	6.3	19.7	55.9	18	63

Ref: Australian Bureau of Statistics, Census Data 2011

Review of other data available from the ABS (refer to the HIA for additional data) the social profile of the local interest/study area is one where families with young children predominate and the majority of the sensitive receivers are subsequently schools. However these families live within an area which exhibits a variety of socio-economic conditions and associated housing types, ranging from the high income, two-parent families and more expensive houses of Wattle Grove to the variation in incomes, family types and dwelling choices seen in areas of Liverpool.

The estimated population growth from 2008 to 2028 in the LGAs associated with these suburbs ranges from 40.9% (Campbelltown LGA) to 53.4% (Liverpool LGA)[1].

[1] Data provided on the NSW population growth by LGA from Health Statistics NSW, http://www.healthstats.nsw.gov.au/Indicator/dem_pop_lgamap

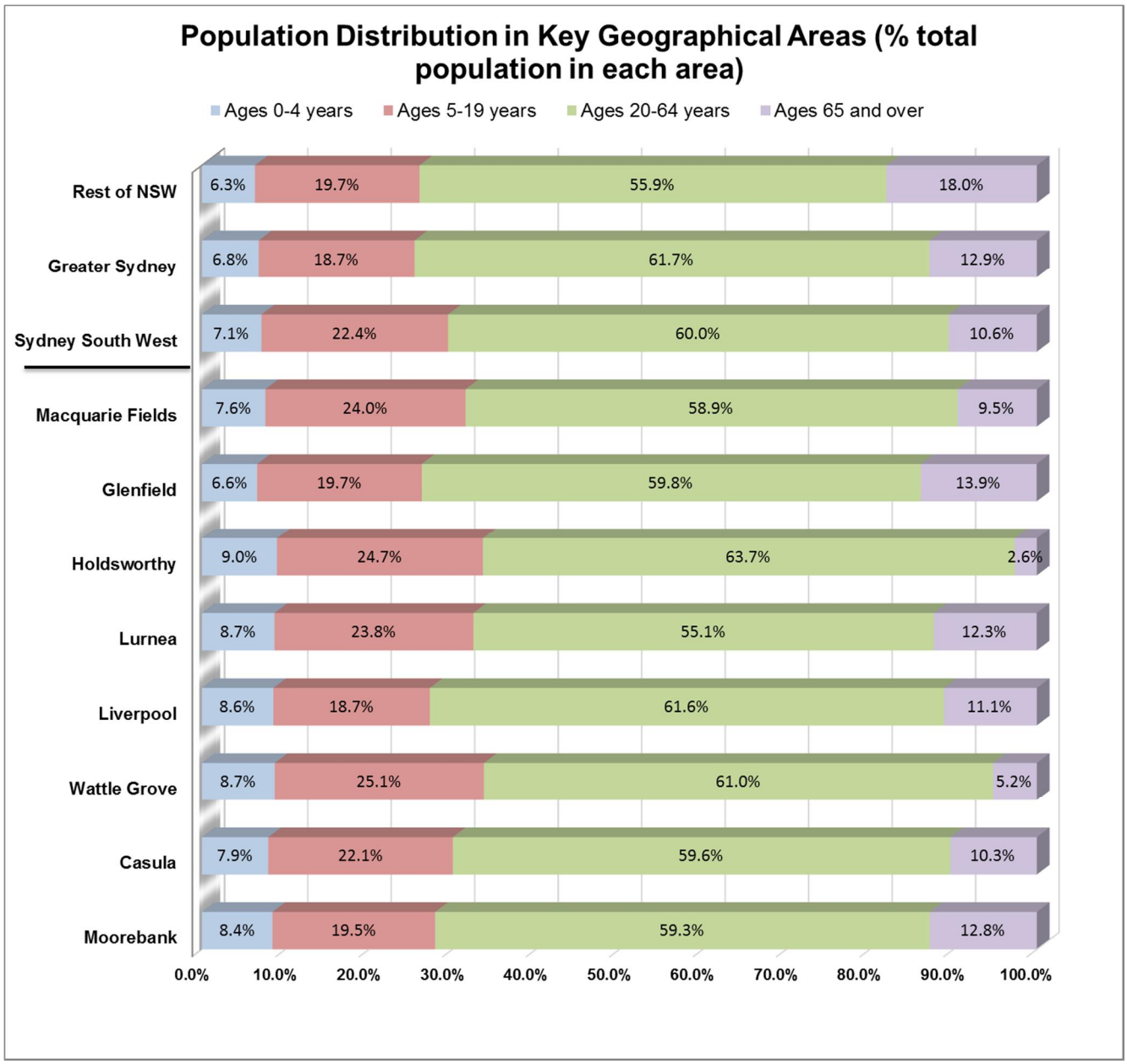


Figure 2.2: Summary of population statistics

2.4 Existing health of population

2.4.1 General

The assessment presented in this report has focused on key pollutants that are associated with construction and combustion sources (from vehicles), including particulate matter (namely $PM_{2.5}$ and PM_{10}). For these pollutants there are a large number of sources in the project area including other combustion sources (other than from the project), other local construction/earthworks and personal exposures (such as smoking) and risk taking behaviours that have the potential to affect the health of any population.

When considering the health of a local community there are a large number of factors to consider. The health of the community is influenced by a complex range of interacting factors including age, socio-economic status, social capital, behaviours, beliefs and lifestyle, life experiences, country of origin, genetic predisposition and access to health and social care. Hence, while it is possible to review existing health statistics for the local areas surrounding the project, 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.

Most of the health indicators presented in this report are not available for each of the smaller suburbs/statistical areas surrounding the site, as outlined in **Sections 2.1 to 2.3**. Health indicators are only available from a mix of larger areas (that incorporate the study area) that comprise the Liverpool LGA, Liverpool District (that includes the Liverpool LGA, Campbelltown LGA as well as part of the Camden and Fairfield LGAs) and the larger Sydney South West Area, Greater Sydney and NSW. There are few health statistics that are reported for the smaller local government areas relevant to this project. The health statistics for these larger areas are assumed to be representative of the smaller population located in the vicinity of the Project.

2.4.2 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) are available for large health population areas in Sydney and NSW. This includes risky alcohol drinking, smoking, consumption of fruit and vegetables, overweight and obesity and adequate physical activity.

Review of the general health for residents in Sydney South West (SWSLHN 2012) indicated that although high level health indicator measures such as life expectancy at birth and deaths from all causes for these residents are the same as the NSW average, on a range of other health indicators local residents have poorer outcomes than the average for NSW. Residents from Sydney South West, on average, have elevated rates of behaviours which have been 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 (SWSLHN 2012). These include:

- Current daily and occasional smoking at 17.0% (higher than the NSW average, dominated by the rate of smoking in males);
- Adequate physical activity at 49.2% (11% worse than the NSW average);

- Very high psychological distress at 11.4% (4% higher than the NSW average); and
- Consuming vegetables in recommended quantities at 7.9% (17% worse than the NSW average). A similar trend is observed for the consumption of fruit in recommended quantities.

The incidence of these health-related behaviours in Sydney South West, compared with other health areas in NSW, and the state of NSW (based on data from 2009) is illustrated in **Figure 2.3**.

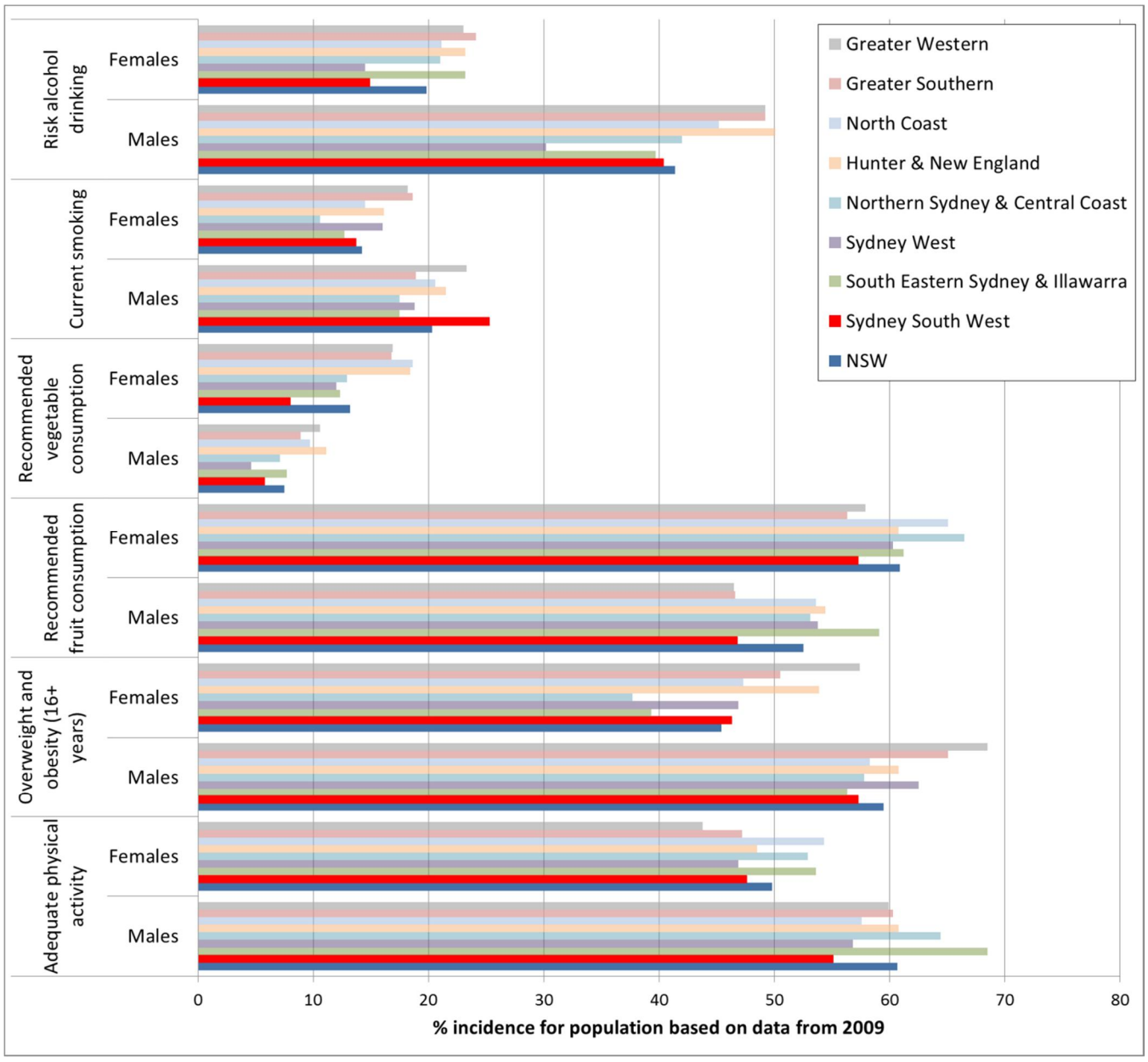


Figure 2.3: Summary of Incidence of Health-Related Behaviours 2009 (source: NSW Health 2010)

Figures 2.4 and 2.5 present a comparison of the rates of the key mortality indicators (all causes, potentially avoidable, cardiovascular disease, lung cancer and chronic obstructive pulmonary disease [COPD in the elderly 65+ years]) and hospitalisations (diabetes, cardiovascular disease, asthma [5-34 years] and COPD [65+ years]) reported in the Sydney South West Area Health Service, with comparison to other NSW area health services (in urban and regional areas) as well as NSW as a whole. **Figure 2.6** presents more refined data on hospitalisations (respiratory disease [including asthma], cardiovascular disease and coronary heart disease) in the local health areas of Liverpool (separated into east and west areas) and Campbelltown (separated into north and south) with comparison against data for Sydney South West and NSW.

Review of this data, with consideration of the observations reported by SWSLHN (2012), indicates the following:

- Mortality[2] rates (all causes and potentially avoidable[3]) reported in Sydney South West, also observed in Campbelltown and Liverpool LGAs, were higher than for NSW;
- In NSW between 1998 and 2007 the incidence rate for all cancers rose by 11% in males, but was stable in females. Higher rates of new cases of lung cancer were reported in Sydney South West (16% higher than the NSW average). It is projected that the number of new cancers in South Western Sydney will increase by 63% in comparison to 42% in NSW.
- Cardiovascular disease accounts for 34% of all deaths in Australia. Mortality rates in Sydney South West for cardiovascular disease are 5% higher than the NSW average and are significantly higher in Liverpool LGA. Cardiovascular disease is higher in Liverpool east, compared with Liverpool west, with the highest rates in the area reported in Campbelltown south.
- Hospitalisation rates for COPD (in the elderly, 65+ years) in Sydney South West are higher than the NSW average, while hospitalisation rates for cardiovascular disease are lower than the NSW average.
- Respiratory disease is higher than the NSW average in Sydney South West with higher rates reported in Liverpool East and Campbelltown (north and south).
- Hospitalisation rates for asthma (5-34 years) are similar in Sydney South West when compared with the NSW average.

[2] Mortality rate is a death rate from all causes that is adjusted to take account differences in age composition within the population considered.

[3] Potentially avoidable deaths are those occurring before the age 75 years, which could be avoided by prevention or clinical interventions.

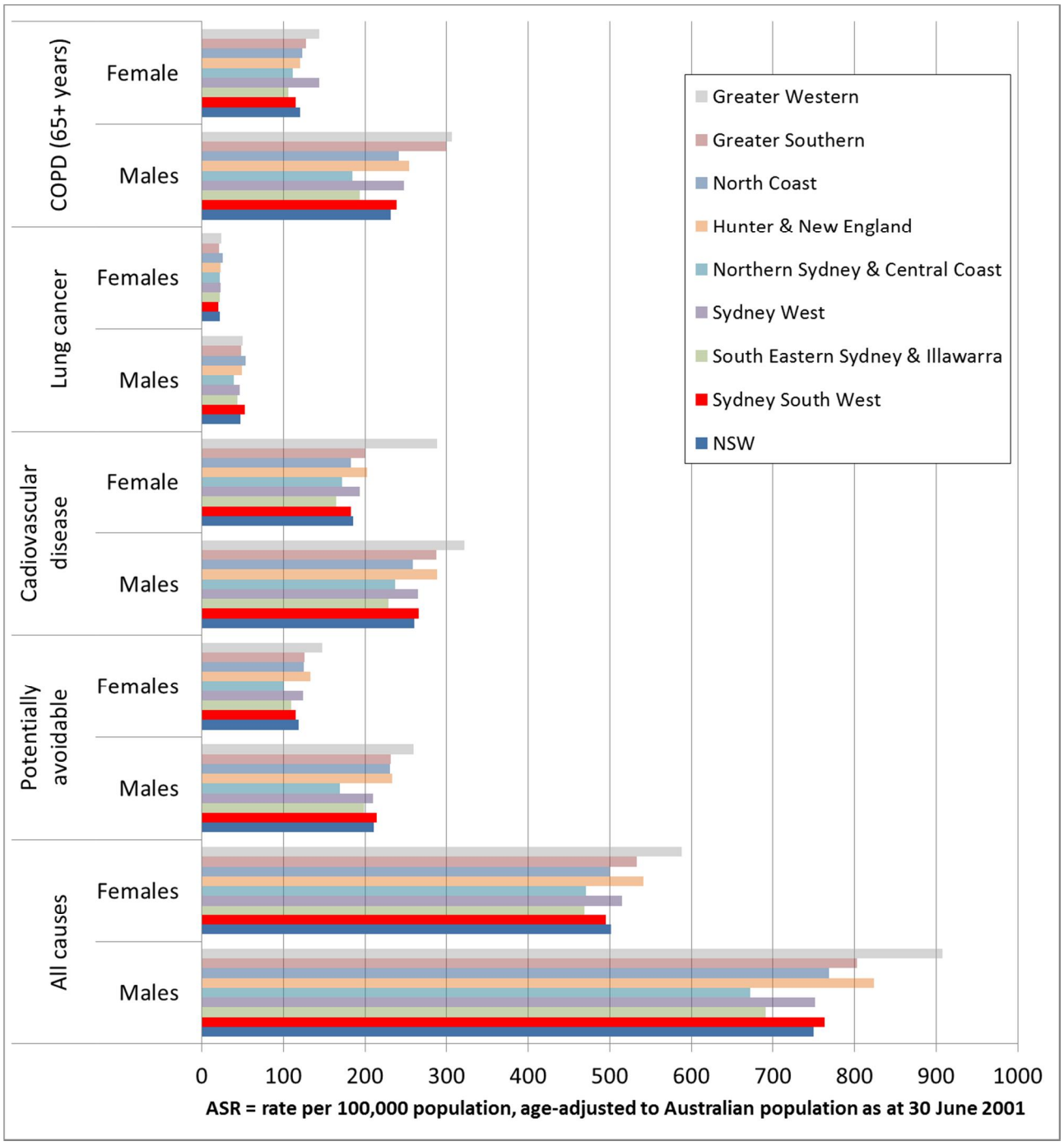


Figure 2.4: Summary of Mortality Data 2003-2007 (source: NSW Health 2010)

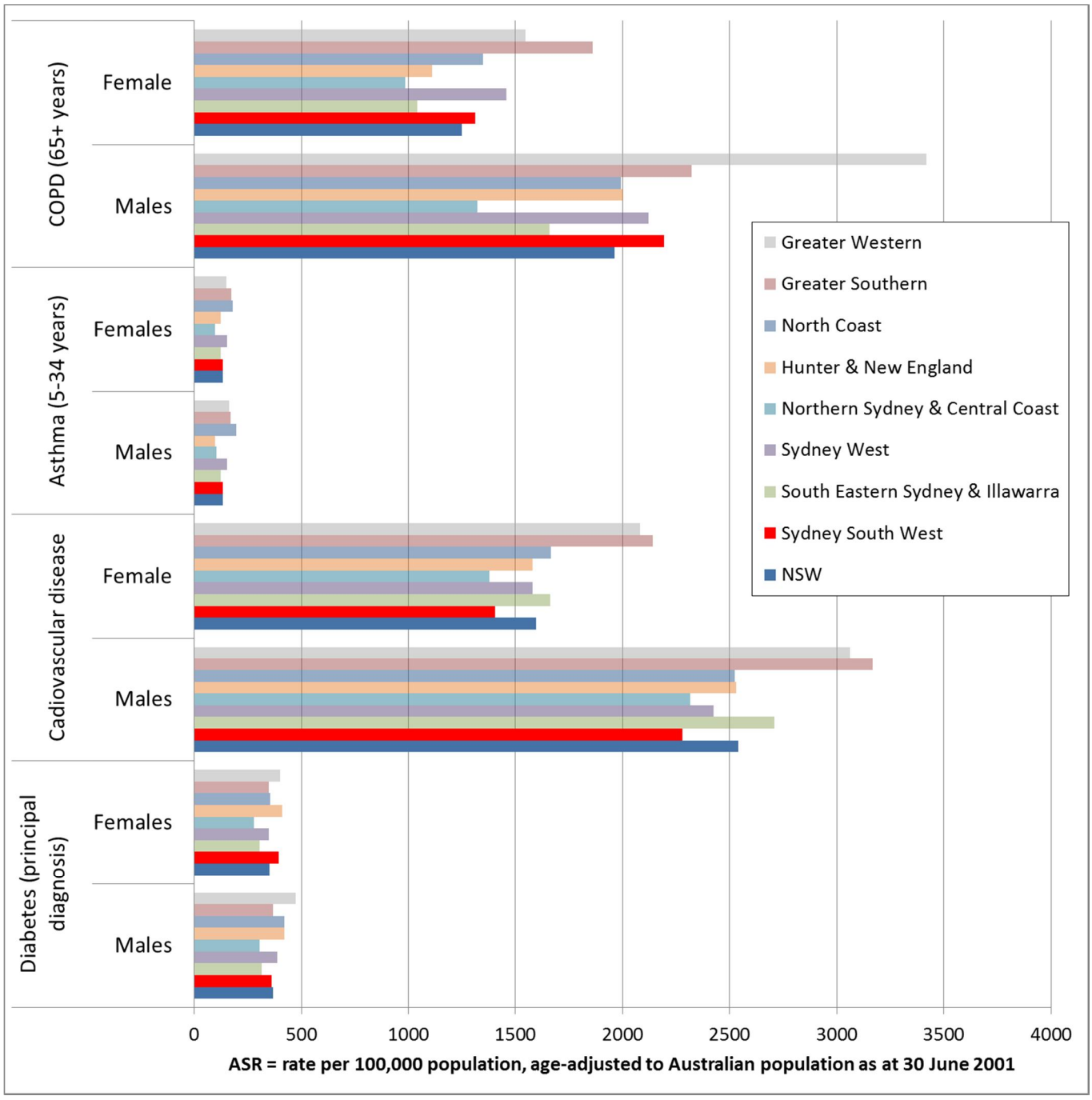


Figure 2.5: Summary of Hospitalisation Data 2008-2009 (source: NSW Health 2010)

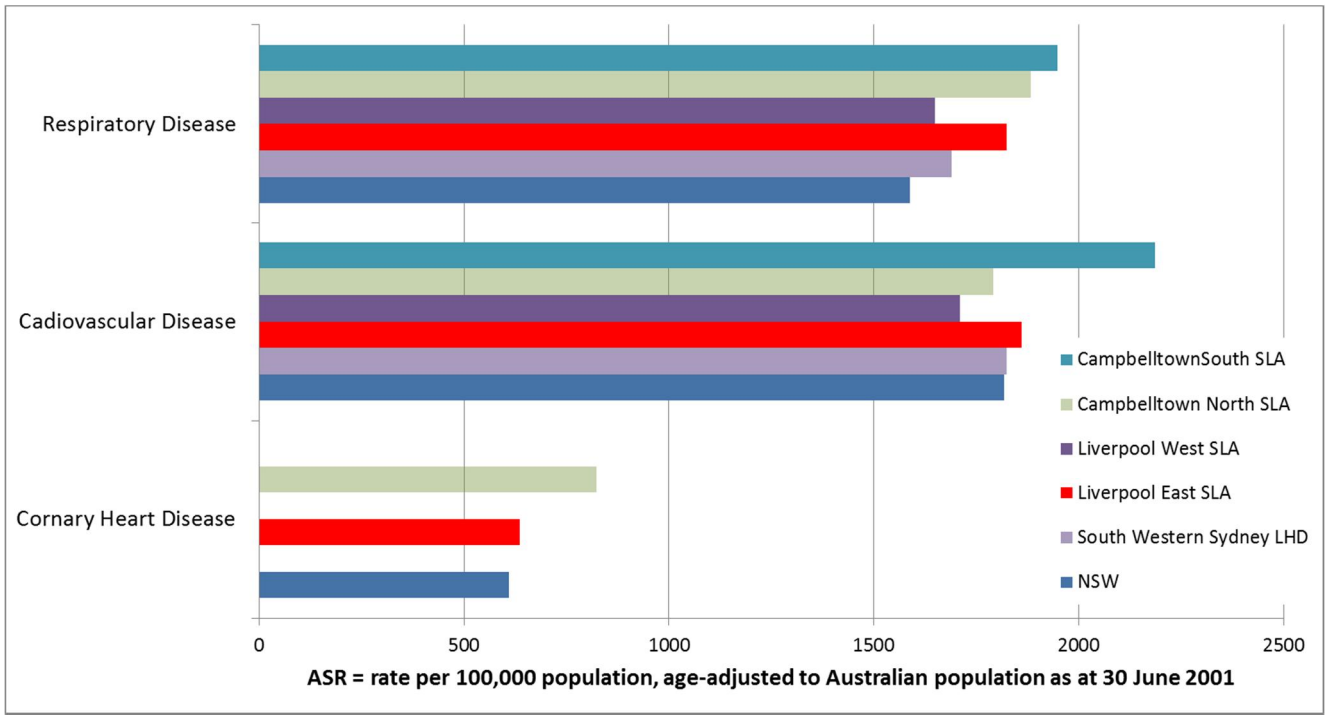


Figure 2.6: Summary of Local Hospitalisation Data 2011 (source: Sydney South West Local Health Area)

In relation to asthma in children, **Figure 2.7** summarises available data in relation to the prevalence and management of asthma in children in the Liverpool and Campbelltown LGAs and the Sydney South West Area with comparison against NSW. Additional statistics on asthma are included in **Appendix A**. These data sets show that children in Sydney South West and Liverpool LGA have lower rates of asthma prevalence than the NSW average, however, they also have a higher rate of reliever medication use and lower rate of preventer medication use suggesting the management of asthma in these areas is poorer when compared with NSW.

It is noted that while the available data in relation to moderate to extreme interference with daily activities suggests that for children aged 2-15 years with asthma in Sydney South West the rate is consistent with that reported in NSW, when more narrow age groups are considered, the following is observed:

- children aged 2-8 years report a higher rate of moderate to extreme interference, with children in Sydney South West reporting the highest rate of interference of all the area health services in NSW;
- children aged 9-15 years report a lower rate of moderate to extreme interference, with children in Sydney South West reporting the lowest rate of interference of all the area health services in NSW.

These data sets suggest that asthma is less well managed in younger children in this area.

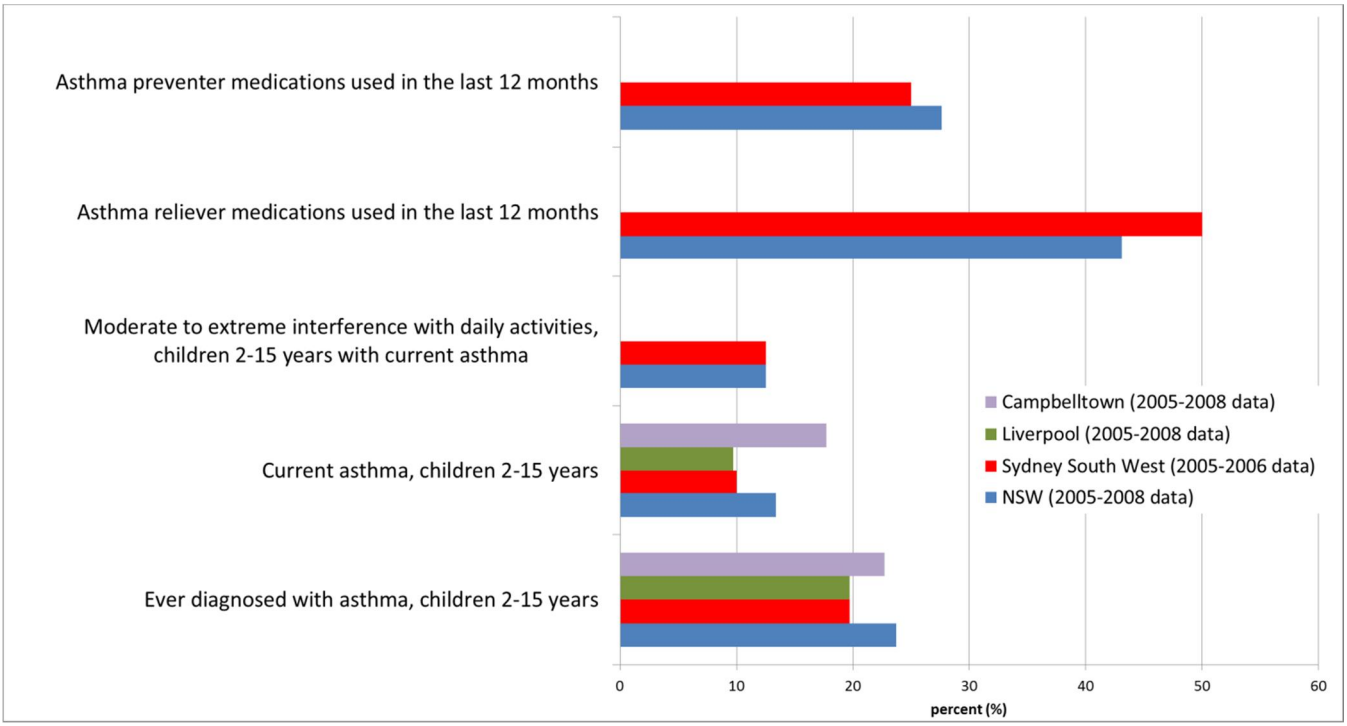


Figure 2.7: Summary of Asthma Prevalence in Children Aged 2-15 years (source: Sydney South West Area Health Service and NSW Health 2008b)

2.4.3 Health statistics

In relation to some more specific health indicators that are of particular relevance for the more detailed assessment of exposure to particulate matter **Table 2.3** presents the available data for population areas defined under the South Western Sydney Local Area Health Service and the Campbelltown and Liverpool areas (or GP health areas). These have been compared with available data for Sydney and NSW. The health indicators include those that are specifically relevant to the quantification of exposure to particulate matter presented in **Section 4.**

For the assessment of potential health impacts from the project, where specific health statistics for the smaller population adjacent to the Project is not available (and not reliable due to the small size of the population), adopting health statistics from the whole of NSW is considered to provide a representative summary of the existing health of the population of interest.

Table 2.3 Summary of key health indicators

Health Indicator	Data available for Population (rate per 100,000 population)						
	Campbelltown South	Campbelltown North	Liverpool West	Liverpool East	Sydney South West Area Health	Greater Sydney	NSW
Mortality							
All causes – all ages*	--	--	--	--	605.7[1]	586.9[1]	670#[2]
All causes ≥30 years*	--	--	--	--	--	--	1087#[2]
Cardiopulmonary ≥30 years*	--	--	--	--	--	--	490#[2]
Cardiovascular – all ages*	--	--	--	--	--	--	164#[2]
Respiratory – all ages*	--	--	--	--	--	--	57#[2]
Hospital admissions							
Coronary heart disease	823.7[3]		636.6[3]		578.3[4]	391.6[4]	608.7[4]
COPD >65 years	1929.6[3]		1677.9[3]		1498.4[4]	1194.2[4]	1470.4[4]
Cardiovascular disease							
All ages	2185.8[6]	1791.2[6]	1710.2[6]	1861.9[6]	1823.7[6]	1582.6[5]	1818.2[6] 1949.9[5]
>65 years*	--	--	--	--	--	--	23352#[3]
Respiratory Disease							
All ages	1948.7[6]	1883.8[6]	1649.2[6]	1824.9[6]	1689.3[6]	1530.3[5]	1587.3[6] 1770.2[5]
>65 years*	--	--	--	--	--	--	8807#[3]
Asthma							
Asthma hospitalisations (ages 5-34 years)	--	--	--	--	137.0[4]	105.1[4]	133.6[4]
Current asthma for ages 2-15 years	--	--	--	--	15.2%[7]	--	15.4%[7]
Current asthma for ages 16 and over	--			--	7.8%[7]	--	10.1%[7]

* Health indicators directly relevant to the characterisation of potential impacts associated with exposure to particulate matter as presented in **Section 4**
# Data provided by NSW Health (upon written request)
All other data has been obtained from Health Statistics New South Wales
1 - Data from 2006-2007
2 – Data for 2005-2007
3 - Data for 2009-2011
4 – Data for 2010-2011
5 – Data for 2011-2012
6 – Data for 2001
7 – Data for 2012
-- No data available

Uncertainties

There are limitations in the use of this data for the quantification of impact and risk. This data is derived from statistics recorded by hospitals and doctors, reported by postcode of residence, and are dependent on the correct categorisation of health problems upon presentation at the hospital. There may be some individuals who may not seek medical assistance particularly with less serious conditions and hence there is expected to be some level of under-reporting of effects commonly considered in relation to morbidity. Quantitatively, the baseline data considered in this assessment is only a general indicator (not a precise measure) of the incidence of these health endpoints.

2.5 Existing air quality

2.5.1 General

The south-western region of Sydney is identified as a major growth centre for the city. The region is also known (as outlined in the LAQIA) to be predisposed to elevated pollution levels, most notably photochemical smog (ozone generation), during the months of spring and summer.

A number of studies were undertaken in the 1980's and 1990's in relation to levels of photochemical smog in south-western Sydney (*Inquiry into the health impacts of air pollution in the Sydney basin* 2006; Hyde 1990; Johnson 1992). These studies considered air quality data reported in 1970's, 1980's and 1990's, emission estimates from key sources within the Sydney urban areas (including projected emissions based on planning needs in Sydney), complex terrain and meteorological evaluations of wind and dispersion patterns in the Sydney basin. The Pilot Study for the Macarthur South and South Creek Valley (Hyde 1990) identified the potential for deterioration of air quality, specifically photochemical smog, if the planned development (at the time) in the area proceeded without emission controls on the ozone precursors, oxides of nitrogen (NO_x) and volatile organic compounds (VOCs, in particular non-methane hydrocarbons derived from vehicle emissions). In the early 1990's the outcomes from this study affected the extent of development proposed in the Hawkesbury Valley. Since completion of these studies air quality in the Sydney basin, including south-western Sydney, has significantly improved. The improvements in air quality have resulted from:

- Significant reductions in particulates in the atmosphere due to the banning of back yard burning and unauthorised incineration in Sydney since the early 1980's, with further restrictions implemented over time[4].
- Improvements in emission controls for all vehicles[5]:
    - Cars built from 2013 emit 3% of the NO_x emitted by cars built in 1976;
    - Diesel trucks built from 2013 emit 8% of the particles emitted by vehicles built in 1996;
    - Total vehicle emissions (NO_x and VOCs) have fallen over the past decades and are predicted to continue to decline.
- Introduction of new industrial emission limits resulting in lower emissions over time.
- Concentrations of carbon monoxide and nitrogen dioxide in ambient air in Sydney have significantly declined from the 1980's (from well above the current NEPM air quality guideline to below the NEPM air quality guideline) as a result of the introduction of unleaded fuel and improved emission controls (NSW DECCW 2010).
- Concentrations of lead in the atmosphere have declined significantly since the introduction of unleaded fuel in 1985 (NSW DECCW 2010).

[4] Refer to the Protection of the Environment Operations (Clean Air) Regulation 2010 for most current details in household burning: http://www.legislation.nsw.gov.au/maintop/view/inforce/subordleg+428+2010+cd+0+N

[5] Reported following analysis of the NSW EPA Air Emissions Inventory, as presented by http://northconnex.com.au/docs/RMS222_NorthConnex_Factsheet_DetailedAirQuality_Northern.pdf

- Concentrations of benzene (and other VOCs) in ambient air have declined due to a greater proportion of the vehicle fleet being fitted with catalytic converters and the lowering of the maximum amount of benzene allowable in fuel in January 2006 (NSW DECCW 2010).

The above measures have resulted in declining emissions of NO_X, VOCs and particulates in Sydney over time despite increases in population, vehicle kilometres travelled and energy consumption, as illustrated in **Figure 2.8**[6]. It is noted that the improvements in air quality in Sydney over the past decades have been considered in future planning decisions (as outlined in Sydney Metropolitan Strategy documents (WSROC 2007)), where ongoing urban development in south-western Sydney has been encouraged.

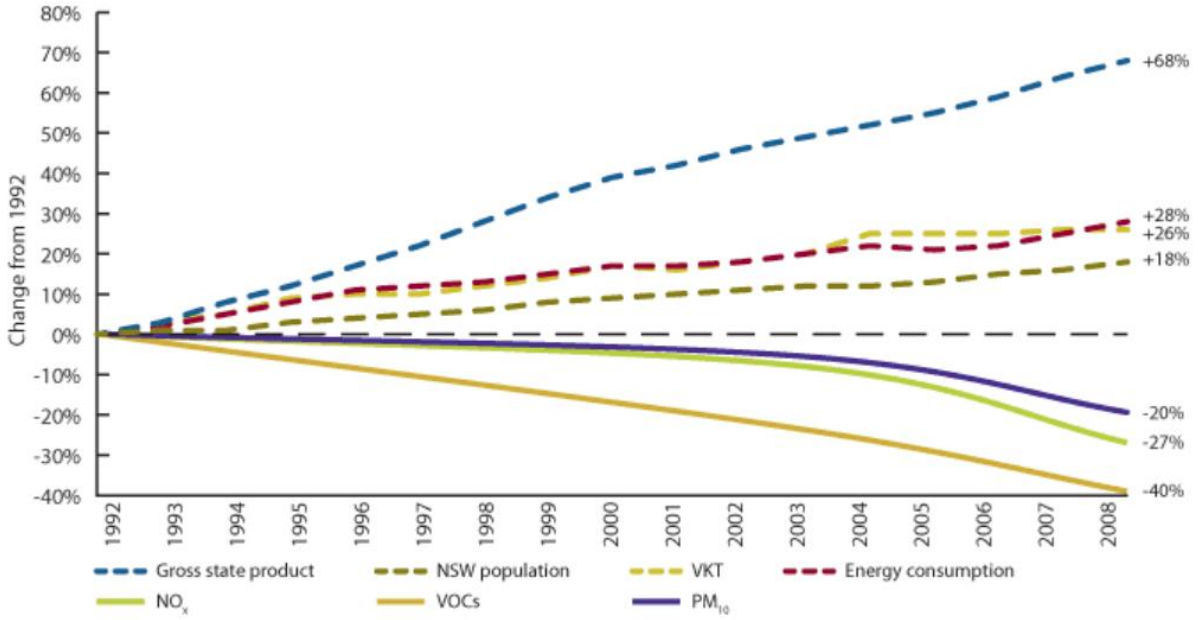


Figure 2.8: Trends in emissions in the Sydney region, compared with key NSW statistic (source: NSW EPA)

In relation to current air quality in Sydney, and more specifically $PM_{2.5}$, review of the sources (emissions) that contribute to the measured $PM_{2.5}$ reported in the Sydney area by the NSW EPA (based on emissions inventory data – for the year 2008, published 2012[7]), as illustrated in **Figure 2.9,** indicates that the most significant sources are household activities (including residential wood heaters – with peak emissions in the winter months from wood-smoke). Emissions from road transport in the Sydney area contribute a consistent amount to the total $PM_{2.5}$ emissions (as would be expected as use of vehicles in Sydney is relatively constant throughout the year). As a percentage of the total emissions, road transport comprises a greater proportion of the total $PM_{2.5}$ emissions in summer compared with winter (where other sources are more dominant).

[6] Available from the NSW EPA: http://www.epa.nsw.gov.au/soe/soe2012/chapter2/chp_2.1.htm#fig2.10

[7] http://www.epa.nsw.gov.au/woodsmoke/index.htm

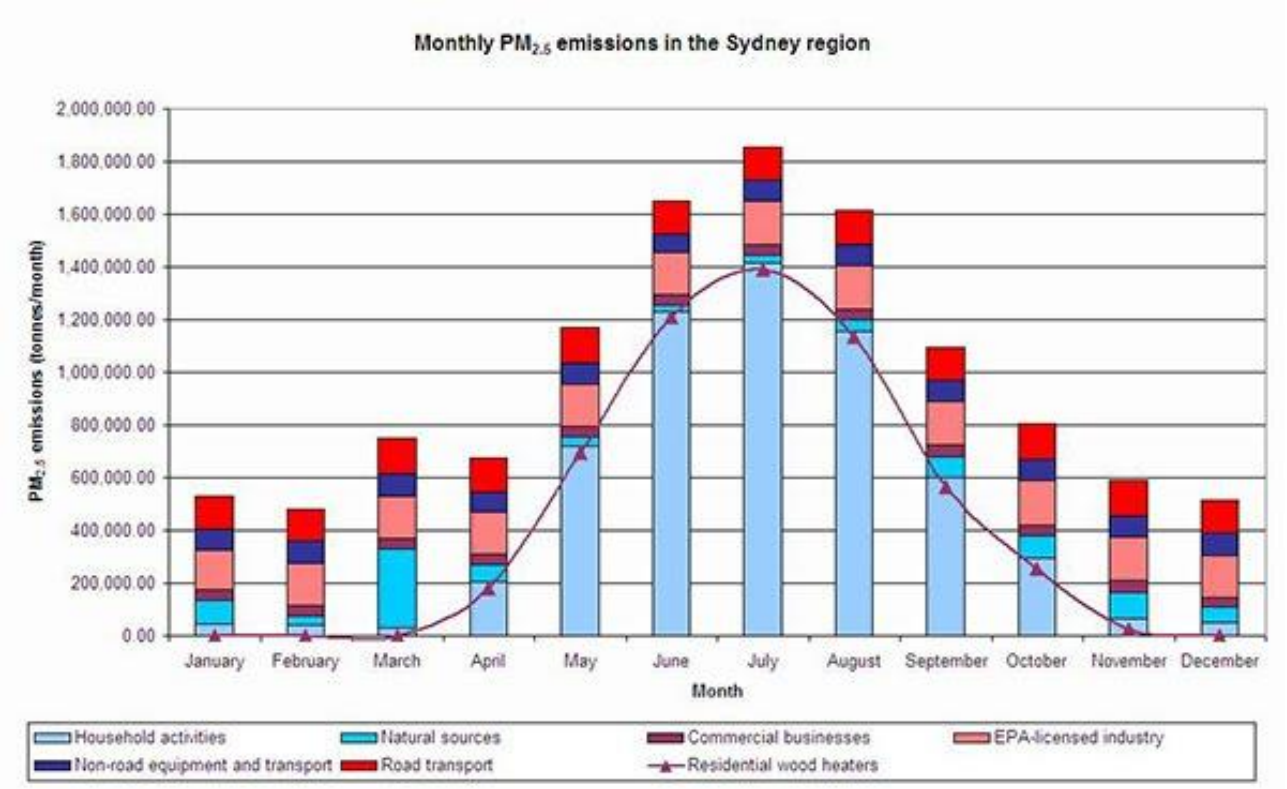


Figure 2.9: $PM_{2.5}$ emissions in Sydney – variability and contributions on monthly basis (2008, source: NSW EPA)

2.5.2 Existing Air Quality Considered in LAQIA

Review of the air quality monitoring data for this region in LAQIA has shown that air quality has improved over the past decade with significant improvements in ambient concentrations of lead, CO, SO_2 and NO_2. However, particulate matter and ozone remain an issue with additional focus placed on reducing traffic emissions through land use changes and sustainable public transport initiatives.

Existing air quality in the local area has been evaluated in the LAQIA. Air quality in the area is influenced by a number of industrial and non-industrial sources in the area. These include existing industries surrounding the Project site, the Glenfield Waste Disposal facility, traffic emissions from the existing road network that includes the South Western Motorway (M5) (adjacent to the northern site boundary), locomotive emissions form the operation of the Southern Sydney Freight Line (SSFL) (west of the site), locomotive emissions from the East Hills rail line (south of the site) and emissions from aircraft at Bankstown Airport (northeast of the site).

Data on existing air quality is available from monitors located on the site (where data is available for 2013), as well as at Liverpool and Prospect (with the data from Prospect used to supplement days where data is missing from the Liverpool station), which form part of the OEH air quality monitoring network in Sydney. Data from these monitoring stations indicate the following in relation to the key pollutants considered in this assessment:

- Existing levels of nitrogen dioxide, carbon monoxide and sulfur dioxide are well below the current guideline established by OEH;
- Existing levels of ozone are generally low and below the NEPM guidelines, however more elevated levels (and some exceedances of the NEPM guideline) are reported in the warmer months (November to February);
- In relation to particulate matter, the following can be noted from the available data:
    - Naturally occurring significant weather events such as dust storms and bushfires are reflected in the particulate matter data;
    - Annual average concentrations of PM_{10} reported from 2009 to 2013 are below the OEH guideline;
    - 24-hour average concentrations of PM_{10} reported between 2009 and 2013 generally met the OEH criteria, with the exception of 2009 where dust storm events in April and November resulted in significant exceedence of the criteria (and a higher number of days of exceedence than allowable with the OEH criteria);
    - In relation to PM10 levels, 2013 was a relatively high year as it included a number of natural particulate matter events (bushfires in particular);
    - PM10 concentrations reported on the Project site were very similar to (in magnitude and variability) to the data reported at the OEH Liverpool monitoring station. In general the concentrations reported at the OEH Liverpool monitoring station were higher than reported on the site;
    - Annual average concentrations of $PM_{2.5}$ reported from 2009 to 2013 are below the NEPC goal, with the exception of 2013 where the data was significantly influenced by bushfire events in the latter part of the year. There were a few exceedances of the 24-hour average goal, however these occurred during the dust storm events in 2009, hazard reduction days in 2011 or bushfires in 2013.
- Existing levels of volatile organic compounds have been measured on the site on a number of occasions during the period 2012-2013. The concentrations of benzene, toluene, ethylbenzene and xylenes were below the NEPM air monitoring investigation levels.

Baseline ambient air quality for the conduct of the LAQIA was selected based on the available data, with most of the concentrations derived from the OEH Liverpool air monitoring station (where concentrations of key pollutants were reported to be slightly higher than on-site in 2013). Data for the assessment of sulfur dioxide levels was derived from the OEH Chullora monitoring station.

Section 3. Review of air impacts

3.1 Air impact assessment

3.1.1 Summary

Emissions to air from the development and operation of the proposed IMT Project have been evaluated and quantified in the LAQIA.

Emissions to air have been estimated during construction as well as operation of the Project. In relation to construction, emissions have been derived from the following sources:

- Construction traffic, plant and equipment where emissions to air are primarily derived from diesel powered vehicles and equipment, however some emissions are derived from motor vehicles; and
- Bulk earthworks where emissions to air are associated with crustal dust emissions.

Operational emissions have been estimated from the following sources:

- IMEX and interstate trains where emissions to air are derived from diesel locomotives;
- IMEX and interstate container storage yard, where emissions are derived from in-terminal vehicles and other container handling equipment within these yards;
- Traffic associated with the IMEX, Interstate, warehousing and commercial operations. Emissions to air are derived from motor vehicles as well as on the road trucks (emissions from diesel exhaust).

These sources result in emissions to air that are primarily derived from diesel combustion engines (locomotives and trucks) and dust (from earthmoving activities, also known as crustal dust). Hence the assessment of impacts to air is focused on hazards associated with dust (of varying size depending on the source) and diesel emissions.

The LAQIA has evaluated the key pollutants that are associated with the emission sources evaluated, including diesel emissions. These include:

- particulate matter (PM) including size fractions PM_{10} and $PM_{2.5}$ which are of importance for the assessment of potential health impacts from crustal dust and diesel emissions. Other measures of particulates or dust, namely total suspended particulates (TSP) and deposited dust have been evaluated in the LAQIA however these measures more specifically relate to nuisance impacts, not health impacts and have not been further evaluated in this assessment;
- oxides of nitrogen (in particular NO_2);
- sulfur dioxide (SO_2);
- volatile organic compounds (VOCs); and
- polycyclic aromatic hydrocarbons (PAHs) which are particularly associated with diesel emissions.

Evaluation of the above emissions and key pollutants in the LAQIA has also considered a number of other sources (with emissions of similar key pollutants) in the local/regional area. These other sources include:

- existing industries to the east and north-east of the Project site (including Greenhills Industrial Estate, Moorebank Business Park);
- the existing landfill (Glenfield Waste Disposals) to the south-west;
- traffic emissions from the existing road network including the South Western Motorway (M5) directly bordering the northern boundary of the site;
- emissions from locomotives on the Southern Sydney Freight Line (SSFL) to the west of the Project boundary;
- locomotive emissions from the East Hills Railway Line to the south of the Project boundary; and
- emissions from aircraft at Bankstown Airport to the northeast.

The assessment of cumulative impacts in the local area have been evaluated in the LAQIA on the basis of predicted emissions from the Project as well as background levels.

Background levels have been determined from available data on existing air quality from monitoring stations located in Liverpool, Prospect and Chullora, predicted emissions from the SSFL (not accounted for in existing background data) and predicted emissions from the Glenfield Waste Disposals landfill (not accounted for the in existing background data).

3.1.2 Assessment scenarios

The assessment of emissions to air from the project has been undertaken within the LAQIA for a number of scenarios that include construction and operations, as outlined below:

Table 3.1 Project assessment scenarios considered in LAQIA

Project Phase	Construction	Operations	Scenario ID
Phase A – (2016/2017)	✓		Scenario 1 – Northern Scenario 2 – Central Scenario 3 – Southern
Phase B – (2023/2024)	✓	✓	Scenario 4 – Northern Scenario 5 – Central Scenario 6 – Southern
Phase C – (2028/2029)	✓	✓	Scenario 7 – Northern Scenario 8 – Central Scenario 9 – Southern
Full Build – (2030)		✓	Scenario 10 – Northern Scenario 11 – Central Scenario 12 – Southern
SIMTA cumulative assessment* (2030)		✓	Cumulative Scenario 1 Cumulative Scenario 2 Cumulative Scenario 3

* In relation to the cumulative assessment scenarios, these have focused on the southern rail access option only (for the Moorebank IMT) and the assessment has addressed nitrogen dioxide (NO_2) and particulates (PM_{10} and $PM_{2.5}$) only as these are the key pollutants relevant to the operation of the terminals

The following sections provide an initial, or screening level review of the predicted impacts associated with these scenarios. This screening level assessment has focused on the maximum predicted impacts (incremental and cumulative as relevant) from the Project to determine of a more detailed review of health impacts is required.

Impacts in all other areas (including the sensitive receivers) are lower than these maximum predicted impacts/concentrations. Further assessment of the sensitive receivers has been undertaken in the detailed review of exposures to particulate matter emissions presented in **Section 4**.

3.1.3 Combustion emissions

Petrol and diesel combustion sources (vehicles and equipment) emit a range of air pollutants that are known to be associated with adverse health impacts. Common air pollutants emitted from these vehicles include:

- Petrol combustion sources: nitrogen oxides, in particular nitrogen dioxide, carbon monoxide, fine particulates and volatile organic compounds. The key volatile organic compounds of concern from motor vehicle emissions include benzene, toluene and xylenes (BTX) which have been associated with a range of health effects that range from headaches to eye irritation and cancer (depending on the compound).
- Diesel combustion sources: nitrogen oxides, in particular nitrogen dioxide, carbon monoxide, fine particulates, volatile organic compounds (in particular BTX and 1,3-butadiene) and aldehydes (formaldehyde and acetaldehyde); and polycyclic aromatic hydrocarbons (EA 2003). Polycyclic aromatic hydrocarbons are another group of compounds where the toxicity will vary depending on the presence of individual polycyclic aromatic hydrocarbons.

The assessment of combustions emissions requires consideration of key urban air pollutants (nitrogen oxides, carbon monoxide), the individual compounds likely to be present in the more general measures of volatile organic compounds (which include BTX, 1,3-butadiene and the aldehydes) and polycyclic aromatic hydrocarbons, and particulates. These are further discussed in the following sections.

3.2 Review of key air pollutants

3.2.1 Oxides of nitrogen

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. Motor vehicles, along with industrial, commercial and residential combustion sources, are primary producers of nitrogen oxides.

In Sydney, the OEH (2012) estimated that on-road vehicles account for about 62 per cent of emissions of nitrogen oxides, industrial facilities account for 12 per cent, other mobile sources account for about 22 per cent with the remainder from domestic/commercial sources.

In terms of health effects, nitrogen dioxide is the only oxide of nitrogen of concern (WHO 2000a). 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 (Morgan et al. 1998). Asthmatics, the elderly and people with existing cardiovascular and respiratory disease are particularly susceptible to the effects of nitrogen dioxide (NEPC, 2010). The health effects associated with exposure to nitrogen dioxide depend on the duration or exposure as well as the concentration; hence guidelines have been developed in Australia (and internationally) that reflect both acute and chronic exposures.

Guidelines are available from the NSW EPA and NEPC (NEPC 2003) that are based on protection from adverse health effects following short-term (acute) and longer-term (chronic) exposure. Review of these guidelines by NEPC (2010) identified additional supporting studies for the evaluation of potential adverse health effects and indicated that these should be considered in the current review of the National Ambient Air Quality NEPM (no interim or finalisation date available). The air guidelines currently available from NEPC are consistent with health based guidelines currently available from the WHO (2005) and the USEPA (2010[8], specifically listed to be protective of exposures to sensitive populations including asthmatics, children and the elderly). On this basis the current NEPC guidelines are considered appropriate for the assessment of potential health impacts associated with the Project.

Assessment of acute exposures:

The NEPC ambient air quality guideline for the assessment of acute (short-term) exposures to nitrogen dioxide relates to the maximum predicted total (cumulative) 1-hour average concentration in air. The guideline of 246 µg/m^3 (or 120 ppbv) is based on a lowest observed adverse effect level (LOAEL) of 409 to 613 µg/m^3 derived from statistical reviews of epidemiological data suggesting an increased incidence of lower respiratory tract symptoms in children and aggravation of asthma. An uncertainty factor of two to protect susceptible people (i.e. asthmatic children) was applied to the LOAEL (NEPC 1998). On this basis the NEPC (and Environment Protection Authority) acute guideline is protective of adverse health effects in all individuals, including sensitive individuals.

Table 3.2 presents a summary of the maximum (for all locations modelled) predicted cumulative 1-hour average concentration of nitrogen dioxide for the scenarios evaluated.

[8] Most recent review of the Primary National Ambient Air Quality Standards for Nitrogen Dioxide published by the USEPA in the Federal Register Volume 75, No. 26, 2010, available from: http://www.gpo.gov/fdsys/pkg/FR-2010-02-09/html/2010-1990.htm

Table 3.2 Review of potential acute health impacts – nitrogen dioxide (NO_2)

Location and scenario	Maximum 1-hour average concentration of NO_2 ($\mu g/m^3$)
Northern rail access	
- Phase A, Scenario 1	105
- Phase B, Scenario 4	131
- Phase C, Scenario 7	131
- Full Build, Scenario 10	130
Central rail access	
- Phase A, Scenario 2	105
- Phase B, Scenario 5	129
- Phase C, Scenario 8	133
- Full Build, Scenario 11	132
Southern rail access	
- Phase A, Scenario 3	105
- Phase B, Scenario 6	128
- Phase C, Scenario 9	133
- Full Build, Scenario 12	133
- Cumulative Scenario 1	146
- Cumulative Scenario 2	143
- Cumulative Scenario 3	139
Acute health based guideline	**246**

All the concentrations of nitrogen dioxide presented in the above table for the Project are well below the acute NEPC guideline of 246 $\mu g/m^3$. Hence there are no adverse health effects expected in relation to acute exposures to nitrogen dioxide in the local area surrounding the Project.

Assessment of chronic exposures:

The NEPC ambient air quality guideline for the assessment of chronic (long-term or lifetime) exposures to nitrogen dioxide relates to the maximum predicted total (cumulative) annual average concentration in air. The guideline of 62 $\mu g/m^3$ (or 30 ppbv) is based on a lowest observed adverse effect level (LOAEL) of the order of 40 – 80 ppbv (approx. 75-150 $\mu g/m^3$) during early and middle childhood years which can lead to the development of recurrent upper and lower respiratory tract symptoms, such as recurrent 'colds', a productive cough and an increased incidence of respiratory infection with resultant absenteeism from school. An uncertainty factor of 2 was applied to the LOAEL to account for susceptible people within the population resulting in a guideline of 20-40 ppbv (38-75 $\mu g/m^3$) (NEPC 1998). On this basis the NEPC (and OEH) chronic guideline is protective of adverse health effects in all individuals, including sensitive individuals.

Table 3.3 presents a summary of the maximum (for all locations modelled) predicted cumulative annual average concentration of nitrogen dioxide for the scenarios evaluated.

Table 3.3 Review of potential chronic health impacts – Nitrogen dioxide (NO_2)

Location and scenario	Maximum annual average concentration of NO_2 (µg/m^3)
Northern rail access	
- Phase A, Scenario 1	23
- Phase B, Scenario 4	39
- Phase C, Scenario 7	38
- Full Build, Scenario 10	34
Central rail access	
- Phase A, Scenario 2	23
- Phase B, Scenario 5	34
- Phase C, Scenario 8	36
- Full Build, Scenario 11	35
Southern rail access	
- Phase A, Scenario 3	23
- Phase B, Scenario 6	33
- Phase C, Scenario 9	36
- Full Build, Scenario 12	36
- Cumulative Scenario 1	43
- Cumulative Scenario 2	40
- Cumulative Scenario 3	38
Chronic health based guideline	**62**

All the concentrations of nitrogen dioxide presented in the above table for the Project are well below the chronic NEPC guideline of 62 µg/m^3. Hence there are no adverse health effects expected in relation to chronic exposures to nitrogen dioxide in the local area surrounding the Project.

As the assessment of potential acute and chronic health impacts associated with the Project are addressed in the guidelines adopted (and considered above), and no predicted impacts exceed these guidelines, no further detailed assessment of these exposures is warranted.

3.2.2 Carbon monoxide

Motor vehicles are the dominant source of carbon monoxide in air (DECCW 2009). Adverse health effects of exposure to carbon monoxide are linked with carboxyhaemoglobin (COHb) in blood. 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).

Guidelines are available in Australia from NEPC (NEPC 2003) and NSW EPA (OEH) that are based on the protection of adverse health effects associated with carbon monoxide. Review of these guidelines by NEPC (2010) identified additional supporting studies[9] for the evaluation of potential adverse health effects and indicated that these should be considered in the current review of the National Ambient Air Quality NEPM (no interim or finalisation date available). The air guidelines currently available from NEPC are consistent with health based guidelines currently available from

[9] Many of the more current studies are epidemiology studies that relate to a mix of urban air pollutants (including particulate matter) where it is more complex to determine the effects that can be attributed to carbon monoxide exposure only.

the WHO (2005) and the USEPA (2011[10], specifically listed to be protective of exposures by sensitive populations including asthmatics, children and the elderly). On this basis the current NEPC guidelines are considered appropriate for the assessment of potential health impacts associated with the project.

The NEPC ambient air quality guideline for the assessment of exposures to carbon monoxide has considered LOAEL (lowest observed adverse effect level) and NOAELs (no observed adverse effect level) associated with a range of health effects in healthy adults, people with ischemic heart disease and foetal effects. In relation to these data, a guideline level of carbon monoxide of nine ppmv (or 10 mg/m^3 or 10 000 µg/m^3) over an 8-hour period was considered to provide protection (for both acute and chronic health effects) for most members of the population. An additional 1.5 fold uncertainty factor to protect more susceptible groups in the population was included. On this basis the NEPC (and the Environment Protection Authority) guideline is protective of adverse health effects in all individuals, including sensitive individuals.

