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Moorebank Precinct West (MPW) – Stage 2 Proposal

Health Risk Assessment

SIMTA

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MOOREBANK PRECINCT WEST STAGE 2 PROPOSAL
HUMAN HEALTH RISK ASSESSMENT

RAMBOLL ENVIRON

MOOREBANK PRECINCT WEST STAGE 2 PROPOSAL
HUMAN HEALTH RISK ASSESSMENT

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EXECUTIVE SUMMARY

Introduction

A Health Risk Assessment has been prepared to support the Environmental Impact Statement for approval of the Moorebank Precinct West (MPW) Stage 2 Proposal (the Proposal). The Proposal involves the development of intermodal freight terminal facilities (IMT), associated commercial infrastructure (i.e. warehousing), a connection to the Rail link, connecting the MPW site to the Southern Sydney Freight Line (SSFL), and a road entry and exit point from Moorebank Avenue.

Overall study approach

A Health Risk Assessment (HRA) uses information about pollutants to estimate a theoretical level of risk for people who might be exposed to defined levels of these substances. The objective of this HRA is to assess potential health risk posed by the air emissions and noise on the surrounding community.

The HRA process comprises five components: issues identification, exposure assessment, toxicity assessment, risk characterisation, and uncertainty assessment. The approach to this HRA was in accordance with approved Australian guidance for performing risk assessments, in particular:

- Health Impact Assessment – A Practical Guide - Centre for Health Equity Training, Research and Evaluation (CHETRE, 2007).
- Environmental Health Risk Assessment: Guidelines for Assessing Human Health Risks from Environmental Hazards (enHealth, 2012a).

It is noted that a Health Impact Assessment (HIA) has not been conducted for the Proposal. HIA has previously been undertaken for the MPW Concept Plan Approval (EnRisks 2014b) and the community consultation underpinning the HIA, and conclusions from the HIA remain applicable to the Proposal.

Overview of the air quality health risk assessment

The focus of the air quality HRA was on the health impacts of emissions from the operational phase of the Proposal. The key air pollutants evaluated in the local air quality assessment were considered as chemicals of potential concern (COPCs) and inhalation of air was the only exposure pathway evaluated.

The human receptors of concern included commercial/industrial workers, residents, school or day care students and recreational users located in the suburbs of Casula, Wattle Grove, Glenfield, and Moorebank. Annual average ground level concentrations (GLCs) of COPCs emitted from operation of the Proposal were predicted by air modelling in the local air quality assessment. A cumulative Proposal scenario was also considered for concurrent operation of the Proposal and MPE Stage 1 Proposal.

Health endpoints and associated exposure-response relationships were previously approved by NSW Health as part of the consultation undertaken for MPE Stage 1, and are therefore also adopted for this HRA (Pacific Environment 2015). The air quality HRA evaluated a range of health endpoints associated with the key air pollutants, including increases in mortality and morbidity as well as excess lifetime cancer risks.

Summary of air quality HRA results

Short-term and long-term exposure to PM_{10} and $PM_{2.5}$ result in low health impacts in the surrounding communities (i.e., fewer than one increased case per year of premature mortality, hospital admissions, and emergency department visits associated with cardiovascular and respiratory diseases or asthma). Short-term and long-term exposure to NO_x, following adjustment for the fraction attributable to NO_2, result in low health impacts in the surrounding communities (i.e. fewer than one increased case per year of premature mortality, hospital admissions, and emergency department visits associated with cardiovascular and respiratory diseases or asthma). Short-term exposure to SO_2 and CO results in negligible impacts in the surrounding communities (i.e. orders of

magnitude below the acceptable risk of one increased case per year, for premature mortality, hospital admissions, and emergency department visits associated with cardiovascular and respiratory diseases or asthma).

Excess lifetime cancer risks for residents/school students, commercial/industrial workers, and recreational populations within the study area are below levels of acceptable risk (i.e. within or below the established acceptable cancer risk range of 10^{-6} to 10^{-4}).

In summary, there are no significant adverse health effects expected in relation to short-term and long-term exposure to key air pollutants associated with the operation of the Proposal alone, and also a cumulative assessment scenario.

Overview of health risk assessment for noise

The main health effects associated with environmental noise include cardiovascular disease, cognitive impairment, sleep disturbance, tinnitus, annoyance, and hearing impairment.

The exposure data for the noise HRA were obtained from the Noise and Vibration Impact Assessment (Wilkinson-Murray, 2016). The risk characterisation was conducted by comparing the predicted noise levels to the corresponding health-based World Health Organisation guideline values for annoyance, sleep disturbance and cognitive impairment (WHO, 1999).

The noise from both operation of the Proposal and cumulative assessment scenario meets the WHO community noise guidelines at all residential receivers. A HQ greater than 1 was predicted for annoyance and cognitive impairment at the nearest industrial receivers, however, the HQs for existing ambient noise already exceed 1 for annoyance and cognitive impairment.

Similarly, although rail noise and total noise exceed WHO community noise guidelines, the existing ambient noise levels alone are already above these guidelines and on this basis the Proposal related noise is expected to have a minimal impact on the local residential area.

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ACRONYMS AND ABBREVIATIONS

ABS	Australian Bureau of Statistics
AQIA	Air Quality Impact Assessment
BaP	Benzo(a)pyrene
Cal/EPA	California Environmental Protection Agency
CCME	Canadian Council of Ministers for the Environment
CO	Carbon Monoxide
COPC	Chemical of Potential Concern
CSM	Conceptual Site Model
dB	decibel
DEMS	Diesel Exhaust in Miners Study
DoD	Department of Defense
DPM	Diesel Particulate Matter
EIS	Environmental Impact Statement
EP&A	Environmental Planning and Assessment
EPBC	Environmental Protection Biodiversity Conservation
EPC	Exposure Point Concentration
EPHC	Environment Protection and Heritage Council
GFA	Gross Floor Area
GLC	Ground Level Concentration
HEI	Health Effects Institute
HIA	Health Impact Assessment
HQ	Hazard Quotient
HRA	Health Risk Assessment
IARC	International Agency for Research on Cancer
IMEX	Import Export
IMT	Intermodal Terminal
LGA	Local Government Area
m^2	square meter
m^3	cubic meter
MAF	Modelling Adjustment Factor
MIC	Moorebank Intermodal Company
MPE	Moorebank Precinct East
MPW	Moorebank Precinct West
NCA	Noise Catchment Area
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NO_2	Nitrogen Dioxide
NSW	New South Wales
OEHHA	Office of Environmental Health Hazard Assessment
OEH	Office of Environment and Heritage
PAH	Polycyclic Aromatic Hydrocarbon
PM	Particulate Matter
RBL	Rating Background Level
REMM	Revised Environmental Mitigation Measure
SEAR	Secretary's Environmental Assessment Requirement
SIMTA	Sydney Intermodal Terminal Alliance
SO_2	Sulfur Dioxide
SPR	Source-Pathway-Receptor
SSD	State Significant Development
SSFL	Southern Sydney Freight Line
SWSLHD	South Western Sydney Local Health District

TEF	Toxicity Equivalent Factor
TEQ	Toxicity Equivalent
TEU	Twenty-Foot Equivalent Unit
µg	microgram
µm	micrometer
URF	Unit Risk Factor
USEPA	United States Environment Protection Agency
VOC	Volatile Organic Compound
WHO	World Health Organization

1. INTRODUCTION

On the 3 June 2016 Concept Plan Approval (SSD 5066) was granted, under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act), to develop the Moorebank Precinct West Project (MPW Project) on the western side of Moorebank Avenue, Moorebank, in south-western Sydney (the MPW site).

The MPW Project involves the development of intermodal freight terminal facilities (IMT), linked to Port Botany, the interstate and intrastate freight rail network. The MPW Project includes associated commercial infrastructure (i.e. warehousing), a rail link connecting the MPW site to the Southern Sydney Freight Line (SSFL), and a road entry and exit point from Moorebank Avenue.

Under the Concept Plan Approval, the MPW Project is to be developed in four phases, being:

- Early Works development phase, comprising:
  - The demolition of existing buildings and structures
  - Service utility terminations and diversion/relocation
  - Removal of existing hardstand/roads/pavements and infrastructure associated with existing buildings
  - Rehabilitation of the excavation/earthmoving training area (i.e. 'dust bowl')
  - Remediation of contaminated land and hotspots, including areas known to contain asbestos, and the removal of:
    - Underground storage tanks (USTs)
    - Unexploded ordnance (UXO) and explosive ordnance waste (EOW) if found
    - Asbestos contaminated buildings
  - Archaeological salvage of Aboriginal and European sites
  - Establishment of a conservation area along the Georges River
  - Establishment of construction facilities (which may include a construction laydown area, site offices, hygiene units, kitchen facilities, wheel wash and staff parking) and access, including site security
  - Vegetation removal, including the relocation of hollow-bearing trees, as required for remediation and demolition purposes
- Development of the intermodal terminal (IMT) facility and initial warehousing facilities
- 'Ramp up' of the IMT capacity and warehousing
- Development of further warehousing.

Approval for the Early Works phase (MPW Concept Plan Approval) was granted as the first stage of the MPW Project within the Concept Plan Approval. Works, approved as part of this stage are anticipated to commence in the third quarter of 2016.

Commonwealth Approval (No. 2011/6086), under the *Environmental Protection Biodiversity Conservation Act 1999* (EPBC Act), was also granted in mid 2016 (soon after the Concept Plan Approval) for the MPW Project. In addition to this, the Planning Proposal (PP_2012_LPOOL_004_00) which provided a rezoning of part of the MPW site, and surrounds, was gazetted on 24 June 2016 into the *Liverpool Local Environmental Plan 2008* (Amendment No. 62).

On 5 December 2014, Moorebank Intermodal Terminal Company (MIC) and SIMTA announced their in-principle agreement to develop the Moorebank IMT Precinct on a whole of precinct basis. This agreement is subject to satisfying several conditions which both parties are currently working towards. SIMTA is therefore seeking approval to build and operate the IMT facility and warehousing under the MPW Project Concept Approval, known as the MPW Stage 2 Proposal (the Proposal).

1.1 Report purpose

This report presents a human health risk assessment (HRA) to address the potential health risks from exposure to air emission and noise from the Proposal.

This report has been prepared to support the Environmental Impact Statement (EIS) for approval of the Proposal. A summary of the works included in the Proposal is provided below.

This report has been prepared as part of a State Significant Development (SSD) Application for which approval is sought under Part 4, Division 4.1 of the EP&A Act. This report has been prepared in accordance with the Secretary's Environmental Assessment Requirements (SEARs) (ref: SSD 16-7709 and dated 14 July 2016) and revised environmental mitigation measures (REMMs) identified in the MPW Concept Plan Approval (SSD_5066).

Table 1-1 provides a summary of the SEARs and the REMMs from the MPW Concept Plan Approval, which are relevant to this report and the section where they have been addressed in this report.

Local air quality impacts have been evaluated in detail in an Air Quality Impact Assessment (Ramboll Environ, 2016), referred to in this document as the Air Quality Impact Assessment or AQIA. Local noise impacts have been evaluated in detail in the report "MPW Stage 2 Noise and Vibration Impact Assessment" prepared by Wilkinson-Murray (2016). This HRA has drawn on information presented in AQIA as well as noise and vibration impact assessment report, and as such should be read in conjunction with these two reports.

Also, this HRA focusses on risk characterisation using the model-predicted air and noise data for MPW Stage 2 to update the previous health risk characterizations performed for the previous phases of the project. For a more comprehensive discussion of project background and toxicity assessment, please refer to the previous HRA reports for MPW Concept Plan Approval (EnRisks 2014a) and MPE Stage 1 (Pacific Environment 2015).

Table 1-1 provides a summary of the SEARs and REMMs from the MPW Concept Plan Approval and the section where they have been addressed in this report.

Table 1-1: Summary of SEARs/REMM for human health risk

Section/ number	SEAR/REMM	Where addressed in this report
	SEARs	
General requirements	a health risk assessment of local and regional impacts associated with the development, including those health risks associated with relevant key issues. The assessment should be undertaken with reference to the Centre for Health Equity Training, Research, an Evaluations' practical guide to impact assessment (August 2007) and shall include: • a discussion of the known potential developments in the local region; • an assessment of the impact on the environmental values of public health; and • an assessment of local and regional impacts including health risks.	This report presents a health risk assessment for local impacts associated with air and noise emissions. Regional impacts have been previously considered for the Concept Plan Approval for both the MPW and MPE sites. Refer to Section 3 for methodology.

Table 1-1: Summary of SEARs/REMM for human health risk		
Section/ number	**SEAR/REMM**	**Where addressed in this report**
REMMs		
17A	Annualised average monitoring for air quality and noise would be regularly reviewed against the guidelines developed in the specialist studies supporting this EIS, as they are based on protecting the health of the community. Should exceedances be identified in these key indicators as a result of the Project, then a further and more targeted monitoring and management program would be developed as required.	Refer to AQIA and Noise Impact Assessment for recommendations for monitoring.

1.2 MPW Stage 2 Proposal overview

The MPW Stage 2 Proposal (the Proposal) involves the construction and operation of an Intermodal terminal (IMT) facility and associated warehousing.

The IMT facility would have the necessary infrastructure to support a container freight throughput volume of 500,000 twenty-foot equivalent units (TEUs) per annum. Specifically, the IMT facility within the Proposal site would include the following key components:

- Truck processing, holding and loading areas – with entrance and exit from Moorebank Avenue via an upgraded intersection and a round-about to distribute traffic between the warehousing precinct and the IMT
- Rail loading and container storage areas – installation of nine rail sidings, with an adjacent container storage area serviced by manual handling equipment
- Administration facility – office building with associated car parking and light vehicle access from Moorebank Avenue
- The Rail link connection – rail sidings within the IMT facility, which would be linked (to the south) to the Rail link (constructed as part of the MPE Project (SSD 14-6766)).

Also included within the Proposal are the following key components:

- Warehousing area – construction and operation of approximately 215,000 m^2 GFA of warehousing, with warehouses ranging in size from 4,000 m^2 to 71,000 m^2. Included within the warehousing area would be ancillary offices, truck and light vehicle parking, associated warehouse access roads.
- Freight village – construction and operation of approximately 800 m^2 of retail premises, with access from the internal road.
- Upgraded intersection on Moorebank Avenue and internal road – including works to Moorebank Avenue, Anzac Road to accommodate the proposed site entrance to Moorebank Avenue, and construction of an internal road.
- Ancillary works – including vegetation clearing, earth works, drainage and on-site detention, utilities installation/connection, signage and landscaping.

1.3 Proposal components and key terms

Table 1-2 provides a summary of the key terms which are included within this EIS. **Figure 1-1** also provides an indication of the operational areas discussed in **Table 1-2**.