The Environment Protection Authority have also established a guideline for 15-minute average (100 mg/m^3) and 1-hour average (30 mg/m^3) concentrations of carbon monoxide in ambient air. The NEPC has also established a guideline for an 8-hour average (10 mg/m^3) concentration of carbon monoxide in ambient air. These guidelines are based on criteria established by the WHO (WHO 2000b) using the same data used by the NEPC to establish the guideline (above) with extrapolation to different periods of exposure on the basis of known physiological variables that affect carbon monoxide uptake.

Table 3.4 presents a summary of the maximum (for all locations modelled) predicted cumulative 1-hour average and 8-hour average concentrations of carbon monoxide for the scenarios evaluated.

[10] Most recent 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

Table 3.4 Review of potential acute and chronic health impacts – Carbon monoxide (CO)

Location and scenario	Maximum 1-hour average concentration of CO (µg/m^3)	Maximum 8-hour average concentration of CO (µg/m^3)
Northern rail access		
- Phase A, Scenario 1	4585	2065
- Phase B, Scenario 4	4590	2079
- Phase C, Scenario 7	4604	2112
- Full Build, Scenario 10	4604	2111
Central rail access		
- Phase A, Scenario 2	4585	2064
- Phase B, Scenario 5	4592	2084
- Phase C, Scenario 8	4600	2106
- Full Build, Scenario 11	4600	2104
Southern rail access		
- Phase A, Scenario 3	4585	2065
- Phase B, Scenario 6	4590	2080
- Phase C, Scenario 9	4598	2099
- Full Build, Scenario 12	4603	2108
Relevant health based guideline	**30 000**	**10 000**

All the concentrations of carbon monoxide presented in the above table are well below the relevant health based guidelines. Hence there are no adverse health effects expected in relation to exposures (acute and chronic) to carbon monoxide in the local area surrounding the Project.

As the assessment of potential acute and chronic health impacts are addressed in the guidelines adopted (and considered above), and no predicted impacts exceed these guidelines, no further detailed assessment of these exposures is warranted.

3.2.3 Sulfur dioxide

The main source of sulfur dioxide in Sydney is from industrial emissions. Sulfur dioxide can also be the result of the combustion of fuels containing sulfur, however Australian fuels are relatively low in sulfur and hence these emissions are not a significant source. Apart from potential health effects associated with exposure to sulfur dioxide, emissions of sulfur dioxide can mix with water vapour in the atmosphere to form acids (acid rain) that can damage vegetation, building materials and soil.

The available studies, including a large number of population-based epidemiological studies, have reported a link between exposure to sulphur dioxide and daily mortality and respiratory and cardiovascular effects. The strongest evidence comes from controlled human studies on short-term exposure to sulphur dioxide and respiratory effects. Effects are greater when the person is exercising and in people with asthma and other respiratory conditions such as COPD (chronic obstructive pulmonary disease) (NEPC 2010).

In relation to the available guidelines for the assessment of sulfur dioxide, the following can be noted in relation to the protection of human health:

- Both long and short-term health effects were considered in the development of the NEPC guidelines for sulfur dioxide;

- Exposure to sulfur dioxide results in the development of an acute irritant response initially in the upper airways which leads to coughing, wheezing, sputum production, increased incidence of respiratory infections and aggravation of asthma and chronic obstructive airways disease (COPD). The impacts from these effects can be mild, such as an irritant cough through to more serious impacts such as increases in mortality and hospital admissions for respiratory disease and asthma.
- Asthmatics were considered to be particularly susceptible to sulfur dioxide and respond very quickly (10–15 mins) to exposure even at low levels. The severity of the response depends on the concentration of SO_2 and the duration of the exposure (NEPC 2010).
- The NEPC guidelines were developed to protect against bronchospasm in asthmatics and addressed both acute exposures (based on 1 hour and 24 hour averages) and chronic exposures (based on an annual average). In addition to these guidelines the OEH also established a guideline for a 10-minute average exposure based on an earlier review of SO_2 impacts by NHMRC (NHMRC 1995).

Further review of health effects associated with exposure to sulfur dioxide by NEPC (NEPC 2010) identified that it was appropriate to establish a guideline based on a threshold (i.e. where exposures below the threshold concentration are not associated with any adverse health effects). Hence it is appropriate that the assessment of potential health effects associated with exposure to sulfur dioxide be undertaken solely on the basis of the NEPC and OEH guidelines as these are based on a threshold that is protective of adverse health effects for all individuals.

Table 3.5 presents a summary of the maximum (for all locations modelled) predicted sulfur dioxide relevant for the scenarios evaluated, with comparison against the relevant acute and chronic health based guideline available from NEPC (NEPC 2003),.

Table 3.5 Review of potential acute and chronic health impacts – Sulfur dioxide (SO_2)

Location and scenario	Maximum 1-hour average concentration of SO_2 (µg/m^3)	Maximum 24-hour average concentration of SO_2 (µg/m^3)	Maximum annual average concentration of SO_2 (µg/m^3)
Northern rail access			
- Phase A, Scenario 1	31.4	8.2	1.8
- Phase B, Scenario 4	31.6	8.2	1.8
- Phase C, Scenario 7	31.6	8.2	1.8
- Full Build, Scenario 10	31.6	8.2	1.8
Central rail access			
- Phase A, Scenario 2	31.4	8.2	1.8
- Phase B, Scenario 5	31.6	8.2	1.8
- Phase C, Scenario 8	31.6	8.2	1.8
- Full Build, Scenario 11	31.5	8.2	1.8
Southern rail access			
- Phase A, Scenario 3	31.4	8.2	1.8
- Phase B, Scenario 6	31.5	8.2	1.8
- Phase C, Scenario 9	31.6	8.2	1.9
- Full Build, Scenario 12	31.6	8.2	1.8
Relevant health based guideline	**570 (0.20 ppm)**	**228 (0.08 ppm)**	**60 (0.02 ppm)**

All the concentrations of sulfur dioxide presented in the above table are well below the relevant health based guidelines. Hence there are no adverse health effects expected in relation to exposures (acute and chronic) to sulfur dioxide in the local area surrounding the Project.

3.3 Review of volatile organic compounds and polycyclic aromatic hydrocarbons

3.3.1 General

The AQIA has considered emissions of volatile organic compounds and polycyclic aromatic hydrocarbons to air from the project. Both volatile organic compounds and polycyclic aromatic hydrocarbons refer to a group of compounds with a mix of different proportions and toxicities. It is the individual compounds within the group that are of importance for evaluating adverse health effects. The composition of individual compounds in the volatile organic compounds and polycyclic aromatic hydrocarbons evaluated will vary depending on the source of the emissions. Hence it is important that the key individual compounds present in emissions considered for this project are speciated (i.e. identified and quantified as a percentage of the total volatile organic compounds or total polycyclic aromatic hydrocarbons) to ensure that potential impacts associated with exposure to these compounds can be adequately assessed.

Volatile organic compounds in air in Sydney (OEH 2012) are primarily derived from domestic/commercial sources (54 per cent) with on-road vehicles contributing around 24 per cent, industrial emissions eight per cent with the remainder from off-road mobile sources and other commercial sources.

The assessment of potential exposures to volatile organic compounds and polycyclic aromatic hydrocarbons has been undertaken by comparing the maximum predicted ground level

concentration with the relevant health based guideline, where this ratio is defined as a Hazard Index (HI). Each individual HI is added up to obtain a total HI for all the volatile organic compounds and/or polycyclic aromatic hydrocarbons considered. The total HI is a sum of the potential hazards associated with all the volatile organic compounds and polycyclic aromatic hydrocarbons together assuming the health effects are additive, and is evaluated as follows:

- A total HI ≤ 1 means that all the maximum predicted concentrations are below the health based guidelines and there are no additive health impacts of concern.
- A total HI > 1 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 volatile organic compounds or polycyclic aromatic hydrocarbons 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.

3.3.2 Volatile organic compounds

Predicted ground level concentrations of VOCs have been presented in the LAQIA. The proportion of each of the individual volatile organic compounds that may be present in the air is then estimated based on the assumed composition of the vehicle fleet and the type of fuel used. For this assessment the VOCs emissions have been assumed to be derived from diesel combustion sources. Most of the VOC emissions comprise a range of hydrocarbons that are of low toxicity (such as methane, ethylene, ethane, butenes, butanes, pentenes, pentanes, heptanes etc) (EPA 2012). From a toxicity perspective the key volatile organic compounds that have been considered for the vehicle emissions are BTX, 1,3-butadiene, acetaldehyde and formaldehyde (consistent with those identified and targeted in studies conducted in Australia on vehicle emissions (DEH 2003; EPA 2012).

Percentage of each individual VOC is based on a weighted average of emissions from the range of vehicle types proposed to be used on the Project, comprising on-road vehicles (82%), off-road vehicles (4%) and locomotives (14%). The percentages are presented in the LAQIA and are derived from the 2008 Calendar Year Air Emissions Inventory for the Greater Metropolitan Region in NSW (EPA 2012).

3.3.3 Polycyclic aromatic hydrocarbons

Predicted ground level concentrations of PAHs have been presented in the LAQIA. PAHs comprise hundreds of individual compounds with a large number of PAHs and nitro-PAHs detected in diesel exhaust (USEPA). The presence of PAHs in diesel exhaust has been found to be more a function of the PAH content of the fuel than of engine technology. For a given refinery and crude oil, diesel fuel PAH correlates with total aromatic content and T90 (distillation temperature where 90% of the fuel is evaporated). Representative data on aromatic content for diesel fuels in Australia are limited, however emissions tests have been conducted on a range of light and heavy vehicles under different traffic congestion conditions (DEH 2003). The data presented from these emissions tests is assumed to include fuels commonly used in Australia and are considered to provide an indication of the likely contribution of PAHs in diesel exhaust.

The PAHs reported in diesel exhaust by DEH (DEH 2003) comprise the 16 most commonly reported (and highest proportion) PAHs that comprise the majority of the PAHs present in exhaust. The data

available from this study is quite dated (from vehicles manufactured from 1990 to 1996) and use of this data is likely to provide an overestimation of polycyclic aromatic hydrocarbon polycyclic aromatic hydrocarbon emissions from current (and future) diesel vehicles. The evaluation of potential health impacts associated with exposure to PAHs from the Project requires consideration of the 16 individual PAHs, which have chronic health effects of most importance.

The toxicity of individual polycyclic aromatic hydrocarbons varies significantly, with some considered to be carcinogenic while others are not carcinogenic. For the carcinogenic polycyclic aromatic hydrocarbons, these are commonly assessed as a group with the total carcinogenic polycyclic aromatic hydrocarbon concentration calculated using weighting factors that relate the toxicity of individual carcinogenic polycyclic aromatic hydrocarbons to the most well studied polycyclic aromatic hydrocarbon, benzo(a)pyrene. For the carcinogenic polycyclic aromatic hydrocarbons the weighting factors presented by CCME (CCME 2010) have been adopted. Other polycyclic aromatic hydrocarbons that are not carcinogenic have been considered separately.

Using the above approach the maximum predicted annual average concentration of PAHs in areas located on the Project Site boundary and in surrounding areas (cumulative total) have been further evaluated on the basis of the:

- Concentrations of the 16 individual PAHs have been calculated based on the percentage contribution of the group of carcinogenic PAHs (as defined by CCME (CCME 2010)) and each individual non-carcinogenic PAH to the total PAH from data presented by DEH (DEH 2003);
- The maximum predicted concentrations of carcinogenic PAHs and all other individual PAHs have been compared with relevant human health risk based guidelines to determine if the potential for exposure to PAHs from the Project requires more detailed evaluation.

3.3.4 Review of health impacts

The predicted (incremental) concentration of individual volatile organic compounds and polycyclic aromatic hydrocarbons associated with the project (based on the speciation as outlined above) have been reviewed against published peer-reviewed health based guidelines that are relevant to acute and chronic exposures (where relevant). 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 the duration of exposure and the nature of the health effects considered where:

- Acute guidelines are based on exposures that may occur for a short period of time (typically between an hour or up to 14 days). These guidelines are available to assess peak exposures (based on the modelled 1-hour maximum concentration) that may be associated with volatile organic compounds in the air;
- 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 both volatile organic compounds and polycyclic aromatic hydrocarbons in the air.

Tables 3.6 and 3.7 present a summary of the maximum predicted 1-hour or annual average concentration with comparison against acute (**Table 3.6**) and chronic (**Table 3.7**) health based guidelines, along with the calculated HI.

Review of the calculations presented in **Tables 3.6 and 3.7** indicates that the maximum predicted concentration of all key VOCs and PAHs likely to be derived from emission sources (all vehicles and locomotives) associated with the Project and other sources in the local area are well below acute and chronic guidelines that are based on the protection of human health (including sensitive individuals). On this basis no further detailed assessment of these exposures is warranted.

Table 3.6 Evaluation of predicted acute VOC impacts

Key VOC	% of total VOCs	Maximum predicted acute 1-hour average concentration * (µg/m^3)				Health based acute guideline (µg/m^3)	Calculated acute HI			
		Phase A	Phase B	Phase C	Full Build		Phase A	Phase B	Phase C	Full Build
Northern rail access										
Total VOCs		3.9	18.7	66.1	64.6					
Benzene	0.16%	0.0063	0.030	0.11	0.10	29^{A} to 170^{T1}	0.00022	0.0010	0.0036	0.0035
Toluene	0.06%	0.0022	0.010	0.037	0.036	4500^{T2}	0.00000049	0.0000023	0.0000082	0.0000080
Xylenes	0.07%	0.0027	0.013	0.045	0.044	2200^{T3}	0.0000012	0.0000058	0.000020	0.000020
1,3-Butadiene	0.02%	0.00073	0.0035	0.012	0.012	660^{O1}	0.0000011	0.0000053	0.000019	0.000018
Formaldehyde	1.35%	0.053	0.25	0.90	0.88	15^{T4}	0.0036	0.017	0.060	0.058
Acetaldehyde	0.23%	0.0089	0.042	0.15	0.15	470^{O2}	0.000019	0.000090	0.00032	0.00031
						Total acute HI	**0.0038**	**0.018**	**0.064**	**0.062**
Central rail access										
Total VOCs		3.5	22.0	52.9	50.8					
Benzene	0.16%	0.0056	0.035	0.084	0.08	29^{A} to 170^{T1}	0.00019	0.0012	0.0029	0.0028
Toluene	0.06%	0.0020	0.012	0.030	0.028	4500^{T2}	0.00000044	0.0000027	0.0000066	0.0000063
Xylenes	0.07%	0.0024	0.015	0.036	0.034	2200^{T3}	0.0000011	0.0000068	0.000016	0.000016
1,3-Butadiene	0.02%	0.00065	0.004	0.0098	0.009	660^{O1}	0.0000010	0.0000062	0.000015	0.000014
Formaldehyde	1.35%	0.047	0.30	0.72	0.7	15^{T4}	0.0032	0.020	0.048	0.046
Acetaldehyde	0.23%	0.0079	0.05	0.12	0.11	470^{O2}	0.000017	0.00011	0.00025	0.00024
						Total acute HI	**0.0034**	**0.021**	**0.051**	**0.049**
Southern rail access										
Total VOCs		4.1	17.9	42.6	13.6					
Benzene	0.16%	0.0065	0.028	0.068	0.022	29^{A} to 170^{T1}	0.00022	0.0010	0.0023	0.0007
Toluene	0.06%	0.0023	0.0100	0.024	0.008	4500^{T2}	0.00000051	0.0000022	0.0000053	0.0000017
Xylenes	0.07%	0.0028	0.012	0.029	0.009	2200^{T3}	0.0000013	0.0000055	0.000013	0.000004
1,3-Butadiene	0.02%	0.00075	0.0033	0.008	0.003	660^{O1}	0.0000011	0.0000050	0.000012	0.000004
Formaldehyde	1.35%	0.055	0.24	0.58	0.18	15^{T4}	0.0037	0.016	0.038	0.012
Acetaldehyde	0.23%	0.0092	0.040	0.096	0.03	470^{O2}	0.000020	0.000086	0.00020	0.00007
						Total acute HI	**0.0039**	**0.017**	**0.041**	**0.013**

Notes for Table 3.6:

* Concentrations presented for the 1 hour average are the predicted incremental 99.9th percentile concentrations (as provided from the LAQIA)

A: Acute inhalation guideline (for exposures from 1 hour to 14 days) from review by ATSDR 2008 for benzene

T1: TCEQ 2007, Benzene, Development Support Document. Texas Commission of Environmental Quality, 1 hour average guideline value (include additional 3.3 fold safety factor). This acute guideline is lower than that derived by the OEHHA (based on older studies)

T2: TCEQ 2008, Toluene, Development Support Document. Texas Commission of Environmental Quality, 1 hour average guideline value (include additional 3.3 fold safety factor)

T3: TCEQ 2009, Xylenes, Development Support Document. Texas Commission of Environmental Quality, 1 hour average guideline value (include additional 3.3 fold safety factor)

T4: TCEQ 2008, Formaldehyde, Development Support Document. Texas Commission of Environmental Quality, 1 hour average guideline value (include additional 3.3 fold safety factor). This guideline is noted to be lower than the acute guideline available from the WHO (2000a, 2010) of 100 µg/m^3 for formaldehyde

O1: OEHHA 2013, Acute (1 hour average) guideline derived by the California Office of Environmental Health Hazard Assessment. The guideline developed is lower than developed by TCEQ (2008) based on the same critical study

O2: OEHHA 2008, Acute (1 hour average) guideline derived by the California Office of Environmental Health Hazard Assessment

Table 3.7 Evaluation of predicted chronic VOC and PAH impacts

Key VOC	% total VOCs or PAHs*	Maximum predicted chronic annual average concentration ** (µg/m^3)				Health based chronic guideline (µg/m^3)	Calculated chronic HI			
		Phase A	Phase B	Phase C	Full Build		Phase A	Phase B	Phase C	Full Build
Northern rail access										
	Total VOCs	**0.17**	**4.6**	**16.3**	**15.8**					
Benzene	0.16%	0.00027	0.0073	0.026	0.0252	$1.7^{W\#}$	$9.3x10^{-6}$	$2.5x10^{-4}$	$8.9x10^{-4}$	$8.7x10^{-4}$
Toluene	0.06%	0.000095	0.0026	0.0091	0.0089	5000^{U}	$2.1x10^{-8}$	$5.7x10^{-7}$	$2.0x10^{-6}$	$2.0x10^{-6}$
Xylenes	0.07%	0.00011	0.0031	0.011	0.0107	220^{A1}	$5.2x10^{-8}$	$1.4x10^{-6}$	$5.0x10^{-6}$	$4.9x10^{-6}$
1,3-Butadiene	0.02%	0.000031	0.00085	0.0030	0.0029	0.3^{U2}	$4.7x10^{-8}$	$1.3x10^{-6}$	$4.6x10^{-6}$	$4.4x10^{-6}$
Formaldehyde	1.35%	0.0023	0.062	0.22	0.2141	3.3^{T1}	$1.5x10^{-4}$	$4.2x10^{-3}$	1.5E-02	1.4E-02
Acetaldehyde	0.23%	0.00038	0.010	0.037	0.0356	9^{U3}	$8.1x10^{-7}$	$2.2x10^{-5}$	$7.8x10^{-5}$	$7.6x10^{-5}$
	Total PAHs	**0.0013**	**0.0049**	**0.0033**	**0.0038**					
Naphthalene	87.65%	0.0012	0.0072	0.0046	0.0036	3^{U4}	0.00041	0.0024	0.0015	0.0012
Acenaphthylene	4.02%	$5.6x10^{-5}$	$3.3x10^{-4}$	$2.1x10^{-4}$	$1.6x10^{-4}$	200^{U5S}	$2.8x10^{-7}$	$1.7x10^{-6}$	$1.1x10^{-6}$	$8.2x10^{-7}$
Acenaphthene	1.96%	$2.7x10^{-5}$	$1.6x10^{-4}$	$1.0x10^{-4}$	$8.0x10^{-5}$	200^{U5S}	$1.4x10^{-7}$	$8.1x10^{-7}$	$5.2x10^{-7}$	$4.0x10^{-7}$
Fluorene	3.31%	$4.6x10^{-5}$	$2.7x10^{-4}$	$1.8x10^{-4}$	$1.4x10^{-4}$	140^{U5}	$3.3x10^{-7}$	$2.0x10^{-6}$	$1.3x10^{-6}$	$9.7x10^{-7}$
Phenanthrene	1.68%	$2.4x10^{-5}$	$1.4x10^{-4}$	$8.9x10^{-5}$	$6.9x10^{-5}$	140^{U5S}	$1.7x10^{-7}$	$9.9x10^{-7}$	$6.4x10^{-7}$	$4.9x10^{-7}$
Anthracene	0.07%	$9.8x10^{-7}$	$5.8x10^{-6}$	$3.7x10^{-6}$	$2.9x10^{-6}$	100^{U5}	$9.8x10^{-9}$	$5.8x10^{-8}$	$3.7x10^{-8}$	$2.9x10^{-8}$
Fluoranthene	0.26%	$3.6x10^{-6}$	$2.1x10^{-5}$	$1.4x10^{-5}$	$1.1x10^{-5}$	140^{U5}	$2.6x10^{-8}$	$1.5x10^{-7}$	$9.7x10^{-8}$	$7.5x10^{-8}$
Pyrene	0.49%	$6.9x10^{-6}$	$4.0x10^{-5}$	$2.6x10^{-5}$	$2.0x10^{-5}$	100^{U5}	$6.9x10^{-8}$	$4.0x10^{-7}$	$2.6x10^{-7}$	$2.0x10^{-7}$
Benzo(a)pyrene TEQ	0.11%	$1.6x10^{-6}$	$9.5x10^{-6}$	$6.1x10^{-6}$	$4.7x10^{-6}$	0.00012^{W2}	0.013	0.079	0.051	0.039
						Total chronic HI	**0.014**	**0.086**	**0.068**	**0.056**
Central rail access										
	Total VOCs	**0.15**	**5.5**	**12.9**	**12.4**					
Benzene	0.16%	0.00025	0.0088	0.021	0.020	$1.7^{W\#}$	$8.5x10^{-6}$	$3.0x10^{-4}$	$7.1x10^{-4}$	$6.8x10^{-4}$
Toluene	0.06%	0.000086	0.0031	0.0072	0.0069	5000^{U}	$1.9x10^{-8}$	$6.8x10^{-7}$	$1.6x10^{-6}$	$1.5x10^{-6}$
Xylenes	0.07%	0.00010	0.0037	0.0088	0.0084	220^{A1}	$4.8x10^{-8}$	$1.7x10^{-6}$	$4.0x10^{-6}$	$3.8x10^{-6}$
1,3-Butadiene	0.02%	0.000029	0.0010	0.0024	0.0023	0.3^{U2}	$4.3x10^{-8}$	$1.5x10^{-6}$	$3.6x10^{-6}$	$3.5x10^{-6}$
Formaldehyde	1.35%	0.0021	0.075	0.17	0.17	3.3^{T1}	$1.4x10^{-4}$	$5.0x10^{-3}$	1.2E-02	1.1E-02
Acetaldehyde	0.23%	0.00035	0.012	0.029	0.028	9^{U3}	$7.4x10^{-7}$	$2.6x10^{-5}$	$6.2x10^{-5}$	$5.9x10^{-5}$
	Total PAHs	**0.0012**	**0.011**	**0.0051**	**0.0040**					
Naphthalene	87.65%	0.0011	0.0092	0.0045	0.0035	3^{U4}	0.00036	0.0031	0.0015	0.0012
Acenaphthylene	4.02%	$4.9x10^{-5}$	$4.2x10^{-4}$	$2.1x10^{-4}$	$1.6x10^{-4}$	200^{U5S}	$2.5x10^{-7}$	$2.1x10^{-6}$	$1.0x10^{-6}$	$8.0x10^{-7}$
Acenaphthene	1.96%	$2.4x10^{-5}$	$2.1x10^{-4}$	$1.0x10^{-4}$	$7.8x10^{-5}$	200^{U5S}	$1.2x10^{-7}$	$1.0x10^{-6}$	$5.0x10^{-7}$	$3.9x10^{-7}$
Fluorene	3.31%	$4.1x10^{-5}$	$3.5x10^{-4}$	$1.7x10^{-4}$	$1.3x10^{-4}$	140^{U5}	$2.9x10^{-7}$	$2.5x10^{-6}$	$1.2x10^{-6}$	$9.5x10^{-7}$
Phenanthrene	1.68%	$2.1x10^{-5}$	$1.8x10^{-4}$	$8.6x10^{-5}$	$6.7x10^{-5}$	140^{U5S}	$1.5x10^{-7}$	$1.3x10^{-6}$	$6.1x10^{-7}$	$4.8x10^{-7}$
Anthracene	0.07%	$8.6x10^{-7}$	$7.4x10^{-6}$	$3.6x10^{-6}$	$2.8x10^{-6}$	100^{U5}	$8.6x10^{-9}$	$7.4x10^{-8}$	$3.6x10^{-8}$	$2.8x10^{-8}$

Key VOC	% total VOCs or PAHs*	Maximum predicted chronic annual average concentration ** (µg/m^3)				Health based chronic guideline (µg/m^3)	Calculated chronic HI			
		Phase A	Phase B	Phase C	Full Build		Phase A	Phase B	Phase C	Full Build
Fluoranthene	0.26%	$3.2x10^{-6}$	$2.7x10^{-5}$	$1.3x10^{-5}$	$1.0x10^{-5}$	140^{U5}	$2.3x10^{-8}$	$1.9x10^{-7}$	$9.4x10^{-8}$	$7.3x10^{-8}$
Pyrene	0.49%	$6.0x10^{-6}$	$5.1x10^{-5}$	$2.5x10^{-5}$	$2.0x10^{-5}$	100^{U5}	$6.0x10^{-8}$	$5.1x10^{-7}$	$2.5x10^{-7}$	$2.0x10^{-7}$
Benzo(a)pyrene TEQ	0.11%	$1.4x10^{-6}$	$1.2x10^{-5}$	$5.8x10^{-6}$	$4.6x10^{-6}$	0.00012^{W2}	0.012	0.100	0.049	0.038
						Total chronic HI	**0.012**	**0.11**	**0.063**	**0.051**
Southern rail access										
	Total VOCs	**0.17**	**4.3**	**10.4**	**56.0**					
Benzene	0.16%	0.00028	0.0068	0.0166	0.089	$1.7^{W\#}$	$9.6x10^{-6}$	$2.3x10^{-4}$	$5.7x10^{-4}$	$3.1x10^{-3}$
Toluene	0.06%	0.00010	0.0024	0.0058	0.0314	5000^{U}	$2.2x10^{-8}$	$5.3x10^{-7}$	$1.3x10^{-6}$	$7.0x10^{-6}$
Xylenes	0.07%	0.00012	0.0029	0.0071	0.038	220^{A1}	$5.4x10^{-8}$	$1.3x10^{-6}$	$3.2x10^{-6}$	$1.7x10^{-5}$
1,3-Butadiene	0.02%	0.00003	0.00079	0.00193	0.0104	0.3^{U2}	$4.9x10^{-8}$	$1.2x10^{-6}$	$2.9x10^{-6}$	$1.6x10^{-5}$
Formaldehyde	1.35%	0.0024	0.058	0.141	0.76	3.3^{T1}	$1.6x10^{-4}$	$3.9x10^{-3}$	$9.4x10^{-3}$	5.1E-02
Acetaldehyde	0.23%	0.00039	0.0096	0.0234	0.126	9^{U3}	$8.4x10^{-7}$	$2.0x10^{-5}$	$5.0x10^{-5}$	$2.7x10^{-4}$
	Total PAHs	**0.0014**	**0.0083**	**0.0053**	**0.0041**					
Naphthalene	87.65%	0.0012	0.0072	0.0046	0.0036	3^{U4}	0.00041	0.0024	0.0015	0.0012
Acenaphthylene	4.02%	$5.6x10^{-5}$	$3.3x10^{-4}$	$2.1x10^{-4}$	$1.6x10^{-4}$	200^{U5S}	$2.8x10^{-7}$	$1.7x10^{-6}$	$1.1x10^{-6}$	$8.2x10^{-7}$
Acenaphthene	1.96%	$2.7x10^{-5}$	$1.6x10^{-4}$	$1.0x10^{-4}$	$8.0x10^{-5}$	200^{U5S}	$1.4x10^{-7}$	$8.1x10^{-7}$	$5.2x10^{-7}$	$4.0x10^{-7}$
Fluorene	3.31%	$4.6x10^{-5}$	$2.7x10^{-4}$	$1.8x10^{-4}$	$1.4x10^{-4}$	140^{U5}	$3.3x10^{-7}$	$2.0x10^{-6}$	$1.3x10^{-6}$	$9.7x10^{-7}$
Phenanthrene	1.68%	$2.4x10^{-5}$	$1.4x10^{-4}$	$8.9x10^{-5}$	$6.9x10^{-5}$	140^{U5S}	$1.7x10^{-7}$	$9.9x10^{-7}$	$6.4x10^{-7}$	$4.9x10^{-7}$
Anthracene	0.07%	$9.8x10^{-7}$	$5.8x10^{-6}$	$3.7x10^{-6}$	$2.9x10^{-6}$	100^{U5}	$9.8x10^{-9}$	$5.8x10^{-8}$	$3.7x10^{-8}$	$2.9x10^{-8}$
Fluoranthene	0.26%	$3.6x10^{-6}$	$2.1x10^{-5}$	$1.4x10^{-5}$	$1.1x10^{-5}$	140^{U5}	$2.6x10^{-8}$	$1.5x10^{-7}$	$9.7x10^{-8}$	$7.5x10^{-8}$
Pyrene	0.49%	$6.9x10^{-6}$	$4.0x10^{-5}$	$2.6x10^{-5}$	$2.0x10^{-5}$	100^{U5}	$6.9x10^{-8}$	$4.0x10^{-7}$	$2.6x10^{-7}$	$2.0x10^{-7}$
Benzo(a)pyrene TEQ	0.11%	$1.6x10^{-6}$	$9.5x10^{-6}$	$6.1x10^{-6}$	$4.7x10^{-6}$	0.00012^{W2}	0.013	0.079	0.051	0.039
						Total chronic HI	**0.014**	**0.085**	**0.062**	**0.094**

Notes for Table 3.6:

* Percentage of each individual PAH is based on data from DEH ((DEH 2003), page 91 for heavy-duty vehicle Segment 1 – congested traffic flow). The percentages adopted are expected to be conservative for the assessment of current and future diesel vehicles as emission standards for newer vehicles have improved over time, and will continue to improve to and beyond 2030.

** Concentrations presented for the annual average are as provided from the LAQIA

W1: WHO 2000 Air Quality Guidelines, value for benzene is based on non-threshold carcinogenic effects (excess lifetime risk of leukaemia). Guideline value based on incremental cancer risk of $1x10^{-5}$, consistent with guidance provided by NEPM (1999 amended 2013) and enHealth (2012)

W2: WHO 2010 Guidelines for Indoor Air Quality, value for BaP is based on non-threshold carcinogenic effects from occupational study of coke workers (lung cancer is critical effect). Guideline value based on incremental cancer risk of $1x10^{-5}$, consistent with guidance provided by NEPM (1999 amended 2013) and enHealth (2012)

T1: TCEQ 2008, Formaldehyde, Development Support Document. Texas Commission of Environmental Quality. The air guideline is derived on the basis of irritation of the eyes and airway discomfort in humans, with review of carcinogenic and other non-carcinogenic effects found to be adequately protected by this guideline. The guideline is more conservative than derived by the WHO (2010)

A1: ATSDR 2007, Toxicological Profile for Xylene, chronic inhalation guideline derived is the most current robust evaluation

U1: USEPA evaluation for toluene (most recently reviewed in 2005). 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 (1999 amended 2013) health based guidelines

U2: USEPA evaluation of 1,3-butadiene (most recently updated in 2002) with the chronic guideline adopted as the lower from the evaluation of non-threshold carcinogenic effects and non-cancer effects. This is the most conservative evaluation of this compound. A more recent review by TCEQ (2013) on the basis of the same critical studies as well as more current studies resulted in a higher chronic air guideline value.

U3: USEPA evaluation of acetaldehyde (most recently updated in 1991). The guideline established is lower than more recent reviews undertaken by the WHO (2000) and the Californian OEHHA where less conservative evaluations are presented.

U4: USEPA evaluation of naphthalene (most recently updated in 1998). The guideline established is and is consistent with the value used to derive the NEPM (1999 amended 2013) health based guidelines

U5: Guideline available from the USEPA. Chronic guidelines for non-carcinogenic polycyclic aromatic hydrocarbons are based on criteria derived from oral studies (for critical effects on the liver, kidney and haematology) which are then converted to an inhalation value (relevant for the protection of public health, including the use of safety factors) for use in this assessment. The value presented in the above table has been converted from an acceptable dose in mg/kg/day to an acceptable air concentration assuming a body weight of 70kg and inhalation of 20 m^3/day (as per (USEPA 2009a))

U5S: No guideline available for individual polycyclic aromatic hydrocarbon, hence a surrogate compound has been used for the purpose of screening. The surrogate compound is a polycyclic aromatic hydrocarbon of similar structure and toxicity. In relation to the surrogates adopted in this evaluation, acenaphthene has been adopted as a surrogate for acenaphthylene, fluoranthene has been adopted as a surrogate for phenanthrene

3.4 Review of particulate matter

3.4.1 General

Particulate matter (PM) 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 <0.005 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 secondary particulates include nitrogen oxides, ammonia, sulfur oxides, and certain organic gases (derived from vehicle exhaust, combustion sources, agricultural, industrial and biogenic emissions).

Numerous epidemiological studies[11] have reported significant positive associations between particulate air pollution and adverse health outcomes, in particular mortality as well as a range of adverse cardiovascular and respiratory effects.

3.4.2 Particulate size and composition

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

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.

The common measures of particulate matter that are considered in the assessment of air quality and health risks are:

- **Total suspended particulates (TSP):** This refers to all particulates with an equivalent aerodynamic particle[12] size below 50 microns (µm) in diameter[13]. 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 (µm) 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

[11] Epidemiology is the study of diseases in populations. Epidemiological evidence can only show that this risk factor is associated (correlated) with a higher incidence of disease in the population exposed to that risk factor. The higher the correlation the more certain the association. Causation (i.e. that a specific risk factor actually causes a disease) cannot be proven with only epidemiological studies. For causation to be determined a range of other studies need to be considered in conjunction with the epidemiology studies.

[12] The term equivalent aerodynamic particle is used to reference the particle to a particle of spherical shape and particle of density 1 g/cm^3

[13] The size, diameter, of dust particles is measured in micrometers (microns, µm).

mostly trapped in the upper respiratory system[14] and do not reach the lungs. Finer particles (smaller than 10 µm, termed "respirable") tend to be transported further from the source and are of more concern with respect to human health as these particles can penetrate into the lungs. Hence not all of the dust characterised as total suspended particulates is relevant for the assessment of health impacts, and total suspended particulates as a measure of impact, has not been further evaluated in this assessment. The assessment has only focused on particulates of a size where significant associations have been identified between exposure and adverse health effects.

- **PM_{10}, particulate matter below 10 µm in diameter, $PM_{2.5}$, particulate matter below 2.5 µm in diameter and PM_1, particulate matter below 0.1 µm in diameter (termed ultrafine particles):** 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[15] and lungs. Once in the lungs adverse health effects may result (OEHHA 2002). It is well accepted nationally and internationally that monitoring for PM_{10} is a good method of determining the community's exposure to potentially harmful dust (regardless of the source) and is most commonly measured in local and regional air quality monitoring programs. Smaller particulates such as $PM_{2.5}$ and PM_1, however, are of most significance with respect to evaluating health effects as a higher proportion of these particles penetrate deep into the lungs. Urban air, that has a significant contribution from combustion sources, tends to have a significant proportion of $PM_{2.5}$ and PM_1 in ambient air.

Evaluation of size alone as a single factor in determining the potential for particulate toxicity and is difficult since the potential health effects are not independent of chemical composition. There are certain particulate size fractions that tend to contain certain chemical components, such as metals in fine particulates (<$PM_{2.5}$) and crustal materials (like soil) in the coarse mode (PM_{10} or larger). In addition, different sources of particulates have the potential to result in the presence of other pollutants in addition to particulate matter. For example combustion sources, prevalent in urban areas, result in the emission of particulate matter (more dominated by $PM_{2.5}$) as well as gaseous pollutants (ozone, nitrogen dioxide, carbon monoxide and sulfur dioxide).

There is strong evidence to conclude (USEPA 2012; WHO 2003, 2013) that fine particles (< 2.5 µm, $PM_{2.5}$) are more hazardous than larger ones (coarse particles), primarily on the basis of studies conducted in urban air environments where there is a higher proportion (as a percentage of all particulates) of fine particulates and other gaseous pollutants present from fuel combustion sources, as compared to particulates derived from crustal origins. Toxicological and controlled human exposure studies indicate that primary particles generated from fossil fuel combustion processes may be a significant contributor to adverse health outcomes with several physical, biological and

[14] 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.

[15] 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.

chemical characteristics of particles found to elicit cardiopulmonary responses. Amongst the characteristics found to be contributing to toxicity in epidemiological and controlled exposure studies are high organic carbon content, metal content, presence of polycyclic aromatic hydrocarbons, presence of other organic components or endotoxins and both small (< 2.5 µm) and extremely small size (< 1 µm) (USEPA 2009b; WHO 2003, 2006b).

A significant amount of research, primarily from large epidemiology studies, has been conducted on the health effects of particulates with causal effects relationships identified for exposure to $PM_{2.5}$ (acting alone or in conjunction with other pollutants) (USEPA 2012). A more limited body of evidence suggests an association between exposure to larger particles, PM_{10} and adverse health effects (USEPA 2009b; WHO 2003). The health effects identified from these studies has been specifically related to $PM_{2.5}$ or PM_{10} as these are the most commonly adopted robust and widespread measures of particulate matter available in urban air environments.

Diesel particulate matter (DPM) primarily comprise fine particles referred to as $PM_{2.5}$ that include including a subgroup with a large number of ultrafine particles (i.e. particles that have a diameter <0.1 µm). Collectively, these particles have a large surface area which makes them an excellent medium for adsorbing organics. Also, their small size makes them highly respirable and able to penetrate deep into the lungs. Hence a number of potentially toxicologically relevant organic compounds are on DPM and include VOCs and PAHs. The presence of VOCs (in gaseous and particulate form) and PAHs in air has been undertaken separately (based on the composition of these organics in diesel emissions) in **Section 3.3**. Hence where DPM is further assessed the focus is on the particulates themselves, characterised as PM_{10} but more importantly as $PM_{2.5}$ and the potential for adverse health effects.

Where construction works occur the assessment of PM_{10} (which is of more significance from earthworks) and to a lesser extent $PM_{2.5}$ adequately addresses the potential for health effects.

3.4.3 Health effects

Health effects that have been associated with exposure to PM_{10} and $PM_{2.5}$ relate to exposure over both the short term (hours or days where effects may occur on the same day or after a day or two) and long term (months or years) and include (Anderson et al. 2004; NEPC 2010; OEHHA 2002; USEPA 2009b; WHO 2003, 2013):

- Respiratory and cardiovascular morbidity, such as aggravation of asthma, respiratory symptoms and an increase in hospital admissions.
- Mortality from all causes, and specifically cardiovascular and respiratory diseases and from lung cancer.

There is good evidence of the effects of short-term exposure to PM_{10} on respiratory health, but for mortality and cardiovascular effects $PM_{2.5}$ is a stronger risk factor than the coarse part of PM_{10} (particles in the 2.5–10 µm range).

In short-term studies (based on 24-hour particulate levels), groups with pre-existing respiratory, lung or heart disease, as well as elderly people were more susceptible to the morbidity and mortality effects of ambient particulate matter exposure (Esworthy 2013; WHO 2013). In longer term studies it

has been suggested that the socially disadvantaged and poorly educated populations respond more strongly in terms of mortality (Esworthy 2013; WHO 2003, 2013).

Based on the available studies, there is no evidence of a safe level of exposure or a threshold below which no adverse health effects occur (NEPC 2010; WHO 2013).

Additional discussion on health effects associated with exposure to $PM_{2.5}$ and PM_{10} is presented in **Section 4.1**, including quantitative associations (exposure-response relationships) between exposure and the most significant health effects.

At present, at the population level, there is not enough evidence to identify differences in the effects of particles with different chemical compositions or emanating from various sources (NEPC 2010; WHO 2013). The evidence for the hazardous nature of combustion-related particulate matter (from both mobile and stationary sources that dominate urban air where most of the epidemiological studies are conducted) is more consistent than that for particulate matter from other sources, and dominate the epidemiological studies used to develop relationships between exposure and adverse health effects. This is the relevant source of particulate matter for this project.

Particulates that are derived from specific sources, such as diesel emissions, are known to comprise other compounds such as volatile organic compounds and polycyclic aromatic hydrocarbons that are known to also be associated with adverse health effects. The presence of these other compounds has been addressed separately however the presence of these (and likely other compounds) compounds and other co-pollutants (also derived from combustion sources) adds to the complexity of utilising data form urban air epidemiological studies for assessing health effects from particulate matter.

Recently, outdoor air pollution has been classified by the International Agency for Research on Cancer (IARC 2013) as carcinogenic (Group 1) to humans based on sufficient evidence that exposure to outdoor air pollution causes lung cancer. Particulate matter, a major component of outdoor air pollution, was evaluated separately and also classified as carcinogenic to humans (Group 1).

In 2012, IARC evaluated exhaust from diesel engines (consisting mostly of particulate matter) and classified these emissions as carcinogenic (Group 1) to humans.

3.4.4 Initial assessment of potential health issues from exposure to particulate matter

For many of the key health effects associated with exposures to PM_{10} and $PM_{2.5}$ the exposure-response relationship is linear (where there is no threshold below which no adverse effects have been identified) (NEPC 2010). This means that any exposure to particulate matter has the potential to be associated with an effect. Guidelines have been established in Australia (and internationally) to determine a level at which cumulative exposure (i.e. exposure to particulates from all sources) are likely to minimise the potential for adverse impacts in a population. The available guidelines are discussed and further considered below.

However as there is no threshold for adverse effects it is also important that any incremental exposure to particulate matter derived from the project is also assessed. The more detailed evaluation of incremental impacts associated with the Project is presented in **Section 4**.

Guidelines

Air quality goals for PM_{10}, and advisory goal for $PM_{2.5}$, have been established by NEPC (NEPC 2002, 2003) that are based on the protection of human health and well-being. The goals apply 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 addition, the assessment of impacts from any development requires consideration of air quality goals/guidelines that are outlined in the Environment Protection Authority's "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (DEC 2005a). The guidelines are primarily derived from the NEPC, with the exception of an annual average PM_{10} guideline which is derived from older goals adopted by the Environment Protection Authority (EPA 1998). The air quality goals relate to total particulate matter burden in the air and not just the particulate matter from the project, hence use of these criteria requires consideration of background levels of particulate matter and other local sources. Similar to the NEPC criteria, these guidelines do not apply to localised "hot-spot" areas such as locations near industry, busy roads or mining. However, in the absence of alternative measures, Environment Protection Authority does apply these criteria to assess the potential for impacts to arise at such locations, particularly for new projects.

Table 3.8 presents a summary of the current NEPC and Environment Protection Authority's air quality goals and guidelines for particulate matter. These guidelines are for cumulative impacts and should also be considered in conjunction with incremental impact calculations presented in **0**.

Table 3.8 Air quality goals for particulates

Pollutant	Averaging period	Criteria	Reference
PM_{10}	24-hour	50 µg/m^3 Maximum of 5 days exceedence per year	(DEC 2005a; NEPC 2003)
	Annual	30 µg/m^3	(DEC 2005a)
$PM_{2.5}$	24-hour	25 µg/m^3	Advisory goal [16] (NEPC 2003)
	Annual	8 µg/m^3	

In relation to the current NEPC PM_{10} guideline, the following is noted (NEPC 1998, 2010):

[16] The $PM_{2.5}$ criteria established by the National Environment Protection Council are advisory goals. The goals have been derived on the basis of available health based information that relates exposure to $PM_{2.5}$ to adverse health effects. However, as $PM_{2.5}$ had not been routinely monitored in the community at the time when the criteria were being considered, existing urban (and regional) levels were not known, and the ability to meet the advisory goals could not be determined in individual states. Hence these criteria were not established as standards as defined in the National Environment Protection Council Act 1994. The relevance of any exceedence of these goals will be fully assessed once a sufficient database of monitoring data is available. They are, however, goals that are based on the protection of population health.

- The guideline 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 guideline.
- On the basis of the available data for key air sheds in Australia, the imposition of a criterion of 50 $\mu g/m^3$ 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 goal is not based on any acceptable level of risk.
- The acceptable number of exceedences per year is not based on an assessment of health, rather it is based on review of existing air quality in urban areas and identifying a number of exceedences that are consistent with these existing areas.
- The assessment undertaken considered exposures and issues relevant to urban air environments that are expected to also be managed through the PM_{10} guideline. These issues included emissions from vehicles and wood heaters.
- Review of the air goals in 2010 did not identify that there was a need to revise the PM_{10} guideline.

A similar approach has been adopted by NEPC (Burgers & Walsh 2002; NEPC 2002) in relation to the derivation of the $PM_{2.5}$ air quality goals, with specific studies related to $PM_{2.5}$ and mortality and morbidity indicators considered.

Table 3.9 presents a comparison of the NEPC guidelines with those established (following more recent reviews) by the WHO (WHO 2005a), the EU and the USEPA (2012). The goals established by the NEPC for $PM_{2.5}$ (and adopted in this assessment) are similar to but slightly more conservative (health protective) than those provided by the WHO, EU and the USEPA. The NEPC and NSW OEH PM_{10} guidelines are also similar to those established by the WHO and EU, however the guidelines are significantly lower than the 24-hour average guideline available from the USEPA.

Table 3.9 Comparison of particulate matter air quality goals

Pollutant	Averaging period	Criteria/Guidelines/Goals			
		NEPC and NSW OEH	WHO (2005)	EU #	USEPA (2012)
PM_{10}	24-hour	**50 µg/m^3** Maximum of 5 days exceedance per year	**50 µg/m^3**	**50 µg/m^3** as limit value with 35 exceedences permitted each year	**150 µg/m^3** (not to be exceeded more than once per year on average over 3 years)
	Annual	**30 µg/m^3**	**20* µg/m^3**	**40 µg/m^3** as limit value	NA
$PM_{2.5}$	24-hour	**25 µg/m^3** (goal)	**25 µg/m^3**	NA	**35 µg/m^3** (98th percentile, averaged over 3 years)
	Annual	**8 µg/m^3** (goal)	**10* µg/m^3**	**25 µg/m^3** as target value from 2010 and limit value from 2015. **20 µg/m^3** as a 3 year average (average exposure indicator) from 2015 with requirements for ongoing percentage reduction and target of **18 µg/m^3** as 3 year average by 2020	**12 µg/m^3** (annual mean averaged over 3 years)

Current EU Air Quality Standards available from http://ec.europa.eu/environment/air/quality/standards.htm

* The WHO Air Quality guidelines are based on the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase with more than 95% confidence in response to $PM_{2.5}$ in the ACS study (Pope et al. 2002). The use of $PM_{2.5}$ guideline is preferred (WHO 2005a).

The air quality guidelines for $PM_{2.5}$ and PM_{10} relate to total concentrations in the air (from all sources including the project). The background air quality data that has been used in the LAQIA for this Project (based on data form 2013) includes a number of days that have been affected by bushfire events. These extreme events result in exceedance of the NEPM guidelines. Hence, review of the 24-hour average and annual average cumulative concentration is complex as it involves evaluating the incremental impact of the project on a background data set that includes these events. Detailed review of the 24-hour and annual average concentrations associated with all phases of the Project are presented in the LAQIA. The review concluded that emissions from the Project do not predict any additional exceedances of the NEPM criteria.

Incremental Impacts of particulate matter

As there is no safe level for particulate matter in ambient air, the incremental impact of $PM_{2.5}$ and PM_{10} emissions to air from the Project have been evaluated in more detail, as presented in **Section 4**.

Section 4. Detailed assessment of exposure to particulate matter

4.1 Summary of adverse 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 2009b):

- 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.

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 2009b).

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 2012). Similar relationships have also been determined for PM_{10} , however, the supporting studies do not show relationships as clear as shown with $PM_{2.5}$ (USEPA 2012).

There are a number of other studies that have been undertaken where other health effects have been evaluated. These studies are suggestive (but do not show effects as clearly as the effects noted above) of an association between exposure to $PM_{2.5}$ and reproductive and developmental effects as well as cancer, mutagenicity and genotoxicity (USEPA 2012). IARC (2013) has classified particulate matter as carcinogenic to human based on data relevant to lung cancer.

Other studies have been reviewed to determine relationships/associations between particulate matter exposure (either PM_{10} or $PM_{2.5}$) and a wide range of other health effects and health measures including 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 2006b). While these relationships/associations have been identified the exposure-response relationships established are not as strong as those discussed above. Also the available baseline data does not include information for many of these health effects which means it is not possible to undertake a quantitative assessment.

The detailed assessment of potential health effects associated with exposure to emissions associated with the project has focused on health effects and exposure-response relationships[17] that are robust and relate to $PM_{2.5}$, being the more important particulate fraction size relevant for emissions from combustion sources (but also include construction sources). These health effects (or endpoints) have been identified include the following:

- Primary health endpoints:
  - Long-term exposure to $PM_{2.5}$ on all-cause mortality (≥ 30 years of age).
  - Short-term exposure on the rate of hospitalisation with cardiovascular and respiratory disease (≥ 65 years of age).
- Secondary health endpoints (to supplement the primary assessment):
  - Long-term exposure to $PM_{2.5}$ on cardiopulmonary mortality (≥ 30 years of age).
  - Short-term exposure to $PM_{2.5}$ on mortality (all causes, cardiovascular and respiratory, all ages).
  - Short-term exposure to PM_{10} on mortality (all causes and all ages).

4.2 Exposure-response relationships

4.2.1 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) 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 (refer to **Section 4.1**). 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

[17] An exposure-response relationship is a quantitative relationship between an exposure concentration of particulate matter in air (what is inhaled) and the health effect evaluated.

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 particulate matter, no threshold has been identified. Non-threshold exposure-response relationships have been identified for the primary and secondary health endpoints considered in this assessment.

A range of exposure-response relationships are available from the many studies that have been undertaken and published. Review of the available studies has been undertaken in Australia for the purpose of developing the NEPC Air Quality Guidelines (Burgers & Walsh 2002; NEPC 2002, 2010), where a range of health endpoints and exposure-response relationships were identified and evaluated. Similar exposure-response relationships have been considered in the development and review of air guidelines established by the WHO (WHO 2005a) and the USEPA (USEPA 2012). These organisations have identified which of the available relationships that have been identified are the most robust.

The exposure-response relationships adopted in this assessment have been identified on the basis of the studies considered in the development of the NEPC Air Quality Guidelines as well as updated supporting studies published in the literature.

The assessment of potential risks associated with exposure to particulate matter 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[18]. 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):

$$RR = exp[\beta(X-X_0)] \quad \text{…Equation 1}$$

Where:

$X-X_0$ = the change in particulate matter concentration to which the population is exposed ($\mu g/m^3$)

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 $\mu g/m^3$ increase in particulate matter exposure.

[18] 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 $\mu g/m^3$,(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 $\mu g/m^3$ and hence use of the linear relationship is expected to provide a more conservative estimate of relative risk.

Based on this equation, where the published studies have derived relative risk values that are associated with a 10 µg/m^3 increase in particulate matter exposure (as presented in **Table 5-**1), the β coefficient can be calculated using the following equation:

$$\beta = \frac{\ln(RR)}{10}$$ … Equation 2

Where:

RR = relative risk for the relevant health endpoint as published and listed in **Table 5-1** (µg/m^3)

10 = increase in particulate matter concentration associated with the RR (all the RR presented in **Table 5-1** are associated with a 10 µg/m^3 increase in particulate matter exposure).

Table 4.1 presents a summary of the health endpoints considered in this assessment, the relevant health impact functions (from the referenced published studies) and the associated β value relevant to the calculation of a relative risk.

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

Table 4.1 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					
PM2.5: 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 seven 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).
PM2.5: 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, M. L. 2012; Bell, Michelle L. et al. 2008)
PM2.5: 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, M. L. 2012; Bell, Michelle L. et al. 2008)
Secondary assessment health endpoints					
PM10: 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)
PM2.5: 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)
PM2.5: Cardiopulmonary 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 seven ecologic (neighbourhood level) covariates (Krewski et al. 2009).
PM2.5: 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)
PM2.5: 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

4.2.2 Exposure to diesel particulate matter

In addition to the above exposure-response relationships, potential exposure to diesel particulate matter (DPM) derived from the Project has been evaluated.

Diesel exhaust (DE) is emitted from “on-road” diesel engines (vehicle engines) and can be formed from the gaseous compounds emitted by diesel engines (secondary particulate matter). After emission from the exhaust pipe, diesel exhaust undergoes dilution and chemical and physical transformations in the atmosphere, as well as dispersion and transport in the atmosphere. The atmospheric lifetime for some compounds present in diesel exhaust ranges from hours to days.

Data from the USEPA (USEPA 2002) indicates that diesel exhaust as measured as diesel particulate matter made up about six per cent of the total ambient/urban air $PM_{2.5}$. In this project, emissions to air from the operation of the tunnel include a significant proportion of diesel powered vehicles (100 per cent of the HGVs and 49.9 per cent of the LDVs). Available evidence indicates that there are human health hazards associated with exposure to diesel particulate matter. The hazards include acute exposure-related symptoms, chronic exposure related non-cancer respiratory effects, and lung cancer.

In relation to non-carcinogenic effects, acute or short-term (e.g. episodic) exposure to diesel particulate matter can cause acute irritation (e.g. eye, throat, bronchial), neurophysiological symptoms (e.g. light-headedness, nausea), and respiratory symptoms (cough, phlegm). There also is evidence for an immunologic effect–exacerbation of allergenic responses to known allergens and asthma-like symptoms. Chronic effects include respiratory effects. The review of these effects (USEPA 2002) identified a threshold concentration for the assessment of chronic non-carcinogenic effects. The review conducted by the USEPA also concluded that exposures to diesel particulate matter also consider $PM_{2.5}$ goals (as these also address the presence of diesel particulate matter in urban air environments). The review found that the diesel particulate matter chronic guideline will also be met if the $PM_{2.5}$ guideline was met. Review of exposure to $PM_{2.5}$ has been assessed separately in relation to the current ambient air guidelines (refer to **Section 3.4.4**) where cumulative impacts of $PM_{2.5}$ for the project have been found to comply with the NEPC $PM_{2.5}$ advisory goal. Hence non-carcinogenic effects associated with exposure to diesel particulate matter are not considered to be of concern.

Review of exposures to diesel particulate matter (USEPA 2002) identified that such exposures are “likely to be carcinogenic to humans by inhalation”. A more recent review by IARC (Attfield et al. 2012; IARC 2012; Silverman et al. 2012) classified diesel engine exhaust as carcinogenic to humans (Group 1) based on sufficient evidence that exposure is associated with an increased risk for lung cancer. In addition, outdoor air pollution and particulate matter (that includes diesel particulate matter) have been classified by IARC as carcinogenic to humans based on sufficient evidence of lung cancer.

Many of the organic compounds present in diesel exhaust are known to have mutagenic and carcinogenic properties and hence it is appropriate that a non-threshold approach is considered for the quantification of lung-cancer endpoints.

In relation to quantifying carcinogenic risks associated with exposure to diesel exhaust, the USEPA (USEPA 2002) has not established a non-threshold value (due to uncertainties identified in the available data).

WHO has used data from studies in rats to estimate unit risk values for cancer (WHO 1996). Using four different studies where lung cancer was the cancer endpoint, WHO calculated a range of 1.6×10^{-5} to 7.1×10^{-5} per µg/m^3 (mean value of 3.4×10^{-5} per µg/m^3). This would suggest that an increase in lifetime exposure to diesel particulate matter between 0.14 and 0.625 µg/m^3 could result in a one in one hundred thousand excess risk of cancer.

The California Environmental Protection Agency has proposed a unit lifetime cancer risk of 3.0×10^{-4} per µg/m^3 diesel particulate matter (OEHHA 1998). This was derived from data on exposed workers and based on evidence that suggested unit risks between 1.5×10^{-4} and 15×10^{-4} per µg/m^3. This would suggest that an increase in lifetime exposure to diesel particulate matter of 0.033 µg/m^3 could result in a one in one hundred thousand excess risk of cancer. This estimate has been widely criticised as overestimating the risk and hence has not been considered in this assessment.

On the basis of the above, the WHO cancer unit risk value (mean value of 3.4×10^{-5} per µg/m^3) has been used to evaluate potential excess lifetime risks associated with incremental impacts from diesel particulate matter exposures. Diesel particulate matter has not been specifically modelled in the AQIA; rather diesel particulate matter is part of the $PM_{2.5}$ assessment. For the purpose of this assessment it has been conservatively assumed that 100 per cent of the incremental $PM_{2.5}$ (from the project only) is derived from diesel sources. This is conservative as not all the vehicles on the site, and accessing the site (and emitting $PM_{2.5}$) would be diesel powered (as there is a mix of petrol and diesel powered vehicles).

4.2.3 Susceptible populations

Review by the USEPA (USEPA 2009b) considered the available studies and identified a number of factors that could potentially contribute to whether an individual is susceptible to particulate matter.

The following is noted from the USEPA (USEPA 2009b) review:

- An evaluation of age-related health effects suggests that older adults have heightened responses for cardiovascular morbidity with PM exposure. In addition, epidemiological and toxicological studies provide evidence, which indicates that children are at an increased risk of PM-related respiratory effects. It should be noted that the health effects observed in children could be initiated by exposures to PM that occurred during key windows of development, such as *in utero*. However further work is required to fully establish this link.
- Evidence from epidemiological and toxicological, and to a lesser extent, controlled human exposure studies indicate increased susceptibility of individuals with underlying cardiovascular diseases and respiratory illnesses, specifically asthma, to PM exposure. Additional controlled human exposure and toxicological studies provide some evidence for increased PM related cardiovascular effects in individuals with underlying respiratory health conditions. However, the results are not consistent with epidemiological studies, resulting in the need for further investigation.

- Individuals with null alleles or polymorphisms in genes that mediate the antioxidant response to oxidative stress, regulate enzyme activity, or regulate levels of procoagulants (i.e., fibrinogen) are more susceptible to PM exposure. However, some studies have shown that polymorphisms in genes can have a protective effect upon PM exposure. Additionally, preliminary evidence suggests that PM exposure can impart epigenetic effects (i.e., DNA methylation), however, this requires further investigation.
- Recently studies have begun to examine the influence of pre-existing chronic inflammatory conditions, such as diabetes and obesity, on PM-related health effects. These studies have found some evidence for increased associations for cardiovascular outcomes along with physiological alterations in markers of inflammation, oxidative stress, and acute phase response.

Overall, the epidemiological, controlled human exposure, and toxicological studies provide evidence for increased susceptibility for various populations, particularly older populations, children and those with underlying health conditions. These populations are addressed in the exposure-response relationships considered in this assessment.

4.3 Particulate impact assessment

4.3.1 Quantification of impact and risk

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)[19] where the exposure-response relationships (presented in **Section 4.2**) have been directly considered on the basis of the approach outlined below.

The calculation of changes in health endpoints associated with exposure to particulate matter as outlined by the WHO (Ostro 2004) has considered the following four elements:

- Estimates of the changes in particulate matter exposure levels (i.e. incremental impacts) due to the project for the relevant modelled scenarios (as provided by the LAQIA);
- Estimates of the number of people exposed to particulate matter at a given location (i.e. population data, refer to **Section 2.3**);
- Baseline incidence of the key health endpoints that are relevant to the population exposed (refer to **Section 2.4**); and

[19] For regional guidance, such as that provided for Europe by the WHO (WHO 2006b, 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 µg/m^3 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).

- Exposure-response relationships expressed as a percentage change in health endpoint per µg/m^3 change in particulate matter exposure (refer to **Section 4.2**), where a relative risk (RR) is determined (refer to Equation 1).

From the above, the increased incidence of a health endpoint corresponding to a particular change in particulate matter concentrations can be calculated using the following:

The attributable fraction/portion (AF) of health effects from air pollution, or impact factor, can be calculated from the relative risk (calculated for the incremental change in particulate matter considered as per Equation 1) as:

$$AF = \frac{RR-1}{RR} \quad \text{… Equation 3}$$

The total number of cases attributable to exposure to particulate matter (where a linear dose-response is assumed) can be calculated as:

$$E = AF \times B \times P \quad \text{… Equation 4}$$

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 2005, 2010) and Europe (Martuzzi et al. 2002; Sjoberg et al. 2009). Where a linear dose-response is assumed (as is the case in this assessment), the calculations are equivalent to the following:

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 (or partial suburbs) surrounding the proposed Project. When considering the potential impact of the Project on the population, the calculation has been undertaken using the following:

- Equation 1 has been used to calculate a relative risk based on the average incremental increase in annual average $PM_{2.5}$ for each suburb or partial suburb. The average incremental increase in concentration is calculated based on the concentrations calculated for each of the receptors located within the suburb, or partial suburb.
- Equation 3 has been used to calculate an attributable fraction.
- Equation 4 has been used to calculate the increased number of cases associated with the incremental $PM_{2.5}$ impact evaluated. The calculation is undertaken utilising the baseline incidence data relevant for the endpoint considered and the population (for the relevant age groups) present in the suburb (or partial suburb).

The above approach can be simplified (mathematically, where a linear dose-response is assumed) as follows:

$$E = \beta \times B \times \Delta X_{suburb} \times P_{suburb} \quad \text{… Equation 5}$$

Where:
β = slope coefficient relevant to the per cent change in response to a 1 µg/m^3 change in particulate matter exposure (as per **Table 4.1**)
B = baseline incidence of a given health effect per person (e.g. annual mortality rate)
ΔX_{suburb} = change (increment) in PM_{10} or $PM_{2.5}$ exposure concentration in µg/m^3 as an average within a suburb, or partial suburb based on the data available for receptors located in the suburb
P_{suburb}= population (residential – based on data form the ABS) within each suburb or partial suburb, for the age group relevant to the health endpoint being calculated

An additional risk can then be calculated as:

$$Risk=\beta \times \Delta X \times B \quad \text{… Equation 6}$$

Where:
β = slope coefficient relevant to the per cent change in response to a 1 µg/m^3 change in particulate matter exposure (as per **Table 4.1**)
ΔX = change (increment) in PM_{10} or $PM_{2.5}$ exposure concentration in µg/m^3 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 increased PM emissions from the Project at specific locations (such as the maximum, or at specific sensitive receptor locations).

For the assessment of potential lung cancer risks associated with exposure to diesel particulate matter, a non-threshold cancer risk is calculated. Non-threshold carcinogenic risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential non-threshold carcinogen. The numerical estimate of excess lifetime cancer risk is calculated as follows for inhalation exposures (USEPA 2009a):

Carcinogenic Risk (inhalation) = Exposure Concentration in Air x Inhalation Unit Risk

4.3.2 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 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 particulate matter 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 µg/m^3 change in particulate matter exposure. For short-term effects, the calculations relate to daily increases in particulate matter exposures and 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 two approaches (Ostro 2004; USEPA 2010):

1. Calculate the daily incidence or risk at each receptor 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; or
2. Calculate the annual incidence/risk based on the incremental annual average concentration at each receptor (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 two approaches result in the same outcome mathematically (calculated incidence or risk). Given that it is much simpler computationally to calculate the incidence (for each receptor) 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 particulate matter concentrations should not be taken as implying or suggesting that the calculation is quantifying the effects of long-term exposure.

Hence for the calculations presented in this technical working paper, for both long-term and short-term effects, annual average concentrations of particulate matter have been utilised.

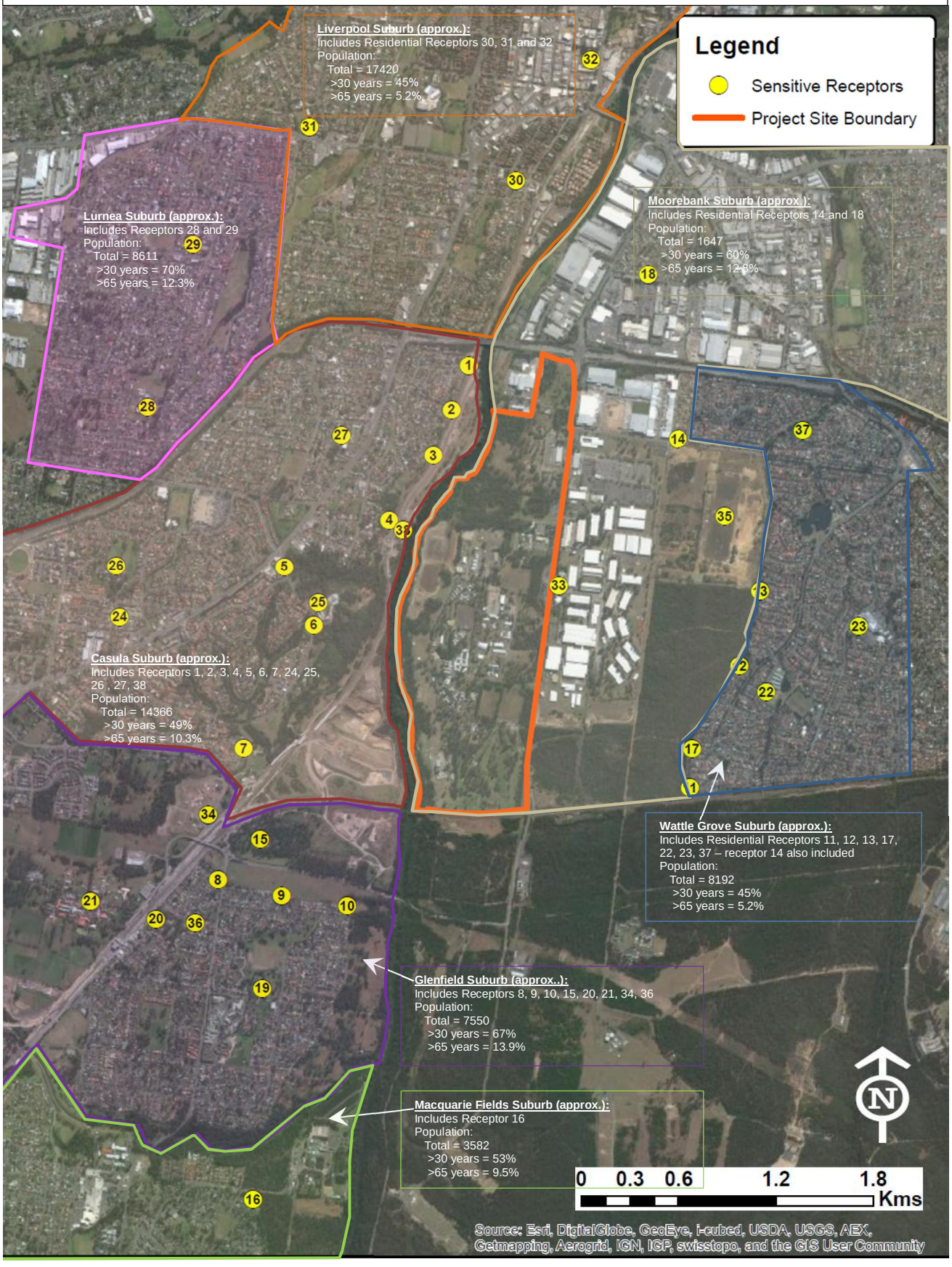
4.3.3 Population exposed

The population exposed is assumed to be represented by the population in the immediate vicinity of the Moorebank Site in the vicinity of the modelled receptor locations. The LAQIA has specifically focused on impacts at sensitive receptor locations within 5km of the site boundary as discussed in **Section 2** and listed in **Table 2.1**.

These receptor locations include a number of areas that can be considered to be occupational (commercial/industrial areas) and/or residential (including schools and retirement homes) and the assessment of exposure has been undertaken on this basis.

Figure 4.1 illustrates the suburbs where population morbidity effects have been evaluated, the location of modelled receptors within each of these areas and basic population statistics within these areas.

Figure 4.1: Location of sensitive receptors within suburbs evaluated (approximate suburb boundaries)



4.3.4 Calculated health impacts

Exposure Concentrations

The assessment of potential health impacts associated with exposure to PM requires consideration of the incremental annual average PM exposure concentrations within the population of concern. This is the increased level of PM exposure associated with emissions from the Project for the scenarios evaluated.

For the quantification of long-term exposures/cancer risk an exposure concentration is calculated. The exposure concentration takes into account the predicted ground level concentration (annual average) at each receptor location as well as the duration of exposure as per USEPA (USEPA 2009a). The exposure concentration is the measure required for the calculation of risk and assessment health impact for the identified health endpoints.

Incremental Risk Calculations

For the assessment of potential exposures by residents in the areas surrounding the Project, it assumed that they my live and attend school in the local area and hence assuming exposure may occur all day, every day is reasonable.

For the assessment of commercial/industrial areas, this assumption is overly conservative and hence the calculated incremental risk in these areas has been modified by a factor of 0.22 to address working 8 hours per day (not 24 hours per day) for 240 days of the year (rather than 365 days).

Similarly for exposures in recreational areas it is overly conservative to assume people will be exposed all day, every day. Hence the calculations have been modified by a factor of 0.047 to address exposures for 4 hours per day (not 24 hours per day) for 104 day per year (assuming exposure 2 days per week rather than every day).

On the basis of the approach outlined above, and for the key health endpoints considered in relation to exposure to $PM_{2.5}$ and PM_{10} (derived from the Project), incremental risks have been calculated based on data from the LAQIA. The calculations have been undertaken for the maximum predicted concentrations as well as concentrations predicted at each of the sensitive receivers surrounding the Project. Detailed calculations for each individual receptor are presented in **Appendix B**.

Error! Reference source not found. **to 4.4** present a summary of the predicted increased annual risks (for the maximum exposed receptors – residential, recreational, school or commercial/industrial (i.e. workplace) adjacent to the Project) relevant to the primary health indicators addressed in this assessment, for the various rail access options considered.

Tables 4.5 to 4.7 present a summary of the predicted increased annual risks (for the maximum exposed receptors – residential, recreational, school or commercial/industrial adjacent to the Project) relevant to the secondary health indicators addressed in this assessment, for the various rail access options considered.

The calculations presented in these tables are considered accurate to one significant figure only due to the level of uncertainty within all aspects of the assessment presented.

Table 4.2 Summary of calculated incremental annual risks associated with exposure to $PM_{2.5}$ – Primary health indicators – Northern rail access

Scenario and receptor group	Calculated incremental annual risks for the following primary health endpoints – maximum for receptor groups evaluated		
	Mortality all causes (long-term exposure, ages ≥30 years)	**Cardiovascular hospitalisations** (short-term exposure, ages ≥65 years)	**Respiratory hospitalisations** (short-term exposure, ages ≥65 years)
Phase A			
- residential	$1.8x10^{-6}$	$5.3x10^{-6}$	$1.0x10^{-6}$
- school	$8.1x10^{-7}$	$2.4x10^{-6}$	$4.6x10^{-7}$
- recreational	$7.5x10^{-8}$	$2.2x10^{-7}$	$4.3x10^{-8}$
- workplace	$3.6x10^{-6}$	$1.1x10^{-5}$	$2.0x10^{-6}$
Phase B			
- residential	$1.0x10^{-5}$	$3.1x10^{-5}$	$6.0x10^{-6}$
- school	$2.2x10^{-6}$	$6.6x10^{-6}$	$1.3x10^{-6}$
- recreational	$2.7x10^{-7}$	$8.1x10^{-7}$	$1.6x10^{-7}$
- workplace	$8.7x10^{-6}$	$2.6x10^{-5}$	$5.0x10^{-6}$
Phase C			
- residential	$2.0x10^{-5}$	$5.9x10^{-5}$	$1.1x10^{-5}$
- school	$4.6x10^{-6}$	$1.3x10^{-5}$	$2.6x10^{-6}$
- recreational	$5.9x10^{-7}$	$1.8x10^{-6}$	$3.4x10^{-7}$
- workplace	$1.6x10^{-5}$	$4.7x10^{-5}$	$9.1x10^{-6}$
Full Build			
- residential	$1.5x10^{-5}$	$4.5x10^{-5}$	$8.7x10^{-6}$
- school	$5.3x10^{-6}$	$1.6x10^{-5}$	$3.1x10^{-6}$
- recreational	$7.7x10^{-7}$	$2.3x10^{-6}$	$4.4x10^{-7}$
- workplace	$1.4x10^{-5}$	$4.0x10^{-5}$	$7.8x10^{-6}$

Table 4.3 Summary of calculated incremental annual risks associated with exposure to $PM_{2.5}$ – Primary health indicators – Central rail access

Scenario and receptor group	Calculated incremental annual risks for the following primary health endpoints – maximum for receptor groups evaluated		
	Mortality all causes (long-term exposure, ages ≥30 years)	**Cardiovascular hospitalisations** (short-term exposure, ages ≥65 years)	**Respiratory hospitalisations** (short-term exposure, ages ≥65 years)
Phase A			
- residential	$1.5x10^{-6}$	$4.5x10^{-6}$	$8.8x10^{-7}$
- school	$1.1x10^{-6}$	$3.3x10^{-6}$	$6.3x10^{-7}$
- recreational	$8.7x10^{-8}$	$2.6x10^{-7}$	$5.0x10^{-8}$
- workplace	$3.1x10^{-6}$	$9.3x10^{-6}$	$1.8x10^{-6}$
Phase B			
- residential	$3.9x10^{-6}$	$1.2x10^{-5}$	$2.2x10^{-6}$
- school	$1.8x10^{-6}$	$5.3x10^{-6}$	$1.0x10^{-6}$
- recreational	$2.4x10^{-7}$	$7.0x10^{-7}$	$1.4x10^{-7}$
- workplace	$1.1x10^{-5}$	$3.3x10^{-5}$	$6.4x10^{-6}$
Phase C			
- residential	$1.1x10^{-5}$	$3.3x10^{-5}$	$6.4x10^{-6}$
- school	$4.7x10^{-6}$	$1.4x10^{-5}$	$2.7x10^{-6}$
- recreational	$6.9x10^{-7}$	$2.0x10^{-6}$	$4.0x10^{-7}$
- workplace	$1.7x10^{-5}$	$5.1x10^{-5}$	$9.9x10^{-6}$
Full Build			
- residential	$1.8x10^{-5}$	$5.2x10^{-5}$	$1.0x10^{-5}$
- school	$5.8x10^{-6}$	$1.7x10^{-5}$	$3.3x10^{-6}$
- recreational	$9.2x10^{-7}$	$2.7x10^{-6}$	$5.3x10^{-7}$
- workplace	$1.5x10^{-5}$	$4.4x10^{-5}$	$8.5x10^{-6}$

Table 4.4 Summary of calculated incremental annual risks associated with exposure to $PM_{2.5}$ – Primary health indicators – Southern rail access

Scenario and receptor group	Calculated incremental annual risks for the following primary health endpoints – maximum for receptor groups evaluated		
	Mortality all causes (long-term exposure, ages ≥30 years)	**Cardiovascular hospitalisations** (short-term exposure, ages ≥65 years)	**Respiratory hospitalisations** (short-term exposure, ages ≥65 years)
Phase A			
- residential	$1.3x10^{-6}$	$4.0x10^{-6}$	$7.6x10^{-7}$
- school	$8.0x10^{-7}$	$2.4x10^{-6}$	$4.6x10^{-7}$
- recreational	$7.4x10^{-8}$	$2.2x10^{-7}$	$4.3x10^{-8}$
- workplace	$3.6x10^{-6}$	$1.1x10^{-5}$	$2.1x10^{-6}$
Phase B			
- residential	$5.9x10^{-6}$	$1.7x10^{-5}$	$3.4x10^{-6}$
- school	$2.4x10^{-6}$	$7.1x10^{-6}$	$1.4x10^{-6}$
- recreational	$3.5x10^{-7}$	$1.0x10^{-6}$	$2.0x10^{-7}$
- workplace	$1.1x10^{-5}$	$3.3x10^{-5}$	$6.3x10^{-6}$
Phase C			
- residential	$1.0x10^{-5}$	$3.1x10^{-5}$	$6.0x10^{-6}$
- school	$4.2x10^{-6}$	$1.2x10^{-5}$	$2.4x10^{-6}$
- recreational	$6.4x10^{-7}$	$1.9x10^{-6}$	$3.6x10^{-7}$
- workplace	$1.6x10^{-5}$	$4.8x10^{-5}$	$9.3x10^{-6}$
Full Build			
- residential	$1.4x10^{-5}$	$4.3x10^{-5}$	$8.2x10^{-6}$
- school	$5.5x10^{-6}$	$1.6x10^{-5}$	$3.1x10^{-6}$
- recreational	$8.9x10^{-7}$	$2.6x10^{-6}$	$5.1x10^{-7}$
- workplace	$1.6x10^{-5}$	$4.8x10^{-5}$	$9.3x10^{-6}$
Cumulative Scenario 1			
- residential	$2.0x10^{-5}$	$6.0x10^{-5}$	$1.2x10^{-5}$
- school	$8.2x10^{-6}$	$2.4x10^{-5}$	$4.7x10^{-6}$
- recreational	$1.2x10^{-6}$	$3.5x10^{-6}$	$6.7x10^{-7}$
- workplace	$3.9x10^{-5}$	$1.2x10^{-4}$	$2.2x10^{-5}$
Cumulative Scenario 2			
- residential	$1.6x10^{-5}$	$4.6x10^{-5}$	$9.0x10^{-6}$
- school	$6.5x10^{-6}$	$1.9x10^{-5}$	$3.7x10^{-6}$
- recreational	$8.9x10^{-7}$	$2.6x10^{-6}$	$5.1x10^{-7}$
- workplace	$3.4x10^{-5}$	$1.0x10^{-4}$	$2.0x10^{-5}$
Cumulative Scenario 3			
- residential	$1.3x10^{-5}$	$3.8x10^{-5}$	$7.3x10^{-6}$
- school	$5.1x10^{-6}$	$1.5x10^{-5}$	$2.9x10^{-6}$
- recreational	$6.2x10^{-7}$	$1.8x10^{-6}$	$3.6x10^{-7}$
- workplace	$3.0x10^{-5}$	$8.9x10^{-5}$	$1.7x10^{-5}$

Table 4.5 Summary of calculated incremental risks for secondary health indicators – Exposure to $PM_{2.5}$ and PM_{10} – Northern rail access

Particulate fraction:	PM10	PM2.5	PM2.5	PM2.5	PM2.5	DPM
Health endpoint:	**Mortality - All Causes,** Short-Term, All ages	**Mortality - All Causes,** Short-Term, All ages	**Mortality – Cardiopulmonary** Long-term, ≥ 30 years	**Mortality – Cardiovascular** Short-Term, All ages	**Mortality – Respiratory,** Short-Term, All ages	**Lung cancer – all ages**
Scenario and receptor group	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Lifetime Risk**
Phase A						
- residential	$6.1x10^{-7}$	$1.8x10^{-7}$	$1.8x10^{-6}$	$4.5x10^{-8}$	$3.1x10^{-8}$	$9.6x10^{-7}$
- school	$2.8x10^{-7}$	$8.1x10^{-8}$	$8.2x10^{-7}$	$2.0x10^{-8}$	$1.4x10^{-8}$	$4.4x10^{-7}$
- recreational	$9.3x10^{-9}$	$7.5x10^{-9}$	$7.6x10^{-8}$	$1.9x10^{-9}$	$1.3x10^{-9}$	$4.1x10^{-8}$
- workplace	$1.2x10^{-6}$	$3.6x10^{-7}$	$3.6x10^{-6}$	$9.0x10^{-8}$	$6.1x10^{-8}$	$1.9x10^{-6}$
Phase B						
- residential	$8.6x10^{-7}$	$1.0x10^{-6}$	$1.1x10^{-5}$	$2.6x10^{-7}$	$1.8x10^{-7}$	$5.6x10^{-6}$
- school	$2.8x10^{-7}$	$2.2x10^{-7}$	$2.2x10^{-6}$	$5.6x10^{-8}$	$3.8x10^{-8}$	$1.2x10^{-6}$
- recreational	$1.7x10^{-8}$	$2.7x10^{-8}$	$2.8x10^{-7}$	$6.9x10^{-9}$	$4.7x10^{-9}$	$1.5x10^{-7}$
- workplace	$9.4x10^{-7}$	$8.7x10^{-7}$	$8.8x10^{-6}$	$2.2x10^{-7}$	$1.5x10^{-7}$	$4.7x10^{-6}$
Phase C						
- residential	$1.4x10^{-6}$	$2.0x10^{-6}$	$2.0x10^{-5}$	$5.0x10^{-7}$	$3.4x10^{-7}$	$1.1x10^{-5}$
- school	$4.1x10^{-7}$	$4.5x10^{-7}$	$4.6x10^{-6}$	$1.1x10^{-7}$	$7.8x10^{-8}$	$2.5x10^{-6}$
- recreational	$3.8x10^{-8}$	$5.9x10^{-8}$	$6.0x10^{-7}$	$1.5x10^{-8}$	$1.0x10^{-8}$	$3.2x10^{-7}$
- workplace	$1.1x10^{-6}$	$1.6x10^{-6}$	$1.6x10^{-5}$	$4.0x10^{-7}$	$2.7x10^{-7}$	$8.6x10^{-6}$
Full Build						
- residential	$1.0x10^{-6}$	$1.5x10^{-6}$	$1.5x10^{-5}$	$3.8x10^{-7}$	$2.6x10^{-7}$	$8.2x10^{-6}$
- school	$3.5x10^{-7}$	$5.3x10^{-7}$	$5.4x10^{-6}$	$1.3x10^{-7}$	$9.2x10^{-8}$	$2.9x10^{-6}$
- recreational	$4.9x10^{-8}$	$7.7x10^{-8}$	$7.8x10^{-7}$	$1.9x10^{-8}$	$1.3x10^{-8}$	$4.2x10^{-7}$
- workplace	$8.8x10^{-7}$	$1.4x10^{-6}$	$1.4x10^{-5}$	$3.4x10^{-7}$	$2.3x10^{-7}$	$7.4x10^{-6}$

Table 4.6 Summary of calculated incremental risks for secondary health indicators – Exposure to $PM_{2.5}$ and PM_{10} – Central rail access

Particulate fraction:	PM10	PM2.5	PM2.5	PM2.5	PM2.5	DPM
Health endpoint:	**Mortality - All Causes,** Short-Term, All ages	**Mortality - All Causes,** Short-Term, All ages	**Mortality – Cardiopulmonary** Long-term, ≥ 30 years	**Mortality – Cardiovascular** Short-Term, All ages	**Mortality – Respiratory,** Short-Term, All ages	**Lung cancer – all ages**
Scenario and receptor group	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Lifetime Risk**
Phase A						
- residential	$5.4x10^{-7}$	$1.5x10^{-7}$	$1.5x10^{-6}$	$3.9x10^{-8}$	$2.6x10^{-8}$	$8.2x10^{-7}$
- school	$4.0x10^{-7}$	$1.1x10^{-7}$	$1.1x10^{-6}$	$2.8x10^{-8}$	$1.9x10^{-8}$	$5.9x10^{-7}$
- recreational	$9.0x10^{-9}$	$8.7x10^{-9}$	$8.8x10^{-8}$	$2.2x10^{-9}$	$1.5x10^{-9}$	$4.7x10^{-8}$
- workplace	$1.1x10^{-6}$	$3.1x10^{-7}$	$3.2x10^{-6}$	$7.9x10^{-8}$	$5.4x10^{-8}$	$1.7x10^{-6}$
Phase B						
- residential	$5.6x10^{-7}$	$3.9x10^{-7}$	$4.0x10^{-6}$	$9.9x10^{-8}$	$6.7x10^{-8}$	$2.1x10^{-6}$
- school	$3.0x10^{-7}$	$1.8x10^{-7}$	$1.8x10^{-6}$	$4.5x10^{-8}$	$3.1x10^{-8}$	$9.6x10^{-7}$
- recreational	$1.5x10^{-8}$	$2.4x10^{-8}$	$2.4x10^{-7}$	$5.9x10^{-9}$	$4.1x10^{-9}$	$1.3x10^{-7}$
- workplace	$1.3x10^{-6}$	$1.1x10^{-6}$	$1.1x10^{-5}$	$2.8x10^{-7}$	$1.9x10^{-7}$	$6.0x10^{-6}$
Phase C						
- residential	$1.0x10^{-6}$	$1.1x10^{-6}$	$1.1x10^{-5}$	$2.8x10^{-7}$	$1.9x10^{-7}$	$6.0x10^{-6}$
- school	$4.7x10^{-7}$	$4.7x10^{-7}$	$4.7x10^{-6}$	$1.2x10^{-7}$	$8.0x10^{-8}$	$2.5x10^{-6}$
- recreational	$4.4x10^{-8}$	$6.9x10^{-8}$	$7.0x10^{-7}$	$1.7x10^{-8}$	$1.2x10^{-8}$	$3.7x10^{-7}$
- workplace	$1.2x10^{-6}$	$1.7x10^{-6}$	$1.7x10^{-5}$	$4.3x10^{-7}$	$3.0x10^{-7}$	$9.3x10^{-6}$
Full Build						
- residential	$1.1x10^{-6}$	$1.8x10^{-6}$	$1.8x10^{-5}$	$4.5x10^{-7}$	$3.0x10^{-7}$	$9.5x10^{-6}$
- school	$3.8x10^{-7}$	$5.8x10^{-7}$	$5.9x10^{-6}$	$1.5x10^{-7}$	$1.0x10^{-7}$	$3.1x10^{-6}$
- recreational	$5.9x10^{-8}$	$9.2x10^{-8}$	$9.3x10^{-7}$	$2.3x10^{-8}$	$1.6x10^{-8}$	$5.0x10^{-7}$
- workplace	$9.7x10^{-7}$	$1.5x10^{-6}$	$1.5x10^{-5}$	$3.8x10^{-7}$	$2.6x10^{-7}$	$8.0x10^{-6}$

Table 4.7 Summary of calculated incremental risks for secondary health indicators – Exposure to $PM_{2.5}$ and PM_{10} – Southern rail access

Particulate fraction:	PM10	PM2.5	PM2.5	PM2.5	PM2.5	DPM
Health endpoint:	Mortality - All Causes, Short-Term, All ages	Mortality - All Causes, Short-Term, All ages	Mortality – Cardiopulmonary Long-term, ≥ 30 years	Mortality – Cardiovascular Short-Term, All ages	Mortality – Respiratory, Short-Term, All ages	Lung cancer – all ages
Scenario and receptor group	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Lifetime Risk**
Phase A						
- residential	$4.5x10^{-7}$	$1.3x10^{-7}$	$1.3x10^{-6}$	$3.4x10^{-8}$	$2.3x10^{-8}$	$7.2x10^{-7}$
- school	$2.7x10^{-7}$	$8.0x10^{-8}$	$8.1x10^{-7}$	$2.0x10^{-8}$	$1.4x10^{-8}$	$4.3x10^{-7}$
- recreational	$8.3x10^{-9}$	$7.4x10^{-9}$	$7.5x10^{-8}$	$1.9x10^{-9}$	$1.3x10^{-9}$	$4.0x10^{-8}$
- workplace	$1.2x10^{-6}$	$3.6x10^{-7}$	$3.7x10^{-6}$	$9.2x10^{-8}$	$6.2x10^{-8}$	$2.0x10^{-6}$
Phase B						
- residential	$6.4x10^{-7}$	$5.9x10^{-7}$	$5.9x10^{-6}$	$1.5x10^{-7}$	$1.0x10^{-7}$	$3.2x10^{-6}$
- school	$3.0x10^{-7}$	$2.4x10^{-7}$	$2.4x10^{-6}$	$6.0x10^{-8}$	$4.1x10^{-8}$	$1.3x10^{-6}$
- recreational	$2.2x10^{-8}$	$3.5x10^{-8}$	$3.5x10^{-7}$	$8.9x10^{-9}$	$6.0x10^{-9}$	$1.9x10^{-7}$
- workplace	$1.1x10^{-6}$	$1.1x10^{-6}$	$1.1x10^{-5}$	$2.8x10^{-7}$	$1.9x10^{-7}$	$6.0x10^{-6}$
Phase C						
- residential	$9.3x10^{-7}$	$1.0x10^{-6}$	$1.1x10^{-5}$	$2.6x10^{-7}$	$1.8x10^{-7}$	$5.7x10^{-6}$
- school	$4.2x10^{-7}$	$4.2x10^{-7}$	$4.3x10^{-6}$	$1.1x10^{-7}$	$7.2x10^{-8}$	$2.3x10^{-6}$
- recreational	$4.1x10^{-8}$	$6.4x10^{-8}$	$6.4x10^{-7}$	$1.6x10^{-8}$	$1.1x10^{-8}$	$3.4x10^{-7}$
- workplace	$1.1x10^{-6}$	$1.6x10^{-6}$	$1.6x10^{-5}$	$4.1x10^{-7}$	$2.8x10^{-7}$	$8.7x10^{-6}$
Full Build						
- residential	$9.3x10^{-7}$	$1.4x10^{-6}$	$1.5x10^{-5}$	$3.6x10^{-7}$	$2.5x10^{-7}$	$7.8x10^{-6}$
- school	$3.6x10^{-7}$	$5.5x10^{-7}$	$5.5x10^{-6}$	$1.4x10^{-7}$	$9.4x10^{-8}$	$2.9x10^{-6}$
- recreational	$5.7x10^{-8}$	$8.9x10^{-8}$	$9.0x10^{-7}$	$2.3x10^{-8}$	$1.5x10^{-8}$	$4.8x10^{-7}$
- workplace	$1.1x10^{-6}$	$1.6x10^{-6}$	$1.6x10^{-5}$	$4.1x10^{-7}$	$2.8x10^{-7}$	$8.7x10^{-6}$
Cumulative Scenario 1						
- residential	$1.3x10^{-6}$	2.0x10-6	2.0x10-5	$5.1x10^{-7}$	3.5x10-7	1.1x10-5
- school	5.4x10-7	8.2x10-7	8.3x10-6	2.1x10-7	1.4x10-7	4.4x10-6
- recreational	$7.5x10^{-8}$	1.2x10-7	1.2x10-6	3.0x10-8	2.0x10-8	6.3x10-7
- workplace	2.6x10-6	3.9x10-6	3.9x10-5	9.8x10-7	6.7x10-7	2.1x10-5
Cumulative Scenario 2						
- residential	$1.0x10^{-6}$	$1.6x10^{-6}$	$1.6x10^{-5}$	$3.9x10^{-7}$	$2.7x10^{-7}$	$8.4x10^{-6}$

Particulate fraction:	PM10	PM2.5	PM2.5	PM2.5	PM2.5	DPM
Health endpoint:	**Mortality - All Causes,** Short-Term, All ages	**Mortality - All Causes,** Short-Term, All ages	**Mortality – Cardiopulmonary** Long-term, ≥ 30 years	**Mortality – Cardiovascular** Short-Term, All ages	**Mortality – Respiratory,** Short-Term, All ages	**Lung cancer – all ages**
Scenario and receptor group	**Risk**	**Risk**	**Risk**	**Risk**	**Risk**	**Lifetime Risk**
- school	$4.3x10^{-7}$	$6.5x10^{-7}$	$6.6x10^{-6}$	$1.6x10^{-7}$	$1.1x10^{-7}$	$3.5x10^{-6}$
- recreational	$5.7x10^{-8}$	$8.9x10^{-8}$	$9.0x10^{-7}$	$2.2x10^{-8}$	$1.5x10^{-8}$	$4.8x10^{-7}$
- workplace	$2.2x10^{-6}$	$3.4x10^{-6}$	$3.4x10^{-5}$	$8.6x10^{-7}$	$5.9x10^{-7}$	$1.8x10^{-5}$
Cumulative Scenario 3						
- residential	$8.4x10^{-7}$	$1.3x10^{-6}$	$1.3x10^{-5}$	$3.2x10^{-7}$	$2.2x10^{-7}$	$6.9x10^{-6}$
- school	$3.3x10^{-7}$	$5.1x10^{-7}$	$5.1x10^{-6}$	$1.3x10^{-7}$	$8.7x10^{-8}$	$2.7x10^{-6}$
- recreational	$4.0x10^{-8}$	$6.2x10^{-8}$	$6.3x10^{-7}$	$1.6x10^{-8}$	$1.1x10^{-8}$	$3.4x10^{-7}$
- workplace	$2.0x10^{-6}$	$3.0x10^{-6}$	$3.0x10^{-5}$	$7.6x10^{-7}$	$5.2x10^{-7}$	$1.6x10^{-5}$

Increased Incidence of Health Effects

Based on analysis of the potential health impacts on the population adjacent to the Project site, the calculated increased population incidence, or number of cases, for the primary health endpoints associated with $PM_{2.5}$ exposure are summarised in **Table 4.8**. These calculated values are considered accurate to one significant figure only due to the level of uncertainty within all aspects of the assessment presented.

Table 4.8 Calculated increased population incidence (additional cases per year) – Exposure to PM2.5 – Primary Indicators

Scenario	**Calculated incremental annual incidence for the following primary health endpoints (summed over all suburbs)**		
	Mortality all causes (long-term exposure, ages ≥30 years)	**Cardiovascular hospitalisations** (short-term exposure, ages ≥65 years)	**Respiratory hospitalisations** (short-term exposure, ages ≥65 years)
Northern Rail Access			
- Phase A	0.02	0.008	0.002
- Phase B	0.05	0.03	0.006
- Phase C	0.1	0.06	0.01
- Full Build	0.1	0.07	0.01
Central Rail Access			
- Phase A	0.02	0.009	0.002
- Phase B	0.04	0.02	0.004
- Phase C	0.1	0.06	0.01
- Full Build	0.1	0.07	0.01
Southern rail access			
- Phase A	0.01	0.008	0.002
- Phase B	0.05	0.03	0.006
- Phase C	0.09	0.05	0.01
- Full Build	0.1	0.07	0.01
- Cumulative Scenario 1	0.2	0.1	0.02
- Cumulative Scenario 2	0.2	0.09	0.02
- Cumulative Scenario 3	0.1	0.07	0.01

Calculations are presented in **Appendix C**, including calculations for the secondary endpoints (where the calculated increased incidence is similar to and lower than presented for the primary health endpoints).

4.4 Acceptability of health risk impacts

4.4.1 General

Based on the assessment outlined and presented in **Sections 4.1** to **4.2.3**, potential health impacts associated with the project have been assessed on the basis of two calculations:

1. Calculation of an annual risk for each health endpoint. This is an incremental risk over and above the baseline risk (or incidence) of the effect occurring for any member of the population, where exposed to the particulate matter concentration estimated.
2. Calculation of an increased incidence of the health effect occurring within the population exposed. This calculates the increased number of cases (mortality or hospitalisations) that

may occur for the population assumed to be exposed to the particulate matter concentration estimated.

To determine if the calculated annual risk or increased incidence within a population associated with particulate matter impacts from the project may be considered to be acceptable a number of factors need to be considered. These are further discussed in the following sections.

4.4.2 Acceptable risk levels

General

The acceptability of an additional population risk is the subject of some discussion as there are currently no guidelines available in Australia, or internationally, in relation to an acceptable level of population risk associated with exposure to particulate matter. More specifically there are no guidelines available that relate to an acceptable level of risk for a small population (associated with impacts from a specific activity or project) compared with risks that are relevant to whole urban populations (that are considered when deriving guidelines). The following provides additional discussion in relation to evaluating calculated risk levels.

> "*The solution to developing better criteria for environmental contaminants is not to adopt arbitrary thresholds of 'acceptable risk' in an attempt to manage the public's perception of risk, or develop oversimplified tools for enforcement or risk assessment. Rather, the solution is to standardize the process by which risks are assessed, and to undertake efforts to narrow the gap between the public's understanding of actual vs. perceived risk. A more educated public with regard to the actual sources of known risks to health, environmental or otherwise, will greatly facilitate the regulatory agencies' ability to prioritize their efforts and standards to reduce overall risks to public health*." (Kelly 1991).

Most human activities that have contributed to economic progress present also some disadvantages, including risks of different kinds that adversely affect human health. These risks include air or water pollution due to industrial activities (coal power generation, chemical plants, and transportation), food contaminants (pesticide residues, additives), and soil contamination (hazardous waste). Despite all possible efforts to reduce these threats, it is clear that the zero risk objective is unobtainable or simply not necessary for human and environmental protection and that a certain level of risk in a given situation is deemed "acceptable" as the effects are so small as to be negligible or undetectable. Risk managers need to cope with some residual risks and thus must adopt some measure of an acceptable risk.

Much has been written about how to determine the acceptability of risk. The general consensus in the literature is that "acceptability" of a risk is a judgment decision properly made by those exposed to the hazard or their designated health officials. It is not a scientifically derived value or a decision made by outsiders to the process. Acceptability is based on many factors, such as the number of people exposed, the consequences of the risk, the degree of control over exposure, and many other factors.

The USEPA (Hoffman 1988) "*surveyed a range of health risks that our society faces*" and reviewed acceptable-risk standards of government and independent institutions. The survey found that "*No*

fixed level of risk could be identified as acceptable in all cases and under all regulatory programs...," and that: "...*the acceptability of risk is a relative concept and involves consideration of different factors*". Considerations may include:

- The certainty and severity of the risk.
- The reversibility of the health effect.
- The knowledge or familiarity of the risk.
- Whether the risk is voluntarily accepted or involuntarily imposed.
- Whether individuals are compensated for their exposure to the risk.
- The advantages of the activity.
- The risks and advantages for any alternatives.

To regulate a technology in a logically defensible way, one must consider all its consequences, i.e. both risks and benefits.

10^{-6} as an 'acceptable' risk level?

The concept of $1x10^{-6}$ (10^{-6}) was originally an arbitrary number, finalised by the U.S. Food and Drug Administration (FDA) in 1977 as a screening level of "essentially zero" or *de minimus* risk. The term *de minimus* is an abbreviation of the legal concept, "*de minimus non curat lex*: the law does not concern itself with trifles." In other words, 10^{-6} was developed as a level of risk below which risk was considered a "trifle" and not of concern in a legal case.

This concept was traced back to a 1961 proposal by two scientists from the National Cancer Institute regarding methods to determine "safety" levels in carcinogenicity testing. The FDA applied the concept in risk assessment in its efforts to deal with diethylstilboestrol as a growth promoter in cattle. The threshold of one-in-a-million risk of developing cancer was established as a screening level to determine what carcinogenic animal drug residues merited further regulatory consideration. In the FDA legislation, the regulators specifically stated that this level of "essentially zero" was not to be interpreted as equal to an acceptable level of residues in meat products. Since then, the use of risk assessment and 10^{-6} (or variations thereof) have been greatly expanded to almost all areas of chemical regulation, to the point where today one-in-a-million (10^{-6}) risk means different things to different regulatory agencies in different countries. What the FDA intended to be a lower regulatory level of "zero risk" below which no consideration would be given as to risk to human health, for many regulators it somehow came to be considered a maximum or target level of "acceptable" risk (Kelly 1991).

When evaluating human health risks, the quantification of risk can involve the calculation of an increased lifetime chance of cancer (as is calculated for diesel particulate matter in this assessment) or an increased probability of some adverse health effect (or disease) occurring, over and above the baseline incidence of that health effect/disease in the community (as is calculated for exposure to particulate matter).

In the context of human health risks, 10^{-6} is a shorthand description for an increased chance of 0.000001 in 1 (one chance in a million) of developing a specific adverse health effect due to exposure (over a lifetime or a shorter duration as relevant for particulate matter) to a substance. The number 10^{-5} represents 1 chance in 100,000, and so on.

Where cancer may be considered, lifetime exposure to a substance associated with a cancer risk of $1x10^{-6}$ would increase an individual's current chances of developing cancer from all causes (which is 40 per cent, or 0.4 – the background incidence of cancer in a lifetime) from 0.4 to 0.400001, an increase of 0.00025 per cent.

For other health indicators considered in this assessment, such as cardiovascular hospitalisations for people aged 65 years and older (for example), an increased risk of 10^{-6} (one chance in a million) would increase an individual's (aged 65 years and older) chance of hospitalisation for cardiovascular disease (above the baseline incidence of 23 per cent, or 0.23) from 0.23 to 0.230001, an increase of 0.00043 per cent.

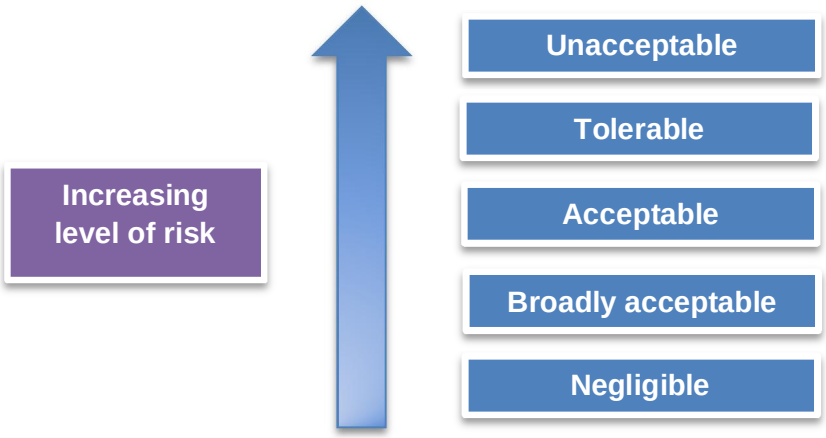
To provide more context in relation to the concept of a one in a million risk, the following presents a range of everyday life occurrences. The activity and the time spent undertaking the activity that is associated with reaching a risk of one in a million for mortality are listed below (Higson 1989; NSW Planning 2011).

- Motor vehicle accident – 2.5 days spent driving a motor vehicle to reach one in a million chance of having an accident that causes mortality (death).
- Home accidents – 3.3 days spent within a residence to reach a one in a million chance of having an accident at home that causes mortality.
- Pedestrian accident (being struck by vehicles) – 10 days spent walking along roads to reach a one in a million chance of being struck by a vehicle that causes mortality.
- Train accident – 12 days spent travelling on a train to reach a one in a million chance of being involved in an accident that causes mortality.
- Falling down stairs[1] – 66 days spent requiring the use of stairs in day-to-day activities to reach a one in a million chance of being involved in a fall that causes mortality.
- Falling objects – 121 days spent in day-to-day activities to reach a one in a million chance of being hit by a falling object that causes mortality.

This risk level should also be considered in the context that everyone has a cumulative risk of death that ultimately must equal one and the annual risk of death for most of one's life is about one in 1000.

While various terms have been applied, it is clear that the two ends of what is a spectrum of risk are the "negligible" level and the "unacceptable" level. Risk levels intermediate between these are frequently adopted by regulators with varying terms often used to describe the levels. When considering a risk derived for an environmental impact it is important to consider that the level of risk that may be considered acceptable will lie somewhere between what is negligible and unacceptable, as illustrated below.

[1] Mortality risks as presented by: http://www.riskcomm.com/visualaids/riskscale/datasources.php



The calculated individual lifetime risk of death or illness due to an exposure to a range of different environmental hazards covers many orders of magnitude, ranging from well less than 10^{-6} to levels of 10^{-3} and higher (in some situations). However, most figures for an acceptable or a tolerable risk range between 10^{-6} to 10^{-4}, used for either one year of exposure or a whole life exposure. It is noteworthy that 10^{-6} as a criterion for "acceptable risk" has not been applied to all sources of exposure or all agents that pose risk to public health.

A review of the evolution of 10^{-6} reveals that *perception* of risk is a major determinant of the circumstances under which this criterion is used. The risk level 10^{-6} is not consistently applied to all environmental legislation. Rather, it seems to be applied according to the general perception of the risk associated with the source being regulated and where the risk is being regulated (with different levels selected in different countries for the same sources).

A review of acceptable risk levels at the USEPA (Schoeny 2008) points out that risk assessors can identify risks and possibly calculate their value but cannot determine what is acceptable. Acceptability is a value judgment that varies with type of risk, culture, voluntariness and many other factors. Acceptability may be set by convention or law. The review also states that the USEPA aims for risk levels between 10^{-6} and 10^{-4} for risks calculated to be linear at low dose, while for other endpoints, not thought to be linear at low dose, the risk is compared to Reference Dose/ Concentrations or guideline levels. The USEPA typically uses a target reference risk range of 10^{-4} to 10^{-6} for carcinogens in drinking water, which is in line with World Health Organization (WHO) guidelines for drinking water quality which, where practical, base guideline values for genotoxic carcinogens on the upper bound estimate of an excess lifetime cancer risk of 10^{-5}.

There are many different ways to define acceptable risk and each way gives different weight to the views of different stakeholders in the debate. No definition of ‘acceptable’ will be acceptable to all stakeholders. Resolving such issues, therefore, becomes a political (in the widest sense) rather than a strictly health process.

The following is a list of standpoints that could be used as a basis for determining when a risk is acceptable or, perhaps, tolerable.

The WHO (Fewtrell & Bartram 2001) address standards related to water quality. They offer the following guidelines for determining acceptable risk. A risk is acceptable when:

- It falls below an arbitrary defined probability.
- It falls below some level that is already tolerated.
- It falls below an arbitrary defined attributable fraction of total disease burden in the community.
- The cost of reducing the risk would exceed the costs saved.
- The cost of reducing the risk would exceed the costs saved when the 'costs of suffering' are also factored in.
- The opportunity costs would be better spent on other, more pressing, public health problems.
- Public health professionals say it is acceptable.
- The general public say it is acceptable (or more likely, do not say it is not).
- Politicians say it is acceptable.

In everyday life individual risks are rarely considered in isolation. It could be argued that a sensible approach would be to consider health risks in terms of the total disease burden of a community and to define acceptability in terms of it falling below an arbitrary defined level. A problem with this approach is that the current burden of disease attributable to a single factor, such as air pollution, may not be a good indicator of the potential reductions available from improving other environmental health factors. For diseases such as cardiovascular disease where causes are multifactorial, reducing the disease burden by one route may have little impact on the overall burden of disease.

Overall

It is not possible to provide a rigid definition of acceptable risk due to the complex and context-driven nature of the challenge. It is possible to propose some general guidelines as to what might be an acceptable risk for specific development projects.

If the level of 10^{-6} (one chance in a million) were retained as a level of increased risk that would be considered as a negligible risk in the community, then the level of risk that could be considered to be tolerable would lie between this level and an upper level that is considered to be unacceptable.

While there is no guidance available on what level of risk is considered to be unacceptable in the community, a level of 10^{-4} for increased risk (one chance in 10,000) has been generally adopted by health authorities as a point where risk is considered to be unacceptable in the development of drinking water guidelines (that impact on whole populations) (for exposure to carcinogens as well as for annual risks of disease (Fewtrell & Bartram 2001)) and in the evaluation of exposures from pollutants in air (DEC 2005b).

Between an increased risk level considered negligible (10^{-6}) and unacceptable (10^{-4}) lie risks that may be considered to be tolerable or even acceptable. Tolerable risks are those that can be tolerated (and where the best available, and most appropriate, technology has been implemented to minimise exposure) in order to realise some benefit.

In a societal context, risks are inevitable and any new development will be accompanied by risks which are not amenable or economically feasible to reduce below a certain level. It is not good

policy to impose an arbitrary risk level to such developments without consideration of the myriad factors that should be brought into play to determine what is 'tolerable'.

When considering the impacts associated with this Project, it is important to note that there are a range of benefits associated with the project (refer to Section 3 of the EIS). Hence for this Project the calculated risks have been considered to be tolerable when in the range of 10^{-6} and 10^{-4} of increased risk and where the increased incidence of the health impacts are considered to be insignificant (refer to discussion in **Section 4.4.3**).

4.4.3 Determination of significance of incremental impacts

The assessment of potential health impacts associated with emissions to air from the project has not only calculated an increased annual risk, relevant to the health endpoints considered, but also an increased incidence, i.e. the additional number of cases, of the adverse effects occurring within the population potentially exposed. The calculated increased incidence needs to be considered in terms of what may be significant.

In relation to the calculated increased incidence of an adverse health effect occurring in a population, the following is noted for the primary health indicators (based on statistics available from NSW Health):

- In relation to mortality (all causes), the health statistics available show that for the year 2010 – 2011 the variability in all admissions data reported (based on the 95 per cent confidence interval for data reported in south western Sydney) is around ± two per cent. This is the variability in the data reported in one year. Each year the mortality rate also varies with around three per cent variability reported in the mortality rate (number reported for all causes) between 2009/10 and 2010/11. Based on the baseline incidence of mortality considered in this assessment a variability of two to three per cent equates to a variability of around one case per year (where the maximum impacts are considered). Hence any estimation of mortality in the population less than one case per year could not be detected (above normal variability) in the health statistics.
- In relation to cardiovascular disease hospitalisations, the health statistics available show that for the year 2011 – 2012 the variability in all admissions data reported (based on the 95 percent confidence interval for data reported in south western Sydney) is around ± 1.5 percent. This is the variability in the data reported in one year. Each year the rate of hospitalisations (all ages) also varies with around three per cent variability reported in the number of hospitalisations for people aged 65 years and older between 2010/11 and 2011/12. Based on the baseline incidence of cardiovascular hospitalisations considered in this assessment for individuals aged 65 years and older a variability of 1.5 per cent equates to a variability of around 40 cases per year (where the maximum impacts are considered). Hence any estimation of increased incidence of cardiovascular hospitalisations in the population aged 65 years and older less than 40 cases per year could not be detected (above normal variability) in the health statistics.
- In relation to respiratory disease hospitalisations, the health statistics available show that for the year 2011 – 2012 the variability in all admissions data reported (based on the 95 percent confidence interval for data reported in south western Sydney) is around ± 1.5 percent. This is the variability in the data reported in one year. Each year the rate of hospitalisations (all

ages) also varies with around three-four per cent variability reported in the number of hospitalisations (all ages) between 2010/11 and 2011/12. Based on the baseline incidence of respiratory hospitalisations considered in this assessment for individuals aged 65 years and older a variability of 1.5 per cent equates to a variability of around 17 cases per year (where the maximum impacts are considered). Hence any estimation of increased incidence of cardiovascular hospitalisations in the population aged 65 years and older less than 17 cases per year could not be detected (above normal variability) in the health statistics.

Where changes arising from an individual project are well below 1 case per year and are not detectable in the normal fluctuations in health statistics such impacts are considered to be negligible.

4.5 Discussion of potential health impacts from the project

4.5.1 General

The assessment presented in this section has focused on the quantification of health impacts associated with exposure, primarily to $PM_{2.5}$ (which has the most robust exposure-response relationships and is the primary pollutant from combustion emissions) and PM_{10}.

In relation to the increased impact of PM_{10} and $PM_{2.5}$ concentrations, the LAQIA predicted increased concentrations in the local community of:

- PM_{10}:
  - Southern rail access – up to 1.4 µg/m^3 as an annual average and up to 9 µg/m^3 as a 24-hour average
  - Central rail access - up to 1.5 µg/m^3 as an annual average and up to 10 µg/m^3 as a 24-hour average
  - Northern rail access - up to 1.3 µg/m^3 as an annual average and up to 8.5 µg/m^3 as a 24-hour average
- $PM_{2.5}$:
  - Southern rail access – up to 1.2 µg/m^3 as an annual average and up to 2.3 µg/m^3 as a 24-hour average
  - Central rail access - up to 1.2 µg/m^3 as an annual average and up to 2.4 µg/m^3 as a 24-hour average
  - Northern rail access - up to 1.1 µg/m^3 as an annual average and up to 2.3 µg/m^3 as a 24-hour average

Incremental annual risk and increased incidence for a range of primary and secondary health indicators associated with exposure to $PM_{2.5}$ and PM_{10} have been calculated and are presented in **Section 0**. The following discussion relates to a review of these calculated health impacts within the context of the discussion presented in **Section 4.4**.

4.5.2 Primary health indicators

In relation to the primary health indicators considered in relation to exposure to $PM_{2.5}$ derived from the Project, the following can be noted in relation to the various phases of the Project:

- For the assessment of **mortality** from all causes (for people aged 30 years and over) the following has been calculated:
  - Phase A: Early works - The increased annual risks (mortality) are calculated to be:
    - Up to $2x10^{-6}$ for the maximum residential, school or recreational receptor; and
    - Up to $4x10^{-6}$ for the maximum workplace receptor.
  - Phase B - The increased annual risks (mortality) are calculated to be:
    - Up to $1x10^{-5}$ for the maximum residential, school or recreational receptor; and
    - Up to $1x10^{-5}$ for the maximum workplace receptor.
  - Phase C - The increased annual risks (mortality) are calculated to be:
    - Up to $2x10^{-5}$ for the maximum residential, school or recreational receptor; and
    - Up to $2x10^{-5}$ for the maximum workplace receptor.
  - Full Build - The increased annual risks (mortality) are calculated to be:
    - Up to $2x10^{-5}$ for the maximum residential, school or recreational receptor; and
    - Up to $2x10^{-5}$ for the maximum workplace receptor.
  - Cumulative assessment - The increased annual risks (mortality) are calculated to be:
    - Up to $2x10^{-5}$ for the maximum residential, school or recreational receptor; and
    - Up to $4x10^{-5}$ for the maximum workplace receptor.
  - The increased incidence within the local population is calculated to be up to 0.02 for Phase A, 0.05 for Phase B, 0.1 for Phase C, 0.1 for Full Build and 0.2 for the cumulative assessment.

    Based on the discussion presented in **Section 4.4.2**, the calculated risks are within the range of tolerable risks associated with impacts from a specific project.

    With further consideration of the calculated increased population incidence of mortality as discussed in **Section 4.4.3**, the calculated increased risks are considered to be negligible.

- For the assessment of **cardiovascular hospitalisations** (for people aged 65 years and over) the following has been calculated:
  - Phase A: Early works - The increased annual risks are calculated to be:
    - Up to $5x10^{-6}$ for the maximum residential, school or recreational receptor; and
    - Up to $1x10^{-5}$ for the maximum workplace receptor.
  - Phase B - The increased annual risks are calculated to be:
    - Up to $3x10^{-5}$ for the maximum residential, school or recreational receptor; and
    - Up to $3x10^{-5}$ for the maximum workplace receptor.
  - Phase C - The increased annual risks are calculated to be:
    - Up to $6x10^{-5}$ for the maximum residential, school or recreational receptor; and
    - Up to $5x10^{-5}$ for the maximum workplace receptor.
  - Full Build - The increased annual risks are calculated to be:
    - Up to $5x10^{-5}$ for the maximum residential, school or recreational receptor; and
    - Up to $5x10^{-5}$ for the maximum workplace receptor.

- Cumulative assessment - The increased annual risks (mortality) are calculated to be:
  - Up to $6x10^{-5}$ for the maximum residential, school or recreational receptor; and
  - Up to $1x10^{-4}$ for the maximum workplace receptor.
- The increased incidence within the local population is calculated to be up to 0.009 for Phase A, 0.03 for Phase B, 0.06 for Phase C, 0.07 for Full Build and 0.1 for the cumulative assessment.

  Based on the discussion presented in **Section 4.4.2**, the calculated risks are within the range of tolerable risks associated with impacts from a specific project, with the exception of the cumulative assessment where risks calculated for workplace exposures (based on impacts predicted on the site boundary) are considered to be elevated and unacceptable.