Table 1-2: EIS key terms

Term	Definition
Moorebank Precinct West (MPW) Concept Plan Approval (Concept approval and Early Works)	MPW Concept Plan and Stage 1 Approval (SSD 5066) granted on 3 June 2016 for the development of the MPW Intermodal terminal facility at Moorebank and the undertaking of the Early Works. Granted under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act 1979*. This reference also includes associated Conditions of Approval and Revised Environmental Management Measures, which form part of the documentation for the approval. N.B. Previously the MIC Concept Plan Approval
Moorebank Precinct West (MPW) EPBC Approval	Commonwealth Approval (No. 2011/6086), granted in mid-2016 under the *Environmental Biodiversity Protection Conservation Act 1999*, for the impact of the MPW Project on listed threatened species and communities and impacts on the environment by a Commonwealth agency.
Moorebank Precinct West (MPW) Concept Plan EIS	The Environmental Impact Statement prepared to support the application for approval of the MPW Concept Plan and Early Works (Stage 1) under the *Environment Protection and Biodiversity Conservation Act 1999* and the *Environmental Planning and Assessment Act 1979*. N.B. Previously the MIC Concept Plan EIS
Revised Environmental Management Measures (REMMs)	The environmental management measures for the MPW Concept Plan Approval as presented within the MIC Supplementary Response to Submissions (SRtS) (PB, 2015) and approved under the MPW Concept Plan Approval.
Moorebank Precinct West (MPW) Planning Proposal	Planning Proposal (PP_2012_LPOOL_004_00) to rezone the MPW site from 'SP2- Defence to 'IN1- Light Industrial' and 'E3- Management', as part of an amendment to the *Liverpool Local Environmental Plan 2008* (as amended) gazetted on 24 June 2016.
Moorebank Precinct West (MPW) Project	The MPW Intermodal Terminal Facility as approved under the MPW Concept Plan Approval (5066) and the MPW EPBC Approval (2011/6086). N.B. Previously the MIC Project
Moorebank Precinct West (MPW) site	The site which is the subject of the MPW Concept Plan Approval, MPW EPBC Proposal and MPW Planning Proposal (comprising Lot 1 DP1197707 and Lots 100, 101 DP1049508 and Lot 2 DP 1197707). The MPW site does not include the rail link as referenced in the MPW Concept Plan Approval or MPE Concept Plan Approval. N.B. Previously the MIC site.
Early Works	Works approved under Stage 1 of the MPW Concept Plan Approval (SSD 5066), within the MPW site, including: establishment of construction compounds, building demolition, remediation, heritage impact mitigation works and establishment of the conservation area.

Early Works Approval	Approval for the Early Works (Stage 1) component of the MPW Project under the MPW Concept Plan Approval (SSD 5066) and the (yet to be granted) MPW EPBC Approval. Largely contained in Schedule 3 of the MPW Concept Plan Approval.
Early Works area	Includes the area of the MPW site subject to the Early works approved under the MPW Concept Plan Approval (SSD 5066).
Proposal	MPW Stage 2 Proposal (the subject of this EIS), namely Stage 2 of the MPW Concept Plan Approval (SSD 5066) including construction and operation of an IMT facility, warehouses, a Rail link connection and Moorebank Avenue/Anzac Road intersection works.
Proposal site	The subject of this EIS, the part of the MPW site which includes all areas to be disturbed by the MPW Stage 2 Proposal (including the operational area and construction area).
IMT facility	The Intermodal terminal facility on the Proposal site, including truck processing, holding and loading areas, rail loading and container storage areas, nine rail sidings, loco shifter and an administration facility and workshop.
internal road	Main internal road through the Proposal site which generally travels along the western perimeter of the site. Provides access between Moorebank Avenue and the IMT and warehouses.
Rail link connection	Rail connection located within the Proposal site which connects to the Rail link included in the MPE Stage 1 Proposal (SSD 14-6766).
Proposal operational rail line	The section of the Rail link connection and Rail link between the SSFL and the Rail link connection (included in the MPE Stage 1 Proposal) to be utilised for the operation of the Proposal.
construction area	Extent of construction works, namely areas to be disturbed during the construction of the Proposal.
operational area	Extent of operational activities for the operation of the Proposal.
Moorebank conservation area/conservation area	Vegetated area to remain to the west of the Georges River, to be subject to biodiversity offset, as part of the MPW Project.
Moorebank Precinct (MP)	Refers to the whole Moorebank intermodal precinct, i.e. the MPE site and the MPW site.
Moorebank Precinct East (MPE) Project	The Intermodal terminal facility on the MPE site as approved by the MPE Concept Plan Approval (MP 10_0913) and including the MPE Stage 1 Proposal (14-6766). N.B. Previously the SIMTA Concept Plan Approval
Moorebank Precinct East (MPE) site	The site which is the subject of the MPE Concept Plan Approval, and includes the site which is the subject of the MPE Stage 1 Approval. N.B. Previously the SIMTA site
Moorebank Precinct East (MPE) Stage 1 Proposal	MPE Stage 1 Proposal (14-6766) for the development of the Intermodal terminal facility at Moorebank. This reference also includes associated conditions of approval and environmental management measures which form part of the documentation for the approval. N.B. Previously the SIMTA Stage 1 Proposal
Rail link	Part of the MPE Stage 1 Proposal (14-6766), connecting the MPE site to the SSFL. The Rail link (as discussed above) is to be utilised for the operation of the Proposal.

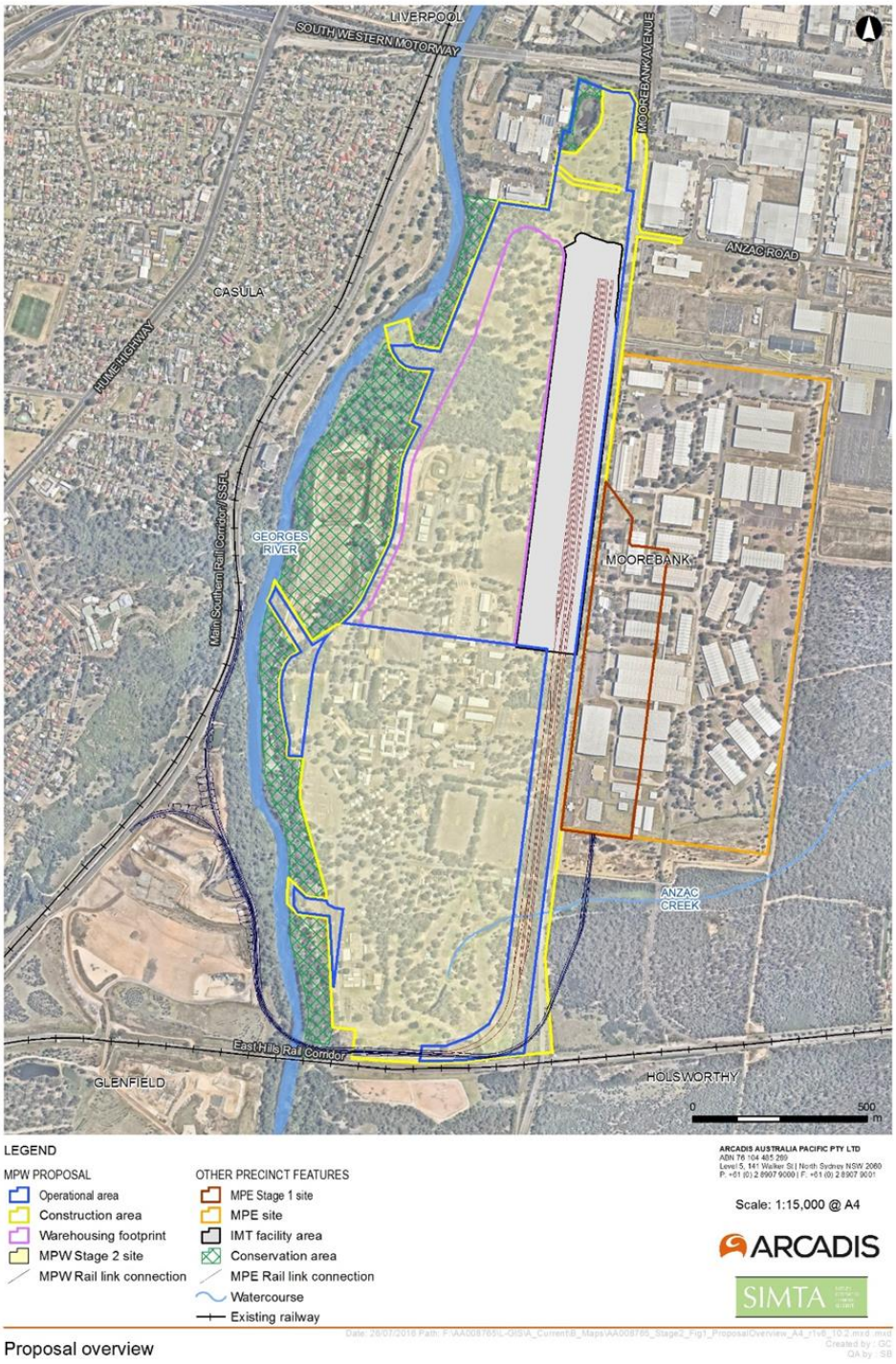

Figure 1-1: Proposal overview

2. PROPOSAL OVERVIEW

2.1 Site description

The Proposal site is generally bounded by the Georges River to the west, Moorebank Avenue to the east, the East Hills Railway Line to the south and the M5 Motorway to the north. It is located on Moorebank Avenue, Moorebank and forms Lot 1 in Deposited Plan (DP) 1197707[1]. The Proposal site also contains Lots 100 and 101 DP1049508, which are located north of Bapaume Road and west of Moorebank Avenue. The Proposal site is located wholly within Commonwealth Land.

The Proposal would also require works to upgrade the intersection of the MPW site with Moorebank Avenue and would therefore be undertaken on the following parcels of land:

- Moorebank Avenue, owned by the Commonwealth Government, south of Anzac Road Lot 2, DP 1197707 (formerly part of Lot 3001, DP 1125930)
- Moorebank Avenue, owned by Roads and Maritime Services, north of Anzac Road
- A portion of Bapaume Road, a public road that is the responsibility of Liverpool City Council
- A portion of Anzac Road, owned by Liverpool City Council, to the east of Moorebank Avenue

The key existing features of the site are:

- Relatively flat topography, with the western edge flowing down towards the Georges River, which forms the western boundary to the MPW site
- A number of linked ponds in the south-west corner of the Proposal site, within the existing golf course, that link to Anzac Creek, which is an ephemeral tributary of the Georges River
- An existing stormwater system comprising pits, pipes and open channels
- Direct frontage to Moorebank Avenue, which is a publicly used private road, south of Anzac Road and a publicly owned and used road north of Anzac Road
- The majority of the site has been developed and comprises low-rise buildings (including warehouses, administrative offices, operative buildings and residential buildings), access roads, open areas and landscaped fields for the former School of Military Engineering (SME) and the Royal Australian Engineers (RAE) Golf Course and Club. Defence has since vacated and all buildings on the site are currently unoccupied and will be removed during the Early Works
- Native and exotic vegetation is scattered across the Proposal site
- The riparian area of the Georges River lies to the west of the Proposal site and contains a substantial corridor of native and introduced vegetation. The riparian vegetation corridor provides a wildlife corridor and a buffer for the protection of soil stability, water quality and aquatic habitats. This area has been defined as a conservation area as part of the MPW Concept Plan Approval
- As stated above, the majority of the Proposal site has been developed, however heritage and biodiversity values still remain on the site
- A strip of land (up to approximately 250 metres wide) along the western edge of the MPW site lies below the 1% annual exceedance probability (AEP) flood level
- The site is privately owned by the Commonwealth and leased by SIMTA.

A number of residential suburbs are located in proximity to the Proposal site, including:

- Wattle Grove, located approximately 1,000 m from the Proposal site and 1,000 m from the Rail link connection to the east. The Rail link, which will be used during operation of the Proposal is 1,260 m to the west of Wattle Grove at its closest point

[1] Previously legally described as "Lot 3001, DP 1125930" in the MPW Concept Plan Approval (SSD 5066), however has since been subdivided.

- Moorebank, located approximately 630 m from the Proposal site and more than 1,400 m from the Rail link connection to the north. The Rail link is 2,500 m to the south of Moorebank at its closest point
- Casula, located approximately 330 m from the Proposal site and 1,200 m from the Rail link connection to the west. The Rail link is approximately 290 m to the east of Casula at the closest point
- Glenfield, located approximately 820 metres from the Proposal site and 1,100 metres from the Rail link connection to the south-west. The Rail link is approximately 750 m to the east of Glenfield at its closest point.

2.2 Construction overview

Subject to planning approval, construction of the Proposal is planned to commence in the third quarter of 2017. The total period of construction works for the Proposal is anticipated to be approximately 36 months.

The construction works have been divided into seven 'works periods' which are interrelated and also may potentially overlap. Subject to confirmation of construction staging, the order of these construction works periods may shift slightly.

- Pre-construction fill placement and stockpiling.
- Site preparation activities.
- Bulk earthworks, drainage and utilities.
- Moorebank Avenue intersection works and internal road networks.
- IMT facility and Rail link connection construction.
- Construction and fit-out of warehousing.
- Miscellaneous structural construction and finishing works.

An indicative construction programme and full description of the activities included in each works period is outlined in the main body of the EIS.

2.3 Operations overview

The Proposal would involve the operation of the IMT facility, Rail link connection, Rail link and warehousing. The Proposal would provide a freight transport facility to support the transport of freight by rail between Victoria, Queensland, regional NSW and Port Botany, with freight distributed through one of the following container flows:

- Transferred directly between trains within the Proposal site
- Temporarily stored in the IMT facility
- Transferred directly to warehousing within the Proposal site
- Transferred directly by truck to the MPE site
- Loaded directly on to heavy vehicles for distribution to markets via the nearby major road network.

Once operational, the IMT facility would handle an annual container freight volume of 500,000 TEU. Access (entrance and exit) to the Proposal site for heavy and light vehicles would be via the new site access off Moorebank Avenue. Trucks accessing the warehousing area of the Proposal site would continue to the internal road on the western perimeter of the Proposal site and onto the warehouse access roads to the warehousing.

2.3.1 IMT facility

The main vehicle entrance to the IMT facility would be controlled through the use of truck processing gates. Truck processing gates would include gantry structures which would be located over the extent of the entrance and exit lanes.

The circulation of trucks through the IMT facility would be as follows:

- Trucks would enter the site via the main entrance off Moorebank Avenue and would be processed at the truck processing gates. Only authorised/cleared trucks would be permitted to proceed into the IMT facility. Non authorised trucks would be instructed to turn around and exit via the main access to the Proposal site.
- Authorised trucks would be held within the truck holding area and/or progress to the loading areas.
- Once in location these trucks would be loaded/unloaded using manual container handling equipment.
- Once loaded/unloaded, trucks would exit the IMT facility via weighbridges (as necessary). Subject to being determined to be at the approved weight, trucks would proceed via the truck processing gates onto Moorebank Avenue.