  With further consideration of the calculated increased population incidence of hospitalisations as discussed in **Section 4.4.3**, the calculated increased risks are generally considered to be negligible. In relation to the cumulative scenarios potential exposures in the adjacent commercial/industrial areas should be minimised as much as possible through the use of mitigation measures.

- For the assessment of **respiratory hospitalisations** (for people aged 65 years and over) the following has been calculated:
  - Phase A: Early works - The increased annual risks are calculated to be:
    - Up to $1x10^{-6}$ for the maximum residential, school or recreational receptor; and
    - Up to $2x10^{-6}$ for the maximum workplace receptor.
  - Phase B - The increased annual risks are calculated to be:
    - Up to $6x10^{-6}$ for the maximum residential, school or recreational receptor; and
    - Up to $6x10^{-6}$ for the maximum workplace receptor.
  - Phase C - The increased annual risks are calculated to be:
    - Up to $1x10^{-5}$ for the maximum residential, school or recreational receptor; and
    - Up to $1x10^{-5}$ for the maximum workplace receptor.
  - Full Build - The increased annual risks are calculated to be:
    - Up to $1x10^{-5}$ for the maximum residential, school or recreational receptor; and
    - Up to $9x10^{-6}$ for the maximum workplace receptor.
  - Cumulative assessment - The increased annual risks (mortality) are calculated to be:
    - Up to $1x10^{-5}$ for the maximum residential, school or recreational receptor; and
    - Up to $2x10^{-5}$ for the maximum workplace receptor.
  - The increased incidence within the local population is calculated to be up to 0.002 for Phase A, 0.006 for Phase B, 0.01 for Phase C, 0.01 for Full Build and 0.02 for the cumulative assessment.

    Based on the discussion presented in **Section 4.4.2**, the calculated risks are within the range of tolerable risks associated with impacts from a specific project.

    With further consideration of the calculated increased population incidence of hospitalisations as discussed in **Section 4.4.3**, the calculated increased risks are considered to be negligible.

4.5.3 Secondary health indicators

In relation to the secondary health indicators considered in relation to exposure to $PM_{2.5}$ and PM_{10} derived from the project:

- For the assessment of **mortality** from all causes (all ages) and from cardiopulmonary (ages 30 years and over), cardiovascular (all ages) and respiratory disease (all ages) the following has been calculated:
  - Phase A: Early works - The increased annual risks are calculated to be up to $4x10^{-6}$ for the maximum receptor.
  - Phase B - The increased annual risks are calculated to be up to $1x10^{-5}$ for the maximum receptor.
  - Phase C - The increased annual risks are calculated to be up to $2x10^{-5}$ for the maximum receptor.
  - Full Build - The increased annual risks are calculated to be up to $2x10^{-5}$ for the maximum receptor.
  - SIMTA - The increased annual risks are calculated to be up to $4x10^{-5}$ for the maximum receptor.
- For the assessment of **an incremental lifetime cancer risk** associated with exposure to diesel particulate matter (DPM) the following has been calculated:
  - Phase A: Early works - The increased lifetime risks are calculated to be up to $2x10^{-6}$ for the maximum receptor.
  - Phase B - The increased lifetime risks are calculated to be up to $6x10^{-6}$ for the maximum receptor.
  - Phase C - The increased lifetime risks are calculated to be up to $1x10^{-5}$ for the maximum receptor.
  - Full Build - The increased lifetime risks are calculated to be up to $9x10^{-6}$ for the maximum receptor.
  - SIMTA - The increased lifetime risks are calculated to be up to $2x10^{-5}$ for the maximum receptor.

    Based on the discussion presented in **Section 4.4.2**, these risks are negligible for some health indicators with the remainder within the range of tolerable risks associated with impacts from a specific project.

4.5.4 Impact of project on asthma

A common concern in relation to exposure to particulate matter relates to the potential for impacts on children with asthma. The available studies that have evaluated the potential impact of exposure to particulate matter with asthma indicators (hospital visits and medication use) are more limited, and considered to be less robust (showing less statistical significance); however they have shown the presence of potential adverse effects (and relationship) for particulates, particularly $PM_{2.5}$ in the range 9.7 $\mu g/m^3$ to 30 $\mu g/m^3$ (USEPA 2012).

Background $PM_{2.5}$ concentrations exceed the current levels of $PM_{2.5}$ in ambient air in Sydney, and exceed the predicted cumulative (background plus incremental) concentrations of $PM_{2.5}$ for this project. Hence any use of relationships established for levels of exposure in excess of what is being considered in this assessment should be done with caution. Due to this limitation, along with the

issue that much of the necessary baseline data is limited in availability, the outcomes of any assessment of particulate matter exposures and asthma are only considered to be qualitative.

Review by the WHO in the report "Effects of Air Pollution on Children's Health and Development" (WHO 2005b) concluded that the evidence on asthma and air pollution is sufficient to suggest a causal link between air pollution, in particular where living in proximity to traffic, and aggravation of asthma. One way of measuring aggravation of asthma is through the monitoring the use of bronchodilators (also known as asthma relievers).

Most of the available studies in relation to increased use of asthma relievers and exposure to particulate matter relate to PM_{10}. This is mainly due to the nature of the available studies where coarse particulate matter levels were measured in air rather than the finer $PM_{2.5}$. In this study it is recognised that most of the PM_{10} impacts predicted comprise significant levels of $PM_{2.5}$ due to the source being vehicle emissions.

Review of available data by the WHO (Anderson et al. 2004), as summarised for Europe (EC 2011) identified relative risk of a 0.4 per cent (95 per cent confidence interval:-1.7 per cent to 2.6 per cent) increase in bronchodilator days per 10 $\mu g/m^3$ increase in PM_{10} for children aged 5 – 14 years. Based on this study a β coefficient of 0.0004 can be determined and applied for the age group 5 – 14 years considered in this assessment (age group where data on asthma use and population are available). This relationship was established following analysis of data from studies conducted in Europe, including panel studies of children with existing asthma symptoms.

To calculate the increased annual incidence, or increase in use of medication each year for the population of concern in this assessment, additional information is required as follows:

- Increased concentration of PM_{10} (annual average): This has been taken to be the average residential concentration calculated for each suburb (or part suburb).
- The number of children aged 5-14 years in each of the suburbs (or partial suburbs) has been considered based on data from the ABS (for the Census year 2011).
- Population exposed: It is assumed that the number of children currently with asthma is 15.2 per cent of the total population of children. The per cent of children with asthma is based on the NSW rate of current asthma reported by NSW Health[20] for children aged 2 – 15 years for 2012. This rate has been adopted for assessing children aged 5 – 14 years.
- Based on data from Australia for 2002 – 2004, the rate of daily use of reliever medications by children aged 5 – 14 years was 7.2 per cent (ACAM 2007). This value has been rounded up top 10% for south western Sydney to better reflect the reported higher level of use of reliever medication. This incidence is multiplied by 365 to obtain the annual incidence of asthma medication use, ie 0.1 x 365 = 36.5. The baseline incidence of children with asthma using medication each year is the % children with asthma x annual incidence of medication use (ie 0.152*36.5 = 5.55).

[20] NSW Health Statistics for current asthma in children aged 2-15 years. The rate for NSW of 15.4% is equivalent to that reported for Northern Sydney (15.3%). Data available from http://www.healthstats.nsw.gov.au/

- Based on the above the number of additional days per year of bronchodilator use by children associated with the incremental PM_{10} concentration has been estimated for each of the scenarios evaluated. The predicted increase in medication use is presented in **Table 4.9**.

Appendix C presents the calculations undertaken for each suburb and for the whole population.

Table 4.9 Calculated increased use of reliever medication for asthma – children aged 5-14 years

Scenario	Calculated incremental annual use of asthma reliever medication (bronchodilator) by children (summed over all suburbs considered)
Northern Rail Access	
- Phase A	0.82
- Phase B	0.91
- Phase C	1.4
- Full Build	1.2
Central Rail Access	
- Phase A	0.86
- Phase B	0.87
- Phase C	1.4
- Full Build	1.3
Southern rail access	
- Phase A	0.72
- Phase B	0.92
- Phase C	1.3
- Full Build	1.2
- Cumulative Scenario 1	2.1
- Cumulative Scenario 2	1.7
- Cumulative Scenario 3	1.3

The calculated increase in bronchodilator use in children associated with exposure to PM_{10} derived from the project is very low (≤2 increased uses of medication in a year in the whole population of asthmatic children aged 5-14 years) and would not be measurable within the local community.

4.6 Uncertainties

4.6.1 Particulate concentrations

The modelling of particulate impacts involves the use of a number of assumptions in relation to the operation of the project and activities that result in the emission of dust to air. In addition the determining the dispersion of particulate matter from the ventilation facility outlets to the surrounding environment has utilised air dispersion models. While the approach adopted in the LAQIA utilised published peer-reviewed emission estimation techniques, the currently available site-specific data on the operation of the project, site-specific meteorology and terrain data and approved models for the quantification of impacts in the surrounding areas, the overall approach adopted is generally conservative to ensure that where uncertainties are present, the impact is overestimated.

4.6.2 Assessment of the effects of exposure to particulate matter

The available scientific information provides a sufficient basis for determining that exposure to particulate matter (particularly $PM_{2.5}$ and smaller) is associated with adverse health effects in a population. The data is insufficient to provide a thorough understanding of all of the potential toxic

properties of particulates to which humans may be exposed. Over time it is expected that many of the current uncertainties will be refined with the collection of additional data, however some uncertainty will be inherent in any estimate. The influence of the uncertainties may be either positive or negative.

Overall, however, the epidemiological and toxicological data on which the assessment presented in this technical working paper are based on current and robust for the assessment of risks to human health associated with the potential exposure to particulate matter from combustion sources. When drawing conclusions in relation to the assessment presented, the following also need to be considered.

Exposure-response function

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. This is illustrated by **Figures 4.2 to 4.4** that show the variability in the relative risk estimates calculated in published studies for the US (and Canadian) population that are relevant to the primary health endpoints considered in this assessment (USEPA 2012). A similar variability is observed where additional studies from Europe, Asia and Australia/New Zealand are considered.

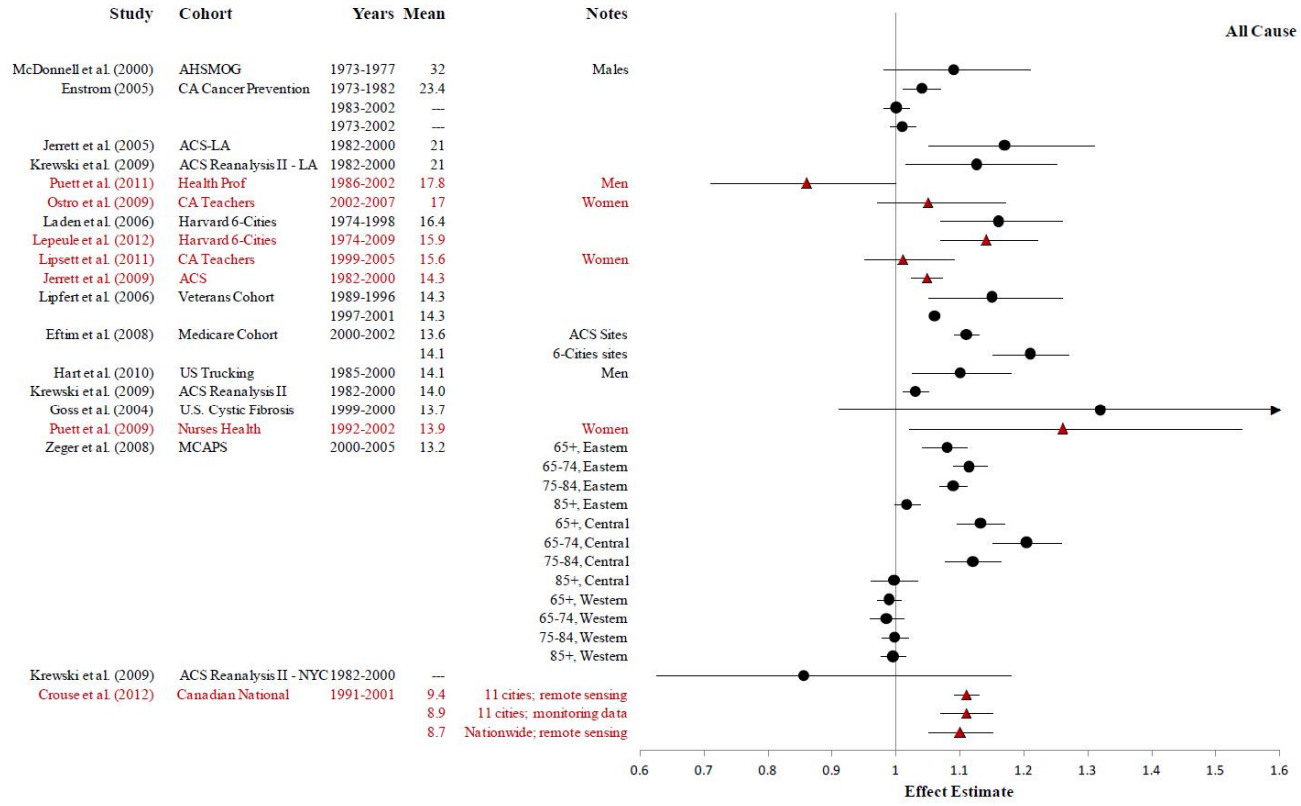


Figure 4.2 All-cause mortality relative risk estimates for long-term exposure to $PM_{2.5}$ (USEPA 2012, note studies in red are those completed since 2009)

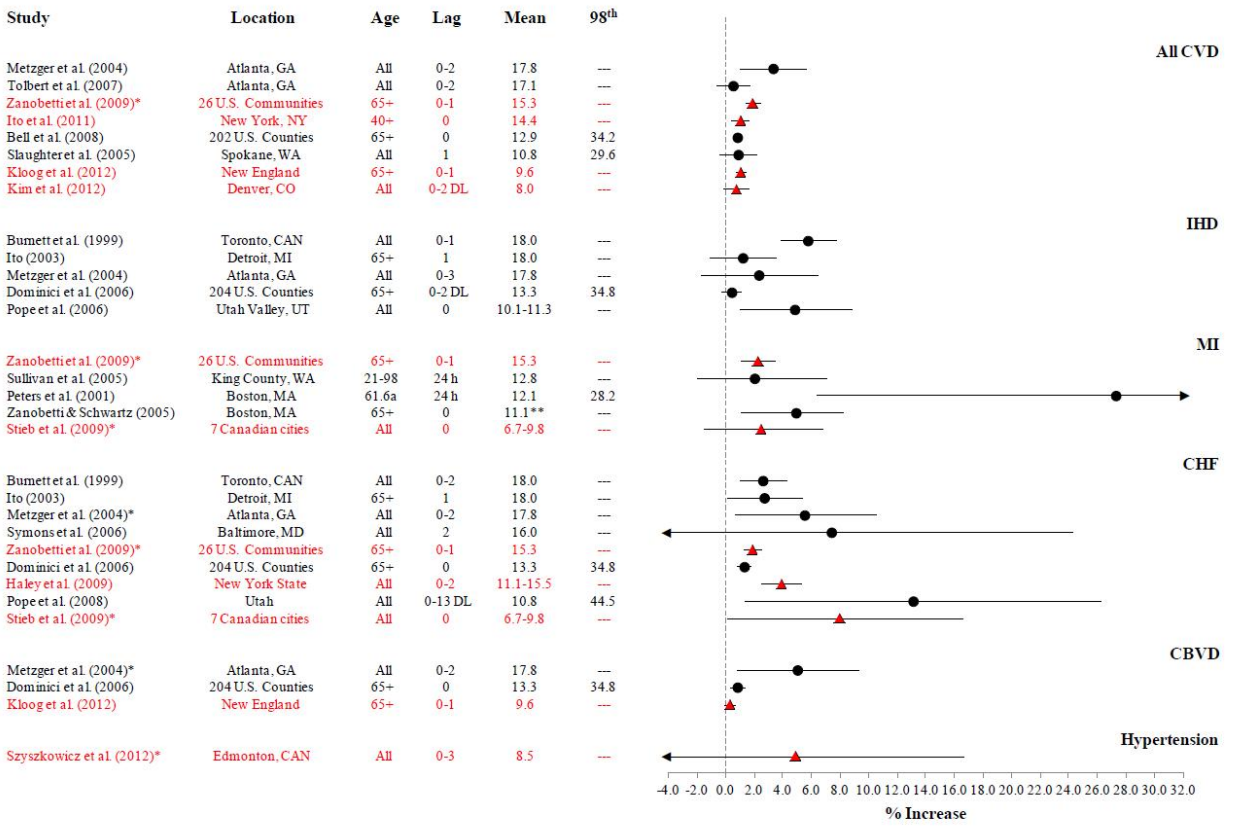


Figure 4.3 Per cent increase in cardiovascular-related hospital admissions for a 10 µg/m^3 increase in short-term (24-hour average) exposure to $PM_{2.5}$ (USEPA 2012, note studies in red are those completed since 2009)

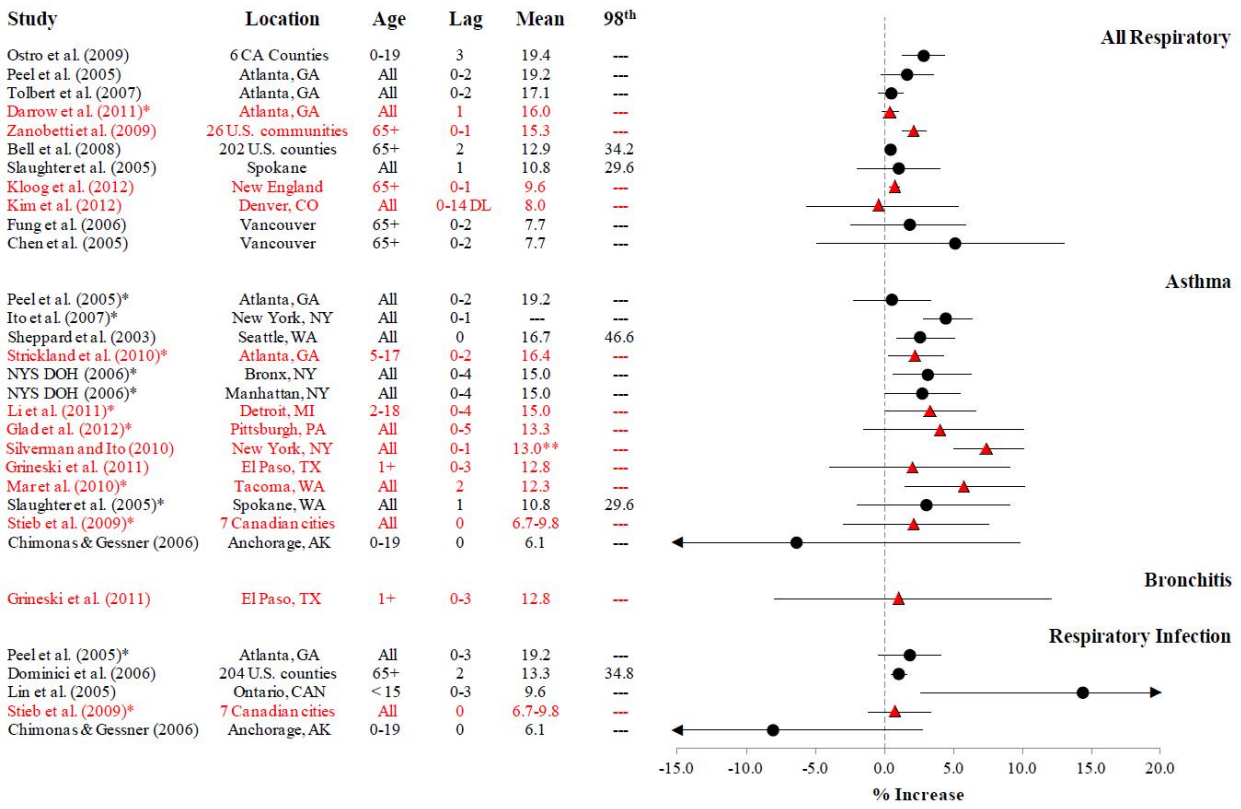


Figure 4.4 Per cent increase in respiratory-related hospital admissions for a 10 µg/m^3 increase in short-term (24-hour average) exposure to $PM_{2.5}$ (USEPA 2012, note studies in red are those completed since 2009)

The above figures illustrate the variability inherent in the studies used to estimate exposure-response functions. The variability is expected to reflect the local and regional variability in the characteristics of particulate matter to which the population is exposed.

Based on the available data, and the detailed reviews undertaken by organisations such as the USEPA (USEPA 2010, 2012) and WHO (WHO 2003, 2006a, 2006b) and discussions with NSW Health, the adopted exposure-response estimates are considered to be current, robust and relevant to the characterisation of impacts form PM.

Shape of exposure-response function

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 responsible for these effects and the observed shape of the dose-response relationship is complex. For example, it is not possible to determine if the observed no threshold response is relevant to exposure to particulates from all sources, or whether it relates to particulates from combustion sources only. Most studies have demonstrated that there is 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.

Co-pollutants

It is likely that some of the health effects observed relate to both particulate matter and other related/correlated pollutants. Many of the pollutants evaluated come from a common source (e.g. fuel combustion) hence the use of only particulate matter as an index for the mix of pollutants is reasonable but conservative, particularly where there are multiple sources, or the scenario being evaluated is not from a source type that is likely to have dominated the studies underlying the relative risk values used in the risk assessment.

Selected health outcomes

The assessment of risk has utilised exposure-response functions and relative risk values that relate to the more significant health endpoints where the most significant and robust positive associations have been identified. The approach does not include all possible subsets of effects that have been considered in various published studies. However, the assessment undertaken has considered the health endpoints/outcomes that incorporate many of the subsets, and has utilised the most current and robust relationships.

Diesel particulate matter evaluation

The health hazard conclusions associated with exposure to diesel particulate matter are based on studies that are dominated by exhaust emissions from diesel engines built prior to the mid-1990s. With current engine use including some new and many older engines (engines typically stay in service for a long time), the health hazard conclusions, in general, are likely to be applicable to engines currently in use. However as new and cleaner diesel engines, together with different diesel fuels, replace a substantial number of existing engines; the general applicability of the health hazard conclusions may require further evaluation. The NEPC (NEPC 2009) has established a program to reduce diesel emissions from the Australian heavy vehicle fleet. This is expected to lower the potential for emissions over time and hence reduce the risk.

Section 5. Conclusions

In relation to the assessment of health impacts from any new project, both incremental impacts and cumulative impacts need to be considered. These have been addressed in the assessment presented based on information available from the Local Air Quality Impact Assessment conducted for the Project (Environ 2014).

The assessment conducted has considered potential exposures in the local community, at a number of residential and other sensitive (school) receptor locations, to project related emissions to air during a number of scenarios where both construction and operational impacts have been considered (2016/2017, 2023/2024 and 2028/2029) and at completion of the Project in 2030 (where emissions are associated with operations only). These scenarios have been evaluated on the basis of three rail access options onto the site (northern central and southern rail access). In addition three cumulative scenarios (that include the operation of both the Moorebank and SIMTA IMTs) have been considered (for the year 2030 at full operations based on the southern rail access option).

Emissions evaluated included those derived from construction and major earthworks as well as combustion emissions, specifically diesel emissions from trucks and locomotives. More specifically this included an assessment of potential exposures to nitrogen dioxide, carbon monoxide, sulfur dioxide, volatile organic compounds (associated with diesel emissions), polycyclic aromatic hydrocarbons and particulate matter (as PM_{10} and $PM_{2.5}$).

Exposures to nitrogen dioxide, carbon monoxide, sulfur dioxide, volatile organic compounds (associated with diesel emissions) and polycyclic aromatic hydrocarbons were evaluated on the basis of available guidelines that are protective of adverse health effects for all members of the population including sensitive groups (such as young children and the elderly). The assessment concluded that exposures to these emissions were considered to be negligible.

The more detailed assessment of potential exposures to particulate matter concluded the following:

- Cumulative impacts of $PM_{2.5}$ and PM_{10} were shown to meet goals established by OEH and NEPC that are based on the protection of community health and wellbeing. On this basis, cumulative impacts meet these goals and are not considered to be of concern.
- Incremental impacts associated with $PM_{2.5}$ and PM_{10} have also been evaluated. The evaluation has calculated increased lifetime risks and the increase in the number of cases for a range of key health effects. The health effects included premature mortality (from all causes and from specific causes such as cardiovascular, respiratory disease or lung cancer and increased risks of cancer) as well as increased hospitalisations for pre-existing illnesses such as cardiovascular disease and respiratory disease. These calculations have been undertaken on the basis of established exposure-effects relationships for exposure to $PM_{2.5}$, PM_{10} and diesel particulate matter (DPM, where 100% of the $PM_{2.5}$ from the site is assumed to be DPM) that are relevant to all members of the population including sensitive groups such as the elderly, young children and individuals with pre-existing illness.
- For the assessment of potential impacts of $PM_{2.5}$ and PM_{10} from the Project over all phases of operation, and rail access options considered, potential health impacts are low (not significant) in the surrounding community. Regardless of this assessment, where possible

the best available technology and mitigation measures should be implemented to minimise exposures to particulates in the community.

- In relation to the assessment of cumulative impacts from the operation of both the Moorebank and SIMTA IMTs, the predicted health impacts are generally considered to be low (not significant); however there is the potential for risks in adjacent commercial/industrial areas to be at a level that is considered unacceptable. Mitigation measures need to be implemented to minimise exposure to particulates in the adjacent workplaces.

Overall, on the basis of the assessment conducted, cumulative and incremental impacts from the operation of the Project overall years associated with construction/development and operation, on the health of the adjacent community (including sensitive groups) are generally considered to be low and acceptable. Where possible the best available technology and mitigation measures should be implemented to minimise exposures to particulates in the community,

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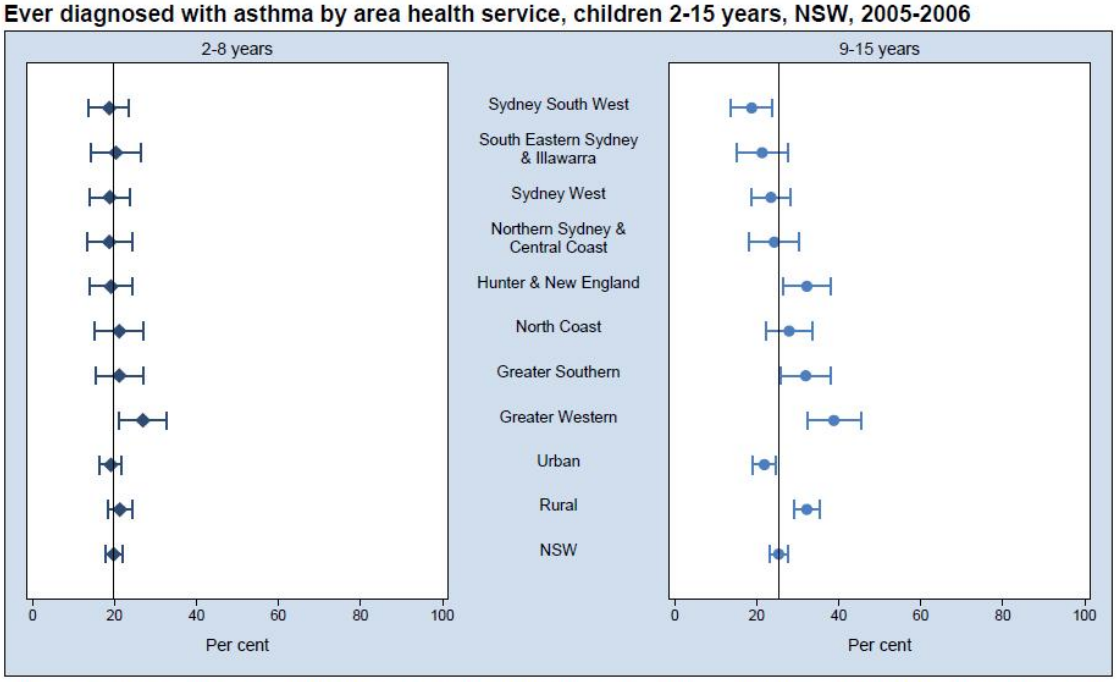
Appendix A Summary of existing asthma health statistics

A1 Asthma in children

The following graphs are reproduced from the NSW Population Health Survey, 2006 – 2006 Report on child health published by NSW Health (2008).

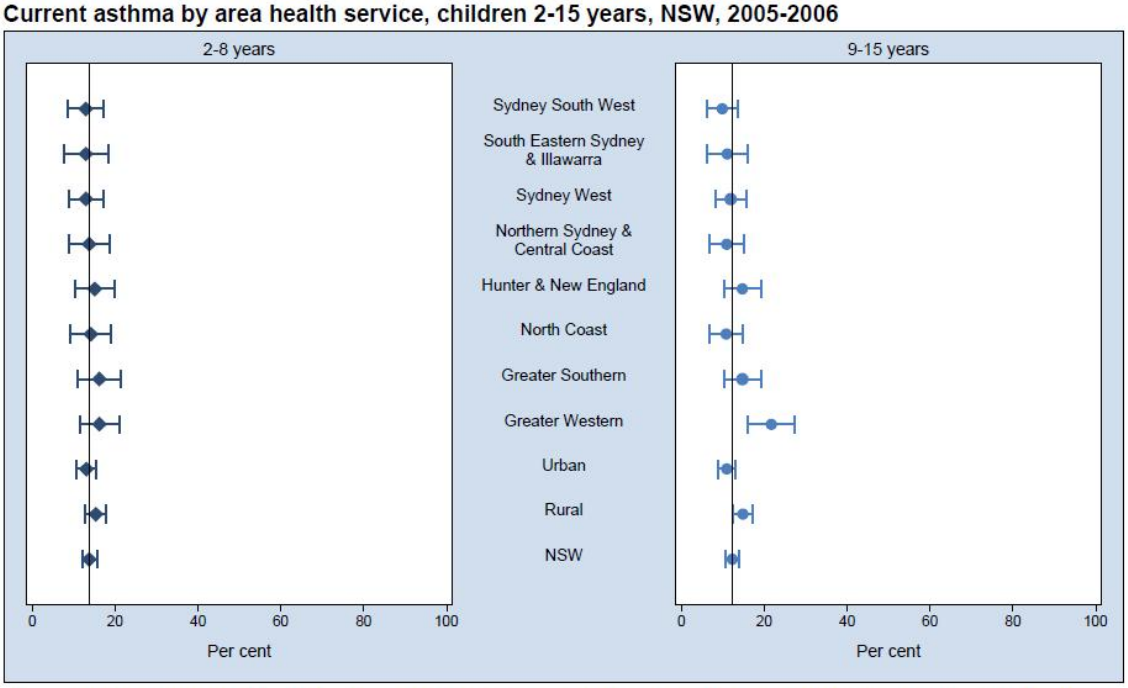
Ever diagnosed with asthma by area health service, children 2-15 years, NSW, 2005-2006



Note: Estimates are based on 3,938 respondents in NSW. For this indicator 11 (0.28%) were not stated (Don't know or Refused) in NSW. The indicator includes those children who have ever been told by a doctor or hospital that they have asthma. The question used to define the indicator was: Has child ever been told by a doctor or hospital heor she has asthma?

Source: New South Wales Population Health Survey 2006 (HOIST). Centre for Epidemiology and Research, NSW Department of Health.

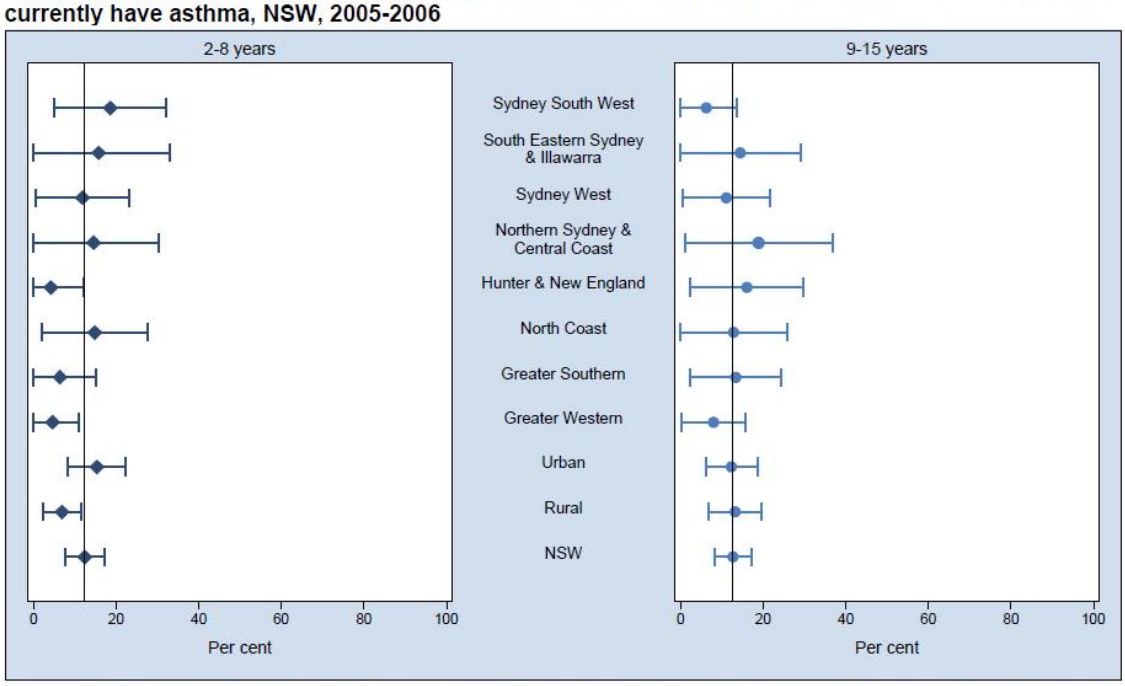
Current asthma by area health service, children 2-15 years, NSW, 2005-2006



Note: Estimates are based on 3,937 respondents in NSW. For this indicator 12 (0.30%) were not stated (Don't know or Refused) in NSW. The indicator includes those children with symptoms of asthma or who had treatment for asthma in the last 12 months. The questions used to define the indicator were: Has child ever been told by a doctor or hospital he or she has asthma? Has child had symptoms of asthma or treatment for asthma in the last 12 months?

Source: New South Wales Population Health Survey 2006 (HOIST). Centre for Epidemiology and Research, NSW Department of Health.

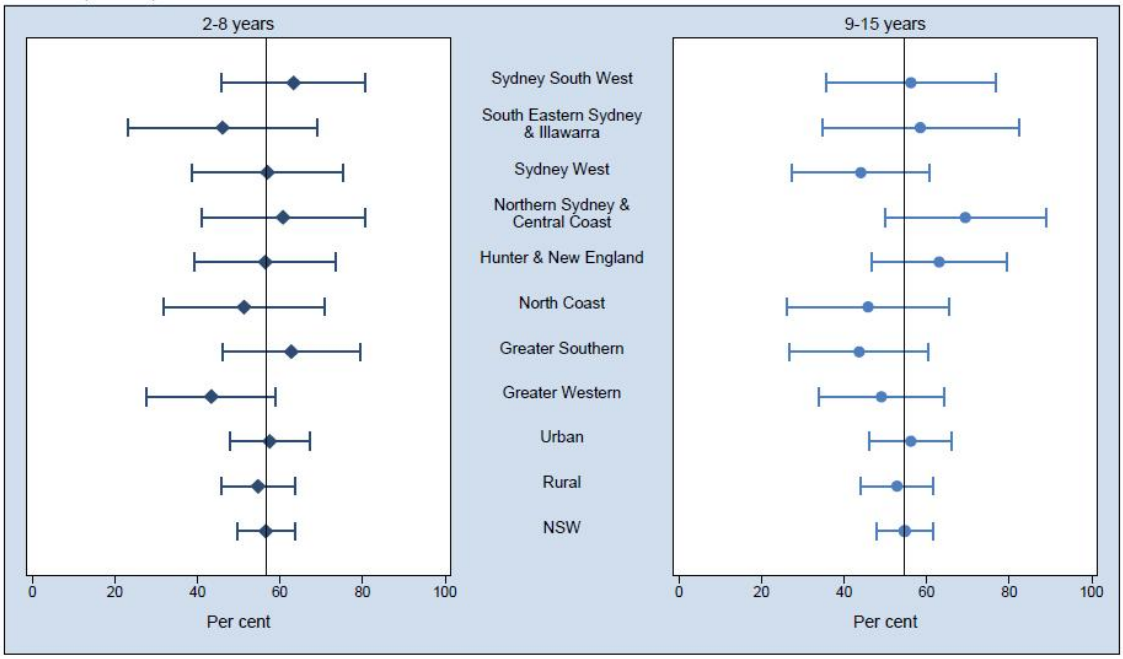
Moderate to extreme interference with daily activities by area health service, children 2-15 years who currently have asthma, NSW, 2005-2006



Note: Estimates are based on 536 respondents in NSW. For this indicator 3 (0.56%) were not stated (Don't know or Refused) in NSW. The indicator includes those children whose asthma interfered with their ability to manage day-to-day activities moderately, quite a lot, or extremely in the last 4 weeks. The questions used to define the indicator were: Have you ever been told by a doctor or hospital you have asthma? Have you had symptoms of asthma or taken treatment for asthma in the last 12 months? During the last 4 weeks, did your asthma interfere with your ability to manage your day to day activities? and Did it interfere with these activities: A little bit, Moderately, Quite a lot, or Extremely?

Source: New South Wales Population Health Survey 2006 (HOIST). Centre for Epidemiology and Research, NSW Department of Health.

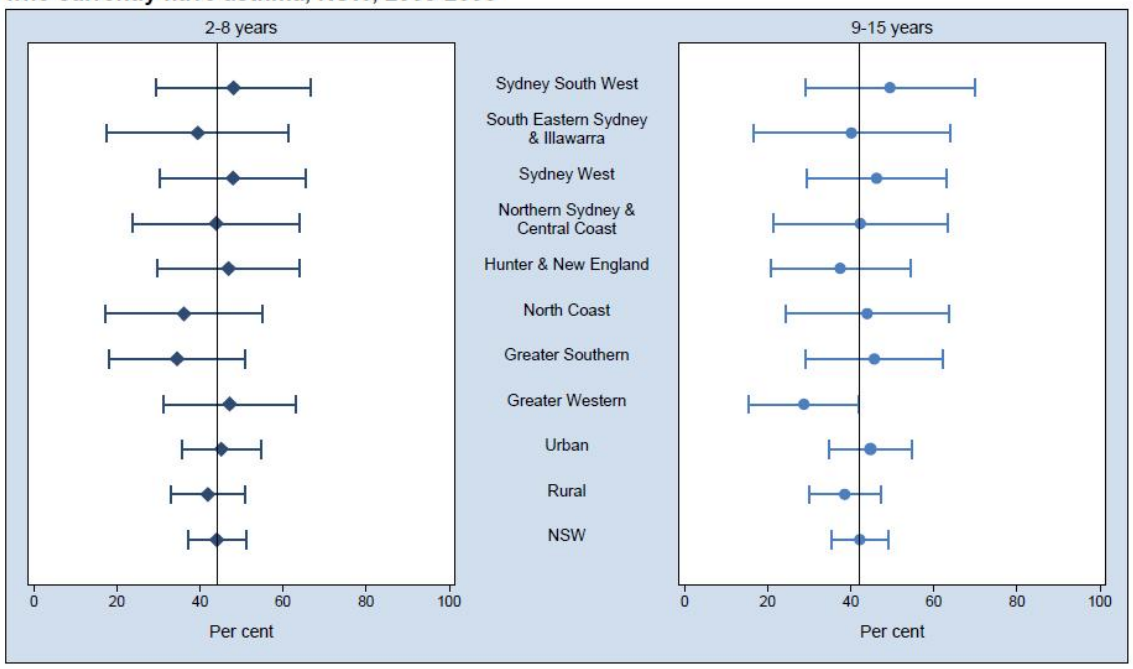
Written asthma management plan by area health service, children 2-15 years who currently have asthma, NSW, 2005-2006



Note: Estimates are based on 536 respondents in NSW. For this indicator 3 (0.56%) were not stated (Don't know or Refused) in NSW. The indicator includes those who have current asthma and who have a written asthma management plan. The questions used to define the indicator were: Has child ever been told by a doctor that he or she has asthma? Does child currently have asthma? Does child have a written asthma management plan from his or her doctor on how to treat their asthma?

Source: New South Wales Population Health Survey 2006 (HOIST). Centre for Epidemiology and Research, NSW Department of Health.

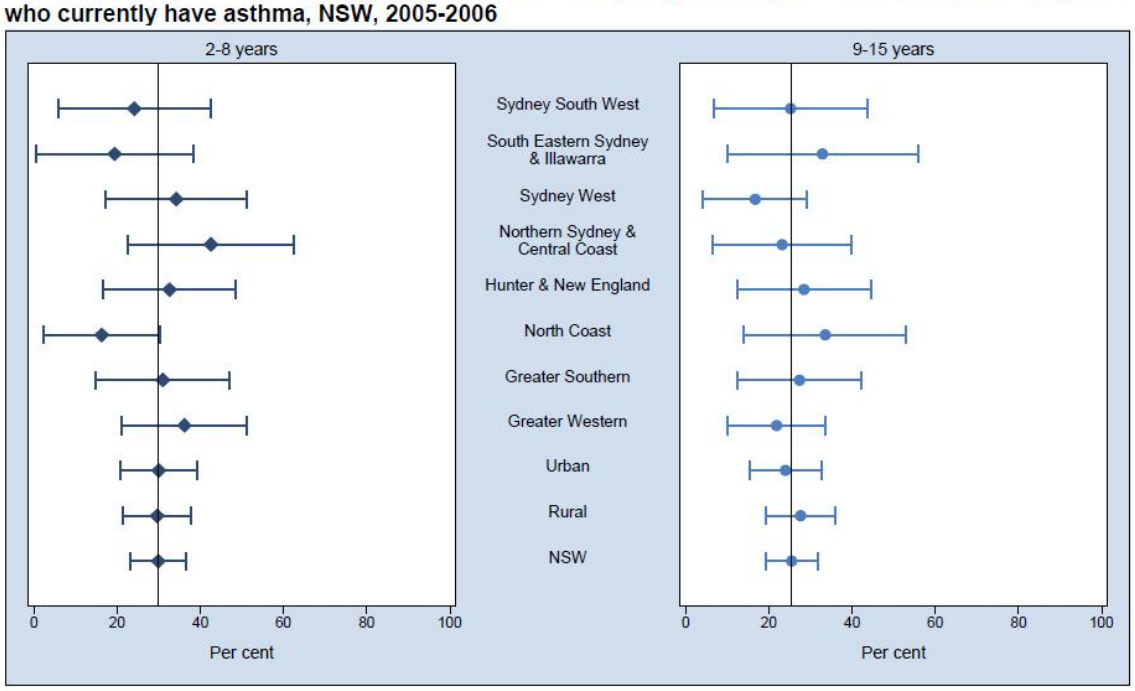
Asthma reliever medications used in the last 12 months by area health service, children 2-15 years who currently have asthma, NSW, 2005-2006



Note: Estimates are based on 544 respondents in NSW. For this indicator 12 (2.16%) were not stated (Don't know or Refused) in NSW. The indicator includes those who have used reliever medication for asthma in the last 12 months. The questions used to define the indicator were: Has child ever been told by a doctor or hospital he or she has asthma? Has child had symptoms of asthma or treatment for asthma in the last 12 months? What are the names or brands of all the medications child took for asthma in the last 12 months? Reliever medications include short-acting beta-agonists (Salbutamol, Ventolin, Asmol, Bricanyl, short-acting anti-cholinergics (Atrovent), combined inhaled steroid and long-acting beta agonists (Seretide and Symbicort), and long acting beta agonists (Symbicort and Seretide).

Source: New South Wales Population Health Survey 2006 (HOIST). Centre for Epidemiology and Research, NSW Department of Health.

Asthma preventer medications used in the last 12 months by area health service, children 2-15 years who currently have asthma, NSW, 2005-2006



Note: Estimates are based on 544 respondents in NSW. For this indicator 12 (2.16%) were not stated (Don't know or Refused) in NSW. The indicator includes those who have used preventer medication for asthma in the last 12 months. The questions used to define the indicator were: Has child ever been told by a doctor or hospital he or she has asthma? Has child had symptoms of asthma or treatment for asthma in the last 12 months? What are the names or brands of all the medications child took for asthma in the last 12 months? Preventer medications include combined inhaled steroids and long acting beta agonists (Seretide and Symbicort), inhaled corticosteroids (Pulmicort, Flixotide, Qvar; and Alvesco), leukotriene receptor antagonists (Singulair and Accolate), oral steroids (Prednisone), and cromones (Intal, Intal Forte, and Tilade).

Source: New South Wales Population Health Survey 2006 (HOIST). Centre for Epidemiology and Research, NSW Department of Health.

Appendix B $PM_{2.5}$ and PM_{10} risk calculations for primary and secondary health indicators

Quantification of Effects - PM2.5 and PM10
Southern Rail Access - Phase A

Particulate Fraction:	**PM2.5**	**PM2.5**	**PM2.5**	**PM10**	**PM2.5**	**PM2.5**	**PM2.5**	**PM2.5**	**Incremental Risk -DPM**
Endpoint:	**Mortality - All Causes**	**Hospitalisations - Cardiovascular**	**Hospitalisations - Respiratory**	**Mortality - All Causes**	**Mortality - All Causes**	**Mortality - Cardiopulmonary**	**Mortality - Cardiovascular**	**Mortality - Respiratory**	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		Increase in Annual Average PM10 Concentration (µg/m³)	Increase in Annual Average PM2.5 Concentration (µg/m³)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk
Maximum Receptor												
Boundary location	**Commercial/Industrial**	1.3574	0.2616	**3.6E-06**	**1.1E-05**	**2.1E-06**	**1.2E-06**	**3.6E-07**	**3.7E-06**	**9.2E-08**	**6.2E-08**	**2.0E-06**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.0639	0.0119	7.5E-07	2.2E-06	4.3E-07	2.6E-07	7.5E-08	7.6E-07	1.9E-08	1.3E-08	4.1E-07
Corryton Ct	Residential	0.0740	0.0139	8.7E-07	2.6E-06	5.0E-07	3.0E-07	8.7E-08	8.8E-07	2.2E-08	1.5E-08	4.7E-07
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.0719	0.0135	8.5E-07	2.5E-06	4.9E-07	2.9E-07	8.5E-08	8.6E-07	2.2E-08	1.5E-08	4.6E-07
Anzac Road (Receptor 2 in Simta report)	Residential	0.0777	0.0159	1.0E-06	3.0E-06	5.7E-07	3.1E-07	1.0E-07	1.0E-06	2.5E-08	1.7E-08	5.4E-07
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.0777	0.0159	2.2E-07	6.5E-07	1.3E-07	6.9E-08	2.2E-08	2.2E-07	5.6E-09	3.8E-09	1.2E-07
Yallum Cres (Receptor 1 in Simta report)	Residential	0.0733	0.0138	8.7E-07	2.6E-06	5.0E-07	2.9E-07	8.7E-08	8.8E-07	2.2E-08	1.5E-08	4.7E-07
Wattle Grove Public School	Residential/School	0.0603	0.0113	7.1E-07	2.1E-06	4.1E-07	2.4E-07	7.1E-08	7.2E-07	1.8E-08	1.2E-08	3.8E-07
St Marks Coptic College	Residential/School	0.0446	0.0084	5.3E-07	1.6E-06	3.0E-07	1.8E-07	5.3E-08	5.3E-07	1.3E-08	9.1E-09	2.8E-07
Anzac Creek Park	Residential	0.0440	0.0086	5.4E-07	1.6E-06	3.1E-07	1.8E-07	5.4E-08	5.5E-07	1.4E-08	9.4E-09	2.9E-07
Anzac Creek Park	Recreational	0.0440	0.0086	2.6E-08	7.6E-08	1.5E-08	8.3E-09	2.6E-09	2.6E-08	6.5E-10	4.4E-10	1.4E-08
Moorebank Ave	Commercial/Industrial	0.8617	0.1842	2.6E-06	7.6E-06	1.5E-06	7.6E-07	2.6E-07	2.6E-06	6.4E-08	4.4E-08	1.4E-06
DNSDC proposed relocation	Commercial/Industrial	0.0822	0.0158	2.2E-07	6.5E-07	1.3E-07	7.3E-08	2.2E-08	2.2E-07	5.5E-09	3.8E-09	1.2E-07
Average Residential		**0.0615**	**0.0118**	**7.4E-07**	**2.2E-06**	**4.3E-07**	**2.5E-07**	**7.4E-08**	**7.5E-07**	**1.9E-08**	**1.3E-08**	**4.0E-07**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.0246	0.0055	3.4E-07	1.0E-06	2.0E-07	9.9E-08	3.4E-08	3.5E-07	8.7E-09	5.9E-09	1.9E-07
Anzac Road (Receptor 2 in Simta report)	Residential	0.0777	0.0159	1.0E-06	3.0E-06	5.7E-07	3.1E-07	1.0E-07	1.0E-06	2.5E-08	1.7E-08	5.4E-07
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.0777	0.0159	2.2E-07	6.5E-07	1.3E-07	6.9E-08	2.2E-08	2.2E-07	5.6E-09	3.8E-09	1.2E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.0440	0.0086	5.4E-07	1.6E-06	3.1E-07	1.8E-07	5.4E-08	5.5E-07	1.4E-08	9.4E-09	2.9E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.0440	0.0086	2.6E-08	7.6E-08	1.5E-08	8.3E-09	2.6E-09	2.6E-08	6.5E-10	4.4E-10	1.4E-08
Average Residential		**0.0475**	**0.0097**	**6.1E-07**	**1.8E-06**	**3.5E-07**	**1.9E-07**	**6.1E-08**	**6.2E-07**	**1.5E-08**	**1.0E-08**	**3.3E-07**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.0169	0.0035	2.2E-07	6.6E-07	1.3E-07	6.8E-08	2.2E-08	2.3E-07	5.6E-09	3.8E-09	1.2E-07
Liverpool West Public School	Residential/School	0.0129	0.0026	1.6E-07	4.9E-07	9.4E-08	5.2E-08	1.6E-08	1.7E-07	4.1E-09	2.8E-09	8.9E-08
Liverpool Public School	Residential/School	0.0108	0.0022	1.4E-07	4.1E-07	8.0E-08	4.3E-08	1.4E-08	1.4E-07	3.5E-09	2.4E-09	7.5E-08
Average Residential		**0.0135**	**0.0028**	**1.8E-07**	**5.2E-07**	**1.0E-07**	**5.4E-08**	**1.8E-08**	**1.8E-07**	**4.4E-09**	**3.0E-09**	**9.5E-08**
Lurnea												
Lurnea High School	Residential/School	0.0219	0.0042	2.7E-07	7.9E-07	1.5E-07	8.8E-08	2.7E-08	2.7E-07	6.7E-09	4.6E-09	1.4E-07
St Francis Xavier Primary School Lurnea	Residential/School	0.0166	0.0033	2.1E-07	6.1E-07	1.2E-07	6.7E-08	2.1E-08	2.1E-07	5.2E-09	3.6E-09	1.1E-07
Average Residential		**0.0192**	**0.0038**	**2.4E-07**	**7.0E-07**	**1.4E-07**	**7.7E-08**	**2.4E-08**	**2.4E-07**	**6.0E-09**	**4.1E-09**	**1.3E-07**
Casula												
Lakewood Crescent	Residential	0.0481	0.0104	6.6E-07	2.0E-06	3.8E-07	1.9E-07	6.6E-08	6.7E-07	1.7E-08	1.1E-08	3.5E-07
St Andrews Boulevard	Residential	0.0709	0.0145	9.2E-07	2.7E-06	5.2E-07	2.9E-07	9.2E-08	9.3E-07	2.3E-08	1.6E-08	4.9E-07
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.1053	0.0205	1.3E-06	3.8E-06	7.4E-07	4.2E-07	1.3E-07	1.3E-06	3.3E-08	2.2E-08	7.0E-07
Dunmore Cres	Residential	0.1120	0.0212	1.3E-06	4.0E-06	7.6E-07	4.5E-07	1.3E-07	1.3E-06	3.4E-08	2.3E-08	7.2E-07
Leacocks Lane	Residential	0.0517	0.0097	6.1E-07	1.8E-06	3.5E-07	2.1E-07	6.1E-08	6.2E-07	1.6E-08	1.1E-08	3.3E-07
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.0669	0.0125	7.9E-07	2.3E-06	4.5E-07	2.7E-07	7.9E-08	8.0E-07	2.0E-08	1.4E-08	4.3E-07
Slessor Road	Residential	0.0416	0.0078	4.9E-07	1.5E-06	2.8E-07	1.7E-07	4.9E-08	5.0E-07	1.2E-08	8.5E-09	2.7E-07
Maple Grove Retirement Village	Residential	0.0250	0.0048	3.0E-07	8.9E-07	1.7E-07	1.0E-07	3.0E-08	3.0E-07	7.6E-09	5.2E-09	1.6E-07
All Saints Catholic Senior College	Residential/School	0.0679	0.0127	8.0E-07	2.4E-06	4.6E-07	2.7E-07	8.0E-08	8.1E-07	2.0E-08	1.4E-08	4.3E-07
Casula High School	Residential/School	0.0235	0.0045	2.8E-07	8.4E-07	1.6E-07	9.5E-08	2.8E-08	2.9E-07	7.1E-09	4.9E-09	1.5E-07
Casula Public School	Residential/School	0.0520	0.0101	6.4E-07	1.9E-06	3.7E-07	2.1E-07	6.4E-08	6.4E-07	1.6E-08	1.1E-08	3.4E-07
Casula Powerhouse Arts Centre	Recreational	0.1333	0.0251	7.4E-08	2.2E-07	4.3E-08	4.7E-09	7.4E-09	7.5E-08	1.9E-09	1.3E-09	4.0E-08
Average Residential		**0.0665**	**0.0128**	**8.1E-07**	**2.4E-06**	**4.6E-07**	**2.7E-07**	**8.1E-08**	**8.2E-07**	**2.0E-08**	**1.4E-08**	**4.4E-07**
Glenfield												
Canterbury Road	Residential	0.0243	0.0046	2.9E-07	8.6E-07	1.7E-07	9.8E-08	2.9E-08	2.9E-07	7.3E-09	5.0E-09	1.6E-07
Ferguson Street	Residential	0.0284	0.0054	3.4E-07	1.0E-06	1.9E-07	1.1E-07	3.4E-08	3.4E-07	8.5E-09	5.8E-09	1.8E-07
Good enough St (Receptor 4 in Simta Report)	Residential	0.0369	0.0069	4.4E-07	1.3E-06	2.5E-07	1.5E-07	4.4E-08	4.4E-07	1.1E-08	7.5E-09	2.4E-07
Cambridge Avenue	Residential	0.0355	0.0067	4.2E-07	1.2E-06	2.4E-07	1.4E-07	4.2E-08	4.2E-07	1.1E-08	7.2E-09	2.3E-07
Glenwood Public School	Residential/School	0.0168	0.0032	2.0E-07	6.0E-07	1.2E-07	6.7E-08	2.0E-08	2.0E-07	5.1E-09	3.5E-09	1.1E-07
Glenfield Public School	Residential/School	0.0167	0.0032	2.0E-07	6.0E-07	1.2E-07	6.7E-08	2.0E-08	2.0E-07	5.1E-09	3.5E-09	1.1E-07
Hurlstone Agricultural High School	Residential/School	0.0151	0.0029	1.8E-07	5.4E-07	1.0E-07	6.1E-08	1.8E-08	1.8E-07	4.6E-09	3.1E-09	9.8E-08
Glenfield new land release	Residential	0.0293	0.0055	3.5E-07	1.0E-06	2.0E-07	1.2E-07	3.5E-08	3.5E-07	8.8E-09	6.0E-09	1.9E-07
Playground Learning Centre, Chesham Parade	Residential	0.0180	0.0034	2.2E-07	6.4E-07	1.2E-07	7.2E-08	2.2E-08	2.2E-07	5.4E-09	3.7E-09	1.2E-07
Average Residential		**0.0246**	**0.0046**	**2.9E-07**	**8.7E-07**	**1.7E-07**	**9.9E-08**	**2.9E-08**	**3.0E-07**	**7.4E-09**	**5.0E-09**	**1.6E-07**
Macquarie Fields												
Hickory Place	Residential	0.0095	0.0018	1.2E-07	3.4E-07	6.6E-08	3.8E-08	1.2E-08	1.2E-07	2.9E-09	2.0E-09	6.2E-08
Maximum residential receptors		**0.1120**	**0.0212**	**1.3E-06**	**4.0E-06**	**7.6E-07**	**4.5E-07**	**1.3E-07**	**1.3E-06**	**3.4E-08**	**2.3E-08**	**7.2E-07**
Maximum school receptors		**0.0679**	**0.0127**	**8.0E-07**	**2.4E-06**	**4.6E-07**	**2.7E-07**	**8.0E-08**	**8.1E-07**	**2.0E-08**	**1.4E-08**	**4.3E-07**
Maximum recreational receptors		**0.1333**	**0.0251**	**7.4E-08**	**2.2E-07**	**4.3E-08**	**8.3E-09**	**7.4E-09**	**7.5E-08**	**1.9E-09**	**1.3E-09**	**4.0E-08**
Maximum commercial/industrial receptors		**1.3574**	**0.2616**	**3.6E-06**	**1.1E-05**	**2.1E-06**	**1.2E-06**	**3.6E-07**	**3.7E-06**	**9.2E-08**	**6.2E-08**	**2.0E-06**

Quantification of Effects - PM2.5 and PM10
Southern Rail Access - Phase B

Particulate Fraction:	PM2.5	PM2.5	PM2.5	PM10	PM2.5	PM2.5	PM2.5	PM2.5	Incremental Risk -DPM
Endpoint:	Mortality - All Causes	Hospitalisations - Cardiovascular	Hospitalisations - Respiratory	Mortality - All Causes	Mortality - All Causes	Mortality - Cardiopulmonary	Mortality - Cardiovascular	Mortality - Respiratory	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		Increase in Annual Average PM10 Concentration (µg/m³)	Increase in Annual Average PM2.5 Concentration (µg/m³)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk
Maximum Receptor												
Boundary location	**Commercial/Industrial**	1.2067	0.7980	**1.1E-05**	**3.3E-05**	**6.3E-06**	**1.1E-06**	**1.1E-06**	**1.1E-05**	**2.8E-07**	**1.9E-07**	**6.0E-06**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.0669	0.0341	2.2E-06	6.4E-06	1.2E-06	2.7E-07	2.1E-07	2.2E-06	5.4E-08	3.7E-08	1.2E-06
Corryton Ct	Residential	0.0781	0.0415	2.6E-06	7.7E-06	1.5E-06	3.1E-07	2.6E-07	2.6E-06	6.6E-08	4.5E-08	1.4E-06
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.0767	0.0424	2.7E-06	7.9E-06	1.5E-06	3.1E-07	2.7E-07	2.7E-06	6.7E-08	4.6E-08	1.4E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.1033	0.0623	3.9E-06	1.2E-05	2.2E-06	4.2E-07	3.9E-07	4.0E-06	9.9E-08	6.7E-08	2.1E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1033	0.0623	8.6E-07	2.6E-06	4.9E-07	9.1E-08	8.6E-08	8.7E-07	2.2E-08	1.5E-08	4.7E-07
Yallum Cres (Receptor 1 in Simta report)	Residential	0.0822	0.0414	2.6E-06	7.7E-06	1.5E-06	3.3E-07	2.6E-07	2.6E-06	6.6E-08	4.5E-08	1.4E-06
Wattle Grove Public School	Residential/School	0.0632	0.0330	2.1E-06	6.2E-06	1.2E-06	2.5E-07	2.1E-07	2.1E-06	5.3E-08	3.6E-08	1.1E-06
St Marks Coptic College	Residential/School	0.0451	0.0238	1.5E-06	4.4E-06	8.6E-07	1.8E-07	1.5E-07	1.5E-06	3.8E-08	2.6E-08	8.1E-07
Anzac Creek Park	Residential	0.0535	0.0309	1.9E-06	5.8E-06	1.1E-06	2.1E-07	1.9E-07	2.0E-06	4.9E-08	3.3E-08	1.1E-06
Anzac Creek Park	Recreational	0.0535	0.0309	9.2E-08	2.7E-07	5.2E-08	1.0E-08	9.2E-09	9.3E-08	2.3E-09	1.6E-09	4.9E-08
Moorebank Ave	Commercial/Industrial	0.7780	0.6180	8.6E-06	2.5E-05	4.9E-06	6.9E-07	8.6E-07	8.7E-06	2.2E-07	1.5E-07	4.6E-06
DNSDC proposed relocation	Commercial/Industrial	0.0917	0.0555	7.7E-07	2.3E-06	4.4E-07	8.1E-08	7.7E-08	7.8E-07	1.9E-08	1.3E-08	4.2E-07
Average Residential		**0.0692**	**0.0378**	**2.4E-06**	**7.1E-06**	**1.4E-06**	**2.8E-07**	**2.4E-07**	**2.4E-06**	**6.0E-08**	**4.1E-08**	**1.3E-06**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.0423	0.0248	1.6E-06	4.6E-06	9.0E-07	1.7E-07	1.6E-07	1.6E-06	4.0E-08	2.7E-08	8.4E-07
Anzac Road (Receptor 2 in Simta report)	Residential	0.1033	0.0623	3.9E-06	1.2E-05	2.2E-06	4.2E-07	3.9E-07	4.0E-06	9.9E-08	6.7E-08	2.1E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1033	0.0623	8.6E-07	2.6E-06	4.9E-07	9.1E-08	8.6E-08	8.7E-07	2.2E-08	1.5E-08	4.7E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.0535	0.0309	1.9E-06	5.8E-06	1.1E-06	2.1E-07	1.9E-07	2.0E-06	4.9E-08	3.3E-08	1.1E-06
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.0535	0.0309	9.2E-08	2.7E-07	5.2E-08	1.0E-08	9.2E-09	9.3E-08	2.3E-09	1.6E-09	4.9E-08
Average Residential		**0.0631**	**0.0372**	**2.3E-06**	**7.0E-06**	**1.3E-06**	**2.5E-07**	**2.3E-07**	**2.4E-06**	**5.9E-08**	**4.0E-08**	**1.3E-06**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.0267	0.0162	1.0E-06	3.0E-06	5.9E-07	1.1E-07	1.0E-07	1.0E-06	2.6E-08	1.8E-08	5.5E-07
Liverpool West Public School	Residential/School	0.0184	0.0109	6.9E-07	2.0E-06	3.9E-07	7.4E-08	6.8E-08	6.9E-07	1.7E-08	1.2E-08	3.7E-07
Liverpool Public School	Residential/School	0.0160	0.0097	6.1E-07	1.8E-06	3.5E-07	6.4E-08	6.1E-08	6.2E-07	1.5E-08	1.1E-08	3.3E-07
Average Residential		**0.0203**	**0.0123**	**7.7E-07**	**2.3E-06**	**4.4E-07**	**8.2E-08**	**7.7E-08**	**7.8E-07**	**2.0E-08**	**1.3E-08**	**4.2E-07**
Lurnea												
Lurnea High School	Residential/School	0.0261	0.0138	8.7E-07	2.6E-06	5.0E-07	1.0E-07	8.7E-08	8.8E-07	2.2E-08	1.5E-08	4.7E-07
St Francis Xavier Primary School Lurnea	Residential/School	0.0217	0.0125	7.9E-07	2.3E-06	4.5E-07	8.7E-08	7.9E-08	8.0E-07	2.0E-08	1.4E-08	4.3E-07
Average Residential		**0.0239**	**0.0131**	**8.3E-07**	**2.5E-06**	**4.7E-07**	**9.6E-08**	**8.3E-08**	**8.4E-07**	**2.1E-08**	**1.4E-08**	**4.5E-07**
Casula												
Lakewood Crescent	Residential	0.0921	0.0513	3.2E-06	9.6E-06	1.9E-06	3.7E-07	3.2E-07	3.3E-06	8.2E-08	5.6E-08	1.7E-06
St Andrews Boulevard	Residential	0.1145	0.0685	4.3E-06	1.3E-05	2.5E-06	4.6E-07	4.3E-07	4.4E-06	1.1E-07	7.4E-08	2.3E-06
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.1533	0.0931	5.9E-06	1.7E-05	3.4E-06	6.2E-07	5.9E-07	5.9E-06	1.5E-07	1.0E-07	3.2E-06
Dunmore Cres	Residential	0.1584	0.0900	5.7E-06	1.7E-05	3.2E-06	6.4E-07	5.7E-07	5.7E-06	1.4E-07	9.7E-08	3.1E-06
Leacocks Lane	Residential	0.0546	0.0265	1.7E-06	4.9E-06	9.6E-07	2.2E-07	1.7E-07	1.7E-06	4.2E-08	2.9E-08	9.0E-07
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.0741	0.0372	2.3E-06	6.9E-06	1.3E-06	3.0E-07	2.3E-07	2.4E-06	5.9E-08	4.0E-08	1.3E-06
Slessor Road	Residential	0.0462	0.0268	1.7E-06	5.0E-06	9.7E-07	1.9E-07	1.7E-07	1.7E-06	4.3E-08	2.9E-08	9.1E-07
Maple Grove Retirement Village	Residential	0.0272	0.0143	9.0E-07	2.7E-06	5.2E-07	1.1E-07	9.0E-08	9.1E-07	2.3E-08	1.5E-08	4.9E-07
All Saints Catholic Senior College	Residential/School	0.0747	0.0367	2.3E-06	6.9E-06	1.3E-06	3.0E-07	2.3E-07	2.3E-06	5.8E-08	4.0E-08	1.2E-06
Casula High School	Residential/School	0.0257	0.0132	8.3E-07	2.5E-06	4.8E-07	1.0E-07	8.3E-08	8.4E-07	2.1E-08	1.4E-08	4.5E-07
Casula Public School	Residential/School	0.0680	0.0380	2.4E-06	7.1E-06	1.4E-06	2.7E-07	2.4E-07	2.4E-06	6.0E-08	4.1E-08	1.3E-06
Casula Powerhouse Arts Centre	Recreational	0.2037	0.1185	3.5E-07	1.0E-06	2.0E-07	2.2E-08	3.5E-08	3.5E-07	8.9E-09	6.0E-09	1.9E-07
Average Residential		**0.0911**	**0.0512**	**3.2E-06**	**9.6E-06**	**1.8E-06**	**3.7E-07**	**3.2E-07**	**3.3E-06**	**8.1E-08**	**5.5E-08**	**1.7E-06**
Glenfield												
Canterbury Road	Residential	0.0244	0.0144	9.1E-07	2.7E-06	5.2E-07	9.8E-08	9.1E-08	9.2E-07	2.3E-08	1.6E-08	4.9E-07
Ferguson Street	Residential	0.0271	0.0161	1.0E-06	3.0E-06	5.8E-07	1.1E-07	1.0E-07	1.0E-06	2.6E-08	1.7E-08	5.5E-07
Good enough St (Receptor 4 in Simta Report)	Residential	0.0351	0.0213	1.3E-06	4.0E-06	7.7E-07	1.4E-07	1.3E-07	1.4E-06	3.4E-08	2.3E-08	7.2E-07
Cambridge Avenue	Residential	0.0331	0.0196	1.2E-06	3.7E-06	7.1E-07	1.3E-07	1.2E-07	1.2E-06	3.1E-08	2.1E-08	6.6E-07
Glenwood Public School	Residential/School	0.0172	0.0097	6.1E-07	1.8E-06	3.5E-07	6.9E-08	6.1E-08	6.2E-07	1.5E-08	1.1E-08	3.3E-07
Glenfield Public School	Residential/School	0.0176	0.0104	6.5E-07	1.9E-06	3.7E-07	7.1E-08	6.5E-08	6.6E-07	1.6E-08	1.1E-08	3.5E-07
Hurlstone Agricultural High School	Residential/School	0.0157	0.0090	5.7E-07	1.7E-06	3.3E-07	6.3E-08	5.7E-08	5.7E-07	1.4E-08	9.8E-09	3.1E-07
Glenfield new land release	Residential	0.0311	0.0182	1.1E-06	3.4E-06	6.6E-07	1.3E-07	1.1E-07	1.2E-06	2.9E-08	2.0E-08	6.2E-07
Playground Learning Centre, Chesham Parade	Residential	0.0183	0.0108	6.8E-07	2.0E-06	3.9E-07	7.4E-08	6.8E-08	6.9E-07	1.7E-08	1.2E-08	3.7E-07
Average Residential		**0.0244**	**0.0144**	**9.1E-07**	**2.7E-06**	**5.2E-07**	**9.8E-08**	**9.1E-08**	**9.2E-07**	**2.3E-08**	**1.6E-08**	**4.9E-07**
Macquarie Fields												
Hickory Place	Residential	0.0098	0.0053	3.4E-07	1.0E-06	1.9E-07	3.9E-08	3.4E-08	3.4E-07	8.5E-09	5.8E-09	1.8E-07
Maximum residential receptors		**0.1584**	**0.0931**	**5.9E-06**	**1.7E-05**	**3.4E-06**	**6.4E-07**	**5.9E-07**	**5.9E-06**	**1.5E-07**	**1.0E-07**	**3.2E-06**
Maximum school receptors		**0.0747**	**0.0380**	**2.4E-06**	**7.1E-06**	**1.4E-06**	**3.0E-07**	**2.4E-07**	**2.4E-06**	**6.0E-08**	**4.1E-08**	**1.3E-06**
Maximum recreational receptors		**0.2037**	**0.1185**	**3.5E-07**	**1.0E-06**	**2.0E-07**	**2.2E-08**	**3.5E-08**	**3.5E-07**	**8.9E-09**	**6.0E-09**	**1.9E-07**
Maximum commercial/industrial receptors		**1.2067**	**0.7980**	**1.1E-05**	**3.3E-05**	**6.3E-06**	**1.1E-06**	**1.1E-06**	**1.1E-05**	**2.8E-07**	**1.9E-07**	**6.0E-06**

Quantification of Effects - PM2.5 and PM10
Southern Rail Access - Phase C

Particulate Fraction:	**PM2.5**	**PM2.5**	**PM2.5**	**PM10**	**PM2.5**	**PM2.5**	**PM2.5**	**PM2.5**	**Incremental Risk -DPM**
Endpoint:	**Mortality - All Causes**	**Hospitalisations - Cardiovascular**	**Hospitalisations - Respiratory**	**Mortality - All Causes**	**Mortality - All Causes**	**Mortality - Cardiopulmonary**	**Mortality - Cardiovascular**	**Mortality - Respiratory**	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		**Increase in Annual Average PM10 Concentration (µg/m³)**	**Increase in Annual Average PM2.5 Concentration (µg/m³)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk**
Maximum Receptor												
Boundary location	**Commercial/Industrial**	1.2775	1.1685	**1.6E-05**	**4.8E-05**	**9.3E-06**	**1.1E-06**	**1.6E-06**	**1.6E-05**	**4.1E-07**	**2.8E-07**	**8.7E-06**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.0989	0.0671	4.2E-06	1.3E-05	2.4E-06	4.0E-07	4.2E-07	4.3E-06	1.1E-07	7.3E-08	2.3E-06
Corryton Ct	Residential	0.1033	0.0755	4.8E-06	1.4E-05	2.7E-06	4.2E-07	4.8E-07	4.8E-06	1.2E-07	8.2E-08	2.6E-06
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.1003	0.0748	4.7E-06	1.4E-05	2.7E-06	4.0E-07	4.7E-07	4.8E-06	1.2E-07	8.1E-08	2.5E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.1377	0.1033	6.5E-06	1.9E-05	3.7E-06	5.5E-07	6.5E-07	6.6E-06	1.6E-07	1.1E-07	3.5E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1377	0.1033	1.4E-06	4.2E-06	8.2E-07	1.2E-07	1.4E-07	1.4E-06	3.6E-08	2.5E-08	7.7E-07
Yallum Cres (Receptor 1 in Simta report)	Residential	0.1123	0.0790	5.0E-06	1.5E-05	2.9E-06	4.5E-07	5.0E-07	5.0E-06	1.3E-07	8.6E-08	2.7E-06
Wattle Grove Public School	Residential/School	0.0844	0.0604	3.8E-06	1.1E-05	2.2E-06	3.4E-07	3.8E-07	3.8E-06	9.6E-08	6.5E-08	2.1E-06
St Marks Coptic College	Residential/School	0.0600	0.0424	2.7E-06	7.9E-06	1.5E-06	2.4E-07	2.7E-07	2.7E-06	6.7E-08	4.6E-08	1.4E-06
Anzac Creek Park	Residential	0.0702	0.0528	3.3E-06	9.9E-06	1.9E-06	2.8E-07	3.3E-07	3.4E-06	8.4E-08	5.7E-08	1.8E-06
Anzac Creek Park	Recreational	0.0702	0.0528	1.6E-07	4.6E-07	9.0E-08	1.3E-08	1.6E-08	1.6E-07	3.9E-09	2.7E-09	8.4E-08
Moorebank Ave	Commercial/Industrial	0.9802	0.8857	1.2E-05	3.6E-05	7.0E-06	8.7E-07	1.2E-06	1.2E-05	3.1E-07	2.1E-07	6.6E-06
DNSDC proposed relocation	Commercial/Industrial	0.1249	0.0957	1.3E-06	3.9E-06	7.6E-07	1.1E-07	1.3E-07	1.3E-06	3.3E-08	2.3E-08	7.2E-07
Average Residential		**0.0930**	**0.0676**	**4.3E-06**	**1.3E-05**	**2.4E-06**	**3.7E-07**	**4.3E-07**	**4.3E-06**	**1.1E-07**	**7.3E-08**	**2.3E-06**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.0543	0.0425	2.7E-06	7.9E-06	1.5E-06	2.2E-07	2.7E-07	2.7E-06	6.8E-08	4.6E-08	1.4E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.1377	0.1033	6.5E-06	1.9E-05	3.7E-06	5.5E-07	6.5E-07	6.6E-06	1.6E-07	1.1E-07	3.5E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1377	0.1033	1.4E-06	4.2E-06	8.2E-07	1.2E-07	1.4E-07	1.4E-06	3.6E-08	2.5E-08	7.7E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.0702	0.0528	3.3E-06	9.9E-06	1.9E-06	2.8E-07	3.3E-07	3.4E-06	8.4E-08	5.7E-08	1.8E-06
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.0702	0.0528	1.6E-07	4.6E-07	9.0E-08	1.3E-08	1.6E-08	1.6E-07	3.9E-09	2.7E-09	8.4E-08
Average Residential		**0.0831**	**0.0629**	**4.0E-06**	**1.2E-05**	**2.3E-06**	**3.3E-07**	**4.0E-07**	**4.0E-06**	**1.0E-07**	**6.8E-08**	**2.1E-06**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.0367	0.0289	1.8E-06	5.4E-06	1.0E-06	1.5E-07	1.8E-07	1.8E-06	4.6E-08	3.1E-08	9.8E-07
Liverpool West Public School	Residential/School	0.0254	0.0193	1.2E-06	3.6E-06	7.0E-07	1.0E-07	1.2E-07	1.2E-06	3.1E-08	2.1E-08	6.6E-07
Liverpool Public School	Residential/School	0.0224	0.0174	1.1E-06	3.3E-06	6.3E-07	9.0E-08	1.1E-07	1.1E-06	2.8E-08	1.9E-08	5.9E-07
Average Residential		**0.0282**	**0.0219**	**1.4E-06**	**4.1E-06**	**7.9E-07**	**1.1E-07**	**1.4E-07**	**1.4E-06**	**3.5E-08**	**2.4E-08**	**7.4E-07**
Lurnea												
Lurnea High School	Residential/School	0.0350	0.0244	1.5E-06	4.6E-06	8.8E-07	1.4E-07	1.5E-07	1.6E-06	3.9E-08	2.6E-08	8.3E-07
St Francis Xavier Primary School Lurnea	Residential/School	0.0298	0.0222	1.4E-06	4.2E-06	8.0E-07	1.2E-07	1.4E-07	1.4E-06	3.5E-08	2.4E-08	7.6E-07
Average Residential		**0.0324**	**0.0233**	**1.5E-06**	**4.4E-06**	**8.4E-07**	**1.3E-07**	**1.5E-07**	**1.5E-06**	**3.7E-08**	**2.5E-08**	**7.9E-07**
Casula												
Lakewood Crescent	Residential	0.1183	0.0876	5.5E-06	1.6E-05	3.2E-06	4.8E-07	5.5E-07	5.6E-06	1.4E-07	9.5E-08	3.0E-06
St Andrews Boulevard	Residential	0.1708	0.1210	7.6E-06	2.3E-05	4.4E-06	6.9E-07	7.6E-07	7.7E-06	1.9E-07	1.3E-07	4.1E-06
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.2311	0.1663	1.0E-05	3.1E-05	6.0E-06	9.3E-07	1.0E-06	1.1E-05	2.6E-07	1.8E-07	5.7E-06
Dunmore Cres	Residential	0.2190	0.1608	1.0E-05	3.0E-05	5.8E-06	8.8E-07	1.0E-06	1.0E-05	2.6E-07	1.7E-07	5.5E-06
Leacocks Lane	Residential	0.0729	0.0462	2.9E-06	8.6E-06	1.7E-06	2.9E-07	2.9E-07	2.9E-06	7.3E-08	5.0E-08	1.6E-06
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.1092	0.0677	4.3E-06	1.3E-05	2.4E-06	4.4E-07	4.3E-07	4.3E-06	1.1E-07	7.3E-08	2.3E-06
Slessor Road	Residential	0.0825	0.0539	3.4E-06	1.0E-05	1.9E-06	3.3E-07	3.4E-07	3.4E-06	8.6E-08	5.8E-08	1.8E-06
Maple Grove Retirement Village	Residential	0.0393	0.0258	1.6E-06	4.8E-06	9.3E-07	1.6E-07	1.6E-07	1.6E-06	4.1E-08	2.8E-08	8.8E-07
All Saints Catholic Senior College	Residential/School	0.1038	0.0653	4.1E-06	1.2E-05	2.4E-06	4.2E-07	4.1E-07	4.2E-06	1.0E-07	7.1E-08	2.2E-06
Casula High School	Residential/School	0.0356	0.0233	1.5E-06	4.4E-06	8.4E-07	1.4E-07	1.5E-07	1.5E-06	3.7E-08	2.5E-08	7.9E-07
Casula Public School	Residential/School	0.0919	0.0669	4.2E-06	1.2E-05	2.4E-06	3.7E-07	4.2E-07	4.3E-06	1.1E-07	7.2E-08	2.3E-06
Casula Powerhouse Arts Centre	Recreational	0.2891	0.2149	6.4E-07	1.9E-06	3.6E-07	4.1E-08	6.4E-08	6.4E-07	1.6E-08	1.1E-08	3.4E-07
Average Residential		**0.1303**	**0.0916**	**5.8E-06**	**1.7E-05**	**3.3E-06**	**5.2E-07**	**5.8E-07**	**5.8E-06**	**1.5E-07**	**9.9E-08**	**3.1E-06**
Glenfield												
Canterbury Road	Residential	0.0429	0.0295	1.9E-06	5.5E-06	1.1E-06	1.7E-07	1.9E-07	1.9E-06	4.7E-08	3.2E-08	1.0E-06
Ferguson Street	Residential	0.0493	0.0335	2.1E-06	6.3E-06	1.2E-06	2.0E-07	2.1E-07	2.1E-06	5.3E-08	3.6E-08	1.1E-06
Good enough St (Receptor 4 in Simta Report)	Residential	0.0660	0.0450	2.8E-06	8.4E-06	1.6E-06	2.7E-07	2.8E-07	2.9E-06	7.2E-08	4.9E-08	1.5E-06
Cambridge Avenue	Residential	0.0616	0.0407	2.6E-06	7.6E-06	1.5E-06	2.5E-07	2.6E-07	2.6E-06	6.5E-08	4.4E-08	1.4E-06
Glenwood Public School	Residential/School	0.0283	0.0195	1.2E-06	3.6E-06	7.0E-07	1.1E-07	1.2E-07	1.2E-06	3.1E-08	2.1E-08	6.6E-07
Glenfield Public School	Residential/School	0.0297	0.0209	1.3E-06	3.9E-06	7.5E-07	1.2E-07	1.3E-07	1.3E-06	3.3E-08	2.3E-08	7.1E-07
Hurlstone Agricultural High School	Residential/School	0.0256	0.0178	1.1E-06	3.3E-06	6.4E-07	1.0E-07	1.1E-07	1.1E-06	2.8E-08	1.9E-08	6.0E-07
Glenfield new land release	Residential	0.0543	0.0367	2.3E-06	6.9E-06	1.3E-06	2.2E-07	2.3E-07	2.3E-06	5.8E-08	4.0E-08	1.2E-06
Playground Learning Centre, Chesham Parade	Residential	0.0314	0.0218	1.4E-06	4.1E-06	7.9E-07	1.3E-07	1.4E-07	1.4E-06	3.5E-08	2.4E-08	7.4E-07
Average Residential		**0.0432**	**0.0295**	**1.9E-06**	**5.5E-06**	**1.1E-06**	**1.7E-07**	**1.9E-07**	**1.9E-06**	**4.7E-08**	**3.2E-08**	**1.0E-06**
Macquarie Fields												
Hickory Place	Residential	0.0149	0.0102	6.5E-07	1.9E-06	3.7E-07	6.0E-08	6.4E-08	6.5E-07	1.6E-08	1.1E-08	3.5E-07
Maximum residential receptors		**0.2311**	**0.1663**	**1.0E-05**	**3.1E-05**	**6.0E-06**	**9.3E-07**	**1.0E-06**	**1.1E-05**	**2.6E-07**	**1.8E-07**	**5.7E-06**
Maximum school receptors		**0.1038**	**0.0669**	**4.2E-06**	**1.2E-05**	**2.4E-06**	**4.2E-07**	**4.2E-07**	**4.3E-06**	**1.1E-07**	**7.2E-08**	**2.3E-06**
Maximum recreational receptors		**0.2891**	**0.2149**	**6.4E-07**	**1.9E-06**	**3.6E-07**	**4.1E-08**	**6.4E-08**	**6.4E-07**	**1.6E-08**	**1.1E-08**	**3.4E-07**
Maximum commercial/industrial receptors		**1.2775**	**1.1685**	**1.6E-05**	**4.8E-05**	**9.3E-06**	**1.1E-06**	**1.6E-06**	**1.6E-05**	**4.1E-07**	**2.8E-07**	**8.7E-06**

Quantification of Effects - PM2.5 and PM10
Southern Rail Access - Phase D

Particulate Fraction:	**PM2.5**	**PM2.5**	**PM2.5**	**PM10**	**PM2.5**	**PM2.5**	**PM2.5**	**PM2.5**	**Incremental Risk -DPM**
Endpoint:	**Mortality - All Causes**	**Hospitalisations - Cardiovascular**	**Hospitalisations - Respiratory**	**Mortality - All Causes**	**Mortality - All Causes**	**Mortality - Cardiopulmonary**	**Mortality - Cardiovascular**	**Mortality - Respiratory**	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		**Increase in Annual Average PM10 Concentration (µg/m³)**	**Increase in Annual Average PM2.5 Concentration (µg/m³)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk**
Maximum Receptor												
Boundary location	**Commercial/Industrial**	1.1938	1.1691	**1.6E-05**	**4.8E-05**	**9.3E-06**	**1.1E-06**	**1.6E-06**	**1.6E-05**	**4.1E-07**	**2.8E-07**	**8.7E-06**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.0773	0.0759	4.8E-06	1.4E-05	2.7E-06	3.1E-07	4.8E-07	4.8E-06	1.2E-07	8.2E-08	2.6E-06
Corryton Ct	Residential	0.0873	0.0857	5.4E-06	1.6E-05	3.1E-06	3.5E-07	5.4E-07	5.5E-06	1.4E-07	9.3E-08	2.9E-06
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.0869	0.0852	5.4E-06	1.6E-05	3.1E-06	3.5E-07	5.4E-07	5.4E-06	1.4E-07	9.2E-08	2.9E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.1247	0.1223	7.7E-06	2.3E-05	4.4E-06	5.0E-07	7.7E-07	7.8E-06	1.9E-07	1.3E-07	4.2E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1247	0.1223	1.7E-06	5.0E-06	9.7E-07	1.1E-07	1.7E-07	1.7E-06	4.3E-08	2.9E-08	9.1E-07
Yallum Cres (Receptor 1 in Simta report)	Residential	0.0911	0.0894	5.6E-06	1.7E-05	3.2E-06	3.7E-07	5.6E-07	5.7E-06	1.4E-07	9.7E-08	3.0E-06
Wattle Grove Public School	Residential/School	0.0700	0.0687	4.3E-06	1.3E-05	2.5E-06	2.8E-07	4.3E-07	4.4E-06	1.1E-07	7.4E-08	2.3E-06
St Marks Coptic College	Residential/School	0.0493	0.0484	3.1E-06	9.0E-06	1.7E-06	2.0E-07	3.0E-07	3.1E-06	7.7E-08	5.2E-08	1.6E-06
Anzac Creek Park	Residential	0.0633	0.0621	3.9E-06	1.2E-05	2.2E-06	2.5E-07	3.9E-07	4.0E-06	9.9E-08	6.7E-08	2.1E-06
Anzac Creek Park	Recreational	0.0633	0.0621	1.8E-07	5.5E-07	1.1E-07	1.2E-08	1.8E-08	1.9E-07	4.6E-09	3.2E-09	9.9E-08
Moorebank Ave	Commercial/Industrial	0.9369	0.9179	1.3E-05	3.8E-05	7.3E-06	8.3E-07	1.3E-06	1.3E-05	3.2E-07	2.2E-07	6.9E-06
DNSDC proposed relocation	Commercial/Industrial	0.1119	0.1098	1.5E-06	4.5E-06	8.7E-07	9.9E-08	1.5E-07	1.5E-06	3.8E-08	2.6E-08	8.2E-07
Average Residential		**0.0792**	**0.0777**	**4.9E-06**	**1.5E-05**	**2.8E-06**	**3.2E-07**	**4.9E-07**	**5.0E-06**	**1.2E-07**	**8.4E-08**	**2.6E-06**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.0538	0.0527	3.3E-06	9.9E-06	1.9E-06	2.2E-07	3.3E-07	3.4E-06	8.4E-08	5.7E-08	1.8E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.1247	0.1223	7.7E-06	2.3E-05	4.4E-06	5.0E-07	7.7E-07	7.8E-06	1.9E-07	1.3E-07	4.2E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1247	0.1223	1.7E-06	5.0E-06	9.7E-07	1.1E-07	1.7E-07	1.7E-06	4.3E-08	2.9E-08	9.1E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.0633	0.0621	3.9E-06	1.2E-05	2.2E-06	2.5E-07	3.9E-07	4.0E-06	9.9E-08	6.7E-08	2.1E-06
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.0633	0.0621	1.8E-07	5.5E-07	1.1E-07	1.2E-08	1.8E-08	1.9E-07	4.6E-09	3.2E-09	9.9E-08
Average Residential		**0.0763**	**0.0748**	**4.7E-06**	**1.4E-05**	**2.7E-06**	**3.1E-07**	**4.7E-07**	**4.8E-06**	**1.2E-07**	**8.1E-08**	**2.5E-06**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.0367	0.0361	2.3E-06	6.7E-06	1.3E-06	1.5E-07	2.3E-07	2.3E-06	5.7E-08	3.9E-08	1.2E-06
Liverpool West Public School	Residential/School	0.0247	0.0242	1.5E-06	4.5E-06	8.7E-07	9.9E-08	1.5E-07	1.5E-06	3.8E-08	2.6E-08	8.2E-07
Liverpool Public School	Residential/School	0.0220	0.0216	1.4E-06	4.0E-06	7.8E-07	8.9E-08	1.4E-07	1.4E-06	3.4E-08	2.3E-08	7.3E-07
Average Residential		**0.0278**	**0.0273**	**1.7E-06**	**5.1E-06**	**9.9E-07**	**1.1E-07**	**1.7E-07**	**1.7E-06**	**4.3E-08**	**3.0E-08**	**9.3E-07**
Lurnea												
Lurnea High School	Residential/School	0.0311	0.0305	1.9E-06	5.7E-06	1.1E-06	1.3E-07	1.9E-07	1.9E-06	4.9E-08	3.3E-08	1.0E-06
St Francis Xavier Primary School Lurnea	Residential/School	0.0283	0.0278	1.8E-06	5.2E-06	1.0E-06	1.1E-07	1.8E-07	1.8E-06	4.4E-08	3.0E-08	9.5E-07
Average Residential		**0.0297**	**0.0292**	**1.8E-06**	**5.4E-06**	**1.1E-06**	**1.2E-07**	**1.8E-07**	**1.9E-06**	**4.6E-08**	**3.2E-08**	**9.9E-07**
Casula												
Lakewood Crescent	Residential	0.1147	0.1125	7.1E-06	2.1E-05	4.1E-06	4.6E-07	7.1E-07	7.2E-06	1.8E-07	1.2E-07	3.8E-06
St Andrews Boulevard	Residential	0.1618	0.1587	1.0E-05	3.0E-05	5.7E-06	6.5E-07	1.0E-06	1.0E-05	2.5E-07	1.7E-07	5.4E-06
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.2324	0.2280	1.4E-05	4.3E-05	8.2E-06	9.3E-07	1.4E-06	1.5E-05	3.6E-07	2.5E-07	7.8E-06
Dunmore Cres	Residential	0.2254	0.2213	1.4E-05	4.1E-05	8.0E-06	9.1E-07	1.4E-06	1.4E-05	3.5E-07	2.4E-07	7.5E-06
Leacocks Lane	Residential	0.0579	0.0568	3.6E-06	1.1E-05	2.1E-06	2.3E-07	3.6E-07	3.6E-06	9.0E-08	6.2E-08	1.9E-06
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.0839	0.0824	5.2E-06	1.5E-05	3.0E-06	3.4E-07	5.2E-07	5.3E-06	1.3E-07	8.9E-08	2.8E-06
Slessor Road	Residential	0.0659	0.0647	4.1E-06	1.2E-05	2.3E-06	2.7E-07	4.1E-07	4.1E-06	1.0E-07	7.0E-08	2.2E-06
Maple Grove Retirement Village	Residential	0.0319	0.0313	2.0E-06	5.8E-06	1.1E-06	1.3E-07	2.0E-07	2.0E-06	5.0E-08	3.4E-08	1.1E-06
All Saints Catholic Senior College	Residential/School	0.0819	0.0804	5.1E-06	1.5E-05	2.9E-06	3.3E-07	5.1E-07	5.1E-06	1.3E-07	8.7E-08	2.7E-06
Casula High School	Residential/School	0.0289	0.0283	1.8E-06	5.3E-06	1.0E-06	1.2E-07	1.8E-07	1.8E-06	4.5E-08	3.1E-08	9.6E-07
Casula Public School	Residential/School	0.0883	0.0867	5.5E-06	1.6E-05	3.1E-06	3.6E-07	5.5E-07	5.5E-06	1.4E-07	9.4E-08	2.9E-06
Casula Powerhouse Arts Centre	Recreational	0.3066	0.3011	8.9E-07	2.6E-06	5.1E-07	5.7E-08	8.9E-08	9.0E-07	2.3E-08	1.5E-08	4.8E-07
Average Residential		**0.1233**	**0.1210**	**7.6E-06**	**2.3E-05**	**4.4E-06**	**5.0E-07**	**7.6E-07**	**7.7E-06**	**1.9E-07**	**1.3E-07**	**4.1E-06**
Glenfield												
Canterbury Road	Residential	0.0365	0.0358	2.3E-06	6.7E-06	1.3E-06	1.5E-07	2.3E-07	2.3E-06	5.7E-08	3.9E-08	1.2E-06
Ferguson Street	Residential	0.0411	0.0404	2.5E-06	7.5E-06	1.5E-06	1.7E-07	2.5E-07	2.6E-06	6.4E-08	4.4E-08	1.4E-06
Good enough St (Receptor 4 in Simta Report)	Residential	0.0549	0.0539	3.4E-06	1.0E-05	1.9E-06	2.2E-07	3.4E-07	3.4E-06	8.6E-08	5.8E-08	1.8E-06
Cambridge Avenue	Residential	0.0496	0.0487	3.1E-06	9.1E-06	1.8E-06	2.0E-07	3.1E-07	3.1E-06	7.8E-08	5.3E-08	1.7E-06
Glenwood Public School	Residential/School	0.0239	0.0235	1.5E-06	4.4E-06	8.5E-07	9.6E-08	1.5E-07	1.5E-06	3.7E-08	2.5E-08	8.0E-07
Glenfield Public School	Residential/School	0.0259	0.0254	1.6E-06	4.7E-06	9.2E-07	1.0E-07	1.6E-07	1.6E-06	4.0E-08	2.8E-08	8.6E-07
Hurlstone Agricultural High School	Residential/School	0.0220	0.0216	1.4E-06	4.0E-06	7.8E-07	8.8E-08	1.4E-07	1.4E-06	3.4E-08	2.3E-08	7.3E-07
Glenfield new land release	Residential	0.0454	0.0446	2.8E-06	8.3E-06	1.6E-06	1.8E-07	2.8E-07	2.8E-06	7.1E-08	4.8E-08	1.5E-06
Playground Learning Centre, Chesham Parade	Residential	0.0270	0.0265	1.7E-06	5.0E-06	9.6E-07	1.1E-07	1.7E-07	1.7E-06	4.2E-08	2.9E-08	9.0E-07
Average Residential		**0.0363**	**0.0356**	**2.2E-06**	**6.6E-06**	**1.3E-06**	**1.5E-07**	**2.2E-07**	**2.3E-06**	**5.7E-08**	**3.9E-08**	**1.2E-06**
Macquarie Fields												
Hickory Place	Residential	0.0125	0.0123	7.8E-07	2.3E-06	4.4E-07	5.0E-08	7.8E-08	7.8E-07	2.0E-08	1.3E-08	4.2E-07
Maximum residential receptors		**0.2324**	**0.2280**	**1.4E-05**	**4.3E-05**	**8.2E-06**	**9.3E-07**	**1.4E-06**	**1.5E-05**	**3.6E-07**	**2.5E-07**	**7.8E-06**
Maximum school receptors		**0.0883**	**0.0867**	**5.5E-06**	**1.6E-05**	**3.1E-06**	**3.6E-07**	**5.5E-07**	**5.5E-06**	**1.4E-07**	**9.4E-08**	**2.9E-06**
Maximum recreational receptors		**0.3066**	**0.3011**	**8.9E-07**	**2.6E-06**	**5.1E-07**	**5.7E-08**	**8.9E-08**	**9.0E-07**	**2.3E-08**	**1.5E-08**	**4.8E-07**
Maximum commercial/industrial receptors		**1.1938**	**1.1691**	**1.6E-05**	**4.8E-05**	**9.3E-06**	**1.1E-06**	**1.6E-06**	**1.6E-05**	**4.1E-07**	**2.8E-07**	**8.7E-06**

Quantification of Effects - PM2.5 and PM10
Central Rail Access - Phase A

Particulate Fraction:	**PM2.5**	**PM2.5**	**PM2.5**	**PM10**	**PM2.5**	**PM2.5**	**PM2.5**	**PM2.5**	**Incremental Risk -DPM**
Endpoint:	**Mortality - All Causes**	**Hospitalisations - Cardiovascular**	**Hospitalisations - Respiratory**	**Mortality - All Causes**	**Mortality - All Causes**	**Mortality - Cardiopulmonary**	**Mortality - Cardiovascular**	**Mortality - Respiratory**	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		**Increase in Annual Average PM10 Concentration (µg/m³)**	**Increase in Annual Average PM2.5 Concentration (µg/m³)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk**
Maximum Receptor												
Boundary location	**Commercial/Industrial**	1.2057	0.2270	**3.1E-06**	**9.3E-06**	**1.8E-06**	**1.1E-06**	**3.1E-07**	**3.2E-06**	**7.9E-08**	**5.4E-08**	**1.7E-06**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.0685	0.0124	7.8E-07	2.3E-06	4.5E-07	2.8E-07	7.8E-08	7.9E-07	2.0E-08	1.3E-08	4.2E-07
Corryton Ct	Residential	0.0731	0.0134	8.5E-07	2.5E-06	4.8E-07	2.9E-07	8.4E-08	8.5E-07	2.1E-08	1.5E-08	4.6E-07
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.0718	0.0132	8.3E-07	2.5E-06	4.8E-07	2.9E-07	8.3E-08	8.4E-07	2.1E-08	1.4E-08	4.5E-07
Anzac Road (Receptor 2 in Simta report)	Residential	0.0890	0.0174	1.1E-06	3.2E-06	6.3E-07	3.6E-07	1.1E-07	1.1E-06	2.8E-08	1.9E-08	5.9E-07
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.0890	0.0174	2.4E-07	7.1E-07	1.4E-07	7.9E-08	2.4E-08	2.4E-07	6.1E-09	4.1E-09	1.3E-07
Yallum Cres (Receptor 1 in Simta report)	Residential	0.0769	0.0140	8.8E-07	2.6E-06	5.1E-07	3.1E-07	8.8E-08	8.9E-07	2.2E-08	1.5E-08	4.8E-07
Wattle Grove Public School	Residential/School	0.0610	0.0111	7.0E-07	2.1E-06	4.0E-07	2.5E-07	7.0E-08	7.1E-07	1.8E-08	1.2E-08	3.8E-07
St Marks Coptic College	Residential/School	0.0460	0.0084	5.3E-07	1.6E-06	3.0E-07	1.9E-07	5.3E-08	5.4E-07	1.3E-08	9.1E-09	2.9E-07
Anzac Creek Park	Residential	0.0479	0.0091	5.7E-07	1.7E-06	3.3E-07	1.9E-07	5.7E-08	5.8E-07	1.4E-08	9.8E-09	3.1E-07
Anzac Creek Park	Recreational	0.0479	0.0091	2.7E-08	8.0E-08	1.5E-08	9.0E-09	2.7E-09	2.7E-08	6.8E-10	4.6E-10	1.4E-08
Moorebank Ave	Commercial/Industrial	0.6191	0.1396	1.9E-06	5.7E-06	1.1E-06	5.5E-07	1.9E-07	2.0E-06	4.9E-08	3.3E-08	1.0E-06
DNSDC proposed relocation	Commercial/Industrial	0.0850	0.0159	2.2E-07	6.5E-07	1.3E-07	7.5E-08	2.2E-08	2.2E-07	5.5E-09	3.8E-09	1.2E-07
Average Residential		**0.0647**	**0.0120**	**7.6E-07**	**2.2E-06**	**4.3E-07**	**2.6E-07**	**7.6E-08**	**7.7E-07**	**1.9E-08**	**1.3E-08**	**4.1E-07**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.0292	0.0061	3.8E-07	1.1E-06	2.2E-07	1.2E-07	3.8E-08	3.9E-07	9.7E-09	6.6E-09	2.1E-07
Anzac Road (Receptor 2 in Simta report)	Residential	0.0890	0.0174	1.1E-06	3.2E-06	6.3E-07	3.6E-07	1.1E-07	1.1E-06	2.8E-08	1.9E-08	5.9E-07
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.0890	0.0174	2.4E-07	7.1E-07	1.4E-07	7.9E-08	2.4E-08	2.4E-07	6.1E-09	4.1E-09	1.3E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.0479	0.0091	5.7E-07	1.7E-06	3.3E-07	1.9E-07	5.7E-08	5.8E-07	1.4E-08	9.8E-09	3.1E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.0479	0.0091	2.7E-08	8.0E-08	1.5E-08	9.0E-09	2.7E-09	2.7E-08	6.8E-10	4.6E-10	1.4E-08
Average Residential		**0.0535**	**0.0104**	**6.6E-07**	**1.9E-06**	**3.8E-07**	**2.1E-07**	**6.5E-08**	**6.6E-07**	**1.7E-08**	**1.1E-08**	**3.5E-07**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.0200	0.0039	2.5E-07	7.4E-07	1.4E-07	8.0E-08	2.5E-08	2.5E-07	6.3E-09	4.3E-09	1.3E-07
Liverpool West Public School	Residential/School	0.0153	0.0029	1.9E-07	5.5E-07	1.1E-07	6.2E-08	1.9E-08	1.9E-07	4.7E-09	3.2E-09	1.0E-07
Liverpool Public School	Residential/School	0.0128	0.0025	1.6E-07	4.6E-07	8.9E-08	5.1E-08	1.6E-08	1.6E-07	3.9E-09	2.7E-09	8.4E-08
Average Residential		**0.0160**	**0.0031**	**2.0E-07**	**5.8E-07**	**1.1E-07**	**6.4E-08**	**2.0E-08**	**2.0E-07**	**5.0E-09**	**3.4E-09**	**1.1E-07**
Lurnea												
Lurnea High School	Residential/School	0.0271	0.0050	3.1E-07	9.3E-07	1.8E-07	1.1E-07	3.1E-08	3.2E-07	7.9E-09	5.4E-09	1.7E-07
St Francis Xavier Primary School Lurnea	Residential/School	0.0198	0.0037	2.4E-07	7.0E-07	1.3E-07	8.0E-08	2.4E-08	2.4E-07	5.9E-09	4.0E-09	1.3E-07
Average Residential		**0.0235**	**0.0044**	**2.7E-07**	**8.1E-07**	**1.6E-07**	**9.4E-08**	**2.7E-08**	**2.8E-07**	**6.9E-09**	**4.7E-09**	**1.5E-07**
Casula												
Lakewood Crescent	Residential	0.0592	0.0120	7.6E-07	2.2E-06	4.3E-07	2.4E-07	7.6E-08	7.7E-07	1.9E-08	1.3E-08	4.1E-07
St Andrews Boulevard	Residential	0.0883	0.0170	1.1E-06	3.2E-06	6.1E-07	3.5E-07	1.1E-07	1.1E-06	2.7E-08	1.8E-08	5.8E-07
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.1244	0.0230	1.5E-06	4.3E-06	8.3E-07	5.0E-07	1.5E-07	1.5E-06	3.7E-08	2.5E-08	7.8E-07
Dunmore Cres	Residential	0.1340	0.0242	1.5E-06	4.5E-06	8.8E-07	5.4E-07	1.5E-07	1.5E-06	3.9E-08	2.6E-08	8.2E-07
Leacocks Lane	Residential	0.0690	0.0123	7.8E-07	2.3E-06	4.5E-07	2.8E-07	7.8E-08	7.9E-07	2.0E-08	1.3E-08	4.2E-07
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.1003	0.0178	1.1E-06	3.3E-06	6.4E-07	4.0E-07	1.1E-07	1.1E-06	2.8E-08	1.9E-08	6.0E-07
Slessor Road	Residential	0.0554	0.0099	6.2E-07	1.8E-06	3.6E-07	2.2E-07	6.2E-08	6.3E-07	1.6E-08	1.1E-08	3.4E-07
Maple Grove Retirement Village	Residential	0.0316	0.0057	3.6E-07	1.1E-06	2.1E-07	1.3E-07	3.6E-08	3.6E-07	9.1E-09	6.2E-09	1.9E-07
All Saints Catholic Senior College	Residential/School	0.0985	0.0175	1.1E-06	3.3E-06	6.3E-07	4.0E-07	1.1E-07	1.1E-06	2.8E-08	1.9E-08	5.9E-07
Casula High School	Residential/School	0.0296	0.0054	3.4E-07	1.0E-06	1.9E-07	1.2E-07	3.4E-08	3.4E-07	8.5E-09	5.8E-09	1.8E-07
Casula Public School	Residential/School	0.0614	0.0114	7.2E-07	2.1E-06	4.1E-07	2.5E-07	7.2E-08	7.2E-07	1.8E-08	1.2E-08	3.9E-07
Casula Powerhouse Arts Centre	Recreational	0.1636	0.0294	8.7E-08	2.6E-07	5.0E-08	5.6E-09	8.7E-09	8.8E-08	2.2E-09	1.5E-09	4.7E-08
Average Residential		**0.0846**	**0.0155**	**9.8E-07**	**2.9E-06**	**5.6E-07**	**3.4E-07**	**9.7E-08**	**9.9E-07**	**2.5E-08**	**1.7E-08**	**5.3E-07**
Glenfield												
Canterbury Road	Residential	0.0291	0.0053	3.3E-07	9.8E-07	1.9E-07	1.2E-07	3.3E-08	3.3E-07	8.4E-09	5.7E-09	1.8E-07
Ferguson Street	Residential	0.0338	0.0061	3.8E-07	1.1E-06	2.2E-07	1.4E-07	3.8E-08	3.9E-07	9.7E-09	6.6E-09	2.1E-07
Good enough St (Receptor 4 in Simta Report)	Residential	0.0439	0.0079	5.0E-07	1.5E-06	2.8E-07	1.8E-07	4.9E-08	5.0E-07	1.2E-08	8.5E-09	2.7E-07
Cambridge Avenue	Residential	0.0431	0.0077	4.9E-07	1.4E-06	2.8E-07	1.7E-07	4.9E-08	4.9E-07	1.2E-08	8.4E-09	2.6E-07
Glenwood Public School	Residential/School	0.0207	0.0038	2.4E-07	7.0E-07	1.4E-07	8.3E-08	2.4E-08	2.4E-07	6.0E-09	4.1E-09	1.3E-07
Glenfield Public School	Residential/School	0.0200	0.0036	2.3E-07	6.8E-07	1.3E-07	8.0E-08	2.3E-08	2.3E-07	5.8E-09	3.9E-09	1.2E-07
Hurlstone Agricultural High School	Residential/School	0.0181	0.0033	2.1E-07	6.2E-07	1.2E-07	7.3E-08	2.1E-08	2.1E-07	5.2E-09	3.6E-09	1.1E-07
Glenfield new land release	Residential	0.0371	0.0067	4.2E-07	1.2E-06	2.4E-07	1.5E-07	4.2E-08	4.3E-07	1.1E-08	7.2E-09	2.3E-07
Playground Learning Centre, Chesham Parade	Residential	0.0214	0.0039	2.5E-07	7.3E-07	1.4E-07	8.6E-08	2.4E-08	2.5E-07	6.2E-09	4.2E-09	1.3E-07
Average Residential		**0.0297**	**0.0054**	**3.4E-07**	**1.0E-06**	**1.9E-07**	**1.2E-07**	**3.4E-08**	**3.4E-07**	**8.5E-09**	**5.8E-09**	**1.8E-07**
Macquarie Fields												
Hickory Place	Residential	0.0113	0.0021	1.3E-07	3.9E-07	7.5E-08	4.5E-08	1.3E-08	1.3E-07	3.3E-09	2.2E-09	7.0E-08
Maximum residential receptors		**0.1340**	**0.0242**	**1.5E-06**	**4.5E-06**	**8.8E-07**	**5.4E-07**	**1.5E-07**	**1.5E-06**	**3.9E-08**	**2.6E-08**	**8.2E-07**
Maximum school receptors		**0.0985**	**0.0175**	**1.1E-06**	**3.3E-06**	**6.3E-07**	**4.0E-07**	**1.1E-07**	**1.1E-06**	**2.8E-08**	**1.9E-08**	**5.9E-07**
Maximum recreational receptors		**0.1636**	**0.0294**	**8.7E-08**	**2.6E-07**	**5.0E-08**	**9.0E-09**	**8.7E-09**	**8.8E-08**	**2.2E-09**	**1.5E-09**	**4.7E-08**
Maximum commercial/industrial receptors		**1.2057**	**0.2270**	**3.1E-06**	**9.3E-06**	**1.8E-06**	**1.1E-06**	**3.1E-07**	**3.2E-06**	**7.9E-08**	**5.4E-08**	**1.7E-06**

Quantification of Effects - PM2.5 and PM10
Central Rail Access - Phase B

Particulate Fraction:	**PM2.5**	**PM2.5**	**PM2.5**	**PM10**	**PM2.5**	**PM2.5**	**PM2.5**	**PM2.5**	**Incremental Risk -DPM**
Endpoint:	**Mortality - All Causes**	**Hospitalisations - Cardiovascular**	**Hospitalisations - Respiratory**	**Mortality - All Causes**	**Mortality - All Causes**	**Mortality - Cardiopulmonary**	**Mortality - Cardiovascular**	**Mortality - Respiratory**	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		**Increase in Annual Average PM10 Concentration (µg/m³)**	**Increase in Annual Average PM2.5 Concentration (µg/m³)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk**
Maximum Receptor												
Boundary location	**Commercial/Industrial**	1.4947	0.8008	**1.1E-05**	**3.3E-05**	**6.4E-06**	**1.3E-06**	**1.1E-06**	**1.1E-05**	**2.8E-07**	**1.9E-07**	**6.0E-06**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.0824	0.0289	1.8E-06	5.4E-06	1.0E-06	3.3E-07	1.8E-07	1.8E-06	4.6E-08	3.1E-08	9.8E-07
Corryton Ct	Residential	0.0879	0.0336	2.1E-06	6.3E-06	1.2E-06	3.5E-07	2.1E-07	2.1E-06	5.3E-08	3.6E-08	1.1E-06
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.0802	0.0334	2.1E-06	6.2E-06	1.2E-06	3.2E-07	2.1E-07	2.1E-06	5.3E-08	3.6E-08	1.1E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.0871	0.0481	3.0E-06	9.0E-06	1.7E-06	3.5E-07	3.0E-07	3.1E-06	7.6E-08	5.2E-08	1.6E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.0871	0.0481	6.7E-07	2.0E-06	3.8E-07	7.7E-08	6.7E-08	6.7E-07	1.7E-08	1.1E-08	3.6E-07
Yallum Cres (Receptor 1 in Simta report)	Residential	0.0990	0.0346	2.2E-06	6.5E-06	1.3E-06	4.0E-07	2.2E-07	2.2E-06	5.5E-08	3.8E-08	1.2E-06
Wattle Grove Public School	Residential/School	0.0724	0.0270	1.7E-06	5.0E-06	9.8E-07	2.9E-07	1.7E-07	1.7E-06	4.3E-08	2.9E-08	9.2E-07
St Marks Coptic College	Residential/School	0.0477	0.0189	1.2E-06	3.5E-06	6.8E-07	1.9E-07	1.2E-07	1.2E-06	3.0E-08	2.0E-08	6.4E-07
Anzac Creek Park	Residential	0.0486	0.0235	1.5E-06	4.4E-06	8.5E-07	2.0E-07	1.5E-07	1.5E-06	3.7E-08	2.5E-08	8.0E-07
Anzac Creek Park	Recreational	0.0486	0.0235	7.0E-08	2.1E-07	4.0E-08	9.2E-09	7.0E-09	7.0E-08	1.8E-09	1.2E-09	3.8E-08
Moorebank Ave	Commercial/Industrial	0.8497	0.5792	8.0E-06	2.4E-05	4.6E-06	7.5E-07	8.0E-07	8.1E-06	2.0E-07	1.4E-07	4.3E-06
DNSDC proposed relocation	Commercial/Industrial	0.0897	0.0434	6.0E-07	1.8E-06	3.4E-07	7.9E-08	6.0E-08	6.1E-07	1.5E-08	1.0E-08	3.2E-07
Average Residential		**0.0727**	**0.0302**	**1.9E-06**	**5.6E-06**	**1.1E-06**	**2.9E-07**	**1.9E-07**	**1.9E-06**	**4.8E-08**	**3.3E-08**	**1.0E-06**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.0339	0.0182	1.1E-06	3.4E-06	6.6E-07	1.4E-07	1.1E-07	1.2E-06	2.9E-08	2.0E-08	6.2E-07
Anzac Road (Receptor 2 in Simta report)	Residential	0.0871	0.0481	3.0E-06	9.0E-06	1.7E-06	3.5E-07	3.0E-07	3.1E-06	7.6E-08	5.2E-08	1.6E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.0871	0.0481	6.7E-07	2.0E-06	3.8E-07	7.7E-08	6.7E-08	6.7E-07	1.7E-08	1.1E-08	3.6E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.0486	0.0235	1.5E-06	4.4E-06	8.5E-07	2.0E-07	1.5E-07	1.5E-06	3.7E-08	2.5E-08	8.0E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.0486	0.0235	7.0E-08	2.1E-07	4.0E-08	9.2E-09	7.0E-09	7.0E-08	1.8E-09	1.2E-09	3.8E-08
Average Residential		**0.0546**	**0.0283**	**1.8E-06**	**5.3E-06**	**1.0E-06**	**2.2E-07**	**1.8E-07**	**1.8E-06**	**4.5E-08**	**3.1E-08**	**9.6E-07**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.0232	0.0118	7.5E-07	2.2E-06	4.3E-07	9.3E-08	7.5E-08	7.5E-07	1.9E-08	1.3E-08	4.0E-07
Liverpool West Public School	Residential/School	0.0166	0.0079	5.0E-07	1.5E-06	2.9E-07	6.7E-08	5.0E-08	5.1E-07	1.3E-08	8.6E-09	2.7E-07
Liverpool Public School	Residential/School	0.0145	0.0072	4.5E-07	1.3E-06	2.6E-07	5.8E-08	4.5E-08	4.6E-07	1.1E-08	7.8E-09	2.4E-07
Average Residential		**0.0181**	**0.0090**	**5.7E-07**	**1.7E-06**	**3.2E-07**	**7.3E-08**	**5.7E-08**	**5.7E-07**	**1.4E-08**	**9.7E-09**	**3.1E-07**
Lurnea												
Lurnea High School	Residential/School	0.0244	0.0102	6.4E-07	1.9E-06	3.7E-07	9.8E-08	6.4E-08	6.5E-07	1.6E-08	1.1E-08	3.5E-07
St Francis Xavier Primary School Lurnea	Residential/School	0.0196	0.0090	5.7E-07	1.7E-06	3.3E-07	7.9E-08	5.7E-08	5.7E-07	1.4E-08	9.8E-09	3.1E-07
Average Residential		**0.0220**	**0.0096**	**6.0E-07**	**1.8E-06**	**3.5E-07**	**8.9E-08**	**6.0E-08**	**6.1E-07**	**1.5E-08**	**1.0E-08**	**3.3E-07**
Casula												
Lakewood Crescent	Residential	0.0662	0.0355	2.2E-06	6.6E-06	1.3E-06	2.7E-07	2.2E-07	2.3E-06	5.7E-08	3.8E-08	1.2E-06
St Andrews Boulevard	Residential	0.0912	0.0475	3.0E-06	8.9E-06	1.7E-06	3.7E-07	3.0E-07	3.0E-06	7.6E-08	5.1E-08	1.6E-06
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.1276	0.0622	3.9E-06	1.2E-05	2.2E-06	5.1E-07	3.9E-07	4.0E-06	9.9E-08	6.7E-08	2.1E-06
Dunmore Cres	Residential	0.1389	0.0614	3.9E-06	1.1E-05	2.2E-06	5.6E-07	3.9E-07	3.9E-06	9.8E-08	6.6E-08	2.1E-06
Leacocks Lane	Residential	0.0536	0.0202	1.3E-06	3.8E-06	7.3E-07	2.2E-07	1.3E-07	1.3E-06	3.2E-08	2.2E-08	6.9E-07
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.0779	0.0288	1.8E-06	5.4E-06	1.0E-06	3.1E-07	1.8E-07	1.8E-06	4.6E-08	3.1E-08	9.8E-07
Slessor Road	Residential	0.0509	0.0200	1.3E-06	3.7E-06	7.2E-07	2.0E-07	1.3E-07	1.3E-06	3.2E-08	2.2E-08	6.8E-07
Maple Grove Retirement Village	Residential	0.0279	0.0109	6.9E-07	2.0E-06	3.9E-07	1.1E-07	6.9E-08	7.0E-07	1.7E-08	1.2E-08	3.7E-07
All Saints Catholic Senior College	Residential/School	0.0755	0.0282	1.8E-06	5.3E-06	1.0E-06	3.0E-07	1.8E-07	1.8E-06	4.5E-08	3.1E-08	9.6E-07
Casula High School	Residential/School	0.0260	0.0101	6.4E-07	1.9E-06	3.6E-07	1.0E-07	6.4E-08	6.4E-07	1.6E-08	1.1E-08	3.4E-07
Casula Public School	Residential/School	0.0583	0.0263	1.7E-06	4.9E-06	9.5E-07	2.3E-07	1.7E-07	1.7E-06	4.2E-08	2.9E-08	9.0E-07
Casula Powerhouse Arts Centre	Recreational	0.1785	0.0796	2.4E-07	7.0E-07	1.4E-07	1.5E-08	2.4E-08	2.4E-07	5.9E-09	4.1E-09	1.3E-07
Average Residential		**0.0810**	**0.0359**	**2.3E-06**	**6.7E-06**	**1.3E-06**	**3.3E-07**	**2.3E-07**	**2.3E-06**	**5.7E-08**	**3.9E-08**	**1.2E-06**
Glenfield												
Canterbury Road	Residential	0.0272	0.0111	7.0E-07	2.1E-06	4.0E-07	1.1E-07	7.0E-08	7.1E-07	1.8E-08	1.2E-08	3.8E-07
Ferguson Street	Residential	0.0302	0.0124	7.8E-07	2.3E-06	4.5E-07	1.2E-07	7.8E-08	7.9E-07	2.0E-08	1.3E-08	4.2E-07
Good enough St (Receptor 4 in Simta Report)	Residential	0.0399	0.0163	1.0E-06	3.1E-06	5.9E-07	1.6E-07	1.0E-07	1.0E-06	2.6E-08	1.8E-08	5.6E-07
Cambridge Avenue	Residential	0.0383	0.0152	9.6E-07	2.8E-06	5.5E-07	1.5E-07	9.6E-08	9.7E-07	2.4E-08	1.6E-08	5.2E-07
Glenwood Public School	Residential/School	0.0184	0.0075	4.7E-07	1.4E-06	2.7E-07	7.4E-08	4.7E-08	4.8E-07	1.2E-08	8.1E-09	2.6E-07
Glenfield Public School	Residential/School	0.0193	0.0080	5.0E-07	1.5E-06	2.9E-07	7.7E-08	5.0E-08	5.1E-07	1.3E-08	8.6E-09	2.7E-07
Hurlstone Agricultural High School	Residential/School	0.0173	0.0070	4.4E-07	1.3E-06	2.5E-07	6.9E-08	4.4E-08	4.4E-07	1.1E-08	7.6E-09	2.4E-07
Glenfield new land release	Residential	0.0349	0.0140	8.8E-07	2.6E-06	5.0E-07	1.4E-07	8.8E-08	8.9E-07	2.2E-08	1.5E-08	4.8E-07
Playground Learning Centre, Chesham Parade	Residential	0.0201	0.0083	5.2E-07	1.6E-06	3.0E-07	8.1E-08	5.2E-08	5.3E-07	1.3E-08	9.0E-09	2.8E-07
Average Residential		**0.0273**	**0.0111**	**7.0E-07**	**2.1E-06**	**4.0E-07**	**1.1E-07**	**7.0E-08**	**7.1E-07**	**1.8E-08**	**1.2E-08**	**3.8E-07**
Macquarie Fields												
Hickory Place	Residential	0.0104	0.0042	2.6E-07	7.8E-07	1.5E-07	4.2E-08	2.6E-08	2.7E-07	6.6E-09	4.5E-09	1.4E-07
Maximum residential receptors		**0.1389**	**0.0622**	**3.9E-06**	**1.2E-05**	**2.2E-06**	**5.6E-07**	**3.9E-07**	**4.0E-06**	**9.9E-08**	**6.7E-08**	**2.1E-06**
Maximum school receptors		**0.0755**	**0.0282**	**1.8E-06**	**5.3E-06**	**1.0E-06**	**3.0E-07**	**1.8E-07**	**1.8E-06**	**4.5E-08**	**3.1E-08**	**9.6E-07**
Maximum recreational receptors		**0.1785**	**0.0796**	**2.4E-07**	**7.0E-07**	**1.4E-07**	**1.5E-08**	**2.4E-08**	**2.4E-07**	**5.9E-09**	**4.1E-09**	**1.3E-07**
Maximum commercial/industrial receptors		**1.4947**	**0.8008**	**1.1E-05**	**3.3E-05**	**6.4E-06**	**1.3E-06**	**1.1E-06**	**1.1E-05**	**2.8E-07**	**1.9E-07**	**6.0E-06**