The anticipated daily truck and car numbers associated with operation of the Proposal are provided in **Table 2-1**.

Table 2-1: Operational truck and car trips

Trip type		**Vehicle movements per day (2 way)**
Truck movements	External truck trips via external road network	1,458
Car movements	IMT facility	292
	Warehouses	2,378
	Total Daily Employee Car Trip Generation (IMT facility and warehouses)	**2,670**

The IMT facility would accommodate 12 train movements per day (6 in each direction). It is anticipated that, subject to unloading, trains would be processed within two and a half hours of entering the IMT facility. The IMT facility would operate 24 hours a day, 7 days a week.

2.3.2 Warehousing

Heavy and light vehicles would access the warehouses via the main site access off Moorebank Avenue. Light vehicles would park in the allocated parking area adjacent to each warehouse, and heavy vehicles would progress to the truck loading/unloading areas alongside each warehouse. Once in location these trucks would be loaded/unloaded via manual handling equipment. Once loaded the trucks would then be distributed to markets via the nearby major road network, transported to the adjacent MPE site, or transported directly to the IMT facility for dispatch via rail.

The warehouses on the Proposal site would generally be operational for 18 hours a day, and five to seven days a week.

2.3.3 Freight village (Precinct Amenities)

Vehicles would access the precinct amenities area via the main site access off Moorebank Avenue and the internal road. Light vehicles would access and egress the area directly via the allocated parking area adjacent to the precinct amenities area. Whereas service vehicles would enter the area via the one-way service road, which loops around the rear of the precinct amenities area and exits via the car park.

The operational hours of the freight village would be 7am to 6pm, seven days per week, and there would be a total of 25 staff members during operation.

3. APPROACH TO ASSESSMENT

3.1 Health Risk Assessment

A Health Risk Assessment (HRA) uses information about pollutants to estimate a theoretical level of risk for people who might be exposed to defined levels of these substances. HRAs are often conducted by considering possible or theoretical community exposures predicted from air dispersion modelling or using environmental concentrations that have been measured in the potentially affected population. Conservative safety margins are built into a HRA to ensure protection of the public. In a HRA, the most vulnerable people (e.g. children, the sick and elderly) are carefully considered to make sure that all members of the public will be protected.

HRA is used extensively as a tool 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.

The HRA process comprises five components: issues identification, exposure assessment, toxicity assessment, risk characterisation, and uncertainty assessment. Some of the key factors and questions that are taken into consideration at each of these components include the following:

- **Issue Identification** – Identifies issues that can be assessed through a risk assessment and assists in establishing a context for the risk assessment.
- **Exposure Assessment** – identifies the groups of people who may be exposed to hazardous agents and quantifies the exposure concentrations.
- **Toxicity Assessment** – Identifies hazards and health endpoints associated with exposure to hazardous agents and provides a review of the current understanding of the toxicity and risk relationship of the exposure of humans to the hazards.
- **Risk Characterisation** – provides the quantitative evaluation of potential risks to human health. The characterisation of risk is based on the review of exposure-response relationship and the assessment of the magnitude of exposure.
- **Uncertainty Assessment** – identifies potential sources of uncertainty and qualitative discussion of the magnitude of uncertainty and expected effects on risk estimates.

The objective of this HRA was to assess potential health risk posed by air emission and noise from the MPW Stage 2 Proposal on surrounding communities. The HRA was undertaken in accordance with approved Australian guidance for performing risk assessments including:

- enHealth. 2012a. Environmental Health Risk Assessment: Guidelines for Assessing Human Health Risks from Environmental Hazards.
- enHealth. 2012b. Exposure Factors Guide.
- National Health and Medical Research Council (NHMRC). 2006. Approach to Hazard Assessment for Air Quality.
- National Environment Protection Council (NEPC). 2011. Methodology for Setting Air Quality Standards in Australia.

Where considered appropriate, Ramboll Environ also referred to guidance from international authorities during preparation of the HRA, such as the World Health Organization (WHO) and the United States Environment Protection Agency (USEPA).

3.2 Health Impact Assessment

A Health Impact Assessment (HIA) has not been conducted for the Proposal. A HIA has previously been undertaken for the MPW Concept Plan Approval (EnRisks 2014b). The community consultation underpinning the HIA, and conclusions from the HIA remain applicable to the Proposal.

EnRisks (2014b) identified a number of potential impacts (both positive and negative) on the health and wellbeing of the local communities (including sensitive receptors). These impacts relate to the economic environment, transport, the natural environment, sustainability, lifestyle, and the social environment. Aspects of the natural environment considered impacts from light spill, noise, vibration, local and regional air quality, remediation of contaminated land, landscape and visual character, local ecology, flood control, water quality, and waste management.

It was concluded that the negative impacts identified can be effectively mitigated through a wide range of measures, some of which require further evaluation in the detailed design of various stages of the MPW Concept Plan Approval. For the four key areas of identified impacts (air quality, noise, traffic, and community consultation), specific recommendations were made in EnRisks (2014b) with the aim of enhancing positive impacts and mitigating negative impacts of the MPW Concept Plan Approval.

This HRA gives consideration to the previous impacts identified in the HIA for the MPW Project, and where possible mitigates these impacts. Of particular note is that for both air quality and noise impacts, a Best Practice Review has been completed for the Proposal to identify all measures to minimise the impacts identified through the HIA.

4. HEALTH RISK ASSESSMENT – AIR QUALITY

The air quality HRA has been conducted to evaluate the potential health risks to surrounding communities from exposure to air emissions from the MPW Stage 2 Proposal. The focus of this air quality HRA is on the health impacts of emissions from the operational phase of the Proposal. Emissions to air from the construction sources were not evaluated in this HRA, consistent with previous assessment for the MPE Stage 1, which was approved by NSW Health as part of consultation undertaken (Pacific Environment, 2015). Components of the construction phase were evaluated in the HRA for the MPW Concept Plan Approval (EnRisks 2014a), however only because they overlapped with various operational phases of the Concept Plan and that there was less clarity on the staging for the MPW Project.

Construction phase impacts for the Proposal would be temporary, relatively easily controlled and are demonstrated in the AQIA to comply with the relevant air quality standards.

The air quality data used in the HRA has been generated through air modelling in the AQIA. Prior to the evaluation of health risk, the existing health of the local populations and the existing air quality in the local areas were evaluated in the baseline assessment.

4.1 Baseline assessment

The air quality HRA has focused on key air pollutants associated with emission sources from the operation of the Proposal. For these air pollutants there are a large number of other sources in the local area that have the potential to affect the health of local communities, including other combustion sources, other local construction/earthworks, and personal exposures (such as smoking). The health of the community is also 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.

It is necessary therefore to review existing health statistics and air quality for the local areas surrounding the proposed site and compare them to the greater Sydney area and NSW, prior to an evaluation of the health impacts attributed to the Proposal.

4.1.1 Surrounding area and population

The Proposal site is located within the Liverpool LGA in the Sydney south-western region. The study area considered within the AQIA encompasses the local air shed in which the construction and operation of the MPW Proposal would likely have influence. It includes the proposed MPW site and surrounding land zoned for commercial, industrial, and DoD purposes. The Georges River is located adjacent to the western boundary of the MPW site and the site is surrounded by land zoned for public recreation,, parks and nature reserves. Surrounding residential suburbs include Casula, Moorebank, Glenfield and Wattle Grove, comprising low to medium density housing (**Figure 4-1**).

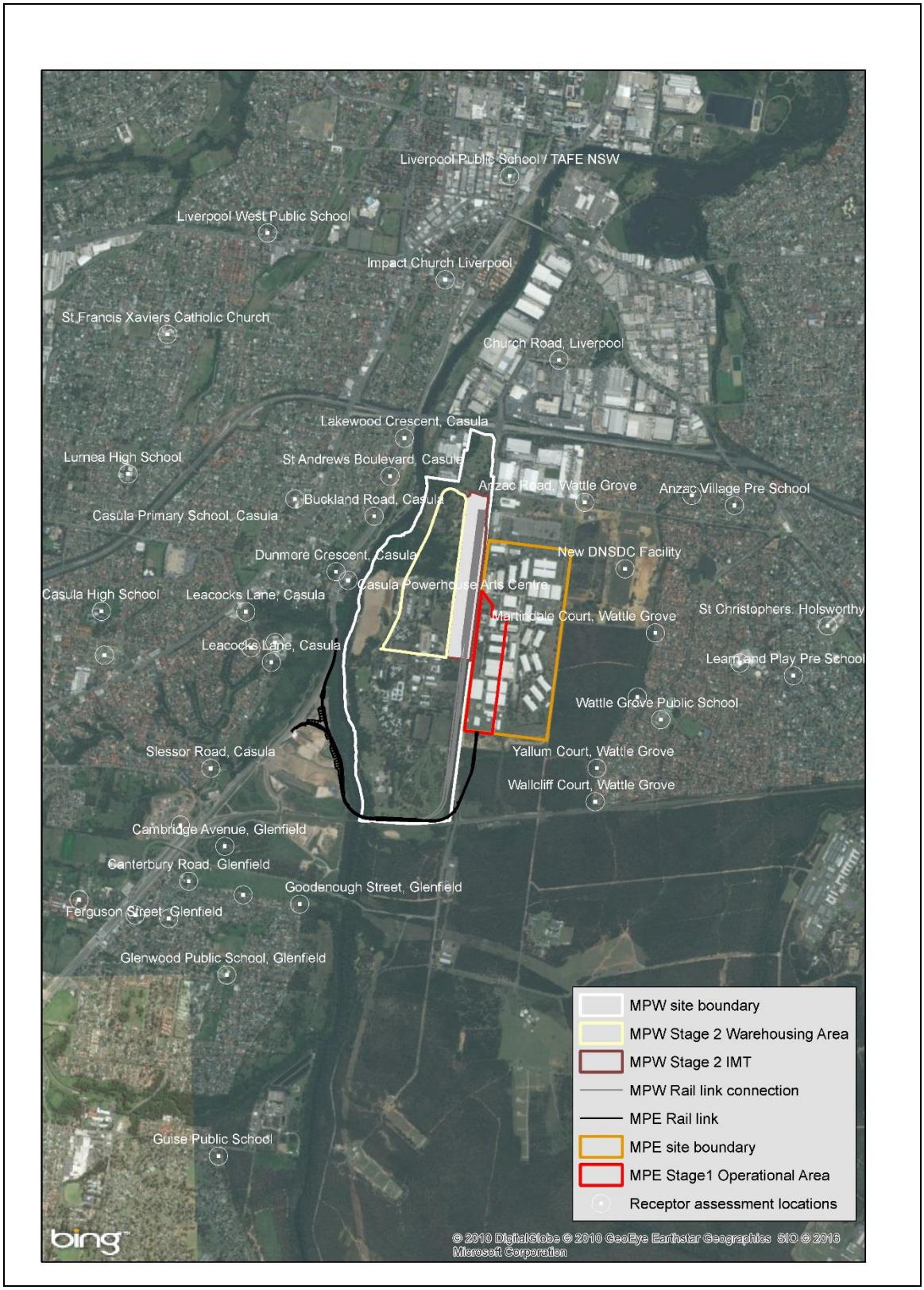

Figure 4-1: Surrounding residential suburbs and study area

4.1.2 Population statistics

Population statistics for the surrounding suburbs of Casula, Glenfield, Wattle Grove, and Moorebank were obtained from the Australian Bureau of Statistics (ABS) for the census year 2011 and are summarised in **Table 4.1**.

Table 4.1: Summary of population statistics

Location	Total population	% of population by key age group				
		< 5 years	5-14 years	15-64 years	65+ years	30+ years
Casula	14,696	7.9	15	67	10	49
Wattle Grove	8,192	8.7	18	69	5.2	45
Moorebank	7,595	8.4	13	66	13	60
Glenfield	7,558	6.6	12	67	14	67
Sydney South West	360,166	7.1	15	68	11	50
Greater Sydney	4,391,674	6.8	12	68	13	60
Rest of NSW (excluding Sydney)	2,512,949	6.3	13	63	18	63

Based on this general population data, the population composition in the suburbs of Moorebank, Casula, and Glenfield are largely similar to Sydney Southwest and Greater Sydney, while Wattle Grove is characterised by a lower proportion of people aged 65 years and over, reflecting the presence of a higher percentage of military families in this suburb (EnRisk 2014a). According to the Liverpool Community Health Profile (South Western Sydney Local Health District [SWSLHD] 2014), the population in the Liverpool LGA is predicted to increase significantly from 188,088 people in 2011 to 288,959 in 2031. The predicted population growth in various age groups is shown in **Figure 4-2**, and the most significant population growth is predicted for people less than 69 years of age.

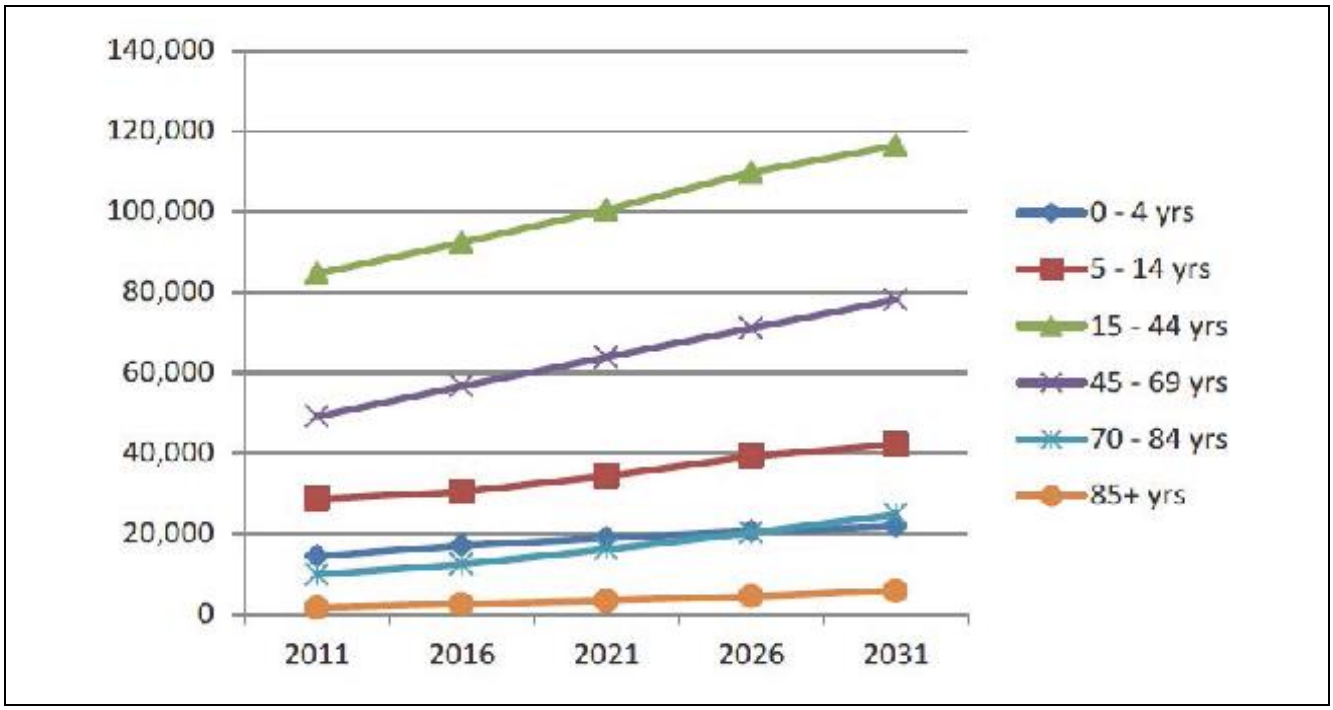

Figure 4-2: Predicted population growth in Liverpool LGA (Source: SWSLHD 2014)

(Source: SWSLHD 2014)

4.1.3 Existing health of population

Most of the health indicators presented in this report are not available for each of the smaller suburbs surrounding the proposed MPW site. Health indicators are only available from a mix of larger areas (that incorporate the study area) that comprise the Liverpool LGA, the larger Sydney South West Area, Greater Sydney and NSW. The health statistics for these larger areas are assumed to be representative of the smaller population located in the vicinity of the proposed MPW site.

Information on the incidence of health-related behaviours, the key mortality indicators and hospitalisations, and the prevalence and management of asthma in children in local areas, as well as in Greater Sydney and NSW, was discussed in detail in the HRA report prepared by EnRisks (2014a) for the MPW Concept Plan Approval.

Table 4.2 presents the data on baseline health incidence for the local population as well as in Sydney South West, Greater Sydney and NSW. The data in **Table 4.2** indicates that the baseline health status of the local population does not differ significantly from the data for NSW as a whole.

Based on the available information, there are no underlying health issues that would make the local communities more vulnerable to the effects of environmental factors, such as air pollution or noise from the Proposal, when compared with the rest of Sydney and NSW.

Table 4.2: Summary of baseline health incidence

Health indicator	Incidence for population (rate per 100,000 population)			
	Liverpool LGA	Sydney South West Area	Greater Sydney	NSW
Mortality				
All causes-all ages	556 [a]	543 [b]	587 [c]	529 [b]
All causes-30+ years	--	--	--	1065 [b]
Cardiovascular disease- all ages[1]	162 [a]	160 [a]	--	155 [b]
Cardiovascular disease- 30+ years[2]	--	--	--	299 [b]
Cardiopulmonary 30+ years	--	--	--	490 [d]
Ischemic heart disease 30+ years[3]	71 [a]	72 [a]	--	67 [b]
Respiratory disease all ages	--	52 [e]	--	50 [f]
Respiratory disease 30+ years[4]	--	52 [e]	--	50 [f]
Lung cancer 30+ years[5]	38 [g]	36 [f]	--	35 [f]
Hospital Admissions				
Respiratory disease 65+ years	--	--	--	4476 [h]
Respiratory disease 15-64 years[6]	--	--	--	899 [h]
Cardiac disease 65+ years[7]	--	--	--	9159 [h]
Cardiovascular disease 65+ years[1]	--	--	--	9159 [h]
Pneumonia and bronchitis 65+ years[8]	--	--	--	1236 [h]
Ischemic heart disease 65+ years[9]	--	2805 [h]	--	3331 [h]
COPD 65+ years	1678 [i]	1482 [h]	1194 [j]	1489 [h]
Asthma				
ED Visits 1-14 years[10]	--	--	--	804 [b]

Notes:

1. Used circulatory disease mortality data.
2. Used circulatory disease mortality data for 25+ years
3. Used coronary heart disease mortality data for all ages.
4. Used respiratory disease mortality data for all ages.
5. Used lung cancer mortality data for all ages.
6. Used respiratory disease hospitalisation data for 17-64 years.
7. Used data for cardiovascular disease hospitalisation data for 65+ years.
8. Used all pneumonia and influenza hospitalisation data.
9. Used coronary heart disease hospitalisation data for 75+ years.
10. Used ED presentations for asthma data for 0-17 years.

[a] 2012-2013 data (NSW HealthStats[2])
[b] 2013 data (NSW HealthStats).
[c] 2006-2007 data (Table 2.3 in EnRisks 2014a).
[d] 2005-2007 data (Table 2.3 in EnRisks 2014a).
[e] 2010-2011 data (NSW HealthStats).
[f] 2011 data (NSW HealthStats).
[g] 2004-2008 data (SWS LHD 2014).
[h] 2013-2014 data (NSW HealthStats).
[i] 2009-2011 data (Table 2.3 in EnRisks 2014a).
[j] 2010-2011 data (Table 2.3 in EnRisks 2014a).

Abbreviations: COPD: Chronic Obstructive Pulmonary Disease; ED: Emergency Department; LGA: Local Government Area; SWS LHD: South Western Sydney Local Health District

[2] Available at: http://www.healthstats.nsw.gov.au/

4.1.4 Existing air quality

Existing air quality in the local area has been evaluated in the AQIA. Local air quality is influenced by a number of industrial and non-industrial sources, including existing industries surrounding the proposed MPW site, the Glenfield Waste Disposal facility, traffic emissions from the existing road network, locomotive emissions from the East Hills rail line (south of the site) and the Southern Sydney Freight Line (SSFL)/Main Southern rail line (to the west), and emissions from aircraft at Bankstown Airport (northeast of the site).

Background air quality is described in the AQIA with reference to monitoring data from a nearby monitoring station operated by the Office of Environment and Heritage (OEH). The Liverpool OEH monitoring site is located on Rose Street, situated in a mixed residential and commercial area. The monitoring station measures PM_{10}, $PM_{2.5}$, oxides of nitrogen (NO_x), ozone (O_3) and carbon monoxide (CO). However, the Liverpool site does not include monitoring for sulphur dioxide (SO_2) and reference is therefore also made to the OEH monitoring site at Chullora, located approximately 12 km northeast of the Proposal site.

Annual mean PM_{10} concentrations range from 18 µg/m³ to 21 µg/m³ and on average over the past 5 years baseline concentrations are 77% of the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) standards. Annual mean $PM_{2.5}$ concentrations range from 6 µg/m³ to 9 µg/m³ and on average over the past 5 years baseline concentrations are 103% of the AAQ NEPM standard. Exceedances of the 24-hour average reporting standards for both PM_{10} and $PM_{2.5}$ have occurred in three of the past five years. Existing concentrations of PM_{10} and $PM_{2.5}$ for the Liverpool area are strongly influenced by vehicle emissions and wood heaters. Although $PM_{2.5}$ concentrations for the Liverpool area are currently non-compliant with the NEPM AAQ standards, regulatory initiatives such as wood heater compliance programs and improvements in vehicle emission standards are expected to play a role in driving down ambient concentrations in the medium term.

For NO_2, SO_2 and CO there have been no exceedances of the air quality standards for the previous five years and in general background air quality for these pollutants is considered good. On average over the past five years, baseline concentrations for NO_2 are 33% of the AAQ NEPM standard for annual mean and 42% for maximum 1 hour average. Relative to the AAQ NEPM standards, baseline concentrations for CO and SO_2 are even lower. For example, maximum 1-hour baseline concentrations are 12% of the AAQ NEPM standard for CO and 10% for SO_2.

4.2 Air modelling

4.2.1 Assessment scenario

The focus of this air quality HRA was the health impacts of emissions from the operation sources related to the MPW Stage 2 Proposal, including the IMT facility with an annual container freight volume of 500,000 TEUs and warehousing with a total GFA of 215,000 m^2. As previously described, emissions from the construction sources related to the Proposal were not evaluated in this HRA.

As noted earlier, SIMTA is proposing to develop an IMEX facility on the land to the immediate east of the MPW site, known as the MPE Stage 1 Proposal. It is anticipated that, from the first quarter of 2019, the MPE Stage 1 Proposal (with an annual container freight volume of 250,000 TEUs) will operate simultaneously with the Proposal. Therefore, a cumulative assessment scenario in this air quality HRA includes the simultaneous operation of the Proposal plus the MPE Stage 1 Proposal (hereafter referred to as the cumulative Proposal).

There are a number of other sources in the local/regional area with emissions of similar air key pollutants. The assessment of cumulative impacts on the local area has been evaluated in the AQIA on the basis of predicted emissions from the MPW Stage 2 Proposal and MPE Stage 1 Proposal as well as background levels.

It was noted in the AQIA that the proposed Glenfield Material Recycling Facility would result in a minor change to local air quality and wasn't therefore quantitatively assessed as part of the cumulative modelling scenario. The existing operations and proposed modification at the Glenfield Waste site are assumed to be accounted for in the consideration of background in the AQIA.

Background levels were determined from available data on existing air quality from monitoring stations located in Liverpool. The cumulative impacts on the local area from all sources were compared against the relevant impact assessment criteria or NEPM air quality standards in the AQIA. Results indicated that the predicted increase in concentrations of key air pollutants from the construction and operation of the Proposal were considered minor when compared against existing background levels. The predicted ground level concentrations were below the air quality standards for short-term and long-term impacts, except for the annual average concentrations of $PM_{2.5}$; however, such exceedance was because the background concentrations of $PM_{2.5}$ already exceeded the NEPM air quality standard.

The HRA, therefore, focuses on the change in health outcomes as a result of new emission sources in the area that are added to existing background concentrations; that is from the operation of the Proposal and cumulative Proposal.

An assessment of regional air quality impacts is not a requirement of the SEARs for air quality, therefore no quantitative assessment has been undertaken for changes to regional air quality in this HRA (i.e. assessment of photochemical smog (ozone) on a regional scale). Regional air quality has been previously considered for the Concept Plan Approval for both the MPW and MPE sites. It is expected that changes in regional air quality as a result of the operation of the cumulative Proposal would be negligible, or may even result in a reduction in regional emissions, as a result of the efficiencies achieved by replacing road freight with rail freight.

4.2.2 Emission sources

The air quality data used in the HRA has been generated through air modelling in the AQIA. Emissions to air from the operation of the Proposal and MPE Stage 1 Proposal have been evaluated and quantified with consideration of the mitigation measures in the REMMs. The three operational emission sources modelled in the AQIA included:

- The IMT facility from the Proposal, which would operate 24 hours a day, seven days a week;
- The warehousing from the Proposal, which would operate 18 hours a day, seven days a week;
- The IMEX facility from the MPE Stage 1 Proposal, which would operate 24 hours a day, seven days a week.

These sources result in emissions to air that are primarily derived from diesel locomotives at the IMT and IMEX facilities, traffic and equipment associated with the IMEX, IMT, warehousing and commercial operations, and container handling activities. Hence, the assessment of impacts to air was focused primarily on health hazards associated with diesel emissions.

The key air pollutants the AQIA has evaluated included:

- PM_{10} and $PM_{2.5}$;
- Nitrogen oxides (in particular NO_2);
- SO_2;
- CO;
- Volatile organic compounds (VOCs); and
- Polycyclic aromatic hydrocarbons (PAHs).

4.2.3 Modelled locations

The populations that may be exposed to air emissions from the Proposal are communities in the surrounding suburbs of Casula, Moorebank, Glenfield, and Wattle Grove. A total of 31 locations

representative of the surrounding suburbs and other sensitive receptors (e.g., schools, day care centres, and aged care homes/facilities) have been identified and selected as discrete sensitive receptors in the AQIA. These locations are the same as those modelled in the EIS for the MPW Concept Plan Approval and the MPE Stage 1 EIS in order to ensure consistency in interpretation of results and facilitate assessment of cumulative impact based on previous modelling.

The modelled locations are shown in **Figure 4-1** and listed in **Table 4.3**.

Table 4.3: Off-site sensitive receptors

Receptor location	Suburb	Receptor population	Distance (km)/direction from site[1]
Lakewood Crescent	Casula	Residential	1.2 NW
St Andrews Boulevard	Casula	Residential	1.1 NW
Buckland Road	Casula	Residential	1.0 NW
Dunmore Crescent	Casula	Residential	1.0 NW
Leacocks Lane	Casula	Residential	1.7 W
Leacocks Lane_Mid	Casula	Residential	1.4 W
Slessor Road	Casula	Residential	1.8 SW
Canterbury Road	Glenfield	Residential	2.3 SW
Ferguson Street	Glenfield	Residential	1.9 SW
Goodenough Street	Glenfield	Residential	1.7 SW
Wallcliff Court	Wattle Grove	Residential	1.0 SE
Corryton Court	Wattle Grove	Residential	1.0 E
Martindale Court	Wattle Grove	Residential	1.1 E
Anzac Road	Moorebank	Residential and Commercial/Industrial	1.0 NE
Cambridge Avenue	Glenfield	Residential	1.9 SW
Yallum Court	Wattle Grove	Residential	0.8 SE
Church Road	Moorebank	Residential	1.8 N
Glenwood Public School	Glenfield	Residential/School	2.6 SW
Glenfield Public School	Glenfield	Residential/School	2.7 SW
Hurlstone Agricultural School	Glenfield	Residential/School	3.0 SW
Wattle Grove Public School	Wattle Grove	Residential/School	1.1 E
St Marks Coptic College	Wattle Grove	Residential/School	1.7 E
Maple Grove Retirement Village	Casula	Residential	2.6 W
All Saints Catholic College	Casula	Residential/School	1.4 W
Casula High School	Casula	Residential/School	2.7 W
Casula Primary School	Casula	Residential/School	1.5 NW
Glenfield Rise Development	Glenfield	Residential	2.1 SW
New DNSDC Facility	Moorebank	Commercial/Industrial	1.0 NE
Playground Learning Centre	Glenfield	Residential	2.5 SW
Wattle Grove Long Day Care Centre	Wattle Grove	Residential and Recreational	1.6 NE
Casula Powerhouse Arts Centre	Casula	Recreational	1.0 W

Note:[1] Measured from IMT operational area

4.3 Health risk assessment methodology

The various components for the air quality HRA are discussed in the following subsections.

4.3.1 Issue identification

To identify the issues that can be assessed through the risk assessment and assist in establishing a context for the risk assessment, a conceptual site model (CSM) was developed. A CSM is a site-specific qualitative description of the chemical source(s), the pathway(s) by which chemicals may migrate through the environmental media, and the populations that may potentially be exposed. This relationship is commonly known as a Source-Pathway-Receptor (SPR) linkage. Where one or more elements of the SPR linkage are missing, the exposure pathway is considered to be incomplete and no further assessment is required.