Quantification of Effects - PM2.5 and PM10
Central Rail Access - Phase C

Particulate Fraction:	**PM2.5**	**PM2.5**	**PM2.5**	**PM10**	**PM2.5**	**PM2.5**	**PM2.5**	**PM2.5**	**Incremental Risk -DPM**
Endpoint:	**Mortality - All Causes**	**Hospitalisations - Cardiovascular**	**Hospitalisations - Respiratory**	**Mortality - All Causes**	**Mortality - All Causes**	**Mortality - Cardiopulmonary**	**Mortality - Cardiovascular**	**Mortality - Respiratory**	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		**Increase in Annual Average PM10 Concentration (µg/m³)**	**Increase in Annual Average PM2.5 Concentration (µg/m³)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk**
Maximum Receptor												
Boundary location	**Commercial/Industrial**	1.3800	1.2429	**1.7E-05**	**5.1E-05**	**9.9E-06**	**1.2E-06**	**1.7E-06**	**1.7E-05**	**4.3E-07**	**3.0E-07**	**9.3E-06**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.1032	0.0754	4.8E-06	1.4E-05	2.7E-06	4.1E-07	4.8E-07	4.8E-06	1.2E-07	8.2E-08	2.6E-06
Corryton Ct	Residential	0.1108	0.0824	5.2E-06	1.5E-05	3.0E-06	4.5E-07	5.2E-07	5.2E-06	1.3E-07	8.9E-08	2.8E-06
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.1067	0.0800	5.0E-06	1.5E-05	2.9E-06	4.3E-07	5.0E-07	5.1E-06	1.3E-07	8.7E-08	2.7E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.1478	0.1072	6.8E-06	2.0E-05	3.9E-06	5.9E-07	6.8E-07	6.8E-06	1.7E-07	1.2E-07	3.6E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1478	0.1072	1.5E-06	4.4E-06	8.5E-07	1.3E-07	1.5E-07	1.5E-06	3.8E-08	2.6E-08	8.0E-07
Yallum Cres (Receptor 1 in Simta report)	Residential	0.1189	0.0879	5.5E-06	1.6E-05	3.2E-06	4.8E-07	5.5E-07	5.6E-06	1.4E-07	9.5E-08	3.0E-06
Wattle Grove Public School	Residential/School	0.0903	0.0662	4.2E-06	1.2E-05	2.4E-06	3.6E-07	4.2E-07	4.2E-06	1.1E-07	7.2E-08	2.3E-06
St Marks Coptic College	Residential/School	0.0638	0.0458	2.9E-06	8.6E-06	1.7E-06	2.6E-07	2.9E-07	2.9E-06	7.3E-08	5.0E-08	1.6E-06
Anzac Creek Park	Residential	0.0762	0.0558	3.5E-06	1.0E-05	2.0E-06	3.1E-07	3.5E-07	3.6E-06	8.9E-08	6.0E-08	1.9E-06
Anzac Creek Park	Recreational	0.0762	0.0558	1.7E-07	4.9E-07	9.5E-08	1.4E-08	1.7E-08	1.7E-07	4.2E-09	2.8E-09	8.9E-08
Moorebank Ave	Commercial/Industrial	1.0519	0.9322	1.3E-05	3.8E-05	7.4E-06	9.3E-07	1.3E-06	1.3E-05	3.3E-07	2.2E-07	7.0E-06
DNSDC proposed relocation	Commercial/Industrial	0.1327	0.1007	1.4E-06	4.1E-06	8.0E-07	1.2E-07	1.4E-07	1.4E-06	3.5E-08	2.4E-08	7.5E-07
Average Residential		**0.0993**	**0.0730**	**4.6E-06**	**1.4E-05**	**2.6E-06**	**4.0E-07**	**4.6E-07**	**4.6E-06**	**1.2E-07**	**7.9E-08**	**2.5E-06**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.0581	0.0427	2.7E-06	8.0E-06	1.5E-06	2.3E-07	2.7E-07	2.7E-06	6.8E-08	4.6E-08	1.5E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.1478	0.1072	6.8E-06	2.0E-05	3.9E-06	5.9E-07	6.8E-07	6.8E-06	1.7E-07	1.2E-07	3.6E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1478	0.1072	1.5E-06	4.4E-06	8.5E-07	1.3E-07	1.5E-07	1.5E-06	3.8E-08	2.6E-08	8.0E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.0762	0.0558	3.5E-06	1.0E-05	2.0E-06	3.1E-07	3.5E-07	3.6E-06	8.9E-08	6.0E-08	1.9E-06
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.0762	0.0558	1.7E-07	4.9E-07	9.5E-08	1.4E-08	1.7E-08	1.7E-07	4.2E-09	2.8E-09	8.9E-08
Average Residential		**0.0896**	**0.0654**	**4.1E-06**	**1.2E-05**	**2.4E-06**	**3.6E-07**	**4.1E-07**	**4.2E-06**	**1.0E-07**	**7.1E-08**	**2.2E-06**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.0393	0.0297	1.9E-06	5.6E-06	1.1E-06	1.6E-07	1.9E-07	1.9E-06	4.7E-08	3.2E-08	1.0E-06
Liverpool West Public School	Residential/School	0.0275	0.0205	1.3E-06	3.8E-06	7.4E-07	1.1E-07	1.3E-07	1.3E-06	3.3E-08	2.2E-08	7.0E-07
Liverpool Public School	Residential/School	0.0241	0.0183	1.2E-06	3.4E-06	6.6E-07	9.7E-08	1.2E-07	1.2E-06	2.9E-08	2.0E-08	6.2E-07
Average Residential		**0.0303**	**0.0228**	**1.4E-06**	**4.3E-06**	**8.2E-07**	**1.2E-07**	**1.4E-07**	**1.5E-06**	**3.6E-08**	**2.5E-08**	**7.8E-07**
Lurnea												
Lurnea High School	Residential/School	0.0387	0.0268	1.7E-06	5.0E-06	9.7E-07	1.6E-07	1.7E-07	1.7E-06	4.3E-08	2.9E-08	9.1E-07
St Francis Xavier Primary School Lurnea	Residential/School	0.0326	0.0238	1.5E-06	4.5E-06	8.6E-07	1.3E-07	1.5E-07	1.5E-06	3.8E-08	2.6E-08	8.1E-07
Average Residential		**0.0357**	**0.0253**	**1.6E-06**	**4.7E-06**	**9.1E-07**	**1.4E-07**	**1.6E-07**	**1.6E-06**	**4.0E-08**	**2.7E-08**	**8.6E-07**
Casula												
Lakewood Crescent	Residential	0.1282	0.0880	5.5E-06	1.6E-05	3.2E-06	5.2E-07	5.5E-07	5.6E-06	1.4E-07	9.5E-08	3.0E-06
St Andrews Boulevard	Residential	0.1776	0.1232	7.8E-06	2.3E-05	4.4E-06	7.1E-07	7.8E-07	7.8E-06	2.0E-07	1.3E-07	4.2E-06
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.2431	0.1730	1.1E-05	3.2E-05	6.2E-06	9.8E-07	1.1E-06	1.1E-05	2.8E-07	1.9E-07	5.9E-06
Dunmore Cres	Residential	0.2506	0.1763	1.1E-05	3.3E-05	6.4E-06	1.0E-06	1.1E-06	1.1E-05	2.8E-07	1.9E-07	6.0E-06
Leacocks Lane	Residential	0.0828	0.0522	3.3E-06	9.7E-06	1.9E-06	3.3E-07	3.3E-07	3.3E-06	8.3E-08	5.6E-08	1.8E-06
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.1194	0.0761	4.8E-06	1.4E-05	2.7E-06	4.8E-07	4.8E-07	4.8E-06	1.2E-07	8.2E-08	2.6E-06
Slessor Road	Residential	0.0805	0.0582	3.7E-06	1.1E-05	2.1E-06	3.2E-07	3.7E-07	3.7E-06	9.3E-08	6.3E-08	2.0E-06
Maple Grove Retirement Village	Residential	0.0416	0.0284	1.8E-06	5.3E-06	1.0E-06	1.7E-07	1.8E-07	1.8E-06	4.5E-08	3.1E-08	9.6E-07
All Saints Catholic Senior College	Residential/School	0.1178	0.0740	4.7E-06	1.4E-05	2.7E-06	4.7E-07	4.7E-07	4.7E-06	1.2E-07	8.0E-08	2.5E-06
Casula High School	Residential/School	0.0384	0.0257	1.6E-06	4.8E-06	9.3E-07	1.5E-07	1.6E-07	1.6E-06	4.1E-08	2.8E-08	8.7E-07
Casula Public School	Residential/School	0.1023	0.0721	4.5E-06	1.3E-05	2.6E-06	4.1E-07	4.5E-07	4.6E-06	1.1E-07	7.8E-08	2.5E-06
Casula Powerhouse Arts Centre	Recreational	0.3295	0.2329	6.9E-07	2.0E-06	4.0E-07	4.4E-08	6.9E-08	7.0E-07	1.7E-08	1.2E-08	3.7E-07
Average Residential		**0.1427**	**0.0983**	**6.2E-06**	**1.8E-05**	**3.6E-06**	**5.7E-07**	**6.2E-07**	**6.3E-06**	**1.6E-07**	**1.1E-07**	**3.3E-06**
Glenfield												
Canterbury Road	Residential	0.0458	0.0342	2.2E-06	6.4E-06	1.2E-06	1.8E-07	2.2E-07	2.2E-06	5.4E-08	3.7E-08	1.2E-06
Ferguson Street	Residential	0.0533	0.0397	2.5E-06	7.4E-06	1.4E-06	2.1E-07	2.5E-07	2.5E-06	6.3E-08	4.3E-08	1.3E-06
Good enough St (Receptor 4 in Simta Report)	Residential	0.0710	0.0536	3.4E-06	1.0E-05	1.9E-06	2.9E-07	3.4E-07	3.4E-06	8.5E-08	5.8E-08	1.8E-06
Cambridge Avenue	Residential	0.0642	0.0471	3.0E-06	8.8E-06	1.7E-06	2.6E-07	3.0E-07	3.0E-06	7.5E-08	5.1E-08	1.6E-06
Glenwood Public School	Residential/School	0.0312	0.0230	1.5E-06	4.3E-06	8.3E-07	1.3E-07	1.5E-07	1.5E-06	3.7E-08	2.5E-08	7.8E-07
Glenfield Public School	Residential/School	0.0320	0.0241	1.5E-06	4.5E-06	8.7E-07	1.3E-07	1.5E-07	1.5E-06	3.8E-08	2.6E-08	8.2E-07
Hurlstone Agricultural High School	Residential/School	0.0274	0.0203	1.3E-06	3.8E-06	7.3E-07	1.1E-07	1.3E-07	1.3E-06	3.2E-08	2.2E-08	6.9E-07
Glenfield new land release	Residential	0.0560	0.0413	2.6E-06	7.7E-06	1.5E-06	2.3E-07	2.6E-07	2.6E-06	6.6E-08	4.5E-08	1.4E-06
Playground Learning Centre, Chesham Parade	Residential	0.0341	0.0254	1.6E-06	4.7E-06	9.2E-07	1.4E-07	1.6E-07	1.6E-06	4.0E-08	2.8E-08	8.6E-07
Average Residential		**0.0461**	**0.0343**	**2.2E-06**	**6.4E-06**	**1.2E-06**	**1.9E-07**	**2.2E-07**	**2.2E-06**	**5.5E-08**	**3.7E-08**	**1.2E-06**
Macquarie Fields												
Hickory Place	Residential	0.0163	0.0118	7.5E-07	2.2E-06	4.3E-07	6.6E-08	7.5E-08	7.5E-07	1.9E-08	1.3E-08	4.0E-07
Maximum residential receptors		**0.2506**	**0.1763**	**1.1E-05**	**3.3E-05**	**6.4E-06**	**1.0E-06**	**1.1E-06**	**1.1E-05**	**2.8E-07**	**1.9E-07**	**6.0E-06**
Maximum school receptors		**0.1178**	**0.0740**	**4.7E-06**	**1.4E-05**	**2.7E-06**	**4.7E-07**	**4.7E-07**	**4.7E-06**	**1.2E-07**	**8.0E-08**	**2.5E-06**
Maximum recreational receptors		**0.3295**	**0.2329**	**6.9E-07**	**2.0E-06**	**4.0E-07**	**4.4E-08**	**6.9E-08**	**7.0E-07**	**1.7E-08**	**1.2E-08**	**3.7E-07**
Maximum commercial/industrial receptors		**1.3800**	**1.2429**	**1.7E-05**	**5.1E-05**	**9.9E-06**	**1.2E-06**	**1.7E-06**	**1.7E-05**	**4.3E-07**	**3.0E-07**	**9.3E-06**

Quantification of Effects - PM2.5 and PM10
Central Rail Access - Phase D

Particulate Fraction:	**PM2.5**	**PM2.5**	**PM2.5**	**PM10**	**PM2.5**	**PM2.5**	**PM2.5**	**PM2.5**	**Incremental Risk -DPM**
Endpoint:	**Mortality - All Causes**	**Hospitalisations - Cardiovascular**	**Hospitalisations - Respiratory**	**Mortality - All Causes**	**Mortality - All Causes**	**Mortality - Cardiopulmonary**	**Mortality - Cardiovascular**	**Mortality - Respiratory**	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		**Increase in Annual Average PM10 Concentration (µg/m³)**	**Increase in Annual Average PM2.5 Concentration (µg/m³)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk**
Maximum Receptor												
Boundary location	**Commercial/Industrial**	1.0982	1.0753	**1.5E-05**	**4.4E-05**	**8.5E-06**	**9.7E-07**	**1.5E-06**	**1.5E-05**	**3.8E-07**	**2.6E-07**	**8.0E-06**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.0719	0.0705	4.4E-06	1.3E-05	2.5E-06	2.9E-07	4.4E-07	4.5E-06	1.1E-07	7.6E-08	2.4E-06
Corryton Ct	Residential	0.0830	0.0814	5.1E-06	1.5E-05	2.9E-06	3.3E-07	5.1E-07	5.2E-06	1.3E-07	8.8E-08	2.8E-06
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.0844	0.0829	5.2E-06	1.5E-05	3.0E-06	3.4E-07	5.2E-07	5.3E-06	1.3E-07	9.0E-08	2.8E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.1435	0.1408	8.9E-06	2.6E-05	5.1E-06	5.8E-07	8.9E-07	9.0E-06	2.2E-07	1.5E-07	4.8E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1435	0.1408	2.0E-06	5.8E-06	1.1E-06	1.3E-07	2.0E-07	2.0E-06	4.9E-08	3.4E-08	1.1E-06
Yallum Cres (Receptor 1 in Simta report)	Residential	0.0844	0.0828	5.2E-06	1.5E-05	3.0E-06	3.4E-07	5.2E-07	5.3E-06	1.3E-07	9.0E-08	2.8E-06
Wattle Grove Public School	Residential/School	0.0666	0.0653	4.1E-06	1.2E-05	2.4E-06	2.7E-07	4.1E-07	4.2E-06	1.0E-07	7.1E-08	2.2E-06
St Marks Coptic College	Residential/School	0.0481	0.0472	3.0E-06	8.8E-06	1.7E-06	1.9E-07	3.0E-07	3.0E-06	7.5E-08	5.1E-08	1.6E-06
Anzac Creek Park	Residential	0.0665	0.0652	4.1E-06	1.2E-05	2.4E-06	2.7E-07	4.1E-07	4.2E-06	1.0E-07	7.1E-08	2.2E-06
Anzac Creek Park	Recreational	0.0665	0.0652	1.9E-07	5.7E-07	1.1E-07	1.3E-08	1.9E-08	2.0E-07	4.9E-09	3.3E-09	1.0E-07
Moorebank Ave	Commercial/Industrial	0.8424	0.8255	1.1E-05	3.4E-05	6.6E-06	7.5E-07	1.1E-06	1.2E-05	2.9E-07	2.0E-07	6.2E-06
DNSDC proposed relocation	Commercial/Industrial	0.1125	0.1105	1.5E-06	4.5E-06	8.8E-07	1.0E-07	1.5E-07	1.5E-06	3.9E-08	2.6E-08	8.3E-07
Average Residential		**0.0794**	**0.0779**	**4.9E-06**	**1.5E-05**	**2.8E-06**	**3.2E-07**	**4.9E-07**	**5.0E-06**	**1.2E-07**	**8.4E-08**	**2.6E-06**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.0636	0.0624	3.9E-06	1.2E-05	2.3E-06	2.6E-07	3.9E-07	4.0E-06	9.9E-08	6.8E-08	2.1E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.1435	0.1408	8.9E-06	2.6E-05	5.1E-06	5.8E-07	8.9E-07	9.0E-06	2.2E-07	1.5E-07	4.8E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1435	0.1408	2.0E-06	5.8E-06	1.1E-06	1.3E-07	2.0E-07	2.0E-06	4.9E-08	3.4E-08	1.1E-06
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.0665	0.0652	4.1E-06	1.2E-05	2.4E-06	2.7E-07	4.1E-07	4.2E-06	1.0E-07	7.1E-08	2.2E-06
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.0665	0.0652	1.9E-07	5.7E-07	1.1E-07	1.3E-08	1.9E-08	2.0E-07	4.9E-09	3.3E-09	1.0E-07
Average Residential		**0.0850**	**0.0834**	**5.3E-06**	**1.6E-05**	**3.0E-06**	**3.4E-07**	**5.3E-07**	**5.3E-06**	**1.3E-07**	**9.0E-08**	**2.8E-06**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.0418	0.0410	2.6E-06	7.7E-06	1.5E-06	1.7E-07	2.6E-07	2.6E-06	6.5E-08	4.4E-08	1.4E-06
Liverpool West Public School	Residential/School	0.0268	0.0263	1.7E-06	4.9E-06	9.5E-07	1.1E-07	1.7E-07	1.7E-06	4.2E-08	2.8E-08	8.9E-07
Liverpool Public School	Residential/School	0.0242	0.0237	1.5E-06	4.4E-06	8.6E-07	9.7E-08	1.5E-07	1.5E-06	3.8E-08	2.6E-08	8.1E-07
Average Residential		**0.0309**	**0.0303**	**1.9E-06**	**5.7E-06**	**1.1E-06**	**1.2E-07**	**1.9E-07**	**1.9E-06**	**4.8E-08**	**3.3E-08**	**1.0E-06**
Lurnea												
Lurnea High School	Residential/School	0.0317	0.0311	2.0E-06	5.8E-06	1.1E-06	1.3E-07	2.0E-07	2.0E-06	4.9E-08	3.4E-08	1.1E-06
St Francis Xavier Primary School Lurnea	Residential/School	0.0295	0.0290	1.8E-06	5.4E-06	1.0E-06	1.2E-07	1.8E-07	1.8E-06	4.6E-08	3.1E-08	9.8E-07
Average Residential		**0.0306**	**0.0300**	**1.9E-06**	**5.6E-06**	**1.1E-06**	**1.2E-07**	**1.9E-07**	**1.9E-06**	**4.8E-08**	**3.3E-08**	**1.0E-06**
Casula												
Lakewood Crescent	Residential	0.1516	0.1490	9.4E-06	2.8E-05	5.4E-06	6.1E-07	9.4E-07	9.5E-06	2.4E-07	1.6E-07	5.1E-06
St Andrews Boulevard	Residential	0.2164	0.2126	1.3E-05	4.0E-05	7.7E-06	8.7E-07	1.3E-06	1.4E-05	3.4E-07	2.3E-07	7.2E-06
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.2850	0.2801	1.8E-05	5.2E-05	1.0E-05	1.1E-06	1.8E-06	1.8E-05	4.5E-07	3.0E-07	9.5E-06
Dunmore Cres	Residential	0.2330	0.2289	1.4E-05	4.3E-05	8.3E-06	9.4E-07	1.4E-06	1.5E-05	3.6E-07	2.5E-07	7.8E-06
Leacocks Lane	Residential	0.0566	0.0556	3.5E-06	1.0E-05	2.0E-06	2.3E-07	3.5E-07	3.5E-06	8.8E-08	6.0E-08	1.9E-06
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.0780	0.0766	4.8E-06	1.4E-05	2.8E-06	3.1E-07	4.8E-07	4.9E-06	1.2E-07	8.3E-08	2.6E-06
Slessor Road	Residential	0.0606	0.0594	3.7E-06	1.1E-05	2.1E-06	2.4E-07	3.7E-07	3.8E-06	9.5E-08	6.4E-08	2.0E-06
Maple Grove Retirement Village	Residential	0.0310	0.0304	1.9E-06	5.7E-06	1.1E-06	1.2E-07	1.9E-07	1.9E-06	4.8E-08	3.3E-08	1.0E-06
All Saints Catholic Senior College	Residential/School	0.0770	0.0756	4.8E-06	1.4E-05	2.7E-06	3.1E-07	4.8E-07	4.8E-06	1.2E-07	8.2E-08	2.6E-06
Casula High School	Residential/School	0.0288	0.0283	1.8E-06	5.3E-06	1.0E-06	1.2E-07	1.8E-07	1.8E-06	4.5E-08	3.1E-08	9.6E-07
Casula Public School	Residential/School	0.0940	0.0924	5.8E-06	1.7E-05	3.3E-06	3.8E-07	5.8E-07	5.9E-06	1.5E-07	1.0E-07	3.1E-06
Casula Powerhouse Arts Centre	Recreational	0.3167	0.3111	9.2E-07	2.7E-06	5.3E-07	5.9E-08	9.2E-08	9.3E-07	2.3E-08	1.6E-08	5.0E-07
Average Residential		**0.1357**	**0.1333**	**8.4E-06**	**2.5E-05**	**4.8E-06**	**5.5E-07**	**8.4E-07**	**8.5E-06**	**2.1E-07**	**1.4E-07**	**4.5E-06**
Glenfield												
Canterbury Road	Residential	0.0345	0.0338	2.1E-06	6.3E-06	1.2E-06	1.4E-07	2.1E-07	2.2E-06	5.4E-08	3.7E-08	1.1E-06
Ferguson Street	Residential	0.0388	0.0380	2.4E-06	7.1E-06	1.4E-06	1.6E-07	2.4E-07	2.4E-06	6.1E-08	4.1E-08	1.3E-06
Good enough St (Receptor 4 in Simta Report)	Residential	0.0517	0.0507	3.2E-06	9.5E-06	1.8E-06	2.1E-07	3.2E-07	3.2E-06	8.1E-08	5.5E-08	1.7E-06
Cambridge Avenue	Residential	0.0465	0.0456	2.9E-06	8.5E-06	1.6E-06	1.9E-07	2.9E-07	2.9E-06	7.3E-08	4.9E-08	1.6E-06
Glenwood Public School	Residential/School	0.0228	0.0223	1.4E-06	4.2E-06	8.1E-07	9.2E-08	1.4E-07	1.4E-06	3.6E-08	2.4E-08	7.6E-07
Glenfield Public School	Residential/School	0.0247	0.0242	1.5E-06	4.5E-06	8.7E-07	9.9E-08	1.5E-07	1.5E-06	3.8E-08	2.6E-08	8.2E-07
Hurlstone Agricultural High School	Residential/School	0.0210	0.0206	1.3E-06	3.8E-06	7.4E-07	8.4E-08	1.3E-07	1.3E-06	3.3E-08	2.2E-08	7.0E-07
Glenfield new land release	Residential	0.0425	0.0417	2.6E-06	7.8E-06	1.5E-06	1.7E-07	2.6E-07	2.7E-06	6.6E-08	4.5E-08	1.4E-06
Playground Learning Centre, Chesham Parade	Residential	0.0257	0.0252	1.6E-06	4.7E-06	9.1E-07	1.0E-07	1.6E-07	1.6E-06	4.0E-08	2.7E-08	8.6E-07
Average Residential		**0.0342**	**0.0336**	**2.1E-06**	**6.3E-06**	**1.2E-06**	**1.4E-07**	**2.1E-07**	**2.1E-06**	**5.3E-08**	**3.6E-08**	**1.1E-06**
Macquarie Fields												
Hickory Place	Residential	0.0121	0.0118	7.5E-07	2.2E-06	4.3E-07	4.9E-08	7.5E-08	7.5E-07	1.9E-08	1.3E-08	4.0E-07
Maximum residential receptors		**0.2850**	**0.2801**	**1.8E-05**	**5.2E-05**	**1.0E-05**	**1.1E-06**	**1.8E-06**	**1.8E-05**	**4.5E-07**	**3.0E-07**	**9.5E-06**
Maximum school receptors		**0.0940**	**0.0924**	**5.8E-06**	**1.7E-05**	**3.3E-06**	**3.8E-07**	**5.8E-07**	**5.9E-06**	**1.5E-07**	**1.0E-07**	**3.1E-06**
Maximum recreational receptors		**0.3167**	**0.3111**	**9.2E-07**	**2.7E-06**	**5.3E-07**	**5.9E-08**	**9.2E-08**	**9.3E-07**	**2.3E-08**	**1.6E-08**	**5.0E-07**
Maximum commercial/industrial receptors		**1.0982**	**1.0753**	**1.5E-05**	**4.4E-05**	**8.5E-06**	**9.7E-07**	**1.5E-06**	**1.5E-05**	**3.8E-07**	**2.6E-07**	**8.0E-06**

Quantification of Effects - PM2.5 and PM10
Northern Rail Access - Phase A

Particulate Fraction:	PM2.5	PM2.5	PM2.5	PM10	PM2.5	PM2.5	PM2.5	PM2.5	Incremental Risk -DPM
Endpoint:	Mortality - All Causes	Hospitalisations - Cardiovascular	Hospitalisations - Respiratory	Mortality - All Causes	Mortality - All Causes	Mortality - Cardiopulmonary	Mortality - Cardiovascular	Mortality - Respiratory	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		Increase in Annual Average PM10 Concentration (µg/m³)	Increase in Annual Average PM2.5 Concentration (µg/m³)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk (Equation 6)	Risk
Maximum Receptor												
Boundary location	**Commercial/Industrial**	1.3550	0.2570	**3.6E-06**	**1.1E-05**	**2.0E-06**	**1.2E-06**	**3.6E-07**	**3.6E-06**	**9.0E-08**	**6.1E-08**	**1.9E-06**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.0626	0.0116	7.3E-07	2.2E-06	4.2E-07	2.5E-07	7.3E-08	7.4E-07	1.8E-08	1.3E-08	3.9E-07
Corryton Ct	Residential	0.0794	0.0146	9.2E-07	2.7E-06	5.3E-07	3.2E-07	9.2E-08	9.3E-07	2.3E-08	1.6E-08	5.0E-07
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.0768	0.0143	9.0E-07	2.7E-06	5.2E-07	3.1E-07	9.0E-08	9.1E-07	2.3E-08	1.5E-08	4.9E-07
Anzac Road (Receptor 2 in Simta report)	Residential	0.0927	0.0183	1.2E-06	3.4E-06	6.6E-07	3.7E-07	1.2E-07	1.2E-06	2.9E-08	2.0E-08	6.2E-07
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.0927	0.0183	2.5E-07	7.5E-07	1.5E-07	8.2E-08	2.5E-08	2.6E-07	6.4E-09	4.4E-09	1.4E-07
Yallum Cres (Receptor 1 in Simta report)	Residential	0.0790	0.0145	9.2E-07	2.7E-06	5.2E-07	3.2E-07	9.2E-08	9.3E-07	2.3E-08	1.6E-08	4.9E-07
Wattle Grove Public School	Residential/School	0.0639	0.0118	7.4E-07	2.2E-06	4.3E-07	2.6E-07	7.4E-08	7.5E-07	1.9E-08	1.3E-08	4.0E-07
St Marks Coptic College	Residential/School	0.0465	0.0087	5.5E-07	1.6E-06	3.1E-07	1.9E-07	5.5E-08	5.5E-07	1.4E-08	9.4E-09	2.9E-07
Anzac Creek Park	Residential	0.0491	0.0094	5.9E-07	1.8E-06	3.4E-07	2.0E-07	5.9E-08	6.0E-07	1.5E-08	1.0E-08	3.2E-07
Anzac Creek Park	Recreational	0.0491	0.0094	2.8E-08	8.3E-08	1.6E-08	9.3E-09	2.8E-09	2.8E-08	7.1E-10	4.8E-10	1.5E-08
Moorebank Ave	Commercial/Industrial	0.7552	0.1647	2.3E-06	6.8E-06	1.3E-06	6.7E-07	2.3E-07	2.3E-06	5.8E-08	3.9E-08	1.2E-06
DNSDC proposed relocation	Commercial/Industrial	0.0902	0.0170	2.4E-07	7.0E-07	1.3E-07	8.0E-08	2.4E-08	2.4E-07	5.9E-09	4.0E-09	1.3E-07
Average Residential		**0.0666**	**0.0125**	**7.9E-07**	**2.3E-06**	**4.5E-07**	**2.7E-07**	**7.9E-08**	**8.0E-07**	**2.0E-08**	**1.4E-08**	**4.3E-07**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.0324	0.0068	4.3E-07	1.3E-06	2.4E-07	1.3E-07	4.3E-08	4.3E-07	1.1E-08	7.3E-09	2.3E-07
Anzac Road (Receptor 2 in Simta report)	Residential	0.0927	0.0183	1.2E-06	3.4E-06	6.6E-07	3.7E-07	1.2E-07	1.2E-06	2.9E-08	2.0E-08	6.2E-07
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.0927	0.0183	2.5E-07	7.5E-07	1.5E-07	8.2E-08	2.5E-08	2.6E-07	6.4E-09	4.4E-09	1.4E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.0491	0.0094	5.9E-07	1.8E-06	3.4E-07	2.0E-07	5.9E-08	6.0E-07	1.5E-08	1.0E-08	3.2E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.0491	0.0094	2.8E-08	8.3E-08	1.6E-08	9.3E-09	2.8E-09	2.8E-08	7.1E-10	4.8E-10	1.5E-08
Average Residential		**0.0558**	**0.0110**	**6.9E-07**	**2.1E-06**	**4.0E-07**	**2.2E-07**	**6.9E-08**	**7.0E-07**	**1.7E-08**	**1.2E-08**	**3.7E-07**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.0209	0.0042	2.7E-07	7.9E-07	1.5E-07	8.4E-08	2.6E-08	2.7E-07	6.7E-09	4.6E-09	1.4E-07
Liverpool West Public School	Residential/School	0.0151	0.0030	1.9E-07	5.6E-07	1.1E-07	6.1E-08	1.9E-08	1.9E-07	4.7E-09	3.2E-09	1.0E-07
Liverpool Public School	Residential/School	0.0127	0.0025	1.6E-07	4.7E-07	9.1E-08	5.1E-08	1.6E-08	1.6E-07	4.0E-09	2.7E-09	8.6E-08
Average Residential		**0.0162**	**0.0032**	**2.0E-07**	**6.0E-07**	**1.2E-07**	**6.5E-08**	**2.0E-08**	**2.1E-07**	**5.1E-09**	**3.5E-09**	**1.1E-07**
Lurnea												
Lurnea High School	Residential/School	0.0242	0.0046	2.9E-07	8.6E-07	1.7E-07	9.7E-08	2.9E-08	2.9E-07	7.3E-09	5.0E-09	1.6E-07
St Francis Xavier Primary School Lurnea	Residential/School	0.0187	0.0036	2.3E-07	6.8E-07	1.3E-07	7.5E-08	2.3E-08	2.3E-07	5.8E-09	3.9E-09	1.2E-07
Average Residential		**0.0214**	**0.0041**	**2.6E-07**	**7.7E-07**	**1.5E-07**	**8.6E-08**	**2.6E-08**	**2.6E-07**	**6.5E-09**	**4.5E-09**	**1.4E-07**
Casula												
Lakewood Crescent	Residential	0.0939	0.0184	1.2E-06	3.4E-06	6.6E-07	3.8E-07	1.2E-07	1.2E-06	2.9E-08	2.0E-08	6.2E-07
St Andrews Boulevard	Residential	0.1515	0.0283	1.8E-06	5.3E-06	1.0E-06	6.1E-07	1.8E-07	1.8E-06	4.5E-08	3.1E-08	9.6E-07
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.1418	0.0267	1.7E-06	5.0E-06	9.6E-07	5.7E-07	1.7E-07	1.7E-06	4.2E-08	2.9E-08	9.1E-07
Dunmore Cres	Residential	0.1176	0.0220	1.4E-06	4.1E-06	7.9E-07	4.7E-07	1.4E-07	1.4E-06	3.5E-08	2.4E-08	7.5E-07
Leacocks Lane	Residential	0.0533	0.0099	6.2E-07	1.9E-06	3.6E-07	2.1E-07	6.2E-08	6.3E-07	1.6E-08	1.1E-08	3.4E-07
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.0685	0.0127	8.0E-07	2.4E-06	4.6E-07	2.8E-07	8.0E-08	8.1E-07	2.0E-08	1.4E-08	4.3E-07
Slessor Road	Residential	0.0375	0.0071	4.4E-07	1.3E-06	2.5E-07	1.5E-07	4.4E-08	4.5E-07	1.1E-08	7.6E-09	2.4E-07
Maple Grove Retirement Village	Residential	0.0251	0.0047	3.0E-07	8.8E-07	1.7E-07	1.0E-07	3.0E-08	3.0E-07	7.5E-09	5.1E-09	1.6E-07
All Saints Catholic Senior College	Residential/School	0.0692	0.0128	8.1E-07	2.4E-06	4.6E-07	2.8E-07	8.1E-08	8.2E-07	2.0E-08	1.4E-08	4.4E-07
Casula High School	Residential/School	0.0249	0.0047	3.0E-07	8.7E-07	1.7E-07	1.0E-07	2.9E-08	3.0E-07	7.4E-09	5.1E-09	1.6E-07
Casula Public School	Residential/School	0.0628	0.0119	7.5E-07	2.2E-06	4.3E-07	2.5E-07	7.5E-08	7.6E-07	1.9E-08	1.3E-08	4.0E-07
Casula Powerhouse Arts Centre	Recreational	0.1366	0.0255	7.5E-08	2.2E-07	4.3E-08	4.8E-09	7.5E-09	7.6E-08	1.9E-09	1.3E-09	4.1E-08
Average Residential		**0.0819**	**0.0154**	**9.7E-07**	**2.9E-06**	**5.6E-07**	**3.3E-07**	**9.7E-08**	**9.8E-07**	**2.4E-08**	**1.7E-08**	**5.2E-07**
Glenfield												
Canterbury Road	Residential	0.0189	0.0036	2.3E-07	6.7E-07	1.3E-07	7.6E-08	2.3E-08	2.3E-07	5.7E-09	3.9E-09	1.2E-07
Ferguson Street	Residential	0.0209	0.0040	2.5E-07	7.4E-07	1.4E-07	8.4E-08	2.5E-08	2.5E-07	6.3E-09	4.3E-09	1.4E-07
Good enough St (Receptor 4 in Simta Report)	Residential	0.0264	0.0050	3.2E-07	9.4E-07	1.8E-07	1.1E-07	3.2E-08	3.2E-07	8.0E-09	5.4E-09	1.7E-07
Cambridge Avenue	Residential	0.0256	0.0049	3.1E-07	9.1E-07	1.8E-07	1.0E-07	3.1E-08	3.1E-07	7.8E-09	5.3E-09	1.7E-07
Glenwood Public School	Residential/School	0.0146	0.0028	1.8E-07	5.2E-07	1.0E-07	5.9E-08	1.8E-08	1.8E-07	4.4E-09	3.0E-09	9.5E-08
Glenfield Public School	Residential/School	0.0139	0.0027	1.7E-07	5.0E-07	9.6E-08	5.6E-08	1.7E-08	1.7E-07	4.2E-09	2.9E-09	9.0E-08
Hurlstone Agricultural High School	Residential/School	0.0130	0.0025	1.6E-07	4.7E-07	9.0E-08	5.2E-08	1.6E-08	1.6E-07	4.0E-09	2.7E-09	8.5E-08
Glenfield new land release	Residential	0.0248	0.0047	3.0E-07	8.8E-07	1.7E-07	1.0E-07	3.0E-08	3.0E-07	7.5E-09	5.1E-09	1.6E-07
Playground Learning Centre, Chesham Parade	Residential	0.0145	0.0028	1.7E-07	5.2E-07	1.0E-07	5.8E-08	1.7E-08	1.8E-07	4.4E-09	3.0E-09	9.4E-08
Average Residential		**0.0192**	**0.0037**	**2.3E-07**	**6.8E-07**	**1.3E-07**	**7.7E-08**	**2.3E-08**	**2.3E-07**	**5.8E-09**	**4.0E-09**	**1.2E-07**
Macquarie Fields												
Hickory Place	Residential	0.0088	0.0017	1.1E-07	3.1E-07	6.1E-08	3.5E-08	1.1E-08	1.1E-07	2.7E-09	1.8E-09	5.7E-08
Maximum residential receptors		**0.1515**	**0.0283**	**1.8E-06**	**5.3E-06**	**1.0E-06**	**6.1E-07**	**1.8E-07**	**1.8E-06**	**4.5E-08**	**3.1E-08**	**9.6E-07**
Maximum school receptors		**0.0692**	**0.0128**	**8.1E-07**	**2.4E-06**	**4.6E-07**	**2.8E-07**	**8.1E-08**	**8.2E-07**	**2.0E-08**	**1.4E-08**	**4.4E-07**
Maximum recreational receptors		**0.1366**	**0.0255**	**7.5E-08**	**2.2E-07**	**4.3E-08**	**9.3E-09**	**7.5E-09**	**7.6E-08**	**1.9E-09**	**1.3E-09**	**4.1E-08**
Maximum commercial/industrial receptors		**1.3550**	**0.2570**	**3.6E-06**	**1.1E-05**	**2.0E-06**	**1.2E-06**	**3.6E-07**	**3.6E-06**	**9.0E-08**	**6.1E-08**	**1.9E-06**

Quantification of Effects - PM2.5 and PM10
Northern Rail Access - Phase B

Particulate Fraction:	**PM2.5**	**PM2.5**	**PM2.5**	**PM10**	**PM2.5**	**PM2.5**	**PM2.5**	**PM2.5**	**Incremental Risk -DPM**
Endpoint:	**Mortality - All Causes**	**Hospitalisations - Cardiovascular**	**Hospitalisations - Respiratory**	**Mortality - All Causes**	**Mortality - All Causes**	**Mortality - Cardiopulmonary**	**Mortality - Cardiovascular**	**Mortality - Respiratory**	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		**Increase in Annual Average PM10 Concentration (µg/m³)**	**Increase in Annual Average PM2.5 Concentration (µg/m³)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk**
Maximum Receptor												
Boundary location	**Commercial/Industrial**	1.0649	0.6256	**8.7E-06**	**2.6E-05**	**5.0E-06**	**9.4E-07**	**8.7E-07**	**8.8E-06**	**2.2E-07**	**1.5E-07**	**4.7E-06**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.0591	0.0370	2.3E-06	6.9E-06	1.3E-06	2.4E-07	2.3E-07	2.4E-06	5.9E-08	4.0E-08	1.3E-06
Corryton Ct	Residential	0.0729	0.0426	2.7E-06	8.0E-06	1.5E-06	2.9E-07	2.7E-07	2.7E-06	6.8E-08	4.6E-08	1.4E-06
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.0760	0.0422	2.7E-06	7.9E-06	1.5E-06	3.1E-07	2.7E-07	2.7E-06	6.7E-08	4.6E-08	1.4E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.1042	0.0517	3.3E-06	9.7E-06	1.9E-06	4.2E-07	3.3E-07	3.3E-06	8.2E-08	5.6E-08	1.8E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1042	0.0517	7.2E-07	2.1E-06	4.1E-07	9.2E-08	7.2E-08	7.3E-07	1.8E-08	1.2E-08	3.9E-07
Yallum Cres (Receptor 1 in Simta report)	Residential	0.0719	0.0441	2.8E-06	8.2E-06	1.6E-06	2.9E-07	2.8E-07	2.8E-06	7.0E-08	4.8E-08	1.5E-06
Wattle Grove Public School	Residential/School	0.0581	0.0337	2.1E-06	6.3E-06	1.2E-06	2.3E-07	2.1E-07	2.1E-06	5.4E-08	3.7E-08	1.1E-06
St Marks Coptic College	Residential/School	0.0437	0.0239	1.5E-06	4.5E-06	8.6E-07	1.8E-07	1.5E-07	1.5E-06	3.8E-08	2.6E-08	8.1E-07
Anzac Creek Park	Residential	0.0533	0.0279	1.8E-06	5.2E-06	1.0E-06	2.1E-07	1.8E-07	1.8E-06	4.4E-08	3.0E-08	9.5E-07
Anzac Creek Park	Recreational	0.0533	0.0279	8.3E-08	2.4E-07	4.7E-08	1.0E-08	8.2E-09	8.3E-08	2.1E-09	1.4E-09	4.5E-08
Moorebank Ave	Commercial/Industrial	0.7590	0.4728	6.6E-06	1.9E-05	3.8E-06	6.7E-07	6.6E-07	6.6E-06	1.7E-07	1.1E-07	3.5E-06
DNSDC proposed relocation	Commercial/Industrial	0.0934	0.0501	6.9E-07	2.1E-06	4.0E-07	8.3E-08	6.9E-08	7.0E-07	1.8E-08	1.2E-08	3.7E-07
Average Residential		**0.0658**	**0.0368**	**2.3E-06**	**6.9E-06**	**1.3E-06**	**2.6E-07**	**2.3E-07**	**2.3E-06**	**5.9E-08**	**4.0E-08**	**1.3E-06**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.0428	0.0233	1.5E-06	4.3E-06	8.4E-07	1.7E-07	1.5E-07	1.5E-06	3.7E-08	2.5E-08	7.9E-07
Anzac Road (Receptor 2 in Simta report)	Residential	0.1042	0.0517	3.3E-06	9.7E-06	1.9E-06	4.2E-07	3.3E-07	3.3E-06	8.2E-08	5.6E-08	1.8E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1042	0.0517	7.2E-07	2.1E-06	4.1E-07	9.2E-08	7.2E-08	7.3E-07	1.8E-08	1.2E-08	3.9E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.0533	0.0279	1.8E-06	5.2E-06	1.0E-06	2.1E-07	1.8E-07	1.8E-06	4.4E-08	3.0E-08	9.5E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.0533	0.0279	8.3E-08	2.4E-07	4.7E-08	1.0E-08	8.2E-09	8.3E-08	2.1E-09	1.4E-09	4.5E-08
Average Residential		**0.0634**	**0.0327**	**2.1E-06**	**6.1E-06**	**1.2E-06**	**2.5E-07**	**2.1E-07**	**2.1E-06**	**5.2E-08**	**3.5E-08**	**1.1E-06**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.0266	0.0153	9.7E-07	2.9E-06	5.5E-07	1.1E-07	9.6E-08	9.8E-07	2.4E-08	1.7E-08	5.2E-07
Liverpool West Public School	Residential/School	0.0180	0.0103	6.5E-07	1.9E-06	3.7E-07	7.2E-08	6.5E-08	6.6E-07	1.6E-08	1.1E-08	3.5E-07
Liverpool Public School	Residential/School	0.0156	0.0091	5.7E-07	1.7E-06	3.3E-07	6.3E-08	5.7E-08	5.8E-07	1.5E-08	9.9E-09	3.1E-07
Average Residential		**0.0201**	**0.0116**	**7.3E-07**	**2.2E-06**	**4.2E-07**	**8.1E-08**	**7.3E-08**	**7.4E-07**	**1.8E-08**	**1.3E-08**	**3.9E-07**
Lurnea												
Lurnea High School	Residential/School	0.0255	0.0136	8.6E-07	2.5E-06	4.9E-07	1.0E-07	8.6E-08	8.7E-07	2.2E-08	1.5E-08	4.6E-07
St Francis Xavier Primary School Lurnea	Residential/School	0.0212	0.0118	7.4E-07	2.2E-06	4.3E-07	8.5E-08	7.4E-08	7.5E-07	1.9E-08	1.3E-08	4.0E-07
Average Residential		**0.0234**	**0.0127**	**8.0E-07**	**2.4E-06**	**4.6E-07**	**9.4E-08**	**8.0E-08**	**8.1E-07**	**2.0E-08**	**1.4E-08**	**4.3E-07**
Casula												
Lakewood Crescent	Residential	0.2146	0.1660	1.0E-05	3.1E-05	6.0E-06	8.6E-07	1.0E-06	1.1E-05	2.6E-07	1.8E-07	5.6E-06
St Andrews Boulevard	Residential	0.1314	0.0792	5.0E-06	1.5E-05	2.9E-06	5.3E-07	5.0E-07	5.0E-06	1.3E-07	8.6E-08	2.7E-06
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.1350	0.0727	4.6E-06	1.4E-05	2.6E-06	5.4E-07	4.6E-07	4.6E-06	1.2E-07	7.9E-08	2.5E-06
Dunmore Cres	Residential	0.1350	0.0741	4.7E-06	1.4E-05	2.7E-06	5.4E-07	4.7E-07	4.7E-06	1.2E-07	8.0E-08	2.5E-06
Leacocks Lane	Residential	0.0499	0.0247	1.6E-06	4.6E-06	8.9E-07	2.0E-07	1.6E-07	1.6E-06	3.9E-08	2.7E-08	8.4E-07
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.0702	0.0370	2.3E-06	6.9E-06	1.3E-06	2.8E-07	2.3E-07	2.4E-06	5.9E-08	4.0E-08	1.3E-06
Slessor Road	Residential	0.0438	0.0279	1.8E-06	5.2E-06	1.0E-06	1.8E-07	1.8E-07	1.8E-06	4.4E-08	3.0E-08	9.5E-07
Maple Grove Retirement Village	Residential	0.0256	0.0137	8.6E-07	2.6E-06	5.0E-07	1.0E-07	8.6E-08	8.7E-07	2.2E-08	1.5E-08	4.7E-07
All Saints Catholic Senior College	Residential/School	0.0692	0.0352	2.2E-06	6.6E-06	1.3E-06	2.8E-07	2.2E-07	2.2E-06	5.6E-08	3.8E-08	1.2E-06
Casula High School	Residential/School	0.0239	0.0123	7.8E-07	2.3E-06	4.5E-07	9.6E-08	7.8E-08	7.9E-07	2.0E-08	1.3E-08	4.2E-07
Casula Public School	Residential/School	0.0648	0.0351	2.2E-06	6.6E-06	1.3E-06	2.6E-07	2.2E-07	2.2E-06	5.6E-08	3.8E-08	1.2E-06
Casula Powerhouse Arts Centre	Recreational	0.1652	0.0919	2.7E-07	8.1E-07	1.6E-07	1.7E-08	2.7E-08	2.8E-07	6.9E-09	4.7E-09	1.5E-07
Average Residential		**0.0940**	**0.0558**	**3.5E-06**	**1.0E-05**	**2.0E-06**	**3.8E-07**	**3.5E-07**	**3.6E-06**	**8.9E-08**	**6.0E-08**	**1.9E-06**
Glenfield												
Canterbury Road	Residential	0.0234	0.0154	9.7E-07	2.9E-06	5.6E-07	9.4E-08	9.7E-08	9.8E-07	2.4E-08	1.7E-08	5.2E-07
Ferguson Street	Residential	0.0265	0.0174	1.1E-06	3.2E-06	6.3E-07	1.1E-07	1.1E-07	1.1E-06	2.8E-08	1.9E-08	5.9E-07
Good enough St (Receptor 4 in Simta Report)	Residential	0.0339	0.0228	1.4E-06	4.3E-06	8.2E-07	1.4E-07	1.4E-07	1.5E-06	3.6E-08	2.5E-08	7.7E-07
Cambridge Avenue	Residential	0.0314	0.0208	1.3E-06	3.9E-06	7.5E-07	1.3E-07	1.3E-07	1.3E-06	3.3E-08	2.3E-08	7.1E-07
Glenwood Public School	Residential/School	0.0174	0.0107	6.7E-07	2.0E-06	3.9E-07	7.0E-08	6.7E-08	6.8E-07	1.7E-08	1.2E-08	3.6E-07
Glenfield Public School	Residential/School	0.0170	0.0110	6.9E-07	2.1E-06	4.0E-07	6.8E-08	6.9E-08	7.0E-07	1.7E-08	1.2E-08	3.7E-07
Hurlstone Agricultural High School	Residential/School	0.0150	0.0095	6.0E-07	1.8E-06	3.4E-07	6.0E-08	6.0E-08	6.1E-07	1.5E-08	1.0E-08	3.2E-07
Glenfield new land release	Residential	0.0297	0.0192	1.2E-06	3.6E-06	6.9E-07	1.2E-07	1.2E-07	1.2E-06	3.1E-08	2.1E-08	6.5E-07
Playground Learning Centre, Chesham Parade	Residential	0.0178	0.0115	7.3E-07	2.2E-06	4.2E-07	7.2E-08	7.2E-08	7.3E-07	1.8E-08	1.2E-08	3.9E-07
Average Residential		**0.0236**	**0.0154**	**9.7E-07**	**2.9E-06**	**5.5E-07**	**9.5E-08**	**9.7E-08**	**9.8E-07**	**2.4E-08**	**1.7E-08**	**5.2E-07**
Macquarie Fields												
Hickory Place	Residential	0.0095	0.0057	3.6E-07	1.1E-06	2.0E-07	3.8E-08	3.6E-08	3.6E-07	9.0E-09	6.1E-09	1.9E-07
Maximum residential receptors		**0.2146**	**0.1660**	**1.0E-05**	**3.1E-05**	**6.0E-06**	**8.6E-07**	**1.0E-06**	**1.1E-05**	**2.6E-07**	**1.8E-07**	**5.6E-06**
Maximum school receptors		**0.0692**	**0.0352**	**2.2E-06**	**6.6E-06**	**1.3E-06**	**2.8E-07**	**2.2E-07**	**2.2E-06**	**5.6E-08**	**3.8E-08**	**1.2E-06**
Maximum recreational receptors		**0.1652**	**0.0919**	**2.7E-07**	**8.1E-07**	**1.6E-07**	**1.7E-08**	**2.7E-08**	**2.8E-07**	**6.9E-09**	**4.7E-09**	**1.5E-07**
Maximum commercial/industrial receptors		**1.0649**	**0.6256**	**8.7E-06**	**2.6E-05**	**5.0E-06**	**9.4E-07**	**8.7E-07**	**8.8E-06**	**2.2E-07**	**1.5E-07**	**4.7E-06**