Source and chemicals of potential concern

The key air pollutants evaluated in the AQIA (see **Section 4.2.2**) were considered as chemicals of potential concern (COPCs) in this HRA. These key chemicals are discussed further below to refine the COPCs for the assessment.

Most of the VOC emissions comprise a range of hydrocarbons that are of low toxicity (such as methane, ethylene, ethane, butenes, butanes, pentenes, pentanes, and heptanes etc.) (USEPA 2012). From a toxicity perspective, the key VOCs that have been considered for the vehicle emissions in this HRA were benzene and 1,3-butadiene.

Hundreds of PAHs and nitro-PAHs exist in diesel exhaust (USEPA 2012). The toxicity of individual PAHs varies significantly, with the most toxic being benzo(a)pyrene (BaP), which is classified as a probable human carcinogen. Carcinogenic PAHs are commonly assessed as a group using the toxicity equivalent factor (TEF) approach. In this approach, the toxicity contribution of each individual carcinogenic PAH in diesel exhaust is calculated by multiplying its air concentration by its TEF based on relative toxicity potency to BaP, and then the results are summed to obtain BaP Toxicity Equivalent (BaP TEQ)(enHealth 2012a). Therefore, the carcinogenic effect of PAHs was evaluated as BaP TEQ in this HRA, and the TEFs presented by Canadian Council of Ministers for the Environment (CCME 2010) have been adopted to calculate BaP TEQ. This is consistent with the approach to assessing PAHs adopted in the NEPM (NEPC 2013).

The potential health effects of diesel exhaust from trucks and locomotives are associated primarily with particle fraction of diesel. Diesel particulate matter (DPM) has not been specifically modelled in the AQIA; rather DPM was part of the $PM_{2.5}$ assessment for emissions from diesel trucks, locomotives, and equipment as well as non-diesel motor vehicles used within the MPW and MPE site. For the purposes of this HRA, it has been conservatively assumed that 100 percent of the incremental $PM_{2.5}$ is derived from diesel sources. This is a conservative assumption, but has been justified on the basis of the inventory of $PM_{2.5}$ emission sources at the MPW and MPE site (EnRisks 2014a, Pacific Environment, 2015). The data provided for the HRA also assumed that all NOx is NO_2 which is also a conservative assumption. Based on monitoring data from the Liverpool Air Monitoring station, the ratio of NO_2 to NO_x is 0.7, i.e., NO_2 is 70% of the monitored NO_x levels (Pacific Environment, 2015). In summary, the COPCs identified for this HRA included:

- PM_{10} and $PM_{2.5}$ (including DPM);
- NO_2;
- SO_2;
- CO;
- Benzene and 1,3--butadiene; and
- PAHs (as BaP TEQ).

4.3.2 Exposure assessment

Human receptors

The human receptors of concern for this HRA included commercial/industrial workers, residents, school or day care students, and recreational users located in the vicinity of the proposed MPW Stage 2 Site. For residents, it was assumed that they may live all day every day in the local area for 35 years (enHealth 2012b). Therefore, assuming exposure may occur 24 hours per day, 365 days per year is a reasonable assumption. For school or day care students, since they may live and attend school all day every day in the local area, the same assumptions were also applied.

For commercial/industrial workers, it was assumed that exposure may occur eight hours per day, 240 days per year for 30 years (NEPC, 2013). For recreational users, it was assumed that exposure may occur four hours per day, 104 days per year (two days per week) for 35 years (enHealth 2012b, EnRisks 2014a).

Exposure pathways

For a human receptor to be exposed to COPCs, there needs to be an exposure pathway linking the source and the exposed population. An exposure pathway describes the course a chemical takes from the source to the exposed individual and generally includes the following elements (USEPA 1989):

- A source and mechanism of chemical release;
- A retention or transport medium (or media where chemicals are transferred between media);
- A point of potential human contact with the contaminated media; and
- An exposure route (e.g., ingestion, inhalation) at the point of exposure.

The transport mechanisms for COPCs are atmospheric emissions to air and deposition to soil and surface water. Consistent with previous HRA for the Concept Approval, oral (non-inhalation) exposure routes related to deposition were not evaluated. Inhalation of air was the only exposure route evaluated in this HRA.

A detailed assessment of the potential exposure pathways and human receptors is presented in **Table 4.4**.

Table 4.4: Exposure Pathway Assessment

Exposure Pathway	Potentially Complete?			Justification
	Resident/ Student	Commercial Worker	Recreational User	
Air				
Inhalation	Y	Y	Y	Populations in the surrounding communities may be exposed to COPCs in air emitted from the operation sources through inhalation.
Soil				
Incidental Ingestion	L	L	L	Populations in the surrounding communities may be exposed to chemicals in particulate matter deposited from air to soil through non-inhalation exposure routes. However, consistent with both the HRA for the MPW Concept Plan Approval and the HRA for the MPE Stage 1 Approval, non-inhalation exposure routes related to chemicals in deposited particulate matter were not assessed in this HRA.
Dermal Contact	L	L	L	
Surface Water				
Incidental Ingestion	L	L	L	Populations in the surrounding communities may be exposed to chemicals in particulates and dust deposited from air to surface water through non-inhalation exposure routes. However, consistent with both the HRA for the MPW Concept Plan Approval and the HRA for the MPE Stage 1 Approval, non-inhalation exposure routes related to chemicals in deposited particulate matter were not assessed in this HRA.
Dermal Contact	L	L	L	

Y – Pathway complete and quantitatively evaluated in the HRA

L – Pathway complete but considered less significant, therefore not quantitatively evaluated in the HRA

Exposure Point Concentrations

The annual average ground level concentrations (GLCs) of COPCs emitted from operation of the IMT facility and warehousing in MPW Stage 2 and the IMEX facility in MPE Stage 1 were predicted by air modelling in the AQIA at selected sensitive receptor location in the surrounding suburbs. It was assumed that the IMT and IMEX facility as well as the warehousing would operate at the existing throughput for at least 35 years. The annual average GLCs were calculated by averaging the predicted air concentrations (concentrations over the actual time period of operation) from the source over a continuous time period of 24 hours per day and 365 days per year.

For the IMT and IMEX facility which would operate continuously throughout the year, the annual average GLCs were equal to the predicted air concentrations from the source, and they were directly used as exposure point concentrations (EPCs) for the human receptors (i.e. residents, school or day care students, commercial/industrial workers, recreational users).

For warehousing, which would operate 18 hours a day, seven days a week, adjustments to the predicted annual average GLCs were required for workers and residential users. Residents and school or day care students may potentially be exposed to COPCs in air continuously throughout the year, and the annual average GLCs for the warehousing were directly used as EPCs for these human receptors. Commercial/industrial workers and recreational users may not be continuously exposed to COPCs in air, and using annual average GLCs instead of the actual air concentrations as EPCs for these human receptors may underestimate the risk. Therefore, the annual average GLCs for the warehousing were first adjusted back to the actual air concentrations by multiplying a modelling adjustment factor (MAF, calculated as 24 hours/18 hours = 1.3), and then used as EPCs for these human receptors. At each sensitive receptor location, the EPCs from all the operation sources were summed up to obtain the EPCs from the operation of the cumulative Proposal (MPW Stage 2 plus MPE Stage 1), which are shown along with the HRA results in **Section 4.4**.

4.3.3 Toxicity Assessment

The toxicity assessment involved both the qualitative evaluation of the adverse health effects associated with inhalation exposure to COPCs and the quantitative evaluation of the exposure-response relationships. Based on the available information, the most robust health endpoints (effects or outcomes) for the assessment of inhalation exposure to COPCs have been identified, and the exposure-response relationships for these health endpoints were derived from published peer-reviewed sources.

The adverse health effects from each COPC were discussed in detail in the MPE Stage 1 Health Impact Assessment (HIA) (Pacific Environment 2015). The health endpoints and associated exposure-response relationships adopted for this HRA (presented in **Section 4.4**) are consistent with those used in the MPE Stage 1 HIA (Pacific Environment 2015) approved by NSW Health as part of the consultation undertaken for MPE Stage 1.

4.3.4 Risk Characterization

Potential health impacts from inhalation exposure to COPCs associated with the cumulative operation of MPW Stage 2 and MPE Stage 1 have been evaluated based the annual average GLCs predicted in the AQIA. The health effects of both short-term and long-term exposure to PM_{10}, $PM_{2.5}$, NO_2, SO_2 and CO have been assessed for increased annual incidence, in terms of health endpoints of mortality and morbidity.

The increased annual incidence was calculated using the following equation where a linear exposure-response was assumed (Burgers and Walsh 2002, Ostro 2004, USEPA 2005, 2010), which is consistent with the methodology used in the HRA reports of previous stages (EnRisks 2014a, Pacific Environment 2015):

$$E = \beta * EPC_{suburb} * B * P_{suburb}$$

Where:

E	=	Increased annual incidence (number of cases per year for a given health endpoint attributable to the Project)
β	=	Exposure-response function (change in health outcome) per 1 μg/m^3 increase in EPC for a given health endpoint ([μg/m^3]$^{-1}$, as discussed in Section 4.4)
EPC_{suburb}	=	Exposure point concentration associated with the operation of the Project, calculated as mean of annual average GLCs for all locations modelled within a suburb (μg/m^3)
B	=	Baseline health incidence rate per person per year for a given health endpoint (unitless, calculated based on the values presented in Table 4.2)
P_{suburb}	=	Population within a suburb for the age group relevant to the health endpoint being evaluated (as presented in **Table 4.1**)

As discussed in EnRisks (2014a), both long-term and short-term exposure were assessed on the basis of annual average GLCs. Annual average GLCs are used to assess short term exposures because the concentration-response functions are linear, and the same outcome will be obtained by assuming that the annual change in concentrations was derived by 365 equal daily changes or by 365 varied daily changes with the same average value. In other words, the results of the annual incidence for short-term exposure calculated using the following two approaches should be the same mathematically (Ostro 2004, USEPA 2010):

- Calculate the daily incidence based on the 24-hour average concentration and daily health incidence rate, and then sum the daily incidence to get the annual incidence or risk.
- Calculate the annual incidence based on the annual average concentration and annual health incidence rate.

In addition, the excess lifetime cancer risks from inhalation exposures to air toxics, such as DPM, benzene, 1,3-butadiene, and PAHs (as BAP TEQ), associated with the Project were calculated for the human receptors in the local area using the following equation (USEPA 2009):

$$Cancer\ Risk = EPC * ET * EF * ED/AT/CF * URF$$

Where:

EPC	=	Exposure point concentration associated with the operation of the Project at each sensitive receptor location (μg/m^3, as discussed in Section 0)
ET	=	Exposure time (hours per day, as discussed in Section 0)
EF	=	Exposure frequency (days per year, as discussed in Section 0)
ED	=	Exposure duration (years, as discussed in Section 0)
AT	=	Averaging time for cancer risk (i.e. 70 years or 25550 days)
CF	=	Conversion factor (24 hours/day)
URF	=	Unit risk factor ([μg/m^3]$^{-1}$, as discussed in Section 4.4).

Acceptable Risk

A discussion is provided in enHealth (2012a) on the acceptable risk levels for excess lifetime cancer risks or non-threshold risks. However, no direct recommendation on the use of a target level is provided. The enHealth (2012a) document indicates that while a target risk level of 1 x10^{-6} is one of the more commonly used, the target risk level has varied between 10^{-6} and 10^{-3} in different types of risk management situations.

The USEPA (1991) states the following:

- The target risk level of 1 in 1,000,000 for an excess lifetime cancer risk is for exposure to an individual carcinogen by multiple pathways (e.g. ingestion, dermal exposure, and inhalation);
- Action is generally warranted when the excess lifetime cancer risk is greater than 1 in 10,000 for exposure to multiple carcinogens and pathways. This means that when all of the risks for individual carcinogens and pathways posed are added together, the excess lifetime cancer risk should not be greater than one in ten thousand people who have been exposed; and
- When the cumulative risk for a medium is within the range of 1 in 1,000,000 to 1 in 10,000, a decision about whether or not to take action is a site-specific determination.

The revised NEPM (NEPC, 2013) uses an acceptable target risk level of 1×10^{-5} (i.e., 1 in 100,000) to assess all pathways of exposure. Consistent with the previous assessments associated with the project (EnRisks 2014a), the excess lifetime cancer risks have been considered acceptable in the range of 10^{-6} to 10^{-4}.

The increased annual incidence of mortality or morbidity endpoints has been considered to be negligible when it was less than one case per year, which is not detectable above the normal fluctuations in health statistics. For health endpoints or populations where there is great variability in annual incidence, increases in incidence much greater than one case per year may not be detected above the normal variability observed in health statistics.

4.4 Evaluation of health risk for the Proposal

The HRA results for each COPC associated with the operation of the Proposal are summarised in the following sections.

Detailed calculations are presented in **Appendix A** for increased annual incidence for mortality and morbidity endpoints, and **Appendix B** for excess lifetime cancer risk.

4.4.1 Particulate matter

The health endpoints and exposure-response functions (β values) adopted in this HRA for the evaluation of PM_{10} and $PM_{2.5}$ are presented in **Table 4.5** and **Table 4.6**, respectively.

Table 4.5: Health endpoints and exposure-related functions for PM_{10}

Health Endpoint	Exposure period	β (Exposure Response Function per 1 µg/m³ Increase in PM_{10})
All-cause mortality 30+ years	Annual Average	0.004
All-cause mortality all ages	24-Hour Average	0.002
Mortality cardiovascular disease all ages	24-Hour Average	0.002
Hospital admissions respiratory disease 65+ years	24-Hour Average	0.003
Hospital admissions cardiac disease 65+ years	24-Hour Average	0.002
Hospital admissions pneumonia and bronchitis 65+ years	24-Hour Average	0.0013
Hospital admissions respiratory disease 15-64 years	24-Hour Average	0.003
ED visits asthma 1-14 years	24-Hour Average	0.015

Note: Exposure response functions were obtained from Environment Protection and Heritage Council (EPHC 2010) and Health Effects Institute (HEI 2009).
Abbreviations: µg/m³: microgram per cubic meter; ED: Emergency Department; PM: Particulate Matter

Table 4.6: Health endpoints and exposure-related functions for $PM_{2.5}$		
Health Endpoint	**Exposure period**	**β (Exposure Response Function per 1 μg/m³ Increase in $PM_{2.5}$)**
All-cause mortality 30+ years	Annual Average	0.006
Cardiopulmonary mortality 30+	Annual Average	0.014
Mortality ischemic heart disease 30+ years	Annual Average	0.024
Mortality lung cancer 30+ years	Annual Average	0.014
All-cause mortality all ages	24-Hour Average	0.0023
Mortality cardiovascular disease- all ages	24-Hour Average	0.0013
Hospital admissions respiratory disease 65+ years	24-Hour Average	0.004
Hospital admissions cardiac disease 65+ years	24-Hour Average	0.005
Hospital admissions cardiovascular disease 65+ years	24-Hour Average	0.003
Hospital admissions ischemic heart disease 65+ years	24-Hour Average	0.004
Hospital admissions COPD 65+ years	24-Hour Average	0.004
Hospital admissions pneumonia and bronchitis 65+ years	24-Hour Average	0.005
Hospital admissions respiratory disease 15-64 years	24-Hour Average	0.003
ED visits asthma 1-14 years	24-Hour Average	0.0015
Note: Exposure response functions were obtained from EPHC (2010) and HEI (2009). **Abbreviations:** μg/m³: microgram per cubic meter; COPD: Chronic Obstructive Pulmonary Disease ; ED: Emergency Department; PM: Particulate Matter		

The increased annual incidences for the health endpoints evaluated due to PM_{10} and $PM_{2.5}$ exposure for each suburb are summarised in **Table 4.7** and **Table 4.8**. The health outcomes evaluated for exposure to PM include:

- Premature mortality
  - All-causes (ages 30+ years and all ages)
  - Cardiopulmonary (ages 30+ years)
  - Ischemic heart disease (ages 30+ years)
  - Lung cancer (ages 30+ years)
  - Cardiovascular disease (all ages)
- Hospital admissions
  - Respiratory disease (ages 65+ years and ages 15-64 years)
  - Cardiac disease (ages 65+ years)
  - Cardiovascular disease (ages 65+ years)
  - Ischemic heart disease (ages 65+ years)
  - Chronic obstructive pulmonary disease (ages 65+ years)
  - Pneumonia and bronchitis (ages 65+ years)
- Emergency department visits associated with asthma (ages 1-14 years)

Table 4.7: Summary of increased annual incidence associated with exposure to PM_{10} from the operation of Proposal

Health endpoint	Exposure period	Increased annual incidence (case per year)			
		Casula	Glenfield	Moorebank	Wattle Grove
All-cause mortality 30+ years	Annual Average	0.05	0.02	0.04	0.03
All-cause mortality all ages	24-Hour Average	0.02	0.007	0.02	0.02
Mortality cardiovascular disease all ages	24-Hour Average	0.007	0.002	0.005	0.005
Hospital admissions respiratory disease 65+ years	24-Hour Average	0.03	0.01	0.03	0.01
Hospital admissions cardiac disease 65+ years	24-Hour Average	0.04	0.02	0.04	0.02
Hospital admissions pneumonia and bronchitis 65+ years	24-Hour Average	0.004	0.001	0.004	0.001
Hospital admissions respiratory disease 15-64 years	24-Hour Average	0.04	0.01	0.03	0.03
ED visits asthma 1-14 years	24-Hour Average	0.06	0.01	0.04	0.05

Abbreviations: ED: Emergency Department. PM: Particulate Matter

Table 4.8: Summary of increased annual incidence associated with exposure to $PM_{2.5}$ from the operation of Proposal

Health endpoint	Exposure period	Increased annual incidence (case per year)			
		Casula	Glenfield	Moorebank	Wattle Grove
All-cause mortality 30+ years	Annual Average	0.07	0.03	0.06	0.04
Cardiopulmonary mortality 30+	Annual Average	0.07	0.03	0.07	0.05
Mortality ischemic heart disease 30+ years	Annual Average	0.02	0.007	0.02	0.01
Mortality lung cancer 30+ years	Annual Average	0.005	0.002	0.005	0.003
All-cause mortality all ages	24-Hour Average	0.03	0.008	0.02	0.02
Mortality cardiovascular disease- all ages	24-Hour Average	0.004	0.001	0.003	0.003
Hospital admissions respiratory disease 65+ years	24-Hour Average	0.04	0.02	0.04	0.01
Hospital admissions cardiac disease 65+ years	24-Hour Average	0.1	0.04	0.1	0.04
Hospital admissions cardiovascular disease 65+ years	24-Hour Average	0.06	0.02	0.06	0.02
Hospital admissions ischemic heart disease 65+ years	24-Hour Average	0.03	0.01	0.03	0.01
Hospital admissions COPD 65+ years	24-Hour Average	0.01	0.005	0.01	0.005
Hospital admissions pneumonia and bronchitis 65+ years	24-Hour Average	0.01	0.005	0.01	0.005
Hospital admissions respiratory disease 15-64 years	24-Hour Average	0.04	0.01	0.03	0.03
ED visits asthma 1-14 years	24-Hour Average	0.006	0.001	0.004	0.005

Abbreviations: COPD: Chronic Obstructive Pulmonary Disease. ED: Emergency Department. PM: Particulate Matter

The increased annual incidences for the health endpoints evaluated due to Proposal related PM_{10} and $PM_{2.5}$ exposure were all well below one case per year. For the most sensitive health endpoint of PM_{10}, the highest incidence is an additional 0.06 asthma-related emergency department visit per year among 1-14 year-olds in Casula and Wattle Grove (equivalent to 0.6 additional emergency department visit per 10 years).

For the most sensitive health endpoints of $PM_{2.5}$, there would be an additional 0.07 death per year due to all causes among 30+ year-olds in Casula and Moorebank or an additional 0.07 death per year due to cardiopulmonary disease among 30+ year-olds in Casula and Moorebank (equivalent to one additional death per 10 years), which may be attributed to annual exposure to emissions of $PM_{2.5}$ from the operation of the Proposal.

There would be an additional 0.1 hospital admission per year associated with cardiac disease among 65+ year-olds in Casula or Moorebank (equivalent to one additional hospital admission per 10 years), which may be attributed to daily exposure to emissions of $PM_{2.5}$ from the operation of the Proposal .

Based on the estimated increased annual incidence for multiple health endpoints contributing to mortality and morbidity for the Proposal, there are no significant adverse health effects expected in relation to short-term and long-term exposure to PM_{10} and $PM_{2.5}$ in the surrounding local area.

4.4.2 Nitrogen Dioxide

The health endpoints and exposure-response functions (β values) adopted in this HRA for the evaluation of NO_2 (modelled as NO_x) are presented in **Table 4.9**.

Table 4.9: Health endpoints and exposure-response functions for NO_2

Health endpoint	Exposure period	β (Exposure response function per 1 µg/m^3 increase in NO_2)
All-cause mortality 30+ years	Annual Average	0.0028
Cardiovascular mortality 30+ years	Annual Average	0.0028
Respiratory mortality 30+ years	Annual Average	0.0028
All-cause mortality all ages	24-Hour Average	0.001
Mortality respiratory disease all ages	24-Hour Average	0.0023
Mortality cardiovascular disease all ages	24-Hour Average	0.001
Hospital admissions respiratory disease 65+ years	24-Hour Average	0.003
Hospital admissions cardiovascular disease 65+ years	24-Hour Average	0.0014
Hospital admissions respiratory disease 15-64 years	24-Hour Average	0.001
ED visits asthma 1-14 years	24-Hour Average	0.0006

Note:
Exposure response functions were obtained from EPHC (2010) and Cesaroni et al. (2013).
Abbreviations: µg/m$_3$: microgram per cubic meter; ED: Emergency Department; NO_2: Nitrogen Dioxide

The increased annual incidences for the health endpoints evaluated due to Proposal related NO_2 exposure for each suburb are summarised in **Table 4.10**. Health outcomes evaluated for exposure to NO_2 included:

- Premature mortality
  - All-causes (ages 30+ years and all ages)
  - Cardiovascular (ages 30+ years and all ages)
  - Respiratory (ages 30+ years and all ages)

- Hospital admissions
  - Respiratory disease (ages 65+ years and ages 15-64 years)
  - Cardiovascular disease (ages 65+ years)
- Emergency department visits associated with asthma (ages 1-14 years)

The increased annual incidences for the Proposal were below one case per year for all health endpoints and in all locations. The highest increased annual incidence would be 0.9 for all-cause mortality among 30+ year-olds in Casula and Moorebank.

Based on the estimated increased annual incidence for multiple health endpoints contributing to mortality and morbidity, there are no significant adverse health effects expected in relation to short-term and long-term exposure to NO_2 for the Proposal in the surrounding local area.

Table 4.10: Summary of increased annual incidence associated with exposure to NO_2 from the operation of Proposal

Health endpoint	Exposure period	Increased annual incidence (case per year)			
		Casula	Glenfield	Moorebank	Wattle Grove
All-cause mortality 30+ years	Annual Average	0.9	0.4	0.9	0.6
Cardiovascular mortality 30+ years	Annual Average	0.3	0.1	0.3	0.2
Respiratory mortality 30+ years	Annual Average	0.04	0.02	0.04	0.03
All-cause mortality all ages	24-Hour Average	0.3	0.1	0.3	0.2
Mortality respiratory disease	24-Hour Average	0.07	0.02	0.06	0.05
Mortality cardiovascular disease all ages	24-Hour Average	0.1	0.03	0.08	0.07
Hospital admissions respiratory disease 65+ years	24-Hour Average	0.9	0.4	0.9	0.3
Hospital admissions cardiovascular disease 65+ years	24-Hour Average	0.9	0.4	0.8	0.3
Hospital admissions respiratory disease 15-64 years	24-Hour Average	0.4	0.1	0.3	0.3
ED visits asthma 1-14 years	24-Hour Average	0.07	0.02	0.05	0.06

Abbreviations: ED: Emergency Department, NO_2: Nitrogen Dioxide

4.4.3 Sulfur Dioxide

The health endpoints and exposure-response functions (β values) adopted in this HRA for the evaluation of SO_2 are presented in **Table 4.11**.

Table 4.11: Health endpoints and exposure-response functions for SO_2

Health endpoint	Exposure period	β (Exposure response function per 1 µg/m³ increase in SO_2)
All-cause mortality all ages	24-Hour Average	0.0006
Mortality respiratory disease- all ages	24-Hour Average	0.0013
Mortality cardiovascular disease- all ages	24-Hour Average	0.0008
Hospital admissions respiratory disease 65+ years	1- Hour Maximum	0.002
ED visits asthma 1-14 years	24-Hour Average	0.008

Note: Exposure response functions were obtained from Jalaudin et al. (2008), Katsouyanni (2006), and Simpson et al. (2005).
Abbreviations: µg/m3: microgram per cubic meter. ED: Emergency Department. SO_2: Sulfur Dioxide

Only short-term exposure was evaluated for this chemical. The increased annual incidences for the health endpoints evaluated due to Proposal related SO_2 exposure for each suburb are summarised in **Table 4.12**. Health outcomes evaluated for exposure to SO_2 included:

- Premature mortality
  - All-causes (all ages)
  - Respiratory disease (all ages)
  - Cardiovascular disease (all ages)
- Hospital admissions
  - Respiratory disease (ages 65+ years)
- Emergency department visits associated with asthma (ages 1-14 years)

The increased annual incidences for the health endpoints evaluated due to Proposal related SO_2 exposure were all well below one case per year. For the most sensitive health endpoint, there would be an additional 0.005 asthma-related emergency department visit per year among 1-14 year-olds in Casula (equivalent to five additional emergency department visits per 1,000 years), which may be attributed to daily exposure to emissions of SO_2 from the operation of the Proposal.

Based on the estimated increased annual incidence for multiple health endpoints contributing to mortality and morbidity, there are no significant adverse health effects expected in relation to short-term exposure to SO_2 from the Proposal in the surrounding local area.

Table 4.12: Summary of increased annual incidence associated with exposure to SO_2 from the operation of the Proposal

Health endpoint	Exposure period	Increased annual incidence (case per year)			
		Casula	Glenfield	Moorebank	Wattle Grove
All-cause mortality all ages	24-Hour Average	0.001	0.0003	0.0007	0.0008
Mortality respiratory disease- all ages	24-Hour Average	0.0002	0.00005	0.0001	0.0002
Mortality cardiovascular disease- all ages	24-Hour Average	0.0004	0.0001	0.0003	0.0003
Hospital admissions respiratory disease 65+ years	1- Hour Maximum	0.004	0.001	0.002	0.003
ED visits asthma 1-14 years	24-Hour Average	0.005	0.001	0.003	0.004

Abbreviations: ED: Emergency Department. SO_2: Sulfur Dioxide

4.4.4 Carbon Monoxide

The health endpoints and exposure-response functions (β values) adopted in this HRA for the evaluation of CO are presented in **Table 4.13**.

Table 4.13: Health endpoints and exposure-response functions for CO

Health endpoint	Exposure period	β (Exposure response function per 1 µg/m³ increase in CO)
All-cause mortality 30+ years	8-Hour Average	0.000001
Hospital admissions cardiac disease 65+ years	8-Hour Average	0.000003
Hospital admissions cardiovascular disease 65+ years	8-Hour Average	0.0000014

Note: Exposure response functions were obtained from EPHC (2010) and Simpson et al. (2005).

Abbreviations:

µg/m³: microgram per cubic meter
CO: Carbon Monoxide

Only short-term exposure was evaluated for this chemical. The increased annual incidences for the health endpoints evaluated due to Proposal related CO exposure for each suburb are summarised in **Table 4.14**. Health outcomes evaluated for exposure to CO included:

- Premature mortality
  - All-causes (ages 30+ years)
- Hospital admissions
  - Cardiac disease (ages 65+ years)
  - Cardiovascular disease (ages 65+ years)

The increased annual incidences for the health endpoints evaluated due to Proposal related CO exposure were all well below one case per year. For the most sensitive health endpoint, there would be an additional 0.001 hospital admission per year associated with cardiac disease among 65+ year-olds in Casula or Moorebank (equivalent to one additional hospital admission per 1,000 years), which may be attributed to 8-hour exposure to emissions of CO from the operation of the Proposal.

Based on the estimated increased annual incidence for multiple health endpoints contributing to mortality and morbidity, there are no significant adverse health effects expected in relation to short-term exposure to CO from the Proposal in the surrounding local area.

Table 4.14: Summary of increased annual incidence associated with exposure to CO from the operation of the Proposal

Health endpoint	Exposure period	Increased annual incidence (case per year)			
		Casula	Glenfield	Moorebank	Wattle Grove
All-cause mortality 30+ years	8-Hour Average	0.0002	0.00006	0.0002	0.0001
Hospital admissions cardiac disease 65+ years	8-Hour Average	0.001	0.0003	0.0009	0.0004
Hospital admissions cardiovascular disease 65+ years	8-Hour Average	0.00006	0.00002	0.00005	0.00002

Abbreviations: CO: Carbon Monoxide. ED visits asthma 1-14 years

4.4.5 VOCs, DPM and PAHs

The Unit Risk Factors (URFs) adopted in this HRA for VOCs (benzene and 1,3-butadiene), DPM and PAHs (as BAP TEQ) are presented in **Table 4.15**.