Quantification of Effects - PM2.5 and PM10
Northern Rail Access - Phase C

Particulate Fraction:	**PM2.5**	**PM2.5**	**PM2.5**	**PM10**	**PM2.5**	**PM2.5**	**PM2.5**	**PM2.5**	**Incremental Risk -DPM**
Endpoint:	**Mortality - All Causes**	**Hospitalisations - Cardiovascular**	**Hospitalisations - Respiratory**	**Mortality - All Causes**	**Mortality - All Causes**	**Mortality - Cardiopulmonary**	**Mortality - Cardiovascular**	**Mortality - Respiratory**	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		**Increase in Annual Average PM10 Concentration (µg/m³)**	**Increase in Annual Average PM2.5 Concentration (µg/m³)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk**
Maximum Receptor												
Boundary location	**Commercial/Industrial**	1.2546	1.1500	**1.6E-05**	**4.7E-05**	**9.1E-06**	**1.1E-06**	**1.6E-06**	**1.6E-05**	**4.0E-07**	**2.7E-07**	**8.6E-06**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.1015	0.0709	4.5E-06	1.3E-05	2.6E-06	4.1E-07	4.5E-07	4.5E-06	1.1E-07	7.7E-08	2.4E-06
Corryton Ct	Residential	0.1085	0.0816	5.1E-06	1.5E-05	2.9E-06	4.4E-07	5.1E-07	5.2E-06	1.3E-07	8.8E-08	2.8E-06
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.1067	0.0818	5.2E-06	1.5E-05	3.0E-06	4.3E-07	5.2E-07	5.2E-06	1.3E-07	8.9E-08	2.8E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.1486	0.1158	7.3E-06	2.2E-05	4.2E-06	6.0E-07	7.3E-07	7.4E-06	1.8E-07	1.3E-07	3.9E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1486	0.1158	1.6E-06	4.8E-06	9.2E-07	1.3E-07	1.6E-07	1.6E-06	4.1E-08	2.8E-08	8.7E-07
Yallum Cres (Receptor 1 in Simta report)	Residential	0.1153	0.0835	5.3E-06	1.6E-05	3.0E-06	4.6E-07	5.3E-07	5.3E-06	1.3E-07	9.0E-08	2.8E-06
Wattle Grove Public School	Residential/School	0.0878	0.0646	4.1E-06	1.2E-05	2.3E-06	3.5E-07	4.1E-07	4.1E-06	1.0E-07	7.0E-08	2.2E-06
St Marks Coptic College	Residential/School	0.0628	0.0458	2.9E-06	8.6E-06	1.7E-06	2.5E-07	2.9E-07	2.9E-06	7.3E-08	5.0E-08	1.6E-06
Anzac Creek Park	Residential	0.0746	0.0576	3.6E-06	1.1E-05	2.1E-06	3.0E-07	3.6E-07	3.7E-06	9.2E-08	6.2E-08	2.0E-06
Anzac Creek Park	Recreational	0.0746	0.0576	1.7E-07	5.1E-07	9.8E-08	1.4E-08	1.7E-08	1.7E-07	4.3E-09	2.9E-09	9.2E-08
Moorebank Ave	Commercial/Industrial	0.9353	0.8391	1.2E-05	3.4E-05	6.7E-06	8.3E-07	1.2E-06	1.2E-05	2.9E-07	2.0E-07	6.3E-06
DNSDC proposed relocation	Commercial/Industrial	0.1309	0.1026	1.4E-06	4.2E-06	8.1E-07	1.2E-07	1.4E-07	1.4E-06	3.6E-08	2.4E-08	7.7E-07
Average Residential		**0.0978**	**0.0733**	**4.6E-06**	**1.4E-05**	**2.6E-06**	**3.9E-07**	**4.6E-07**	**4.7E-06**	**1.2E-07**	**7.9E-08**	**2.5E-06**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.0625	0.0509	3.2E-06	9.5E-06	1.8E-06	2.5E-07	3.2E-07	3.2E-06	8.1E-08	5.5E-08	1.7E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.1486	0.1158	7.3E-06	2.2E-05	4.2E-06	6.0E-07	7.3E-07	7.4E-06	1.8E-07	1.3E-07	3.9E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1486	0.1158	1.6E-06	4.8E-06	9.2E-07	1.3E-07	1.6E-07	1.6E-06	4.1E-08	2.8E-08	8.7E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.0746	0.0576	3.6E-06	1.1E-05	2.1E-06	3.0E-07	3.6E-07	3.7E-06	9.2E-08	6.2E-08	2.0E-06
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.0746	0.0576	1.7E-07	5.1E-07	9.8E-08	1.4E-08	1.7E-08	1.7E-07	4.3E-09	2.9E-09	9.2E-08
Average Residential		**0.0901**	**0.0705**	**4.4E-06**	**1.3E-05**	**2.5E-06**	**3.6E-07**	**4.4E-07**	**4.5E-06**	**1.1E-07**	**7.6E-08**	**2.4E-06**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.0416	0.0338	2.1E-06	6.3E-06	1.2E-06	1.7E-07	2.1E-07	2.2E-06	5.4E-08	3.7E-08	1.1E-06
Liverpool West Public School	Residential/School	0.0277	0.0219	1.4E-06	4.1E-06	7.9E-07	1.1E-07	1.4E-07	1.4E-06	3.5E-08	2.4E-08	7.4E-07
Liverpool Public School	Residential/School	0.0247	0.0199	1.3E-06	3.7E-06	7.2E-07	9.9E-08	1.3E-07	1.3E-06	3.2E-08	2.1E-08	6.7E-07
Average Residential		**0.0313**	**0.0252**	**1.6E-06**	**4.7E-06**	**9.1E-07**	**1.3E-07**	**1.6E-07**	**1.6E-06**	**4.0E-08**	**2.7E-08**	**8.6E-07**
Lurnea												
Lurnea High School	Residential/School	0.0368	0.0267	1.7E-06	5.0E-06	9.7E-07	1.5E-07	1.7E-07	1.7E-06	4.3E-08	2.9E-08	9.1E-07
St Francis Xavier Primary School Lurnea	Residential/School	0.0315	0.0242	1.5E-06	4.5E-06	8.7E-07	1.3E-07	1.5E-07	1.5E-06	3.8E-08	2.6E-08	8.2E-07
Average Residential		**0.0342**	**0.0255**	**1.6E-06**	**4.8E-06**	**9.2E-07**	**1.4E-07**	**1.6E-07**	**1.6E-06**	**4.0E-08**	**2.8E-08**	**8.7E-07**
Casula												
Lakewood Crescent	Residential	0.3547	0.3168	2.0E-05	5.9E-05	1.1E-05	1.4E-06	2.0E-06	2.0E-05	5.0E-07	3.4E-07	1.1E-05
St Andrews Boulevard	Residential	0.2301	0.1779	1.1E-05	3.3E-05	6.4E-06	9.3E-07	1.1E-06	1.1E-05	2.8E-07	1.9E-07	6.0E-06
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.2351	0.1719	1.1E-05	3.2E-05	6.2E-06	9.5E-07	1.1E-06	1.1E-05	2.7E-07	1.9E-07	5.8E-06
Dunmore Cres	Residential	0.2170	0.1587	1.0E-05	3.0E-05	5.7E-06	8.7E-07	1.0E-06	1.0E-05	2.5E-07	1.7E-07	5.4E-06
Leacocks Lane	Residential	0.0719	0.0470	3.0E-06	8.8E-06	1.7E-06	2.9E-07	3.0E-07	3.0E-06	7.5E-08	5.1E-08	1.6E-06
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.1055	0.0702	4.4E-06	1.3E-05	2.5E-06	4.2E-07	4.4E-07	4.5E-06	1.1E-07	7.6E-08	2.4E-06
Slessor Road	Residential	0.0762	0.0551	3.5E-06	1.0E-05	2.0E-06	3.1E-07	3.5E-07	3.5E-06	8.8E-08	6.0E-08	1.9E-06
Maple Grove Retirement Village	Residential	0.0385	0.0268	1.7E-06	5.0E-06	9.7E-07	1.5E-07	1.7E-07	1.7E-06	4.3E-08	2.9E-08	9.1E-07
All Saints Catholic Senior College	Residential/School	0.1012	0.0667	4.2E-06	1.2E-05	2.4E-06	4.1E-07	4.2E-07	4.2E-06	1.1E-07	7.2E-08	2.3E-06
Casula High School	Residential/School	0.0351	0.0241	1.5E-06	4.5E-06	8.7E-07	1.4E-07	1.5E-07	1.5E-06	3.8E-08	2.6E-08	8.2E-07
Casula Public School	Residential/School	0.0973	0.0722	4.6E-06	1.3E-05	2.6E-06	3.9E-07	4.5E-07	4.6E-06	1.1E-07	7.8E-08	2.5E-06
Casula Powerhouse Arts Centre	Recreational	0.2735	0.1994	5.9E-07	1.8E-06	3.4E-07	3.8E-08	5.9E-08	6.0E-07	1.5E-08	1.0E-08	3.2E-07
Average Residential		**0.1530**	**0.1156**	**7.3E-06**	**2.2E-05**	**4.2E-06**	**6.2E-07**	**7.3E-07**	**7.4E-06**	**1.8E-07**	**1.3E-07**	**3.9E-06**
Glenfield												
Canterbury Road	Residential	0.0418	0.0305	1.9E-06	5.7E-06	1.1E-06	1.7E-07	1.9E-07	1.9E-06	4.8E-08	3.3E-08	1.0E-06
Ferguson Street	Residential	0.0473	0.0340	2.1E-06	6.4E-06	1.2E-06	1.9E-07	2.1E-07	2.2E-06	5.4E-08	3.7E-08	1.2E-06
Good enough St (Receptor 4 in Simta Report)	Residential	0.0618	0.0446	2.8E-06	8.3E-06	1.6E-06	2.5E-07	2.8E-07	2.8E-06	7.1E-08	4.8E-08	1.5E-06
Cambridge Avenue	Residential	0.0582	0.0412	2.6E-06	7.7E-06	1.5E-06	2.3E-07	2.6E-07	2.6E-06	6.5E-08	4.5E-08	1.4E-06
Glenwood Public School	Residential/School	0.0280	0.0203	1.3E-06	3.8E-06	7.3E-07	1.1E-07	1.3E-07	1.3E-06	3.2E-08	2.2E-08	6.9E-07
Glenfield Public School	Residential/School	0.0296	0.0218	1.4E-06	4.1E-06	7.9E-07	1.2E-07	1.4E-07	1.4E-06	3.5E-08	2.4E-08	7.4E-07
Hurlstone Agricultural High School	Residential/School	0.0257	0.0188	1.2E-06	3.5E-06	6.8E-07	1.0E-07	1.2E-07	1.2E-06	3.0E-08	2.0E-08	6.4E-07
Glenfield new land release	Residential	0.0526	0.0382	2.4E-06	7.1E-06	1.4E-06	2.1E-07	2.4E-07	2.4E-06	6.1E-08	4.1E-08	1.3E-06
Playground Learning Centre, Chesham Parade	Residential	0.0310	0.0227	1.4E-06	4.2E-06	8.2E-07	1.2E-07	1.4E-07	1.4E-06	3.6E-08	2.5E-08	7.7E-07
Average Residential		**0.0418**	**0.0302**	**1.9E-06**	**5.6E-06**	**1.1E-06**	**1.7E-07**	**1.9E-07**	**1.9E-06**	**4.8E-08**	**3.3E-08**	**1.0E-06**
Macquarie Fields												
Hickory Place	Residential	0.0151	0.0108	6.8E-07	2.0E-06	3.9E-07	6.1E-08	6.8E-08	6.9E-07	1.7E-08	1.2E-08	3.7E-07
Maximum residential receptors		**0.3547**	**0.3168**	**2.0E-05**	**5.9E-05**	**1.1E-05**	**1.4E-06**	**2.0E-06**	**2.0E-05**	**5.0E-07**	**3.4E-07**	**1.1E-05**
Maximum school receptors		**0.1012**	**0.0722**	**4.6E-06**	**1.3E-05**	**2.6E-06**	**4.1E-07**	**4.5E-07**	**4.6E-06**	**1.1E-07**	**7.8E-08**	**2.5E-06**
Maximum recreational receptors		**0.2735**	**0.1994**	**5.9E-07**	**1.8E-06**	**3.4E-07**	**3.8E-08**	**5.9E-08**	**6.0E-07**	**1.5E-08**	**1.0E-08**	**3.2E-07**
Maximum commercial/industrial receptors		**1.2546**	**1.1500**	**1.6E-05**	**4.7E-05**	**9.1E-06**	**1.1E-06**	**1.6E-06**	**1.6E-05**	**4.0E-07**	**2.7E-07**	**8.6E-06**

Quantification of Effects - PM2.5 and PM10
Northern Rail Access - Phase D

Particulate Fraction:	**PM2.5**	**PM2.5**	**PM2.5**	**PM10**	**PM2.5**	**PM2.5**	**PM2.5**	**PM2.5**	**Incremental Risk -DPM**
Endpoint:	**Mortality - All Causes**	**Hospitalisations - Cardiovascular**	**Hospitalisations - Respiratory**	**Mortality - All Causes**	**Mortality - All Causes**	**Mortality - Cardiopulmonary**	**Mortality - Cardiovascular**	**Mortality - Respiratory**	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		**Increase in Annual Average PM10 Concentration (µg/m³)**	**Increase in Annual Average PM2.5 Concentration (µg/m³)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk**
Maximum Receptor												
Boundary location	**Commercial/Industrial**	0.9996	0.9836	**1.4E-05**	**4.0E-05**	**7.8E-06**	**8.8E-07**	**1.4E-06**	**1.4E-05**	**3.4E-07**	**2.3E-07**	**7.4E-06**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.0775	0.0761	4.8E-06	1.4E-05	2.7E-06	3.1E-07	4.8E-07	4.8E-06	1.2E-07	8.2E-08	2.6E-06
Corryton Ct	Residential	0.0868	0.0852	5.4E-06	1.6E-05	3.1E-06	3.5E-07	5.4E-07	5.4E-06	1.4E-07	9.2E-08	2.9E-06
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.0864	0.0849	5.3E-06	1.6E-05	3.1E-06	3.5E-07	5.3E-07	5.4E-06	1.3E-07	9.2E-08	2.9E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.1285	0.1261	8.0E-06	2.4E-05	4.6E-06	5.2E-07	7.9E-07	8.0E-06	2.0E-07	1.4E-07	4.3E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1285	0.1261	1.7E-06	5.2E-06	1.0E-06	1.1E-07	1.7E-07	1.8E-06	4.4E-08	3.0E-08	9.4E-07
Yallum Cres (Receptor 1 in Simta report)	Residential	0.0906	0.0889	5.6E-06	1.7E-05	3.2E-06	3.6E-07	5.6E-07	5.7E-06	1.4E-07	9.6E-08	3.0E-06
Wattle Grove Public School	Residential/School	0.0695	0.0682	4.3E-06	1.3E-05	2.5E-06	2.8E-07	4.3E-07	4.3E-06	1.1E-07	7.4E-08	2.3E-06
St Marks Coptic College	Residential/School	0.0492	0.0483	3.0E-06	9.0E-06	1.7E-06	2.0E-07	3.0E-07	3.1E-06	7.7E-08	5.2E-08	1.6E-06
Anzac Creek Park	Residential	0.0633	0.0621	3.9E-06	1.2E-05	2.2E-06	2.5E-07	3.9E-07	4.0E-06	9.9E-08	6.7E-08	2.1E-06
Anzac Creek Park	Recreational	0.0633	0.0621	1.8E-07	5.5E-07	1.1E-07	1.2E-08	1.8E-08	1.9E-07	4.6E-09	3.2E-09	9.9E-08
Moorebank Ave	Commercial/Industrial	0.7849	0.7713	1.1E-05	3.2E-05	6.1E-06	6.9E-07	1.1E-06	1.1E-05	2.7E-07	1.8E-07	5.8E-06
DNSDC proposed relocation	Commercial/Industrial	0.1095	0.1075	1.5E-06	4.4E-06	8.5E-07	9.7E-08	1.5E-07	1.5E-06	3.8E-08	2.6E-08	8.0E-07
Average Residential		**0.0794**	**0.0780**	**4.9E-06**	**1.5E-05**	**2.8E-06**	**3.2E-07**	**4.9E-07**	**5.0E-06**	**1.2E-07**	**8.4E-08**	**2.7E-06**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.0573	0.0562	3.5E-06	1.0E-05	2.0E-06	2.3E-07	3.5E-07	3.6E-06	8.9E-08	6.1E-08	1.9E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.1285	0.1261	8.0E-06	2.4E-05	4.6E-06	5.2E-07	7.9E-07	8.0E-06	2.0E-07	1.4E-07	4.3E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.1285	0.1261	1.7E-06	5.2E-06	1.0E-06	1.1E-07	1.7E-07	1.8E-06	4.4E-08	3.0E-08	9.4E-07
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.0633	0.0621	3.9E-06	1.2E-05	2.2E-06	2.5E-07	3.9E-07	4.0E-06	9.9E-08	6.7E-08	2.1E-06
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.0633	0.0621	1.8E-07	5.5E-07	1.1E-07	1.2E-08	1.8E-08	1.9E-07	4.6E-09	3.2E-09	9.9E-08
Average Residential		**0.0781**	**0.0766**	**4.8E-06**	**1.4E-05**	**2.8E-06**	**3.1E-07**	**4.8E-07**	**4.9E-06**	**1.2E-07**	**8.3E-08**	**2.6E-06**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.0385	0.0377	2.4E-06	7.1E-06	1.4E-06	1.5E-07	2.4E-07	2.4E-06	6.0E-08	4.1E-08	1.3E-06
Liverpool West Public School	Residential/School	0.0252	0.0248	1.6E-06	4.6E-06	8.9E-07	1.0E-07	1.6E-07	1.6E-06	3.9E-08	2.7E-08	8.4E-07
Liverpool Public School	Residential/School	0.0227	0.0222	1.4E-06	4.2E-06	8.0E-07	9.1E-08	1.4E-07	1.4E-06	3.5E-08	2.4E-08	7.6E-07
Average Residential		**0.0288**	**0.0282**	**1.8E-06**	**5.3E-06**	**1.0E-06**	**1.2E-07**	**1.8E-07**	**1.8E-06**	**4.5E-08**	**3.1E-08**	**9.6E-07**
Lurnea												
Lurnea High School	Residential/School	0.0313	0.0307	1.9E-06	5.7E-06	1.1E-06	1.3E-07	1.9E-07	2.0E-06	4.9E-08	3.3E-08	1.0E-06
St Francis Xavier Primary School Lurnea	Residential/School	0.0281	0.0275	1.7E-06	5.1E-06	9.9E-07	1.1E-07	1.7E-07	1.8E-06	4.4E-08	3.0E-08	9.4E-07
Average Residential		**0.0297**	**0.0291**	**1.8E-06**	**5.4E-06**	**1.1E-06**	**1.2E-07**	**1.8E-07**	**1.9E-06**	**4.6E-08**	**3.2E-08**	**9.9E-07**
Casula												
Lakewood Crescent	Residential	0.2479	0.2419	1.5E-05	4.5E-05	8.7E-06	1.0E-06	1.5E-06	1.5E-05	3.8E-07	2.6E-07	8.2E-06
St Andrews Boulevard	Residential	0.1975	0.1934	1.2E-05	3.6E-05	7.0E-06	7.9E-07	1.2E-06	1.2E-05	3.1E-07	2.1E-07	6.6E-06
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.2212	0.2169	1.4E-05	4.1E-05	7.8E-06	8.9E-07	1.4E-06	1.4E-05	3.5E-07	2.3E-07	7.4E-06
Dunmore Cres	Residential	0.2050	0.2012	1.3E-05	3.8E-05	7.3E-06	8.2E-07	1.3E-06	1.3E-05	3.2E-07	2.2E-07	6.8E-06
Leacocks Lane	Residential	0.0559	0.0549	3.5E-06	1.0E-05	2.0E-06	2.2E-07	3.5E-07	3.5E-06	8.7E-08	5.9E-08	1.9E-06
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.0825	0.0810	5.1E-06	1.5E-05	2.9E-06	3.3E-07	5.1E-07	5.2E-06	1.3E-07	8.8E-08	2.8E-06
Slessor Road	Residential	0.0652	0.0640	4.0E-06	1.2E-05	2.3E-06	2.6E-07	4.0E-07	4.1E-06	1.0E-07	6.9E-08	2.2E-06
Maple Grove Retirement Village	Residential	0.0311	0.0305	1.9E-06	5.7E-06	1.1E-06	1.2E-07	1.9E-07	1.9E-06	4.8E-08	3.3E-08	1.0E-06
All Saints Catholic Senior College	Residential/School	0.0793	0.0778	4.9E-06	1.5E-05	2.8E-06	3.2E-07	4.9E-07	5.0E-06	1.2E-07	8.4E-08	2.6E-06
Casula High School	Residential/School	0.0281	0.0276	1.7E-06	5.2E-06	1.0E-06	1.1E-07	1.7E-07	1.8E-06	4.4E-08	3.0E-08	9.4E-07
Casula Public School	Residential/School	0.0863	0.0847	5.3E-06	1.6E-05	3.1E-06	3.5E-07	5.3E-07	5.4E-06	1.3E-07	9.2E-08	2.9E-06
Casula Powerhouse Arts Centre	Recreational	0.2648	0.2599	7.7E-07	2.3E-06	4.4E-07	4.9E-08	7.7E-08	7.8E-07	1.9E-08	1.3E-08	4.2E-07
Average Residential		**0.1304**	**0.1278**	**8.1E-06**	**2.4E-05**	**4.6E-06**	**5.2E-07**	**8.0E-07**	**8.1E-06**	**2.0E-07**	**1.4E-07**	**4.3E-06**
Glenfield												
Canterbury Road	Residential	0.0360	0.0354	2.2E-06	6.6E-06	1.3E-06	1.4E-07	2.2E-07	2.3E-06	5.6E-08	3.8E-08	1.2E-06
Ferguson Street	Residential	0.0405	0.0397	2.5E-06	7.4E-06	1.4E-06	1.6E-07	2.5E-07	2.5E-06	6.3E-08	4.3E-08	1.4E-06
Good enough St (Receptor 4 in Simta Report)	Residential	0.0533	0.0523	3.3E-06	9.8E-06	1.9E-06	2.1E-07	3.3E-07	3.3E-06	8.3E-08	5.7E-08	1.8E-06
Cambridge Avenue	Residential	0.0488	0.0479	3.0E-06	8.9E-06	1.7E-06	2.0E-07	3.0E-07	3.0E-06	7.6E-08	5.2E-08	1.6E-06
Glenwood Public School	Residential/School	0.0238	0.0233	1.5E-06	4.4E-06	8.4E-07	9.6E-08	1.5E-07	1.5E-06	3.7E-08	2.5E-08	7.9E-07
Glenfield Public School	Residential/School	0.0257	0.0252	1.6E-06	4.7E-06	9.1E-07	1.0E-07	1.6E-07	1.6E-06	4.0E-08	2.7E-08	8.6E-07
Hurlstone Agricultural High School	Residential/School	0.0219	0.0215	1.4E-06	4.0E-06	7.8E-07	8.8E-08	1.4E-07	1.4E-06	3.4E-08	2.3E-08	7.3E-07
Glenfield new land release	Residential	0.0452	0.0443	2.8E-06	8.3E-06	1.6E-06	1.8E-07	2.8E-07	2.8E-06	7.0E-08	4.8E-08	1.5E-06
Playground Learning Centre, Chesham Parade	Residential	0.0268	0.0263	1.7E-06	4.9E-06	9.5E-07	1.1E-07	1.7E-07	1.7E-06	4.2E-08	2.8E-08	8.9E-07
Average Residential		**0.0358**	**0.0351**	**2.2E-06**	**6.6E-06**	**1.3E-06**	**1.4E-07**	**2.2E-07**	**2.2E-06**	**5.6E-08**	**3.8E-08**	**1.2E-06**
Macquarie Fields												
Hickory Place	Residential	0.0125	0.0123	7.7E-07	2.3E-06	4.4E-07	5.0E-08	7.7E-08	7.8E-07	2.0E-08	1.3E-08	4.2E-07
Maximum residential receptors		**0.2479**	**0.2419**	**1.5E-05**	**4.5E-05**	**8.7E-06**	**1.0E-06**	**1.5E-06**	**1.5E-05**	**3.8E-07**	**2.6E-07**	**8.2E-06**
Maximum school receptors		**0.0863**	**0.0847**	**5.3E-06**	**1.6E-05**	**3.1E-06**	**3.5E-07**	**5.3E-07**	**5.4E-06**	**1.3E-07**	**9.2E-08**	**2.9E-06**
Maximum recreational receptors		**0.2648**	**0.2599**	**7.7E-07**	**2.3E-06**	**4.4E-07**	**4.9E-08**	**7.7E-08**	**7.8E-07**	**1.9E-08**	**1.3E-08**	**4.2E-07**
Maximum commercial/industrial receptors		**0.9996**	**0.9836**	**1.4E-05**	**4.0E-05**	**7.8E-06**	**8.8E-07**	**1.4E-06**	**1.4E-05**	**3.4E-07**	**2.3E-07**	**7.4E-06**

Quantification of Effects - PM2.5 and PM10
Southern Rail Access - Cumulative Scenario 1

Particulate Fraction:	**PM2.5**	**PM2.5**	**PM2.5**	**PM10**	**PM2.5**	**PM2.5**	**PM2.5**	**PM2.5**	**Incremental Risk -DPM**
Endpoint:	**Mortality - All Causes**	**Hospitalisations - Cardiovascular**	**Hospitalisations - Respiratory**	**Mortality - All Causes**	**Mortality - All Causes**	**Mortality - Cardiopulmonary**	**Mortality - Cardiovascular**	**Mortality - Respiratory**	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		**Increase in Annual Average PM10 Concentration (µg/m³)**	**Increase in Annual Average PM2.5 Concentration (µg/m³)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk**
Maximum Receptor												
Boundary location	**Commercial/Industrial**	2.9	2.8	**3.9E-05**	**1.2E-04**	**2.2E-05**	**2.6E-06**	**3.9E-06**	**3.9E-05**	**9.8E-07**	**6.7E-07**	**2.1E-05**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.17	0.17	1.1E-05	3.1E-05	6.1E-06	6.9E-07	1.1E-06	1.1E-05	2.7E-07	1.8E-07	5.7E-06
Corryton Ct	Residential	0.23	0.22	1.4E-05	4.2E-05	8.1E-06	9.2E-07	1.4E-06	1.4E-05	3.6E-07	2.4E-07	7.6E-06
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.23	0.22	1.4E-05	4.2E-05	8.1E-06	9.3E-07	1.4E-06	1.4E-05	3.6E-07	2.4E-07	7.6E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.28	0.28	1.7E-05	5.2E-05	1.0E-05	1.1E-06	1.7E-06	1.8E-05	4.4E-07	3.0E-07	9.4E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.28	0.28	3.8E-06	1.1E-05	2.2E-06	2.5E-07	3.8E-07	3.9E-06	9.7E-08	6.6E-08	2.1E-06
Yallum Cres (Receptor 1 in Simta report)	Residential	0.22	0.21	1.3E-05	4.0E-05	7.7E-06	8.8E-07	1.3E-06	1.4E-05	3.4E-07	2.3E-07	7.3E-06
Wattle Grove Public School	Residential/School	0.17	0.16	1.0E-05	3.1E-05	5.9E-06	6.8E-07	1.0E-06	1.0E-05	2.6E-07	1.8E-07	5.6E-06
St Marks Coptic College	Residential/School	0.11	0.11	6.9E-06	2.0E-05	3.9E-06	4.5E-07	6.9E-07	6.9E-06	1.7E-07	1.2E-07	3.7E-06
Anzac Creek Park	Residential	0.14	0.14	8.6E-06	2.5E-05	4.9E-06	5.6E-07	8.6E-07	8.7E-06	2.2E-07	1.5E-07	4.6E-06
Anzac Creek Park	Recreational	0.14	0.14	4.0E-07	1.2E-06	2.3E-07	2.6E-08	4.0E-08	4.1E-07	1.0E-08	6.9E-09	2.2E-07
Moorebank Ave	Commercial/Industrial	2.65	2.58	3.6E-05	1.1E-04	2.1E-05	2.3E-06	3.6E-06	3.6E-05	9.0E-07	6.2E-07	1.9E-05
DNSDC proposed relocation	Commercial/Industrial	0.31	0.30	4.2E-06	1.2E-05	2.4E-06	2.7E-07	4.2E-07	4.2E-06	1.1E-07	7.2E-08	2.3E-06
Average Residential		**0.19**	**0.18**	**1.2E-05**	**3.4E-05**	**6.6E-06**	**7.6E-07**	**1.2E-06**	**1.2E-05**	**2.9E-07**	**2.0E-07**	**6.2E-06**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.10	0.10	6.4E-06	1.9E-05	3.7E-06	4.2E-07	6.4E-07	6.5E-06	1.6E-07	1.1E-07	3.5E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.28	0.28	1.7E-05	5.2E-05	1.0E-05	1.1E-06	1.7E-06	1.8E-05	4.4E-07	3.0E-07	9.4E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.28	0.28	3.8E-06	1.1E-05	2.2E-06	2.5E-07	3.8E-07	3.9E-06	9.7E-08	6.6E-08	2.1E-06
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.14	0.14	8.6E-06	2.5E-05	4.9E-06	5.6E-07	8.6E-07	8.7E-06	2.2E-07	1.5E-07	4.6E-06
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.14	0.14	4.0E-07	1.2E-06	2.3E-07	2.6E-08	4.0E-08	4.1E-07	1.0E-08	6.9E-09	2.2E-07
Average Residential		**0.17**	**0.16**	**1.0E-05**	**3.0E-05**	**5.9E-06**	**6.7E-07**	**1.0E-06**	**1.0E-05**	**2.6E-07**	**1.8E-07**	**5.5E-06**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.066	0.064	4.1E-06	1.2E-05	2.3E-06	2.7E-07	4.1E-07	4.1E-06	1.0E-07	7.0E-08	2.2E-06
Liverpool West Public School	Residential/School	0.042	0.041	2.6E-06	7.7E-06	1.5E-06	1.7E-07	2.6E-07	2.6E-06	6.6E-08	4.5E-08	1.4E-06
Liverpool Public School	Residential/School	0.040	0.039	2.5E-06	7.3E-06	1.4E-06	1.6E-07	2.5E-07	2.5E-06	6.2E-08	4.2E-08	1.3E-06
Average Residential		**0.050**	**0.048**	**3.1E-06**	**9.0E-06**	**1.7E-06**	**2.0E-07**	**3.0E-07**	**3.1E-06**	**7.7E-08**	**5.2E-08**	**1.6E-06**
Lurnea												
Lurnea High School	Residential/School	0.049	0.048	3.0E-06	9.0E-06	1.7E-06	2.0E-07	3.0E-07	3.1E-06	7.7E-08	5.2E-08	1.6E-06
St Francis Xavier Primary School Lurnea	Residential/School	0.047	0.046	2.9E-06	8.5E-06	1.6E-06	1.9E-07	2.9E-07	2.9E-06	7.2E-08	4.9E-08	1.5E-06
Average Residential		**0.048**	**0.047**	**3.0E-06**	**8.8E-06**	**1.7E-06**	**1.9E-07**	**3.0E-07**	**3.0E-06**	**7.5E-08**	**5.1E-08**	**1.6E-06**
Casula												
Lakewood Crescent	Residential	0.19	0.19	1.2E-05	3.5E-05	6.7E-06	7.6E-07	1.2E-06	1.2E-05	3.0E-07	2.0E-07	6.3E-06
St Andrews Boulevard	Residential	0.25	0.24	1.5E-05	4.5E-05	8.8E-06	1.0E-06	1.5E-06	1.6E-05	3.9E-07	2.6E-07	8.3E-06
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.33	0.32	2.0E-05	6.0E-05	1.2E-05	1.3E-06	2.0E-06	2.0E-05	5.1E-07	3.5E-07	1.1E-05
Dunmore Cres	Residential	0.31	0.30	1.9E-05	5.7E-05	1.1E-05	1.2E-06	1.9E-06	1.9E-05	4.8E-07	3.3E-07	1.0E-05
Leacocks Lane	Residential	0.09	0.09	5.5E-06	1.6E-05	3.1E-06	3.6E-07	5.5E-07	5.5E-06	1.4E-07	9.4E-08	3.0E-06
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.13	0.12	7.8E-06	2.3E-05	4.5E-06	5.1E-07	7.8E-07	7.9E-06	2.0E-07	1.3E-07	4.2E-06
Slessor Road	Residential	0.10	0.10	6.2E-06	1.8E-05	3.5E-06	4.0E-07	6.2E-07	6.2E-06	1.6E-07	1.1E-07	3.3E-06
Maple Grove Retirement Village	Residential	0.05	0.05	3.1E-06	9.3E-06	1.8E-06	2.0E-07	3.1E-07	3.2E-06	7.9E-08	5.4E-08	1.7E-06
All Saints Catholic Senior College	Residential/School	0.12	0.12	7.6E-06	2.2E-05	4.3E-06	4.9E-07	7.6E-07	7.7E-06	1.9E-07	1.3E-07	4.1E-06
Casula High School	Residential/School	0.05	0.05	2.8E-06	8.4E-06	1.6E-06	1.9E-07	2.8E-07	2.9E-06	7.2E-08	4.9E-08	1.5E-06
Casula Public School	Residential/School	0.13	0.13	8.2E-06	2.4E-05	4.7E-06	5.4E-07	8.2E-07	8.3E-06	2.1E-07	1.4E-07	4.4E-06
Casula Powerhouse Arts Centre	Recreational	0.41	0.40	1.2E-06	3.5E-06	6.7E-07	7.5E-08	1.2E-07	1.2E-06	3.0E-08	2.0E-08	6.3E-07
Average Residential		**0.18**	**0.18**	**1.1E-05**	**3.3E-05**	**6.3E-06**	**7.2E-07**	**1.1E-06**	**1.1E-05**	**2.8E-07**	**1.9E-07**	**6.0E-06**
Glenfield												
Canterbury Road	Residential	0.058	0.057	3.6E-06	1.1E-05	2.1E-06	2.3E-07	3.6E-07	3.6E-06	9.0E-08	6.2E-08	1.9E-06
Ferguson Street	Residential	0.065	0.064	4.0E-06	1.2E-05	2.3E-06	2.6E-07	4.0E-07	4.1E-06	1.0E-07	6.9E-08	2.2E-06
Good enough St (Receptor 4 in Simta Report)	Residential	0.086	0.084	5.3E-06	1.6E-05	3.0E-06	3.4E-07	5.3E-07	5.3E-06	1.3E-07	9.1E-08	2.9E-06
Cambridge Avenue	Residential	0.078	0.076	4.8E-06	1.4E-05	2.7E-06	3.1E-07	4.8E-07	4.8E-06	1.2E-07	8.2E-08	2.6E-06
Glenwood Public School	Residential/School	0.040	0.039	2.4E-06	7.2E-06	1.4E-06	1.6E-07	2.4E-07	2.5E-06	6.2E-08	4.2E-08	1.3E-06
Glenfield Public School	Residential/School	0.042	0.041	2.6E-06	7.7E-06	1.5E-06	1.7E-07	2.6E-07	2.6E-06	6.6E-08	4.5E-08	1.4E-06
Hurlstone Agricultural High School	Residential/School	0.036	0.035	2.2E-06	6.6E-06	1.3E-06	1.5E-07	2.2E-07	2.2E-06	5.6E-08	3.8E-08	1.2E-06
Glenfield new land release	Residential	0.071	0.069	4.4E-06	1.3E-05	2.5E-06	2.9E-07	4.4E-07	4.4E-06	1.1E-07	7.5E-08	2.4E-06
Playground Learning Centre, Chesham Parade	Residential	0.044	0.043	2.7E-06	8.0E-06	1.5E-06	1.8E-07	2.7E-07	2.7E-06	6.8E-08	4.6E-08	1.5E-06
Average Residential		**0.058**	**0.056**	**3.6E-06**	**1.1E-05**	**2.0E-06**	**2.3E-07**	**3.6E-07**	**3.6E-06**	**9.0E-08**	**6.1E-08**	**1.9E-06**
Macquarie Fields												
Hickory Place	Residential	0.022	0.021	1.3E-06	3.9E-06	7.6E-07	8.7E-08	1.3E-07	1.3E-06	3.4E-08	2.3E-08	7.2E-07
Maximum residential receptors		**0.3**	**0.3**	**2.0E-05**	**6.0E-05**	**1.2E-05**	**1.3E-06**	**2.0E-06**	**2.0E-05**	**5.1E-07**	**3.5E-07**	**1.1E-05**
Maximum school receptors		**0.1**	**0.1**	**8.2E-06**	**2.4E-05**	**4.7E-06**	**5.4E-07**	**8.2E-07**	**8.3E-06**	**2.1E-07**	**1.4E-07**	**4.4E-06**
Maximum recreational receptors		**0.4**	**0.4**	**1.2E-06**	**3.5E-06**	**6.7E-07**	**7.5E-08**	**1.2E-07**	**1.2E-06**	**3.0E-08**	**2.0E-08**	**6.3E-07**
Maximum commercial/industrial receptors		**2.9**	**2.8**	**3.9E-05**	**1.2E-04**	**2.2E-05**	**2.6E-06**	**3.9E-06**	**3.9E-05**	**9.8E-07**	**6.7E-07**	**2.1E-05**

Quantification of Effects - PM2.5 and PM10
Southern Rail Access - Cumulative Scenario 2

Particulate Fraction:	**PM2.5**	**PM2.5**	**PM2.5**	**PM10**	**PM2.5**	**PM2.5**	**PM2.5**	**PM2.5**	**Incremental Risk -DPM**
Endpoint:	**Mortality - All Causes**	**Hospitalisations - Cardiovascular**	**Hospitalisations - Respiratory**	**Mortality - All Causes**	**Mortality - All Causes**	**Mortality - Cardiopulmonary**	**Mortality - Cardiovascular**	**Mortality - Respiratory**	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		**Increase in Annual Average PM10 Concentration (µg/m³)**	**Increase in Annual Average PM2.5 Concentration (µg/m³)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk**
Maximum Receptor												
Boundary location	**Commercial/Industrial**	2.5	2.5	**3.4E-05**	**1.0E-04**	**2.0E-05**	**2.2E-06**	**3.4E-06**	**3.4E-05**	**8.6E-07**	**5.9E-07**	**1.8E-05**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.15	0.15	9.2E-06	2.7E-05	5.2E-06	6.0E-07	9.1E-07	9.2E-06	2.3E-07	1.6E-07	4.9E-06
Corryton Ct	Residential	0.20	0.20	1.2E-05	3.7E-05	7.1E-06	8.2E-07	1.2E-06	1.3E-05	3.1E-07	2.1E-07	6.7E-06
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.20	0.20	1.2E-05	3.7E-05	7.1E-06	8.2E-07	1.2E-06	1.3E-05	3.1E-07	2.1E-07	6.7E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.24	0.24	1.5E-05	4.4E-05	8.6E-06	9.8E-07	1.5E-06	1.5E-05	3.8E-07	2.6E-07	8.1E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.24	0.24	3.3E-06	9.8E-06	1.9E-06	2.2E-07	3.3E-07	3.3E-06	8.3E-08	5.7E-08	1.8E-06
Yallum Cres (Receptor 1 in Simta report)	Residential	0.19	0.19	1.2E-05	3.5E-05	6.8E-06	7.7E-07	1.2E-06	1.2E-05	3.0E-07	2.0E-07	6.4E-06
Wattle Grove Public School	Residential/School	0.15	0.14	9.0E-06	2.7E-05	5.2E-06	5.9E-07	9.0E-07	9.1E-06	2.3E-07	1.6E-07	4.9E-06
St Marks Coptic College	Residential/School	0.10	0.09	5.9E-06	1.8E-05	3.4E-06	3.9E-07	5.9E-07	6.0E-06	1.5E-07	1.0E-07	3.2E-06
Anzac Creek Park	Residential	0.12	0.12	7.3E-06	2.2E-05	4.2E-06	4.8E-07	7.3E-07	7.4E-06	1.8E-07	1.3E-07	4.0E-06
Anzac Creek Park	Recreational	0.12	0.12	3.4E-07	1.0E-06	2.0E-07	2.3E-08	3.4E-08	3.5E-07	8.7E-09	5.9E-09	1.9E-07
Moorebank Ave	Commercial/Industrial	2.36	2.29	3.2E-05	9.4E-05	1.8E-05	2.1E-06	3.2E-06	3.2E-05	8.0E-07	5.5E-07	1.7E-05
DNSDC proposed relocation	Commercial/Industrial	0.27	0.27	3.7E-06	1.1E-05	2.1E-06	2.4E-07	3.7E-07	3.7E-06	9.3E-08	6.3E-08	2.0E-06
Average Residential		**0.16**	**0.16**	**1.0E-05**	**3.0E-05**	**5.8E-06**	**6.6E-07**	**1.0E-06**	**1.0E-05**	**2.5E-07**	**1.7E-07**	**5.4E-06**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.09	0.09	5.4E-06	1.6E-05	3.1E-06	3.5E-07	5.4E-07	5.4E-06	1.4E-07	9.3E-08	2.9E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.24	0.24	1.5E-05	4.4E-05	8.6E-06	9.8E-07	1.5E-06	1.5E-05	3.8E-07	2.6E-07	8.1E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.24	0.24	3.3E-06	9.8E-06	1.9E-06	2.2E-07	3.3E-07	3.3E-06	8.3E-08	5.7E-08	1.8E-06
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.12	0.12	7.3E-06	2.2E-05	4.2E-06	4.8E-07	7.3E-07	7.4E-06	1.8E-07	1.3E-07	4.0E-06
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.12	0.12	3.4E-07	1.0E-06	2.0E-07	2.3E-08	3.4E-08	3.5E-07	8.7E-09	5.9E-09	1.9E-07
Average Residential		**0.14**	**0.14**	**8.8E-06**	**2.6E-05**	**5.0E-06**	**5.7E-07**	**8.8E-07**	**8.9E-06**	**2.2E-07**	**1.5E-07**	**4.7E-06**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.054	0.053	3.3E-06	9.9E-06	1.9E-06	2.2E-07	3.3E-07	3.4E-06	8.4E-08	5.7E-08	1.8E-06
Liverpool West Public School	Residential/School	0.035	0.034	2.1E-06	6.3E-06	1.2E-06	1.4E-07	2.1E-07	2.2E-06	5.4E-08	3.7E-08	1.2E-06
Liverpool Public School	Residential/School	0.033	0.032	2.0E-06	6.1E-06	1.2E-06	1.3E-07	2.0E-07	2.1E-06	5.2E-08	3.5E-08	1.1E-06
Average Residential		**0.041**	**0.040**	**2.5E-06**	**7.4E-06**	**1.4E-06**	**1.6E-07**	**2.5E-07**	**2.5E-06**	**6.3E-08**	**4.3E-08**	**1.4E-06**
Lurnea												
Lurnea High School	Residential/School	0.040	0.039	2.4E-06	7.2E-06	1.4E-06	1.6E-07	2.4E-07	2.5E-06	6.2E-08	4.2E-08	1.3E-06
St Francis Xavier Primary School Lurnea	Residential/School	0.038	0.037	2.3E-06	6.9E-06	1.3E-06	1.5E-07	2.3E-07	2.3E-06	5.8E-08	4.0E-08	1.3E-06
Average Residential		**0.039**	**0.038**	**2.4E-06**	**7.1E-06**	**1.4E-06**	**1.6E-07**	**2.4E-07**	**2.4E-06**	**6.0E-08**	**4.1E-08**	**1.3E-06**
Casula												
Lakewood Crescent	Residential	0.15	0.15	9.5E-06	2.8E-05	5.4E-06	6.2E-07	9.4E-07	9.6E-06	2.4E-07	1.6E-07	5.1E-06
St Andrews Boulevard	Residential	0.20	0.19	1.2E-05	3.6E-05	7.0E-06	7.9E-07	1.2E-06	1.2E-05	3.1E-07	2.1E-07	6.6E-06
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.25	0.25	1.6E-05	4.6E-05	9.0E-06	1.0E-06	1.6E-06	1.6E-05	3.9E-07	2.7E-07	8.4E-06
Dunmore Cres	Residential	0.24	0.23	1.5E-05	4.3E-05	8.4E-06	9.5E-07	1.5E-06	1.5E-05	3.7E-07	2.5E-07	7.9E-06
Leacocks Lane	Residential	0.07	0.07	4.4E-06	1.3E-05	2.5E-06	2.8E-07	4.3E-07	4.4E-06	1.1E-07	7.5E-08	2.3E-06
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.10	0.10	6.2E-06	1.8E-05	3.5E-06	4.0E-07	6.2E-07	6.3E-06	1.6E-07	1.1E-07	3.3E-06
Slessor Road	Residential	0.080	0.078	4.9E-06	1.5E-05	2.8E-06	3.2E-07	4.9E-07	5.0E-06	1.2E-07	8.5E-08	2.7E-06
Maple Grove Retirement Village	Residential	0.041	0.040	2.5E-06	7.4E-06	1.4E-06	1.6E-07	2.5E-07	2.5E-06	6.3E-08	4.3E-08	1.4E-06
All Saints Catholic Senior College	Residential/School	0.10	0.10	6.0E-06	1.8E-05	3.4E-06	3.9E-07	6.0E-07	6.1E-06	1.5E-07	1.0E-07	3.2E-06
Casula High School	Residential/School	0.037	0.036	2.3E-06	6.8E-06	1.3E-06	1.5E-07	2.3E-07	2.3E-06	5.8E-08	3.9E-08	1.2E-06
Casula Public School	Residential/School	0.11	0.10	6.5E-06	1.9E-05	3.7E-06	4.3E-07	6.5E-07	6.6E-06	1.6E-07	1.1E-07	3.5E-06
Casula Powerhouse Arts Centre	Recreational	0.31	0.30	8.9E-07	2.6E-06	5.1E-07	5.7E-08	8.9E-08	9.0E-07	2.2E-08	1.5E-08	4.8E-07
Average Residential		**0.14**	**0.14**	**8.6E-06**	**2.6E-05**	**4.9E-06**	**5.6E-07**	**8.6E-07**	**8.7E-06**	**2.2E-07**	**1.5E-07**	**4.7E-06**
Glenfield												
Canterbury Road	Residential	0.047	0.046	2.9E-06	8.6E-06	1.7E-06	1.9E-07	2.9E-07	2.9E-06	7.3E-08	5.0E-08	1.6E-06
Ferguson Street	Residential	0.053	0.052	3.3E-06	9.7E-06	1.9E-06	2.1E-07	3.3E-07	3.3E-06	8.3E-08	5.6E-08	1.8E-06
Good enough St (Receptor 4 in Simta Report)	Residential	0.070	0.068	4.3E-06	1.3E-05	2.5E-06	2.8E-07	4.3E-07	4.3E-06	1.1E-07	7.4E-08	2.3E-06
Cambridge Avenue	Residential	0.063	0.061	3.9E-06	1.1E-05	2.2E-06	2.5E-07	3.9E-07	3.9E-06	9.8E-08	6.6E-08	2.1E-06
Glenwood Public School	Residential/School	0.032	0.032	2.0E-06	5.9E-06	1.1E-06	1.3E-07	2.0E-07	2.0E-06	5.0E-08	3.4E-08	1.1E-06
Glenfield Public School	Residential/School	0.034	0.034	2.1E-06	6.3E-06	1.2E-06	1.4E-07	2.1E-07	2.1E-06	5.3E-08	3.6E-08	1.1E-06
Hurlstone Agricultural High School	Residential/School	0.029	0.029	1.8E-06	5.4E-06	1.0E-06	1.2E-07	1.8E-07	1.8E-06	4.6E-08	3.1E-08	9.8E-07
Glenfield new land release	Residential	0.057	0.056	3.5E-06	1.0E-05	2.0E-06	2.3E-07	3.5E-07	3.6E-06	8.9E-08	6.1E-08	1.9E-06
Playground Learning Centre, Chesham Parade	Residential	0.036	0.035	2.2E-06	6.5E-06	1.3E-06	1.4E-07	2.2E-07	2.2E-06	5.6E-08	3.8E-08	1.2E-06
Average Residential		**0.047**	**0.046**	**2.9E-06**	**8.6E-06**	**1.7E-06**	**1.9E-07**	**2.9E-07**	**2.9E-06**	**7.3E-08**	**5.0E-08**	**1.6E-06**
Macquarie Fields												
Hickory Place	Residential	0.018	0.017	1.1E-06	3.2E-06	6.3E-07	7.2E-08	1.1E-07	1.1E-06	2.8E-08	1.9E-08	5.9E-07
Maximum residential receptors		**0.3**	**0.2**	**1.6E-05**	**4.6E-05**	**9.0E-06**	**1.0E-06**	**1.6E-06**	**1.6E-05**	**3.9E-07**	**2.7E-07**	**8.4E-06**
Maximum school receptors		**0.1**	**0.1**	**6.5E-06**	**1.9E-05**	**3.7E-06**	**4.3E-07**	**6.5E-07**	**6.6E-06**	**1.6E-07**	**1.1E-07**	**3.5E-06**
Maximum recreational receptors		**0.3**	**0.3**	**8.9E-07**	**2.6E-06**	**5.1E-07**	**5.7E-08**	**8.9E-08**	**9.0E-07**	**2.2E-08**	**1.5E-08**	**4.8E-07**
Maximum commercial/industrial receptors		**2.5**	**2.5**	**3.4E-05**	**1.0E-04**	**2.0E-05**	**2.2E-06**	**3.4E-06**	**3.4E-05**	**8.6E-07**	**5.9E-07**	**1.8E-05**

Quantification of Effects - PM2.5 and PM10
Southern Rail Access - Cumulative Scenario 3

Particulate Fraction:	**PM2.5**	**PM2.5**	**PM2.5**	**PM10**	**PM2.5**	**PM2.5**	**PM2.5**	**PM2.5**	**Incremental Risk -DPM**
Endpoint:	**Mortality - All Causes**	**Hospitalisations - Cardiovascular**	**Hospitalisations - Respiratory**	**Mortality - All Causes**	**Mortality - All Causes**	**Mortality - Cardiopulmonary**	**Mortality - Cardiovascular**	**Mortality - Respiratory**	
Effect Exposure Duration:	Long-term	Short-term	Short-term	Short-Term	Short-Term	Long-term	Short-Term	Short-Term	(based on WHO)
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	All ages	≥ 30 years	All ages	All ages	Unit Risk
β (change in effect per 1 µg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.0006	0.00094	0.013	0.00097	0.0019	
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0067	0.0049	0.00164	0.00057	
Modifying factor for commercial/industrial exposures (refer to Section 4.3.4 in report)	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22	0.22
Modifying factor for recreational exposures (refer to Section 4.3.4 in report)	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047	0.047

Receptor		**Increase in Annual Average PM10 Concentration (µg/m³)**	**Increase in Annual Average PM2.5 Concentration (µg/m³)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk (Equation 6)**	**Risk**
Maximum Receptor												
Boundary location	**Commercial/Industrial**	2.2	2.2	**3.0E-05**	**8.9E-05**	**1.7E-05**	**2.0E-06**	**3.0E-06**	**3.0E-05**	**7.6E-07**	**5.2E-07**	**1.6E-05**
Sensitive Receptors												
Wattle Grove												
Wallcliff Cres	Residential	0.13	0.12	7.8E-06	2.3E-05	4.5E-06	5.1E-07	7.8E-07	7.9E-06	2.0E-07	1.3E-07	4.2E-06
Corryton Ct	Residential	0.18	0.17	1.1E-05	3.2E-05	6.3E-06	7.2E-07	1.1E-06	1.1E-05	2.8E-07	1.9E-07	5.9E-06
Martindale Ct (Receptor 3 in Simta Report)	Residential	0.18	0.17	1.1E-05	3.2E-05	6.3E-06	7.2E-07	1.1E-06	1.1E-05	2.8E-07	1.9E-07	5.9E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.21	0.20	1.3E-05	3.8E-05	7.3E-06	8.4E-07	1.3E-06	1.3E-05	3.2E-07	2.2E-07	6.9E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.21	0.20	2.8E-06	8.3E-06	1.6E-06	1.8E-07	2.8E-07	2.8E-06	7.1E-08	4.8E-08	1.5E-06
Yallum Cres (Receptor 1 in Simta report)	Residential	0.17	0.16	1.0E-05	3.0E-05	5.9E-06	6.7E-07	1.0E-06	1.0E-05	2.6E-07	1.8E-07	5.5E-06
Wattle Grove Public School	Residential/School	0.13	0.12	7.8E-06	2.3E-05	4.5E-06	5.1E-07	7.8E-07	7.9E-06	2.0E-07	1.3E-07	4.2E-06
St Marks Coptic College	Residential/School	0.08	0.08	5.1E-06	1.5E-05	2.9E-06	3.3E-07	5.1E-07	5.1E-06	1.3E-07	8.7E-08	2.7E-06
Anzac Creek Park	Residential	0.10	0.10	6.2E-06	1.8E-05	3.5E-06	4.1E-07	6.2E-07	6.2E-06	1.6E-07	1.1E-07	3.3E-06
Anzac Creek Park	Recreational	0.10	0.10	2.9E-07	8.6E-07	1.7E-07	1.9E-08	2.9E-08	2.9E-07	7.3E-09	5.0E-09	1.6E-07
Moorebank Ave	Commercial/Industrial	2.08	2.02	2.8E-05	8.3E-05	1.6E-05	1.8E-06	2.8E-06	2.8E-05	7.1E-07	4.8E-07	1.5E-05
DNSDC proposed relocation	Commercial/Industrial	0.24	0.23	3.2E-06	9.6E-06	1.9E-06	2.1E-07	3.2E-07	3.3E-06	8.2E-08	5.6E-08	1.8E-06
Average Residential		**0.14**	**0.14**	**8.7E-06**	**2.6E-05**	**5.0E-06**	**5.7E-07**	**8.6E-07**	**8.7E-06**	**2.2E-07**	**1.5E-07**	**4.7E-06**
Moorebank												
Church Road (Receptor 7 in Simta report)	Residential	0.07	0.07	4.4E-06	1.3E-05	2.5E-06	2.9E-07	4.4E-07	4.4E-06	1.1E-07	7.6E-08	2.4E-06
Anzac Road (Receptor 2 in Simta report)	Residential	0.21	0.20	1.3E-05	3.8E-05	7.3E-06	8.4E-07	1.3E-06	1.3E-05	3.2E-07	2.2E-07	6.9E-06
Anzac Road (Receptor 2 in Simta report)	Commercial/Industrial	0.21	0.20	2.8E-06	8.3E-06	1.6E-06	1.8E-07	2.8E-07	2.8E-06	7.1E-08	4.8E-08	1.5E-06
Wattle Grove Long Day Care Centre, Anzac Creek Park	Residential	0.10	0.10	6.2E-06	1.8E-05	3.5E-06	4.1E-07	6.2E-07	6.2E-06	1.6E-07	1.1E-07	3.3E-06
Wattle Grove Long Day Care Centre, Anzac Creek Park	Recreational	0.10	0.10	2.9E-07	8.6E-07	1.7E-07	1.9E-08	2.9E-08	2.9E-07	7.3E-09	5.0E-09	1.6E-07
Average Residential		**0.12**	**0.12**	**7.4E-06**	**2.2E-05**	**4.2E-06**	**4.8E-07**	**7.4E-07**	**7.4E-06**	**1.9E-07**	**1.3E-07**	**4.0E-06**
Liverpool												
Al Amanah College Liverpool Campus Liverpool	Residential/School	0.044	0.042	2.7E-06	7.9E-06	1.5E-06	1.8E-07	2.7E-07	2.7E-06	6.7E-08	4.6E-08	1.4E-06
Liverpool West Public School	Residential/School	0.027	0.027	1.7E-06	5.0E-06	9.6E-07	1.1E-07	1.7E-07	1.7E-06	4.2E-08	2.9E-08	9.1E-07
Liverpool Public School	Residential/School	0.027	0.026	1.6E-06	4.9E-06	9.4E-07	1.1E-07	1.6E-07	1.7E-06	4.1E-08	2.8E-08	8.9E-07
Average Residential		**0.033**	**0.032**	**2.0E-06**	**5.9E-06**	**1.1E-06**	**1.3E-07**	**2.0E-07**	**2.0E-06**	**5.0E-08**	**3.4E-08**	**1.1E-06**
Lurnea												
Lurnea High School	Residential/School	0.031	0.030	1.9E-06	5.6E-06	1.1E-06	1.2E-07	1.9E-07	1.9E-06	4.8E-08	3.2E-08	1.0E-06
St Francis Xavier Primary School Lurnea	Residential/School	0.029	0.029	1.8E-06	5.3E-06	1.0E-06	1.2E-07	1.8E-07	1.8E-06	4.5E-08	3.1E-08	9.7E-07
Average Residential		**0.030**	**0.029**	**1.8E-06**	**5.5E-06**	**1.1E-06**	**1.2E-07**	**1.8E-07**	**1.9E-06**	**4.6E-08**	**3.2E-08**	**9.9E-07**
Casula												
Lakewood Crescent	Residential	0.12	0.12	7.3E-06	2.2E-05	4.2E-06	4.8E-07	7.3E-07	7.4E-06	1.9E-07	1.3E-07	4.0E-06
St Andrews Boulevard	Residential	0.15	0.15	9.2E-06	2.7E-05	5.3E-06	6.0E-07	9.2E-07	9.3E-06	2.3E-07	1.6E-07	4.9E-06
Buckland Rd Receiver (Receptor 6 in Simta Report)	Residential	0.18	0.18	1.1E-05	3.4E-05	6.5E-06	7.4E-07	1.1E-06	1.1E-05	2.9E-07	1.9E-07	6.1E-06
Dunmore Cres	Residential	0.17	0.17	1.0E-05	3.1E-05	6.0E-06	6.8E-07	1.0E-06	1.1E-05	2.6E-07	1.8E-07	5.6E-06
Leacocks Lane	Residential	0.05	0.05	3.3E-06	9.8E-06	1.9E-06	2.2E-07	3.3E-07	3.3E-06	8.3E-08	5.7E-08	1.8E-06
Leacocks Lane_Mid (Receptor 5 in Simta Report)	Residential	0.08	0.07	4.7E-06	1.4E-05	2.7E-06	3.1E-07	4.7E-07	4.7E-06	1.2E-07	8.0E-08	2.5E-06
Slessor Road	Residential	0.062	0.060	3.8E-06	1.1E-05	2.2E-06	2.5E-07	3.8E-07	3.8E-06	9.6E-08	6.5E-08	2.0E-06
Maple Grove Retirement Village	Residential	0.032	0.031	1.9E-06	5.7E-06	1.1E-06	1.3E-07	1.9E-07	2.0E-06	4.9E-08	3.3E-08	1.0E-06
All Saints Catholic Senior College	Residential/School	0.07	0.07	4.5E-06	1.3E-05	2.6E-06	3.0E-07	4.5E-07	4.6E-06	1.1E-07	7.8E-08	2.4E-06
Casula High School	Residential/School	0.029	0.028	1.8E-06	5.2E-06	1.0E-06	1.2E-07	1.8E-07	1.8E-06	4.4E-08	3.0E-08	9.5E-07
Casula Public School	Residential/School	0.08	0.08	4.9E-06	1.4E-05	2.8E-06	3.2E-07	4.9E-07	4.9E-06	1.2E-07	8.4E-08	2.6E-06
Casula Powerhouse Arts Centre	Recreational	0.22	0.21	6.2E-07	1.8E-06	3.6E-07	4.0E-08	6.2E-08	6.3E-07	1.6E-08	1.1E-08	3.4E-07
Average Residential		**0.10**	**0.10**	**6.4E-06**	**1.9E-05**	**3.6E-06**	**4.2E-07**	**6.4E-07**	**6.4E-06**	**1.6E-07**	**1.1E-07**	**3.4E-06**
Glenfield												
Canterbury Road	Residential	0.037	0.036	2.3E-06	6.8E-06	1.3E-06	1.5E-07	2.3E-07	2.3E-06	5.7E-08	3.9E-08	1.2E-06
Ferguson Street	Residential	0.042	0.041	2.6E-06	7.6E-06	1.5E-06	1.7E-07	2.6E-07	2.6E-06	6.5E-08	4.4E-08	1.4E-06
Good enough St (Receptor 4 in Simta Report)	Residential	0.055	0.053	3.4E-06	1.0E-05	1.9E-06	2.2E-07	3.4E-07	3.4E-06	8.5E-08	5.8E-08	1.8E-06
Cambridge Avenue	Residential	0.049	0.048	3.0E-06	8.9E-06	1.7E-06	2.0E-07	3.0E-07	3.0E-06	7.6E-08	5.2E-08	1.6E-06
Glenwood Public School	Residential/School	0.026	0.025	1.6E-06	4.7E-06	9.1E-07	1.0E-07	1.6E-07	1.6E-06	4.0E-08	2.7E-08	8.5E-07
Glenfield Public School	Residential/School	0.027	0.026	1.7E-06	4.9E-06	9.5E-07	1.1E-07	1.7E-07	1.7E-06	4.2E-08	2.9E-08	9.0E-07
Hurlstone Agricultural High School	Residential/School	0.023	0.023	1.4E-06	4.2E-06	8.2E-07	9.3E-08	1.4E-07	1.4E-06	3.6E-08	2.5E-08	7.7E-07
Glenfield new land release	Residential	0.045	0.044	2.7E-06	8.1E-06	1.6E-06	1.8E-07	2.7E-07	2.8E-06	6.9E-08	4.7E-08	1.5E-06
Playground Learning Centre, Chesham Parade	Residential	0.028	0.027	1.7E-06	5.1E-06	9.9E-07	1.1E-07	1.7E-07	1.7E-06	4.4E-08	3.0E-08	9.3E-07
Average Residential		**0.037**	**0.036**	**2.3E-06**	**6.7E-06**	**1.3E-06**	**1.5E-07**	**2.3E-07**	**2.3E-06**	**5.7E-08**	**3.9E-08**	**1.2E-06**
Macquarie Fields												
Hickory Place	Residential	0.014	0.014	8.8E-07	2.6E-06	5.0E-07	5.7E-08	8.7E-08	8.8E-07	2.2E-08	1.5E-08	4.7E-07
Maximum residential receptors		**0.2**	**0.2**	**1.3E-05**	**3.8E-05**	**7.3E-06**	**8.4E-07**	**1.3E-06**	**1.3E-05**	**3.2E-07**	**2.2E-07**	**6.9E-06**
Maximum school receptors		**0.1**	**0.1**	**5.1E-06**	**1.5E-05**	**2.9E-06**	**3.3E-07**	**5.1E-07**	**5.1E-06**	**1.3E-07**	**8.7E-08**	**2.7E-06**
Maximum recreational receptors		**0.2**	**0.2**	**6.2E-07**	**1.8E-06**	**3.6E-07**	**4.0E-08**	**6.2E-08**	**6.3E-07**	**1.6E-08**	**1.1E-08**	**3.4E-07**
Maximum commercial/industrial receptors		**2.2**	**2.2**	**3.0E-05**	**8.9E-05**	**1.7E-05**	**2.0E-06**	**3.0E-06**	**3.0E-05**	**7.6E-07**	**5.2E-07**	**1.6E-05**