Table 4.15: Unit risk factors used for the calculation of excess lifetime cancer risk

Chemical	Unit risk factor $(\mu g/m^3)^{-1}$
Benzene	0.000029
1,3-Butadiene	0.00017
DPM	0.0003
PAHs (as BaP TEQ)	0.0011

Note: Unit risk factors were obtained from California Environmental Protection Agency (Cal/EPA) Office of Environmental Health Hazard Assessment (OEHHA). 2016. OEHHA Toxicity Criteria Database. Available at: http://oehha.ca.gov/tcdb/index.asp

Abbreviations: $\mu g/m^3$: microgram per cubic meter. BaP: Benzo(a)pyrene. DPM: Diesel Particulate Matter. PAH: Polycyclic Aromatic Hydrocarbon. TEQ: Toxicity Equivalent

Table 4.16 presents a summary of the excess lifetime cancer risks associated with exposure to benzene, 1,3-butadiene, DPM and PAHs (as BAP TEQ), for the maximum exposed receptor in each category (i.e. residential/school, commercial/industrial, or recreational).

The excess lifetime cancer risks associated with the Proposal related exposure to benzene, 1,3-butadiene, and PAHs (as BAP TEQ) were all below the acceptable risk range of 10^{-6} to 10^{-4}. The excess lifetime cancer risks associated with the Proposal related DPM exposure were all within the acceptable risk range of 10^{-6} to 10^{-4}. Therefore, there are no unacceptable cancer risks are expected in relation to long-term exposure to VOCs, DPM and PAHs in the surrounding local area.

Table 4.16: Summary of excess lifetime cancer risks associated with exposure to Benzene, 1,3-Butadiene, PAHs, and DPM from the operation of the Proposal

Chemical	Excess lifetime cancer risk at maximum exposed receptor		
	Residential/School	Recreational	Commercial/Industrial
Benzene	3.5E-07	1.8E-08	4.9E-08
1,3-Butadiene	6.9E-07	3.7E-08	9.3E-08
DPM	6.4E-05	3.0E-06	1.0E-05
PAHs (as BaP TEQ)	1.1E-09	5.4E-11	1.8E-10

Abbreviations: BaP: Benzo(a)pyrene. DPM: Diesel Particulate Matter. PAH: Polycyclic Aromatic Hydrocarbon. TEQ: Toxicity Equivalent

4.5 Evaluation of health risks from the cumulative Proposal

The HRA results for each COPC associated with the operation of the cumulative Proposal are summarised in the following sections. The health endpoints and exposure-response functions (β values) are previously described in **Section 4.4**. The increased annual incidences for the health endpoints evaluated due to cumulative exposure for PM_{10}, $PM_{2.5}$, NO_2, SO_2 and CO for each suburb are summarised in **Table 4.17, Table 4.18, Table 4.19, Table 4.20** and **Table 4.21**.

The increased annual incidences for the health endpoints evaluated due to cumulative Proposal related PM_{10} and $PM_{2.5}$ exposure were all well below one case per year. For the most sensitive health endpoint of PM_{10}, there would be an additional 0.1 asthma-related emergency department visit per year among 1-14 year-olds in Wattle Grove (equivalent to one additional emergency department visit per 10 years), which may be attributed to daily exposure to emissions of PM_{10} from the operation of the cumulative Proposal. For the most sensitive health endpoints of $PM_{2.5}$,

there would be an additional 0.1 death per year due to all causes or cardiopulmonary disease among 30+ year-olds in Casula or an additional 0.1 death per year due to cardiopulmonary disease among 30+ year-olds in Casula and Moorebank (equivalent to one additional death per 10 years), which may be attributed to annual exposure to emissions of $PM_{2.5}$ from the operation of the cumulative Proposal. There would be an additional 0.1 hospital admission per year associated with cardiac disease among 65+ year-olds in Casula or Moorebank (equivalent to one additional hospital admission per 10 years), which may be attributed to daily exposure to emissions of $PM_{2.5}$ from the operation of the cumulative Proposal.

The increased annual incidences for the health endpoints evaluated due to cumulative Proposal related NO_2 exposure were below one case per year for all health endpoints in Glenfield. The increased incidences for the cumulative Proposal were slightly above one case per year for three health endpoints in Casula and Moorebank (all-cause mortality for ages 30+ years due to annual exposure, hospital admissions associated with respiratory disease for ages 65+ years due to daily exposure, and hospital admissions associated with cardiovascular disease for ages 65+ years due to daily exposure) as well as one health endpoint in Wattle Grove (all-cause mortality for ages 30+ years due to annual exposure). For the most sensitive health endpoint, there would be an additional 1.3 deaths per year due to all causes among 30+ year-olds in Casula (equivalent to 13 additional deaths per 10 years), which may be attributed to annual exposure to emissions of NO_2 from the operation of the cumulative Proposal. These calculations were based on a conservative assumption 100% conversion of NO_x is NO_2. A review of NO_2 and NO_x monitoring data from the OEH Liverpool monitoring site for the past 5 years indicates that, on average, ambient ratios of NO_2:NO_x range from 0.6 to 0.8 on an annual basis (average of 0.7 over the 5 year period). In other words, ambient NO_2 is typically approximately 70% of NO_x.

If this adjustment for fraction of NO_x that is NO_2 is applied to the ambient concentrations from the operation of MPW Stage 2 and MPE Stage 1, the predicted NO_2 concentrations in air and the increased annual incidences would be reduced by 30%. That is, the greatest increased annual incidence would be below the threshold of one case per year. The increased annual incidences assuming this more realistic conversion are also presented in **Table 4.19** (values shown in brackets). In addition, the AQIA indicated that the cumulative NO_2 levels for all relevant averaging periods were below the current NEPM air quality standards.

The increased annual incidences for the health endpoints evaluated due to the cumulative Proposal related SO_2 exposure were all well below one case per year. For the most sensitive health endpoint, there would be an additional 0.005 asthma-related emergency department visit per year among 1-14 year-olds in Casula (equivalent to five additional emergency department visits per 1,000 years), which may be attributed to daily exposure to emissions of SO_2 from the operation of the cumulative Proposal.

The increased annual incidences for the health endpoints evaluated due to the cumulative Proposal related CO exposure were all well below one case per year. For the most sensitive health endpoint, there would be an additional 0.001 hospital admission per year associated with cardiac disease among 65+ year-olds in Casula or Moorebank (equivalent to one additional hospital admission per 1,000 years), which may be attributed to 8-hour exposure to emissions of CO from the operation of the Proposal or cumulative Proposal.

Based on the estimated increased annual incidence for multiple health endpoints contributing to mortality and morbidity, there are no significant adverse health effects expected in relation to short-term exposure to PM_{10}, $PM_{2.5}$, NO_2, SO_2 or CO from the cumulative Proposal in the surrounding local area.

Table 4.17: Summary of increased annual incidence associated with exposure to PM_{10} from the cumulative Proposal

Health endpoint	Exposure period	Increased annual incidence (case per year)			
		Casula	Glenfield	Moorebank	Wattle Grove
All-cause mortality 30+ years	Annual Average	0.07	0.03	0.06	0.06
All-cause mortality all ages	24-Hour Average	0.03	0.01	0.03	0.03
Mortality cardiovascular disease all ages	24-Hour Average	0.01	0.004	0.007	0.01
Hospital admissions respiratory disease 65+ years	24-Hour Average	0.04	0.02	0.04	0.02
Hospital admissions cardiac disease 65+ years	24-Hour Average	0.06	0.03	0.06	0.03
Hospital admissions pneumonia and bronchitis 65+ years	24-Hour Average	0.005	0.003	0.005	0.003
Hospital admissions respiratory disease 15-64 years	24-Hour Average	0.06	0.02	0.04	0.06
ED visits asthma 1-14 years	24-Hour Average	0.09	0.03	0.06	0.1

Abbreviations: ED: Emergency Department. PM: Particulate Matter

Table 4.18: Summary of increased annual incidence associated with exposure to $PM_{2.5}$ from the cumulative Proposal

Health endpoint	Exposure period	Increased annual incidence (case per year)			
		Casula	Glenfield	Moorebank	Wattle Grove
All-cause mortality 30+ years	Annual Average	0.1	0.05	0.09	0.08
Cardiopulmonary mortality 30+	Annual Average	0.1	0.05	0.1	0.09
Mortality ischemic heart disease 30+ years	Annual Average	0.02	0.01	0.02	0.02
Mortality lung cancer 30+ years	Annual Average	0.007	0.004	0.007	0.006
All-cause mortality all ages	24-Hour Average	0.04	0.01	0.03	0.04
Mortality cardiovascular disease- all ages	24-Hour Average	0.006	0.002	0.005	0.006
Hospital admissions respiratory disease 65+ years	24-Hour Average	0.06	0.03	0.05	0.03
Hospital admissions cardiac disease 65+ years	24-Hour Average	0.1	0.07	0.1	0.07
Hospital admissions cardiovascular disease 65+ years	24-Hour Average	0.09	0.04	0.08	0.04
Hospital admissions ischemic heart disease 65+ years	24-Hour Average	0.04	0.02	0.04	0.02
Hospital admissions COPD 65+ years	24-Hour Average	0.02	0.009	0.02	0.009
Hospital admissions pneumonia and bronchitis 65+ years	24-Hour Average	0.02	0.01	0.02	0.009
Hospital admissions respiratory disease 15-64 years	24-Hour Average	0.06	0.02	0.04	0.05
ED visits asthma 1-14 years	24-Hour Average	0.008	0.003	0.006	0.009

Abbreviations: COPD: Chronic Obstructive Pulmonary Disease. ED: Emergency Department. PM: Particulate Matter

Table 4.19: Summary of increased annual incidence associated with exposure to NO_2 from the cumulative Proposal

Health endpoint	Exposure period	Increased annual incidence - case per year (values in brackets assume ambient ratio of NO_2 to NO_x of 0.7)			
		Casula	Glenfield	Moorebank	Wattle Grove
All-cause mortality 30+ years	Annual Average	1.3 (0.9)	0.7 (0.5)	1.2 (0.9)	1.1 (0.8)
Cardiovascular mortality 30+ years	Annual Average	0.4 (0.3)	0.2 (0.1)	0.3 (0.2)	0.3 (0.2)
Respiratory mortality 30+ years	Annual Average	0.06 (0.04)	0.03 (0.02)	0.06 (0.04)	0.05 (0.04)
All-cause mortality all ages	24-Hour Average	0.5 (0.3)	0.2 (0.1)	0.4 (0.3)	0.4 (0.3)
Mortality respiratory disease	24-Hour Average	0.1 (0.07)	0.04 (0.03)	0.08 (0.06)	0.09 (0.07)
Mortality cardiovascular disease all ages	24-Hour Average	0.14 (0.1)	0.05 (0.04)	0.11 (0.07)	0.13 (0.09)
Hospital admissions respiratory disease 65+ years	24-Hour Average	1.2 (0.9)	0.6 (0.4)	1.2 (0.8)	0.6 (0.4)
Hospital admissions cardiovascular disease 65+ years	24-Hour Average	1.2 (0.8)	0.6 (0.4)	1.1 (0.8)	0.5 (0.4)
Hospital admissions respiratory disease 15-64 years	24-Hour Average	0.5 (0.4)	0.2 (0.1)	0.4 (0.3)	0.5 (0.4)
ED visits asthma 1-14 years	24-Hour Average	0.1 (0.07)	0.03 (0.02)	0.07 (0.05)	0.1 (0.07)

Abbreviations: ED: Emergency Department, NO_2: Nitrogen Dioxide

Table 4.20: Summary of increased annual incidence associated with exposure to SO_2 from the cumulative Proposal

Health endpoint	Exposure period	Increased annual incidence (case per year)			
		Casula	Glenfield	Moorebank	Wattle Grove
All-cause mortality all ages	24-Hour Average	0.00113	0.0003	0.0007	0.0008
Mortality respiratory disease- all ages	24-Hour Average	0.0002	0.00005	0.0001	0.0002
Mortality cardiovascular disease- all ages	24-Hour Average	0.0004	0.0001	0.0003	0.0003
Hospital admissions respiratory disease 65+ years	1- Hour Maximum	0.004	0.001	0.003	0.003
ED visits asthma 1-14 years	24-Hour Average	0.005	0.001	0.003	0.004

Abbreviations: ED: Emergency Department. SO_2: Sulfur Dioxide

Table 4.21: Summary of increased annual incidence associated with exposure to CO from the cumulative Proposal					
Health endpoint	**Exposure period**	**Increased annual incidence (case per year)**			
		Casula	**Glenfield**	**Moorebank**	**Wattle Grove**
All-cause mortality 30+ years	8-Hour Average	0.0003	0.0001	0.0002	0.0002
Hospital admissions cardiac disease 65+ years	8-Hour Average	0.001	0.0006	0.001	0.0007
Hospital admissions cardiovascular disease 65+ years	8-Hour Average	0.00009	0.00004	0.00008	0.00004
Abbreviations: CO: Carbon Monoxide. ED visits asthma 1-14 years					

The excess lifetime cancer risks associated with the cumulative Proposal related exposure to benzene, 1,3-butadiene, and PAHs (as BAP TEQ), presented in **Table 4.22**, are all below the acceptable risk range of 10^{-6} to 10^{-4}. The excess lifetime cancer risks associated with the cumulative Proposal related DPM exposure were all within the acceptable risk range of 10^{-6} to 10^{-4}. Therefore, there are no unacceptable cancer risks are expected in relation to long-term exposure to VOCs, DPM and PAHs in the surrounding local area.

Table 4.22: Summary of excess lifetime cancer risks associated with exposure to Benzene, 1,3-Butadiene, PAHs, and DPM from the cumulative Proposal

Chemical	Excess lifetime cancer risk at maximum exposed receptor		
	Residential/School	Recreational	Commercial/Industrial
Benzene	4.2E-07	2.2E-08	6.1E-08
1,3-Butadiene	7.8E-07	4.2E-08	1.1E-07
DPM	8.3E-05	4.2E-06	1.4E-05
PAHs (as BaP TEQ)	3.3E-09	1.6E-10	5.4E-10

Abbreviations: BaP: Benzo(a)pyrene. DPM: Diesel Particulate Matter. PAH: Polycyclic Aromatic Hydrocarbon. TEQ: Toxicity Equivalent

4.6 Uncertainties

It is important to evaluate uncertainties associated with the calculations and assumptions used in this air quality HRA so that the results of this risk assessment can be placed in perspective. This section identifies the potential sources of uncertainties, performs a sensitivity analysis for the key quantifiable uncertainties with plausible ranges, and presents a discussion of the significance and expected effects of sensitive variables on risk estimates.

4.6.1 Baseline health incidence

The baseline health incidence data used for the quantification of potential health risk are 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 do 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 health incidence data considered in this assessment is only a general indicator (not a precise measure) of the incidence of these health endpoints. Such limitation in baseline health incidence data may underestimate the risk.