Appendix C Calculation of population incidence for exposure to $PM_{2.5}$ and PM_{10} (asthma only)

Assessment of Increased Incidence

Southern Rail Access - Phase A

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 μg/m^3 PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (μg/m^3):	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.062
Relative Risk:	1.000068	1.000009	1.000005	1.000011	1.000153	1.000011	1.000022	1.000025
Attributable fraction (AF):	6.8E-05	9.4E-06	4.8E-06	1.1E-05	1.5E-04	1.1E-05	2.2E-05	2.5E-05
Increased number of cases in population:	0.003	0.001	0.0002	0.0006	0.003	0.00015	0.00010	0.20
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (μg/m^3):	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.048
Relative Risk:	1.000056	1.000008	1.000004	1.000009	1.000126	1.000009	1.000018	1.000019
Attributable fraction (AF):	5.6E-05	7.7E-06	4.0E-06	9.1E-06	1.3E-04	9.4E-06	1.8E-05	1.9E-05
Increased number of cases in population:	0.0006	0.0004	0.00007	0.00010	0.0006	0.000025	0.000017	0.023
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (μg/m^3):	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0028	0.0135
Relative Risk:	1.000016	1.000002	1.000001	1.000003	1.000036	1.000003	1.000005	1.000005
Attributable fraction (AF):	1.6E-05	2.2E-06	1.1E-06	2.6E-06	3.6E-05	2.7E-06	5.3E-06	5.4E-06
Increased number of cases in population:	0.0016	0.0010	0.00019	0.00031	0.0016	0.000077	0.000053	0.065
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (μg/m^3):	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0038	0.0192
Relative Risk:	1.000022	1.000003	1.000002	1.000004	1.000049	1.000004	1.000007	1.000008
Attributable fraction (AF):	2.2E-05	3.0E-06	1.5E-06	3.5E-06	4.9E-05	3.6E-06	7.1E-06	7.7E-06
Increased number of cases in population:	0.0014	0.0007	0.00014	0.00020	0.0014	0.00005	0.00004	0.060
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (μg/m^3):	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.067
Relative Risk:	1.000074	1.000010	1.000005	1.000012	1.000167	1.000012	1.000024	1.000027
Attributable fraction (AF):	7.4E-05	1.0E-05	5.3E-06	1.2E-05	1.7E-04	1.2E-05	2.4E-05	2.7E-05
Increased number of cases in population:	0.0057	0.0035	0.00069	0.0012	0.0058	0.00029	0.00020	0.31
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (μg/m^3):	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0046	0.0246
Relative Risk:	1.000027	1.000004	1.000002	1.000004	1.000060	1.000005	1.000009	1.000010
Attributable fraction (AF):	2.7E-05	3.7E-06	1.9E-06	4.4E-06	6.0E-05	4.5E-06	8.8E-06	9.8E-06
Increased number of cases in population:	0.0015	0.0009	0.00018	0.00022	0.0015	0.00006	0.000038	0.050
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (μg/m^3):	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0018	0.0095
Relative Risk:	1.000011	1.000001	1.000001	1.000002	1.000024	1.000002	1.000003	1.000004
Attributable fraction (AF):	1.1E-05	1.5E-06	7.5E-07	1.7E-06	2.4E-05	1.8E-06	3.5E-06	3.8E-06
Increased number of cases in population:	0.0002	0.0001	0.00002	0.00004	0.0002	0.00001	0.000007	0.012
Total - All Suburbs	**0.01**	**0.008**	**0.001**	**0.003**	**0.01**	**0.0007**	**0.0005**	**0.72**

Assessment of Increased Incidence

Southern Rail Access - Phase B

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 µg/m^3 PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (µg/m^3):	0.038	0.038	0.038	0.038	0.038	0.038	0.038	0.069
Relative Risk:	1.000219	1.000030	1.000016	1.000036	1.000492	1.000037	1.000072	1.000028
Attributable fraction (AF):	2.2E-04	3.0E-05	1.6E-05	3.6E-05	4.9E-04	3.7E-05	7.2E-05	2.8E-05
Increased number of cases in population:	0.009	0.003	0.0006	0.0020	0.009	0.00049	0.00034	0.221
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.063
Relative Risk:	1.000216	1.000030	1.000015	1.000035	1.000484	1.000036	1.000071	1.000025
Attributable fraction (AF):	2.2E-04	3.0E-05	1.5E-05	3.5E-05	4.8E-04	3.6E-05	7.1E-05	2.5E-05
Increased number of cases in population:	0.0023	0.0015	0.00028	0.00039	0.0023	0.000098	0.000066	0.0305
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.0123	0.0123	0.0123	0.0123	0.0123	0.0123	0.0123	0.0203
Relative Risk:	1.000071	1.000010	1.000005	1.000012	1.000160	1.000012	1.000023	1.000008
Attributable fraction (AF):	7.1E-05	9.8E-06	5.0E-06	1.2E-05	1.6E-04	1.2E-05	2.3E-05	8.1E-06
Increased number of cases in population:	0.0069	0.0044	0.00086	0.00135	0.0069	0.000340	0.000232	0.098
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0239
Relative Risk:	1.000076	1.000011	1.000005	1.000012	1.000171	1.000013	1.000025	1.000010
Attributable fraction (AF):	7.6E-05	1.1E-05	5.4E-06	1.2E-05	1.7E-04	1.3E-05	2.5E-05	9.6E-06
Increased number of cases in population:	0.0050	0.0026	0.00050	0.00071	0.0050	0.00018	0.00012	0.074
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (µg/m^3):	0.051	0.051	0.051	0.051	0.051	0.051	0.051	0.091
Relative Risk:	1.000297	1.000041	1.000021	1.000048	1.000665	1.000050	1.000097	1.000036
Attributable fraction (AF):	3.0E-04	4.1E-05	2.1E-05	4.8E-05	6.6E-04	5.0E-05	9.7E-05	3.6E-05
Increased number of cases in population:	0.0227	0.0141	0.00273	0.0046	0.0229	0.00117	0.00080	0.430
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (µg/m^3):	0.0144	0.0144	0.0144	0.0144	0.0144	0.0144	0.0144	0.0244
Relative Risk:	1.000083	1.000012	1.000006	1.000014	1.000187	1.000014	1.000027	1.000010
Attributable fraction (AF):	8.3E-05	1.2E-05	5.9E-06	1.4E-05	1.9E-04	1.4E-05	2.7E-05	9.8E-06
Increased number of cases in population:	0.0046	0.0028	0.00054	0.00068	0.0046	0.00017	0.000118	0.0499
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0053	0.0098
Relative Risk:	1.000031	1.000004	1.000002	1.000005	1.000069	1.000005	1.000010	1.000004
Attributable fraction (AF):	3.1E-05	4.3E-06	2.2E-06	5.0E-06	6.9E-05	5.2E-06	1.0E-05	3.9E-06
Increased number of cases in population:	0.0006	0.0003	0.00007	0.00012	0.0006	0.00003	0.000021	0.0122
Total - All Suburbs	**0.05**	**0.03**	**0.006**	**0.01**	**0.05**	**0.002**	**0.002**	**0.92**

Assessment of Increased Incidence

Southern Rail Access - Phase C

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 μg/m^3 PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (μg/m^3):	0.068	0.068	0.068	0.068	0.068	0.068	0.068	0.093
Relative Risk:	1.000392	1.000054	1.000028	1.000064	1.000879	1.000066	1.000128	1.000037
Attributable fraction (AF):	3.9E-04	5.4E-05	2.8E-05	6.4E-05	8.8E-04	6.6E-05	1.3E-04	3.7E-05
Increased number of cases in population:	0.016	0.005	0.0010	0.0035	0.016	0.00088	0.00060	0.298
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (μg/m^3):	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.083
Relative Risk:	1.000365	1.000050	1.000026	1.000059	1.000818	1.000061	1.000119	1.000033
Attributable fraction (AF):	3.6E-04	5.0E-05	2.6E-05	5.9E-05	8.2E-04	6.1E-05	1.2E-04	3.3E-05
Increased number of cases in population:	0.0039	0.0025	0.00048	0.00065	0.0040	0.000165	0.000112	0.0401
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (μg/m^3):	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0219	0.0282
Relative Risk:	1.000127	1.000018	1.000009	1.000021	1.000284	1.000021	1.000042	1.000011
Attributable fraction (AF):	1.3E-04	1.8E-05	9.0E-06	2.1E-05	2.8E-04	2.1E-05	4.2E-05	1.1E-05
Increased number of cases in population:	0.0123	0.0079	0.00153	0.00240	0.0124	0.000606	0.000413	0.136
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (μg/m^3):	0.0233	0.0233	0.0233	0.0233	0.0233	0.0233	0.0233	0.0324
Relative Risk:	1.000135	1.000019	1.000010	1.000022	1.000303	1.000023	1.000044	1.000013
Attributable fraction (AF):	1.4E-04	1.9E-05	9.6E-06	2.2E-05	3.0E-04	2.3E-05	4.4E-05	1.3E-05
Increased number of cases in population:	0.0089	0.0046	0.00089	0.00127	0.0090	0.00032	0.00022	0.100
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (μg/m^3):	0.092	0.092	0.092	0.092	0.092	0.092	0.092	0.130
Relative Risk:	1.000532	1.000073	1.000038	1.000086	1.001192	1.000089	1.000174	1.000052
Attributable fraction (AF):	5.3E-04	7.3E-05	3.8E-05	8.6E-05	1.2E-03	8.9E-05	1.7E-04	5.2E-05
Increased number of cases in population:	0.0407	0.0253	0.00490	0.0083	0.0411	0.00209	0.00143	0.615
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (μg/m^3):	0.0295	0.0295	0.0295	0.0295	0.0295	0.0295	0.0295	0.0432
Relative Risk:	1.000171	1.000024	1.000012	1.000028	1.000383	1.000029	1.000056	1.000017
Attributable fraction (AF):	1.7E-04	2.4E-05	1.2E-05	2.8E-05	3.8E-04	2.9E-05	5.6E-05	1.7E-05
Increased number of cases in population:	0.0094	0.0058	0.00112	0.00140	0.0095	0.00035	0.000241	0.0884
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (μg/m^3):	0.0102	0.0102	0.0102	0.0102	0.0102	0.0102	0.0102	0.0149
Relative Risk:	1.000059	1.000008	1.000004	1.000010	1.000133	1.000010	1.000019	1.000006
Attributable fraction (AF):	5.9E-05	8.2E-06	4.2E-06	9.6E-06	1.3E-04	9.9E-06	1.9E-05	5.9E-06
Increased number of cases in population:	0.0012	0.0007	0.00013	0.00023	0.0012	0.00006	0.000040	0.0186
Total - All Suburbs	**0.09**	**0.05**	**0.010**	**0.02**	**0.09**	**0.004**	**0.003**	**1.3**

Assessment of Increased Incidence

Southern Rail Access - Phase D

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 µg/m^3 PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (µg/m^3):	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.079
Relative Risk:	1.000451	1.000062	1.000032	1.000073	1.001011	1.000075	1.000148	1.000032
Attributable fraction (AF):	4.5E-04	6.2E-05	3.2E-05	7.3E-05	1.0E-03	7.5E-05	1.5E-04	3.2E-05
Increased number of cases in population:	0.018	0.006	0.0012	0.0040	0.018	0.00101	0.00069	0.254
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.076
Relative Risk:	1.000434	1.000060	1.000031	1.000070	1.000973	1.000073	1.000142	1.000031
Attributable fraction (AF):	4.3E-04	6.0E-05	3.1E-05	7.0E-05	9.7E-04	7.3E-05	1.4E-04	3.1E-05
Increased number of cases in population:	0.0047	0.0029	0.00057	0.00078	0.0047	0.000196	0.000133	0.0368
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.0273	0.0273	0.0273	0.0273	0.0273	0.0273	0.0273	0.0278
Relative Risk:	1.000158	1.000022	1.000011	1.000026	1.000355	1.000026	1.000052	1.000011
Attributable fraction (AF):	1.6E-04	2.2E-05	1.1E-05	2.6E-05	3.5E-04	2.6E-05	5.2E-05	1.1E-05
Increased number of cases in population:	0.0153	0.0099	0.00191	0.00299	0.0154	0.000756	0.000515	0.134
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0292	0.0292	0.0292	0.0292	0.0292	0.0292	0.0292	0.0297
Relative Risk:	1.000169	1.000023	1.000012	1.000027	1.000379	1.000028	1.000055	1.000012
Attributable fraction (AF):	1.7E-04	2.3E-05	1.2E-05	2.7E-05	3.8E-04	2.8E-05	5.5E-05	1.2E-05
Increased number of cases in population:	0.0111	0.0058	0.00112	0.00158	0.0112	0.00040	0.00027	0.092
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (µg/m^3):	0.121	0.121	0.121	0.121	0.121	0.121	0.121	0.123
Relative Risk:	1.000702	1.000097	1.000050	1.000114	1.001575	1.000117	1.000230	1.000049
Attributable fraction (AF):	7.0E-04	9.7E-05	5.0E-05	1.1E-04	1.6E-03	1.2E-04	2.3E-04	4.9E-05
Increased number of cases in population:	0.0537	0.0335	0.00647	0.0109	0.0542	0.00277	0.00188	0.582
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (µg/m^3):	0.0356	0.0356	0.0356	0.0356	0.0356	0.0356	0.0356	0.0363
Relative Risk:	1.000206	1.000028	1.000015	1.000033	1.000463	1.000035	1.000068	1.000015
Attributable fraction (AF):	2.1E-04	2.8E-05	1.5E-05	3.3E-05	4.6E-04	3.5E-05	6.8E-05	1.5E-05
Increased number of cases in population:	0.0114	0.0070	0.00135	0.00169	0.0115	0.00043	0.000291	0.0741
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0123	0.0123	0.0123	0.0123	0.0123	0.0123	0.0123	0.0125
Relative Risk:	1.000071	1.000010	1.000005	1.000012	1.000160	1.000012	1.000023	1.000005
Attributable fraction (AF):	7.1E-05	9.9E-06	5.1E-06	1.2E-05	1.6E-04	1.2E-05	2.3E-05	5.0E-06
Increased number of cases in population:	0.0015	0.0008	0.00015	0.00028	0.0015	0.00007	0.000048	0.0157
Total - All Suburbs	**0.1**	**0.07**	**0.01**	**0.02**	**0.1**	**0.006**	**0.004**	**1.2**

Assessment of Increased Incidence

Central Rail Access - Phase A

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 µg/m^3 PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (µg/m^3):	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.065
Relative Risk:	1.000070	1.000010	1.000005	1.000011	1.000156	1.000012	1.000023	1.000026
Attributable fraction (AF):	7.0E-05	9.6E-06	4.9E-06	1.1E-05	1.6E-04	1.2E-05	2.3E-05	2.6E-05
Increased number of cases in population:	0.003	0.001	0.0002	0.0006	0.003	0.00016	0.00011	0.207
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.053
Relative Risk:	1.000060	1.000008	1.000004	1.000010	1.000135	1.000010	1.000020	1.000021
Attributable fraction (AF):	6.0E-05	8.3E-06	4.3E-06	9.8E-06	1.4E-04	1.0E-05	2.0E-05	2.1E-05
Increased number of cases in population:	0.0006	0.0004	0.00008	0.00011	0.0007	0.000027	0.000019	0.0258
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0031	0.0160
Relative Risk:	1.000018	1.000002	1.000001	1.000003	1.000041	1.000003	1.000006	1.000006
Attributable fraction (AF):	1.8E-05	2.5E-06	1.3E-06	2.9E-06	4.1E-05	3.0E-06	5.9E-06	6.4E-06
Increased number of cases in population:	0.0017	0.0011	0.00022	0.00034	0.0018	0.000086	0.000059	0.078
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0044	0.0235
Relative Risk:	1.000025	1.000003	1.000002	1.000004	1.000057	1.000004	1.000008	1.000009
Attributable fraction (AF):	2.5E-05	3.5E-06	1.8E-06	4.1E-06	5.7E-05	4.2E-06	8.3E-06	9.4E-06
Increased number of cases in population:	0.0017	0.0009	0.00017	0.00024	0.0017	0.00006	0.00004	0.073
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (µg/m^3):	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.085
Relative Risk:	1.000090	1.000012	1.000006	1.000015	1.000201	1.000015	1.000029	1.000034
Attributable fraction (AF):	9.0E-05	1.2E-05	6.3E-06	1.5E-05	2.0E-04	1.5E-05	2.9E-05	3.4E-05
Increased number of cases in population:	0.0069	0.0043	0.00083	0.0014	0.0069	0.00035	0.00024	0.399
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (µg/m^3):	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0054	0.0297
Relative Risk:	1.000031	1.000004	1.000002	1.000005	1.000070	1.000005	1.000010	1.000012
Attributable fraction (AF):	3.1E-05	4.3E-06	2.2E-06	5.0E-06	7.0E-05	5.2E-06	1.0E-05	1.2E-05
Increased number of cases in population:	0.0017	0.0010	0.00020	0.00025	0.0017	0.00006	0.000044	0.0607
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0021	0.0113
Relative Risk:	1.000012	1.000002	1.000001	1.000002	1.000027	1.000002	1.000004	1.000005
Attributable fraction (AF):	1.2E-05	1.7E-06	8.5E-07	1.9E-06	2.7E-05	2.0E-06	3.9E-06	4.5E-06
Increased number of cases in population:	0.0002	0.0001	0.00003	0.00005	0.0003	0.00001	0.000008	0.0141
Total - All Suburbs	**0.02**	**0.009**	**0.002**	**0.003**	**0.02**	**0.0008**	**0.0005**	**0.86**

Assessment of Increased Incidence

Central Rail Access - Phase B

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 µg/m^3 PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (µg/m^3):	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.073
Relative Risk:	1.000175	1.000024	1.000012	1.000028	1.000392	1.000029	1.000057	1.000029
Attributable fraction (AF):	1.7E-04	2.4E-05	1.2E-05	2.8E-05	3.9E-04	2.9E-05	5.7E-05	2.9E-05
Increased number of cases in population:	0.007	0.002	0.0005	0.0016	0.007	0.00039	0.00027	0.232
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.055
Relative Risk:	1.000164	1.000023	1.000012	1.000027	1.000368	1.000027	1.000054	1.000022
Attributable fraction (AF):	1.6E-04	2.3E-05	1.2E-05	2.7E-05	3.7E-04	2.7E-05	5.4E-05	2.2E-05
Increased number of cases in population:	0.0018	0.0011	0.00022	0.00029	0.0018	0.000074	0.000051	0.0263
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0090	0.0181
Relative Risk:	1.000052	1.000007	1.000004	1.000008	1.000117	1.000009	1.000017	1.000007
Attributable fraction (AF):	5.2E-05	7.2E-06	3.7E-06	8.4E-06	1.2E-04	8.7E-06	1.7E-05	7.3E-06
Increased number of cases in population:	0.0050	0.0032	0.00063	0.00099	0.0051	0.000249	0.000169	0.088
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0096	0.0096	0.0096	0.0096	0.0096	0.0096	0.0096	0.0220
Relative Risk:	1.000056	1.000008	1.000004	1.000009	1.000125	1.000009	1.000018	1.000009
Attributable fraction (AF):	5.6E-05	7.7E-06	3.9E-06	9.0E-06	1.2E-04	9.3E-06	1.8E-05	8.8E-06
Increased number of cases in population:	0.0036	0.0019	0.00037	0.00052	0.0037	0.00013	0.00009	0.068
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (µg/m^3):	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.081
Relative Risk:	1.000208	1.000029	1.000015	1.000034	1.000467	1.000035	1.000068	1.000032
Attributable fraction (AF):	2.1E-04	2.9E-05	1.5E-05	3.4E-05	4.7E-04	3.5E-05	6.8E-05	3.2E-05
Increased number of cases in population:	0.0159	0.0099	0.00192	0.0032	0.0161	0.00082	0.00056	0.382
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (µg/m^3):	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0111	0.0273
Relative Risk:	1.000064	1.000009	1.000005	1.000010	1.000144	1.000011	1.000021	1.000011
Attributable fraction (AF):	6.4E-05	8.9E-06	4.5E-06	1.0E-05	1.4E-04	1.1E-05	2.1E-05	1.1E-05
Increased number of cases in population:	0.0035	0.0022	0.00042	0.00053	0.0036	0.00013	0.000091	0.0558
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0042	0.0104
Relative Risk:	1.000024	1.000003	1.000002	1.000004	1.000054	1.000004	1.000008	1.000004
Attributable fraction (AF):	2.4E-05	3.3E-06	1.7E-06	3.9E-06	5.4E-05	4.1E-06	7.9E-06	4.2E-06
Increased number of cases in population:	0.0005	0.0003	0.00005	0.00009	0.0005	0.00002	0.000016	0.0130
Total - All Suburbs	**0.04**	**0.02**	**0.004**	**0.01**	**0.04**	**0.002**	**0.001**	**0.87**

Assessment of Increased Incidence

Central Rail Access - Phase C

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 μg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (μg/m³):	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.099
Relative Risk:	1.000423	1.000058	1.000030	1.000069	1.000949	1.000071	1.000139	1.000040
Attributable fraction (AF):	4.2E-04	5.8E-05	3.0E-05	6.9E-05	9.5E-04	7.1E-05	1.4E-04	4.0E-05
Increased number of cases in population:	0.017	0.006	0.0011	0.0038	0.017	0.00095	0.00065	0.318
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (μg/m³):	0.065	0.065	0.065	0.065	0.065	0.065	0.065	0.090
Relative Risk:	1.000379	1.000052	1.000027	1.000061	1.000850	1.000063	1.000124	1.000036
Attributable fraction (AF):	3.8E-04	5.2E-05	2.7E-05	6.1E-05	8.5E-04	6.3E-05	1.2E-04	3.6E-05
Increased number of cases in population:	0.0041	0.0026	0.00050	0.00068	0.0041	0.000171	0.000117	0.0432
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (μg/m³):	0.0228	0.0228	0.0228	0.0228	0.0228	0.0228	0.0228	0.0303
Relative Risk:	1.000132	1.000018	1.000009	1.000021	1.000297	1.000022	1.000043	1.000012
Attributable fraction (AF):	1.3E-04	1.8E-05	9.4E-06	2.1E-05	3.0E-04	2.2E-05	4.3E-05	1.2E-05
Increased number of cases in population:	0.0128	0.0082	0.00159	0.00250	0.0129	0.000632	0.000430	0.146
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (μg/m³):	0.0253	0.0253	0.0253	0.0253	0.0253	0.0253	0.0253	0.0357
Relative Risk:	1.000147	1.000020	1.000010	1.000024	1.000329	1.000025	1.000048	1.000014
Attributable fraction (AF):	1.5E-04	2.0E-05	1.0E-05	2.4E-05	3.3E-04	2.5E-05	4.8E-05	1.4E-05
Increased number of cases in population:	0.0096	0.0050	0.00097	0.00137	0.0097	0.00035	0.00024	0.110
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (μg/m³):	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.143
Relative Risk:	1.000570	1.000079	1.000040	1.000092	1.001279	1.000095	1.000187	1.000057
Attributable fraction (AF):	5.7E-04	7.9E-05	4.0E-05	9.2E-05	1.3E-03	9.5E-05	1.9E-04	5.7E-05
Increased number of cases in population:	0.0436	0.0272	0.00525	0.0089	0.0441	0.00225	0.00153	0.673
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (μg/m³):	0.0343	0.0343	0.0343	0.0343	0.0343	0.0343	0.0343	0.0461
Relative Risk:	1.000199	1.000027	1.000014	1.000032	1.000446	1.000033	1.000065	1.000018
Attributable fraction (AF):	2.0E-04	2.7E-05	1.4E-05	3.2E-05	4.5E-04	3.3E-05	6.5E-05	1.8E-05
Increased number of cases in population:	0.0109	0.0067	0.00130	0.00163	0.0110	0.00041	0.000280	0.0942
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (μg/m³):	0.0118	0.0118	0.0118	0.0118	0.0118	0.0118	0.0118	0.0163
Relative Risk:	1.000069	1.000009	1.000005	1.000011	1.000154	1.000011	1.000022	1.000007
Attributable fraction (AF):	6.9E-05	9.5E-06	4.9E-06	1.1E-05	1.5E-04	1.1E-05	2.2E-05	6.5E-06
Increased number of cases in population:	0.0014	0.0008	0.00015	0.00027	0.0014	0.00007	0.000046	0.0204
Total - All Suburbs	**0.1**	**0.06**	**0.01**	**0.02**	**0.1**	**0.005**	**0.003**	**1.4**

Assessment of Increased Incidence

Central Rail Access - Phase D

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 μg/m^3 PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (μg/m^3):	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.079
Relative Risk:	1.000452	1.000062	1.000032	1.000073	1.001014	1.000076	1.000148	1.000032
Attributable fraction (AF):	4.5E-04	6.2E-05	3.2E-05	7.3E-05	1.0E-03	7.6E-05	1.5E-04	3.2E-05
Increased number of cases in population:	0.018	0.006	0.0012	0.0040	0.018	0.00102	0.00069	0.254
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (μg/m^3):	0.083	0.083	0.083	0.083	0.083	0.083	0.083	0.085
Relative Risk:	1.000484	1.000067	1.000034	1.000078	1.001085	1.000081	1.000159	1.000034
Attributable fraction (AF):	4.8E-04	6.7E-05	3.4E-05	7.8E-05	1.1E-03	8.1E-05	1.6E-04	3.4E-05
Increased number of cases in population:	0.0052	0.0033	0.00064	0.00087	0.0052	0.000219	0.000149	0.0410
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (μg/m^3):	0.0303	0.0303	0.0303	0.0303	0.0303	0.0303	0.0303	0.0309
Relative Risk:	1.000176	1.000024	1.000012	1.000029	1.000395	1.000029	1.000058	1.000012
Attributable fraction (AF):	1.8E-04	2.4E-05	1.2E-05	2.9E-05	3.9E-04	2.9E-05	5.8E-05	1.2E-05
Increased number of cases in population:	0.0170	0.0110	0.00212	0.00333	0.0172	0.000841	0.000573	0.149
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (μg/m^3):	0.0253	0.0253	0.0253	0.0253	0.0253	0.0253	0.0253	0.0306
Relative Risk:	1.000147	1.000020	1.000010	1.000024	1.000329	1.000025	1.000048	1.000012
Attributable fraction (AF):	1.5E-04	2.0E-05	1.0E-05	2.4E-05	3.3E-04	2.5E-05	4.8E-05	1.2E-05
Increased number of cases in population:	0.0096	0.0050	0.00097	0.00137	0.0097	0.00035	0.00024	0.095
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (μg/m^3):	0.133	0.133	0.133	0.133	0.133	0.133	0.133	0.136
Relative Risk:	1.000774	1.000107	1.000055	1.000125	1.001735	1.000129	1.000253	1.000054
Attributable fraction (AF):	7.7E-04	1.1E-04	5.5E-05	1.3E-04	1.7E-03	1.3E-04	2.5E-04	5.4E-05
Increased number of cases in population:	0.0591	0.0369	0.00712	0.0121	0.0597	0.00305	0.00207	0.640
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (μg/m^3):	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0336	0.0342
Relative Risk:	1.000195	1.000027	1.000014	1.000032	1.000436	1.000033	1.000064	1.000014
Attributable fraction (AF):	1.9E-04	2.7E-05	1.4E-05	3.2E-05	4.4E-04	3.3E-05	6.4E-05	1.4E-05
Increased number of cases in population:	0.0107	0.0066	0.00127	0.00160	0.0108	0.00040	0.000274	0.0700
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (μg/m^3):	0.0118	0.0118	0.0118	0.0118	0.0118	0.0118	0.0118	0.0121
Relative Risk:	1.000069	1.000009	1.000005	1.000011	1.000154	1.000011	1.000023	1.000005
Attributable fraction (AF):	6.9E-05	9.5E-06	4.9E-06	1.1E-05	1.5E-04	1.1E-05	2.3E-05	4.8E-06
Increased number of cases in population:	0.0014	0.0008	0.00015	0.00027	0.0014	0.00007	0.000046	0.0151
Total - All Suburbs	**0.1**	**0.07**	**0.01**	**0.02**	**0.1**	**0.006**	**0.004**	**1.3**

Assessment of Increased Incidence

Northern Rail Access - Phase A

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 μg/m³ PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (μg/m³):	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.067
Relative Risk:	1.000073	1.000010	1.000005	1.000012	1.000163	1.000012	1.000024	1.000027
Attributable fraction (AF):	7.3E-05	1.0E-05	5.1E-06	1.2E-05	1.6E-04	1.2E-05	2.4E-05	2.7E-05
Increased number of cases in population:	0.003	0.001	0.0002	0.0006	0.003	0.00016	0.00011	0.213
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (μg/m³):	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.056
Relative Risk:	1.000064	1.000009	1.000005	1.000010	1.000143	1.000011	1.000021	1.000022
Attributable fraction (AF):	6.4E-05	8.8E-06	4.5E-06	1.0E-05	1.4E-04	1.1E-05	2.1E-05	2.2E-05
Increased number of cases in population:	0.0007	0.0004	0.00008	0.00011	0.0007	0.000029	0.000020	0.0269
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (μg/m³):	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0032	0.0162
Relative Risk:	1.000019	1.000003	1.000001	1.000003	1.000042	1.000003	1.000006	1.000006
Attributable fraction (AF):	1.9E-05	2.6E-06	1.3E-06	3.0E-06	4.2E-05	3.1E-06	6.1E-06	6.5E-06
Increased number of cases in population:	0.0018	0.0012	0.00023	0.00035	0.0018	0.000090	0.000061	0.078
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (μg/m³):	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041	0.0041	0.0214
Relative Risk:	1.000024	1.000003	1.000002	1.000004	1.000053	1.000004	1.000008	1.000009
Attributable fraction (AF):	2.4E-05	3.3E-06	1.7E-06	3.9E-06	5.3E-05	4.0E-06	7.8E-06	8.6E-06
Increased number of cases in population:	0.0016	0.0008	0.00016	0.00022	0.0016	0.00006	0.00004	0.066
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (μg/m³):	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.082
Relative Risk:	1.000089	1.000012	1.000006	1.000014	1.000200	1.000015	1.000029	1.000033
Attributable fraction (AF):	8.9E-05	1.2E-05	6.3E-06	1.4E-05	2.0E-04	1.5E-05	2.9E-05	3.3E-05
Increased number of cases in population:	0.0068	0.0042	0.00082	0.0014	0.0069	0.00035	0.00024	0.386
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (μg/m³):	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0037	0.0192
Relative Risk:	1.000021	1.000003	1.000001	1.000003	1.000048	1.000004	1.000007	1.000008
Attributable fraction (AF):	2.1E-05	2.9E-06	1.5E-06	3.4E-06	4.8E-05	3.5E-06	6.9E-06	7.7E-06
Increased number of cases in population:	0.0012	0.0007	0.00014	0.00017	0.0012	0.00004	0.000030	0.0392
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (μg/m³):	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0017	0.0088
Relative Risk:	1.000010	1.000001	1.000001	1.000002	1.000022	1.000002	1.000003	1.000004
Attributable fraction (AF):	9.8E-06	1.3E-06	6.9E-07	1.6E-06	2.2E-05	1.6E-06	3.2E-06	3.5E-06
Increased number of cases in population:	0.0002	0.0001	0.00002	0.00004	0.0002	0.00001	0.000007	0.0109
Total - All Suburbs	**0.02**	**0.008**	**0.002**	**0.003**	**0.02**	**0.0007**	**0.0005**	**0.82**

Assessment of Increased Incidence

Northern Rail Access - Phase B

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 µg/m^3 PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (µg/m^3):	0.037	0.037	0.037	0.037	0.037	0.037	0.037	0.066
Relative Risk:	1.000213	1.000029	1.000015	1.000035	1.000478	1.000036	1.000070	1.000026
Attributable fraction (AF):	2.1E-04	2.9E-05	1.5E-05	3.5E-05	4.8E-04	3.6E-05	7.0E-05	2.6E-05
Increased number of cases in population:	0.009	0.003	0.0006	0.0019	0.009	0.00048	0.00033	0.211
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.063
Relative Risk:	1.000190	1.000026	1.000013	1.000031	1.000425	1.000032	1.000062	1.000025
Attributable fraction (AF):	1.9E-04	2.6E-05	1.3E-05	3.1E-05	4.2E-04	3.2E-05	6.2E-05	2.5E-05
Increased number of cases in population:	0.0020	0.0013	0.00025	0.00034	0.0021	0.000086	0.000058	0.0306
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0116	0.0201
Relative Risk:	1.000067	1.000009	1.000005	1.000011	1.000150	1.000011	1.000022	1.000008
Attributable fraction (AF):	6.7E-05	9.3E-06	4.7E-06	1.1E-05	1.5E-04	1.1E-05	2.2E-05	8.0E-06
Increased number of cases in population:	0.0065	0.0042	0.00081	0.00127	0.0066	0.000321	0.000218	0.097
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0127	0.0127	0.0127	0.0127	0.0127	0.0127	0.0127	0.0234
Relative Risk:	1.000074	1.000010	1.000005	1.000012	1.000165	1.000012	1.000024	1.000009
Attributable fraction (AF):	7.4E-05	1.0E-05	5.2E-06	1.2E-05	1.7E-04	1.2E-05	2.4E-05	9.3E-06
Increased number of cases in population:	0.0048	0.0025	0.00049	0.00069	0.0049	0.00017	0.00012	0.072
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (µg/m^3):	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.094
Relative Risk:	1.000324	1.000045	1.000023	1.000052	1.000726	1.000054	1.000106	1.000038
Attributable fraction (AF):	3.2E-04	4.5E-05	2.3E-05	5.2E-05	7.3E-04	5.4E-05	1.1E-04	3.8E-05
Increased number of cases in population:	0.0248	0.0154	0.00298	0.0051	0.0250	0.00128	0.00087	0.444
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (µg/m^3):	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0154	0.0236
Relative Risk:	1.000089	1.000012	1.000006	1.000014	1.000200	1.000015	1.000029	1.000009
Attributable fraction (AF):	8.9E-05	1.2E-05	6.3E-06	1.4E-05	2.0E-04	1.5E-05	2.9E-05	9.4E-06
Increased number of cases in population:	0.0049	0.0030	0.00058	0.00073	0.0050	0.00018	0.000126	0.0482
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0057	0.0095
Relative Risk:	1.000033	1.000005	1.000002	1.000005	1.000074	1.000005	1.000011	1.000004
Attributable fraction (AF):	3.3E-05	4.5E-06	2.3E-06	5.3E-06	7.4E-05	5.5E-06	1.1E-05	3.8E-06
Increased number of cases in population:	0.0007	0.0004	0.00007	0.00013	0.0007	0.00003	0.000022	0.0118
Total - All Suburbs	**0.05**	**0.03**	**0.006**	**0.01**	**0.1**	**0.00**	**0.002**	**0.91**

Assessment of Increased Incidence

Northern Rail Access - Phase C

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 µg/m^3 PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (µg/m^3):	0.073	0.073	0.073	0.073	0.073	0.073	0.073	0.098
Relative Risk:	1.000425	1.000059	1.000030	1.000069	1.000953	1.000071	1.000139	1.000039
Attributable fraction (AF):	4.2E-04	5.9E-05	3.0E-05	6.9E-05	9.5E-04	7.1E-05	1.4E-04	3.9E-05
Increased number of cases in population:	0.017	0.006	0.0011	0.0038	0.017	0.00095	0.00065	0.313
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.070	0.070	0.070	0.070	0.070	0.070	0.070	0.090
Relative Risk:	1.000409	1.000056	1.000029	1.000066	1.000917	1.000068	1.000134	1.000036
Attributable fraction (AF):	4.1E-04	5.6E-05	2.9E-05	6.6E-05	9.2E-04	6.8E-05	1.3E-04	3.6E-05
Increased number of cases in population:	0.0044	0.0028	0.00054	0.00073	0.0044	0.000185	0.000126	0.0435
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.0252	0.0252	0.0252	0.0252	0.0252	0.0252	0.0252	0.0313
Relative Risk:	1.000146	1.000020	1.000010	1.000024	1.000327	1.000024	1.000048	1.000013
Attributable fraction (AF):	1.5E-04	2.0E-05	1.0E-05	2.4E-05	3.3E-04	2.4E-05	4.8E-05	1.3E-05
Increased number of cases in population:	0.0141	0.0091	0.00176	0.00276	0.0142	0.000697	0.000475	0.151
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0255	0.0255	0.0255	0.0255	0.0255	0.0255	0.0255	0.0342
Relative Risk:	1.000148	1.000020	1.000010	1.000024	1.000331	1.000025	1.000048	1.000014
Attributable fraction (AF):	1.5E-04	2.0E-05	1.0E-05	2.4E-05	3.3E-04	2.5E-05	4.8E-05	1.4E-05
Increased number of cases in population:	0.0097	0.0050	0.00097	0.00138	0.0098	0.00035	0.00024	0.106
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (µg/m^3):	0.116	0.116	0.116	0.116	0.116	0.116	0.116	0.153
Relative Risk:	1.000670	1.000092	1.000047	1.000109	1.001503	1.000112	1.000220	1.000061
Attributable fraction (AF):	6.7E-04	9.2E-05	4.7E-05	1.1E-04	1.5E-03	1.1E-04	2.2E-04	6.1E-05
Increased number of cases in population:	0.0513	0.0319	0.00617	0.0105	0.0518	0.00264	0.00180	0.722
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (µg/m^3):	0.0302	0.0302	0.0302	0.0302	0.0302	0.0302	0.0302	0.0418
Relative Risk:	1.000175	1.000024	1.000012	1.000028	1.000393	1.000029	1.000057	1.000017
Attributable fraction (AF):	1.8E-04	2.4E-05	1.2E-05	2.8E-05	3.9E-04	2.9E-05	5.7E-05	1.7E-05
Increased number of cases in population:	0.0096	0.0059	0.00115	0.00144	0.0097	0.00036	0.000247	0.0854
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0108	0.0151
Relative Risk:	1.000063	1.000009	1.000004	1.000010	1.000141	1.000011	1.000021	1.000006
Attributable fraction (AF):	6.3E-05	8.7E-06	4.4E-06	1.0E-05	1.4E-04	1.1E-05	2.1E-05	6.0E-06
Increased number of cases in population:	0.0013	0.0007	0.00013	0.00024	0.0013	0.00006	0.000042	0.0188
Total - All Suburbs	**0.1**	**0.06**	**0.01**	**0.02**	**0.1**	**0.01**	**0.004**	**1.4**

Assessment of Increased Incidence

Northern Rail Access - Phase D

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 μg/m^3 PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (μg/m^3):	0.078	0.078	0.078	0.078	0.078	0.078	0.078	0.079
Relative Risk:	1.000452	1.000062	1.000032	1.000073	1.001014	1.000076	1.000148	1.000032
Attributable fraction (AF):	4.5E-04	6.2E-05	3.2E-05	7.3E-05	1.0E-03	7.6E-05	1.5E-04	3.2E-05
Increased number of cases in population:	0.018	0.006	0.0012	0.0040	0.018	0.00102	0.00069	0.254
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (μg/m^3):	0.077	0.077	0.077	0.077	0.077	0.077	0.077	0.078
Relative Risk:	1.000445	1.000061	1.000031	1.000072	1.000997	1.000074	1.000146	1.000031
Attributable fraction (AF):	4.4E-04	6.1E-05	3.1E-05	7.2E-05	1.0E-03	7.4E-05	1.5E-04	3.1E-05
Increased number of cases in population:	0.0048	0.0030	0.00058	0.00079	0.0048	0.000201	0.000137	0.0377
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (μg/m^3):	0.0282	0.0282	0.0282	0.0282	0.0282	0.0282	0.0282	0.0288
Relative Risk:	1.000164	1.000023	1.000012	1.000027	1.000367	1.000027	1.000054	1.000012
Attributable fraction (AF):	1.6E-04	2.3E-05	1.2E-05	2.7E-05	3.7E-04	2.7E-05	5.4E-05	1.2E-05
Increased number of cases in population:	0.0158	0.0102	0.00197	0.00310	0.0160	0.000783	0.000533	0.139
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (μg/m^3):	0.0291	0.0291	0.0291	0.0291	0.0291	0.0291	0.0291	0.0297
Relative Risk:	1.000169	1.000023	1.000012	1.000027	1.000379	1.000028	1.000055	1.000012
Attributable fraction (AF):	1.7E-04	2.3E-05	1.2E-05	2.7E-05	3.8E-04	2.8E-05	5.5E-05	1.2E-05
Increased number of cases in population:	0.0111	0.0058	0.00111	0.00158	0.0112	0.00040	0.00027	0.092
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (μg/m^3):	0.128	0.128	0.128	0.128	0.128	0.128	0.128	0.130
Relative Risk:	1.000742	1.000102	1.000052	1.000120	1.001663	1.000124	1.000243	1.000052
Attributable fraction (AF):	7.4E-04	1.0E-04	5.2E-05	1.2E-04	1.7E-03	1.2E-04	2.4E-04	5.2E-05
Increased number of cases in population:	0.0567	0.0353	0.00683	0.0116	0.0573	0.00292	0.00199	0.615
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (μg/m^3):	0.0351	0.0351	0.0351	0.0351	0.0351	0.0351	0.0351	0.0358
Relative Risk:	1.000204	1.000028	1.000014	1.000033	1.000456	1.000034	1.000067	1.000014
Attributable fraction (AF):	2.0E-04	2.8E-05	1.4E-05	3.3E-05	4.6E-04	3.4E-05	6.7E-05	1.4E-05
Increased number of cases in population:	0.0112	0.0069	0.00133	0.00167	0.0113	0.00042	0.000287	0.0731
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (μg/m^3):	0.0123	0.0123	0.0123	0.0123	0.0123	0.0123	0.0123	0.0125
Relative Risk:	1.000071	1.000010	1.000005	1.000012	1.000160	1.000012	1.000023	1.000005
Attributable fraction (AF):	7.1E-05	9.8E-06	5.0E-06	1.2E-05	1.6E-04	1.2E-05	2.3E-05	5.0E-06
Increased number of cases in population:	0.0015	0.0008	0.00015	0.00028	0.0015	0.00007	0.000048	0.0156
Total - All Suburbs	**0.1**	**0.07**	**0.01**	**0.02**	**0.1**	**0.01**	**0.004**	**1.2**

Assessment of Increased Incidence

Southern Rail Access - Cumulative Scenario 1

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 µg/m^3 PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (µg/m^3):	0.184	0.184	0.184	0.184	0.184	0.184	0.184	0.188
Relative Risk:	1.001065	1.000147	1.000075	1.000173	1.002389	1.000178	1.000349	1.000075
Attributable fraction (AF):	1.1E-03	1.5E-04	7.5E-05	1.7E-04	2.4E-03	1.8E-04	3.5E-04	7.5E-05
Increased number of cases in population:	0.043	0.015	0.0028	0.0095	0.043	0.00239	0.00163	0.602
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.163	0.163	0.163	0.163	0.163	0.163	0.163	0.167
Relative Risk:	1.000944	1.000130	1.000067	1.000153	1.002118	1.000158	1.000309	1.000067
Attributable fraction (AF):	9.4E-04	1.3E-04	6.7E-05	1.5E-04	2.1E-03	1.6E-04	3.1E-04	6.7E-05
Increased number of cases in population:	0.0101	0.0064	0.00124	0.00169	0.0102	0.000426	0.000290	0.0805
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0484	0.0496
Relative Risk:	1.000281	1.000039	1.000020	1.000045	1.000629	1.000047	1.000092	1.000020
Attributable fraction (AF):	2.8E-04	3.9E-05	2.0E-05	4.5E-05	6.3E-04	4.7E-05	9.2E-05	2.0E-05
Increased number of cases in population:	0.0271	0.0175	0.00338	0.00531	0.0274	0.001341	0.000913	0.240
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0469	0.0469	0.0469	0.0469	0.0469	0.0469	0.0469	0.0480
Relative Risk:	1.000272	1.000038	1.000019	1.000044	1.000610	1.000046	1.000089	1.000019
Attributable fraction (AF):	2.7E-04	3.8E-05	1.9E-05	4.4E-05	6.1E-04	4.6E-05	8.9E-05	1.9E-05
Increased number of cases in population:	0.0178	0.0093	0.00180	0.00255	0.0180	0.00064	0.00044	0.149
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (µg/m^3):	0.175	0.175	0.175	0.175	0.175	0.175	0.175	0.179
Relative Risk:	1.001017	1.000140	1.000072	1.000165	1.002282	1.000170	1.000333	1.000072
Attributable fraction (AF):	1.0E-03	1.4E-04	7.2E-05	1.6E-04	2.3E-03	1.7E-04	3.3E-04	7.2E-05
Increased number of cases in population:	0.0778	0.0485	0.00937	0.0159	0.0785	0.00401	0.00273	0.846
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (µg/m^3):	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565	0.0565	0.0578
Relative Risk:	1.000328	1.000045	1.000023	1.000053	1.000734	1.000055	1.000107	1.000023
Attributable fraction (AF):	3.3E-04	4.5E-05	2.3E-05	5.3E-05	7.3E-04	5.5E-05	1.1E-04	2.3E-05
Increased number of cases in population:	0.0180	0.0111	0.00214	0.00268	0.0182	0.00068	0.000462	0.1181
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0211	0.0211	0.0211	0.0211	0.0211	0.0211	0.0211	0.0216
Relative Risk:	1.000123	1.000017	1.000009	1.000020	1.000275	1.000021	1.000040	1.000009
Attributable fraction (AF):	1.2E-04	1.7E-05	8.7E-06	2.0E-05	2.7E-04	2.1E-05	4.0E-05	8.7E-06
Increased number of cases in population:	0.0025	0.0013	0.00026	0.00048	0.0026	0.00012	0.000082	0.0270
Total - All Suburbs	**0.2**	**0.1**	**0.02**	**0.04**	**0.2**	**0.010**	**0.007**	**2.1**

Assessment of Increased Incidence

Southern Rail Access - Cumulative Scenario 2

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 μg/m^3 PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (μg/m^3):	0.160	0.160	0.160	0.160	0.160	0.160	0.160	0.164
Relative Risk:	1.000926	1.000128	1.000065	1.000150	1.002076	1.000155	1.000303	1.000066
Attributable fraction (AF):	9.2E-04	1.3E-04	6.5E-05	1.5E-04	2.1E-03	1.5E-04	3.0E-04	6.6E-05
Increased number of cases in population:	0.037	0.013	0.0025	0.0082	0.037	0.00208	0.00142	0.524
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (μg/m^3):	0.139	0.139	0.139	0.139	0.139	0.139	0.139	0.143
Relative Risk:	1.000807	1.000111	1.000057	1.000131	1.001809	1.000135	1.000264	1.000057
Attributable fraction (AF):	8.1E-04	1.1E-04	5.7E-05	1.3E-04	1.8E-03	1.3E-04	2.6E-04	5.7E-05
Increased number of cases in population:	0.0087	0.0055	0.00106	0.00144	0.0087	0.000364	0.000248	0.0689
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (μg/m^3):	0.0398	0.0398	0.0398	0.0398	0.0398	0.0398	0.0398	0.0408
Relative Risk:	1.000231	1.000032	1.000016	1.000037	1.000517	1.000039	1.000076	1.000016
Attributable fraction (AF):	2.3E-04	3.2E-05	1.6E-05	3.7E-05	5.2E-04	3.9E-05	7.6E-05	1.6E-05
Increased number of cases in population:	0.0223	0.0144	0.00278	0.00436	0.0225	0.001102	0.000750	0.197
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (μg/m^3):	0.0378	0.0378	0.0378	0.0378	0.0378	0.0378	0.0378	0.0387
Relative Risk:	1.000219	1.000030	1.000015	1.000036	1.000491	1.000037	1.000072	1.000015
Attributable fraction (AF):	2.2E-04	3.0E-05	1.5E-05	3.6E-05	4.9E-04	3.7E-05	7.2E-05	1.5E-05
Increased number of cases in population:	0.0144	0.0075	0.00145	0.00205	0.0145	0.00052	0.00035	0.120
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (μg/m^3):	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.140
Relative Risk:	1.000795	1.000110	1.000056	1.000129	1.001782	1.000133	1.000260	1.000056
Attributable fraction (AF):	7.9E-04	1.1E-04	5.6E-05	1.3E-04	1.8E-03	1.3E-04	2.6E-04	5.6E-05
Increased number of cases in population:	0.0608	0.0379	0.00732	0.0124	0.0614	0.00313	0.00213	0.662
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (μg/m^3):	0.0458	0.0458	0.0458	0.0458	0.0458	0.0458	0.0458	0.0469
Relative Risk:	1.000266	1.000037	1.000019	1.000043	1.000596	1.000044	1.000087	1.000019
Attributable fraction (AF):	2.7E-04	3.7E-05	1.9E-05	4.3E-05	6.0E-04	4.4E-05	8.7E-05	1.9E-05
Increased number of cases in population:	0.0146	0.0090	0.00174	0.00218	0.0148	0.00055	0.000375	0.0959
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (μg/m^3):	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0174	0.0178
Relative Risk:	1.000101	1.000014	1.000007	1.000016	1.000226	1.000017	1.000033	1.000007
Attributable fraction (AF):	1.0E-04	1.4E-05	7.1E-06	1.6E-05	2.3E-04	1.7E-05	3.3E-05	7.1E-06
Increased number of cases in population:	0.0021	0.0011	0.00021	0.00039	0.0021	0.00010	0.000067	0.0222
Total - All Suburbs	**0.2**	**0.09**	**0.02**	**0.03**	**0.2**	**0.008**	**0.005**	**1.7**

Assessment of Increased Incidence

Southern Rail Access - Cumulative Scenario 3

	Primary Indicators (PM2.5)			Secondary Indicators (PM2.5)				Asthma (PM10)
Health Endpoint:	**Mortality - All Causes, Long-term**	**Hospitalisations - Cardiovascular. Short-term**	**Hospitalisations - Respiratory, Short-term**	**Mortality - All Causes, Short-term**	**Mortality - Cardiopulmonary, Long-term**	**Mortality - Cardiovascular, Short-term**	**Mortality - Respiratory, Short-term**	**Increased use of bronchodilator**
Age Group:	≥ 30 years	≥ 65 years	≥ 65 years	All ages	≥ 30 years	All ages	All ages	5-14 years
β (change in effect per 1 µg/m^3 PM) (as per Table 4.1)	0.0058	0.0008	0.00041	0.00094	0.013	0.00097	0.0019	0.0004
Baseline Incidence (per 100,000) (as per Table 2.3)	1087	23352	8807	670	490	164	57	
Baseline Incidence (per person)	0.01087	0.23352	0.08807	0.0067	0.0049	0.00164	0.00057	5.548
Wattle Grove								
Total Population:	8192	8192	8192	8192	8192	8192	8192	8192
% population in assessment age-group:	45%	5%	5%	100%	45%	100%	100%	18%
Suburb average Δx (µg/m^3):	0.137	0.137	0.137	0.137	0.137	0.137	0.137	0.141
Relative Risk:	1.000797	1.000110	1.000056	1.000129	1.001787	1.000133	1.000261	1.000057
Attributable fraction (AF):	8.0E-04	1.1E-04	5.6E-05	1.3E-04	1.8E-03	1.3E-04	2.6E-04	5.7E-05
Increased number of cases in population:	0.032	0.011	0.0021	0.0071	0.032	0.00179	0.00122	0.452
Moorebank								
Total Population:	1647	1647	1647	1647	1647	1647	1647	1647
% population in assessment age-group:	60%	13%	13%	100%	60%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.117	0.117	0.117	0.117	0.117	0.117	0.117	0.120
Relative Risk:	1.000678	1.000094	1.000048	1.000110	1.001521	1.000113	1.000222	1.000048
Attributable fraction (AF):	6.8E-04	9.4E-05	4.8E-05	1.1E-04	1.5E-03	1.1E-04	2.2E-04	4.8E-05
Increased number of cases in population:	0.0073	0.0046	0.00089	0.00121	0.0074	0.000306	0.000209	0.0580
Liverpool								
Total Population:	17420	17420	17420	17420	17420	17420	17420	17420
% population in assessment age-group:	51%	11%	11%	100%	51%	100%	100%	13%
Suburb average Δx (µg/m^3):	0.0317	0.0317	0.0317	0.0317	0.0317	0.0317	0.0317	0.0326
Relative Risk:	1.000184	1.000025	1.000013	1.000030	1.000412	1.000031	1.000060	1.000013
Attributable fraction (AF):	1.8E-04	2.5E-05	1.3E-05	3.0E-05	4.1E-04	3.1E-05	6.0E-05	1.3E-05
Increased number of cases in population:	0.0178	0.0115	0.00221	0.00348	0.0179	0.000879	0.000598	0.157
Lurnea								
Total Population:	8611	8611	8611	8611	8611	8611	8611	8611
% population in assessment age-group:	70%	12%	12%	100%	70%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0292	0.0292	0.0292	0.0292	0.0292	0.0292	0.0292	0.0300
Relative Risk:	1.000170	1.000023	1.000012	1.000027	1.000380	1.000028	1.000056	1.000012
Attributable fraction (AF):	1.7E-04	2.3E-05	1.2E-05	2.7E-05	3.8E-04	2.8E-05	5.6E-05	1.2E-05
Increased number of cases in population:	0.0111	0.0058	0.00112	0.00158	0.0112	0.00040	0.00027	0.093
Casula								
Total Population:	14366	14366	14366	14366	14366	14366	14366	14366
% population in assessment age-group:	49%	10%	10%	100%	49%	100%	100%	15%
Suburb average Δx (µg/m^3):	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.104
Relative Risk:	1.000586	1.000081	1.000041	1.000095	1.001314	1.000098	1.000192	1.000041
Attributable fraction (AF):	5.9E-04	8.1E-05	4.1E-05	9.5E-05	1.3E-03	9.8E-05	1.9E-04	4.1E-05
Increased number of cases in population:	0.0448	0.0279	0.00540	0.0091	0.0453	0.00231	0.00157	0.489
Glenfield								
Total Population:	7550	7550	7550	7550	7550	7550	7550	7550
% population in assessment age-group:	67%	14%	14%	100%	67%	100%	100%	12%
Suburb average Δx (µg/m^3):	0.0359	0.0359	0.0359	0.0359	0.0359	0.0359	0.0359	0.0369
Relative Risk:	1.000208	1.000029	1.000015	1.000034	1.000467	1.000035	1.000068	1.000015
Attributable fraction (AF):	2.1E-04	2.9E-05	1.5E-05	3.4E-05	4.7E-04	3.5E-05	6.8E-05	1.5E-05
Increased number of cases in population:	0.0115	0.0070	0.00136	0.00171	0.0116	0.00043	0.000294	0.0754
Macquarie Fields								
Total Population:	3582	3582	3582	3582	3582	3582	3582	3582
% population in assessment age-group:	53%	10%	10%	100%	53%	100%	100%	16%
Suburb average Δx (µg/m^3):	0.0139	0.0139	0.0139	0.0139	0.0139	0.0139	0.0139	0.0143
Relative Risk:	1.000081	1.000011	1.000006	1.000013	1.000181	1.000013	1.000026	1.000006
Attributable fraction (AF):	8.1E-05	1.1E-05	5.7E-06	1.3E-05	1.8E-04	1.3E-05	2.6E-05	5.7E-06
Increased number of cases in population:	0.0017	0.0009	0.00017	0.00031	0.0017	0.00008	0.000054	0.0178
Total - All Suburbs	**0.1**	**0.07**	**0.01**	**0.02**	**0.1**	**0.006**	**0.004**	**1.3**