4.6.2 Exposure point concentrations

The modelling of air emissions involved the use of a number of assumptions related to the operation of the Proposal. While the approach adopted in the AQIA utilised published peer-reviewed emission estimation techniques, currently available site-specific data, site-specific meteorology and terrain data, and approved dispersion models for the quantification of impacts in the surrounding areas, the overall approach adopted was generally conservative to ensure that where uncertainties are present, the impact is overestimated. In addition, use of the locations with maximum modelled air concentrations to estimate risks likely overestimates risks for the majority of people living, working, and recreating within the study area.

4.6.3 Toxicity assessment

Health endpoints

The health endpoints evaluated in this HRA are the health effects or outcomes where the most significant and robust positive associations with COPCs have been identified. These health endpoints do not include all possible subsets of effects that have been considered in various published studies, and may be insufficient to provide a thorough understanding of all of the potential toxic properties of air pollutants to which humans may be exposed. This uncertainty is

considered inherent in any evaluation, but will be refined over time with the collection of additional data. The influence of this uncertainty may be either positive or negative.

Exposure-Response Function

As discussed in EnRisks (2014a), there is 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 air pollutants to which the population is exposed and the variability within the exposed population. The exposure-response functions used in this HRA have been taken from the Australian studies or the most reliable international studies in the absence of Australian data. They are considered current, robust and relevant to the characterisation of impacts from COPCs.

This HRA assumed a linear exposure-response relationship between the air EPCs associated with the Proposal and the health endpoints evaluated. However, the shape of the exposure-response function and whether there is a threshold for some of the health endpoints remains uncertain.

Most currently available data have demonstrated a linear relationship and no evidence of a threshold; however, for long-term exposure-related mortality, a log-linear relationship is more plausible and should be considered if there is a potential for exposure to very high concentrations. In this assessment, the impact evaluated is localised with low level increases in concentration associated with the Proposal. At low levels, the assumption of a linear relationship is considered appropriate.

Unit Risk Factor for Diesel Particulate Matter

DPM is a complex mixture of thousands of gases and fine particles that contains more than 40 toxic air contaminants. Many of them are known or suspected carcinogens. In this HRA, the URF of 3×10^{-4} $(\mu g/m^3)^{-1}$ published by OEHHA (1998) has been used in the calculation of excess lifetime cancer risks associated with DPM from the Proposal. This URF is consistent with Pacific Environment (2015).

However, the URF derived by OEHHA was based on Garshick et al. (1988), a study that has been judged by several authoritative bodies to be inadequate for derivation of a discrete, quantitative estimate of human risk due to substantial uncertainties (HEI 1999, USEPA 2002, Hesterberg et al., 2011, WHO 1996). Therefore, this sensitivity analysis presents results using alternative USEPA approved URF.

An important issue in extrapolating results from the older epidemiology studies is that diesel exhaust in the older epidemiology studies are based on diesel exhaust composition that is very different compared to more contemporary diesel exhaust. Since 1990s, new and cleaner diesel engines, together with different diesel fuels, have replaced a substantial number of existing engines. Such changes have not only resulted in the quantitative reduction in mass emitted by new technology diesel engines, but have also resulted in qualitative differences in the composition of DPM emitted, with respect to both size and chemicals associated with the exhaust (Hesterberg et al. 2011). Therefore, the exposure-response relationship between DPM and lung cancer is likely to change as newer engines become more prevalent. USEPA evaluated the toxicology and epidemiology evidence related to carcinogenic effect of DPM in 2002, and concluded that even though the scientific evidence supported an association between exposure to diesel exhaust and lung cancer, the data available at that time were not sufficient to confidently estimate a URF. This conclusion was based on a number of factors including equivocal evidence for the presence or absence of a dose-response relationship and uncertainties related to exposure (USEPA 2002).

USEPA estimated that the DPM URF could possibly range from 1×10^{-5} to 1×10^{-3} $(\mu g/m^3)^{-1}$, while acknowledging numerous uncertainties and assumptions in reaching this conclusion. USEPA has not revisited this issue since then.

WHO used data from studies in rats to estimate URF for DPM (WHO 1996). Using four different studies where lung cancer was the endpoint evaluated, WHO calculated a URF range of 1.6×10^{-5} to 7.1×10^{-5} per $\mu g/m^3$ (mean value of 3.4×10^{-5} per $\mu g/m^3$), which is near the low end of the USEPA URF range. Since the WHO values were derived based on animal studies, there are substantial uncertainties for applying them to humans.

The HEI Panel (2015) reviewed new epidemiology studies of diesel exhaust and lung cancer, including those that were key to the 2012 International Agency for Research on Cancer (IARC) evaluation of diesel exhaust (IARC 2012). This Panel focused on two studies, the Trucking Industry Particle Study (the Truckers Study; Garshick et al. 2012), and the Diesel Exhaust in Miners Study (DEMS) (Attfield et al. 2012, Silverman et al. 2012). In this evaluation, the Panel found that both the Truckers Study and DEMS were well-designed, well-conducted studies that made considerable progress toward addressing a number of the serious limitations identified in previous studies of diesel exhaust and lung cancer. The studies included better metrics to specifically quantify diesel exposure, and used better models of historical exposures. The HEI Panel concluded that the studies would be useful for quantitative estimates of historical exposures to diesel exhaust, and thus be appropriate to develop more robust URF values for quantitative HRA. Although there have been some attempts to use these studies to develop quantitative estimates of cancer risk (Vermeulen et al. 2014, Crump 2014, Morfeld and Spallek 2015), the numbers generated can vary considerably. USEPA will likely be following the recommendation by HEI Panel and developing URF values for DPM in the future, but the timing is uncertain.

Given the above uncertainties, a sensitivity analysis was conducted in this HRA by evaluating the excess lifetime cancer risks associated with DPM emitted from the operation of the Proposal using the USEPA URF range of 10^{-5} to 10^{-3} $(\mu g/m^3)^{-1}$. This range, which encompasses the various URF values developed by different regulatory agencies and research groups, better reflects the uncertainty of defining the exposure-response curve for assessing potential cancer risk from diesel exhaust, yet allows comparisons across different exposure scenarios. Results of the sensitivity analysis are presented in **Table 4.23** (Proposal) and **Table 4.24** (cumulative Proposal). The excess lifetime cancer risks calculated using the low end USEPA URF value of 10^{-5} $(\mu g/m^3)^{-1}$ were all below or within the acceptable risk range of 10^{-6} to 10^{-4}. The excess lifetime cancer risks calculated using the high end USEPA URF value of 10^{-3} $(\mu g/m^3)^{-1}$ were within the acceptable risk range of 10^{-6} to 10^{-4} for commercial/industrial and recreational receptors, but above the acceptable risk range for residential/school receptors. These calculations were based on a conservative assumption that all $PM_{2.5}$ is DPM.

Table 4.23: Summary of excess lifetime cancer risks associated with exposure to DPM from the operation of the Proposal – Sensitivity analysis

Chemical	Unit risk factor $(\mu g/m^3)^{-1}$		Excess lifetime cancer risk at maximum exposed receptor		
			Residential/School	Recreational	Commercial/Industrial
DPM	1.0E-05	Low End (USEPA 2002)	2.1E-06	9.8E-08	3.5E-07
	1.0E-03	High End (USEPA 2002)	2.1E-04	9.8E-06	3.5E-05

Source: USEPA. 2002. Health Assessment Document for Diesel Engine Exhaust. EPA/600/8-90/057F. May.

Table 4.24: Summary of excess lifetime cancer risks associated with exposure to DPM from the cumulative Proposal – Sensitivity analysis

Chemical	Unit risk factor $(\mu g/m^3)^{-1}$		Excess lifetime cancer risk at maximum exposed receptor		
			Residential/School	Recreational	Commercial/Industrial
DPM	1.0E-05	Low End (USEPA 2002)	2.8E-06	1.4E-07	4.8E-07
	1.0E-03	High End (USEPA 2002)	2.8E-04	1.4E-05	4.8E-05

4.7 Summary of health risks from air emissions

The air quality HRA evaluated a range of health endpoints associated with the key air pollutants, including increases in mortality and morbidity as well as excess lifetime cancer risks.

The HRA indicates the following:

- Short-term and long-term exposure to PM_{10} and $PM_{2.5}$ result in low health impacts in the surrounding communities and are below the acceptable risk level (i.e., fewer than one increased case per year of premature mortality, hospital admissions, and emergency department visits associated with cardiovascular and respiratory diseases or asthma);
- Short-term and long-term exposure to NO_x, following adjustment for the fraction attributable to NO_2, result in low health impacts in the surrounding communities and are below the acceptable risk level (i.e., fewer than one increased case per year of premature mortality, hospital admissions, and emergency department visits associated with cardiovascular and respiratory diseases or asthma);
- Short-term exposure to SO_2 and CO results in negligible impacts in the surrounding communities and are below the acceptable risk level (i.e., orders of magnitude below one increased case per year of premature mortality, hospital admissions, and emergency department visits associated with cardiovascular and respiratory diseases or asthma);
- Excess lifetime cancer risks for residents/school students, commercial/industrial workers, and recreational populations within the study area are below levels of concern (i.e., within or below the established acceptable cancer risk range of 10^{-6} to 10^{-4}).

In summary, there are no significant adverse health effects expected in relation to short-term and long-term exposure to key air pollutants in the surrounding communities. The increased annual incidences for the health endpoints evaluated were all below the acceptable risk of one additional case per year. The excess lifetime cancer risks were also within or below the acceptable risk range of 10^{-6} to 10^{-4}.

5. HEALTH RISK ASSESSMENT - NOISE

The noise HRA has been conducted to evaluate the potential health risks to surrounding communities from exposure to noise from the operation of the Proposal and the operation of the cumulative Proposal (the Proposal and MPW Stage 1 Proposal). Construction phase impacts for the Proposal would be temporary and are demonstrated in the Noise and Vibration Impact Assessment to comply with the relevant standards.

A noise HRA for the MPE Stage 1 Proposal completed previously by Pacific Environmental (2015) includes an overview of the health effects of environmental noise and presents risks for the MPE Stage 1 Proposal. This noise HRA follows the same methods. The various components for the noise HRA are discussed in the following subsections.

5.1 Exposure assessment

As part of the approval process for the Proposal, a Noise and Vibration Impact Assessment has been undertaken (Wilkinson Murray, 2016). The exposure data for the noise HRA were obtained from this report. The sources of noise that have been considered in this HRA are operational and rail noise. The potentially most affected residential receivers in the vicinity of the Proposal site are located in the suburbs of Casula, Glenfield, and Wattle Grove (Wilkinson Murray, 2016).

In addition to residential receivers, a number of potentially affected non-residential receivers have been identified near the Proposal site. All Saints Senior College and the Casula Powerhouse are located to the west of the Proposal site, across the Georges River, and the nearest industrial receiver, the Defence Joint Logistics Unit (DJLU) is located to the east of the Proposal site, across Moorebank Avenue.

Table 5-1 presents a summary of the potentially most affected receivers near the Proposal site. The locations of residential suburbs and discrete non-residential receivers, in relation to the Proposal site, are presented in **Figure 5-1**.

Table 5-1: Potentially affected receivers

Receiver/Suburb	Population	Distance (km) to Proposal site
Casula	Residential	0.35
Glenfield	Residential	1.8
Wattle Grove	Residential	0.64
All Saints Senior College (S1)	Educational	0.63
Casula Powerhouse (S2)	Educational	0.36
MPE (I1)	Industrial	0.05
DJLU (I2)	Industrial	0.05
ABB (I3)	Industrial	Boundary

Abbreviations:

km: kilometer
DJLU: Defence Joint Logistics Unit

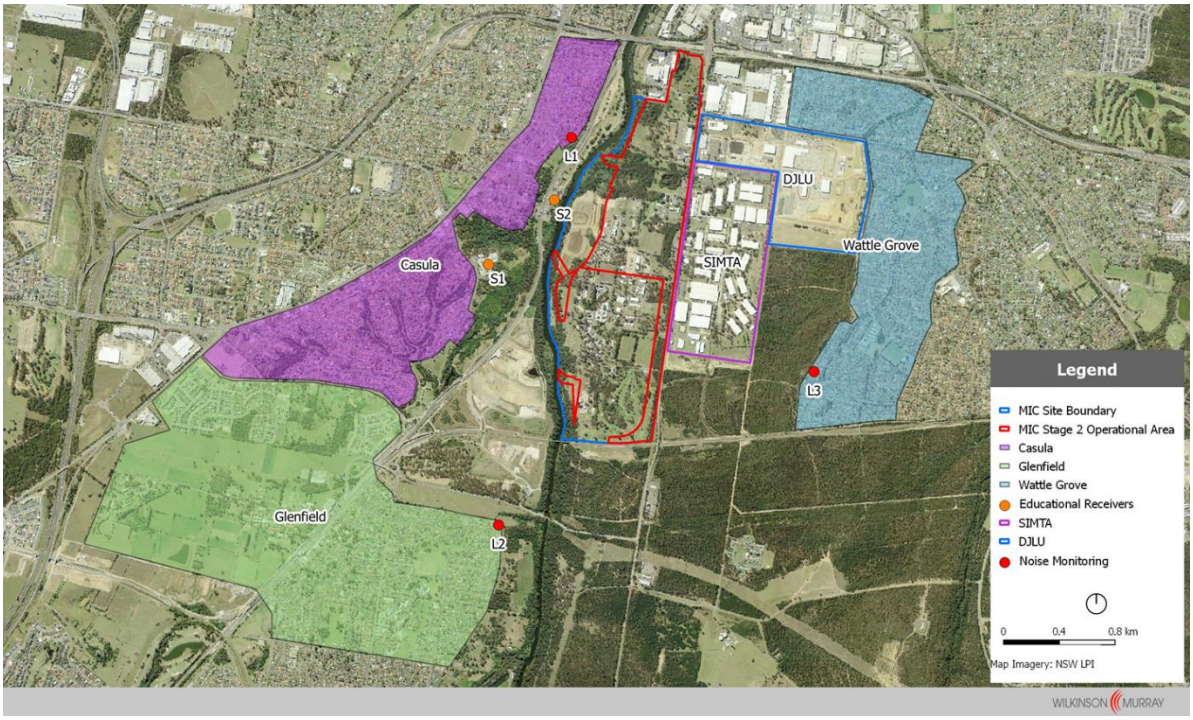

Figure 5-1: Locations of potentially affected receivers

(Source: Wilkinson-Murray 2016)

5.1.1 Baseline noise

The existing ambient noise environment at locations representative of the potentially most affected residential receivers in Casula, Glenfield and Wattle Grove were established through long-term background noise monitoring conducted in accordance with the NSW Industrial Noise Policy (Environment Protection Authority 2000). The existing ambient noise levels (the equivalent noise levels averaged over a time period [$LA_{eq,\ period}$]) are presented in **Table 5-2**.

Table 5-2: Existing ambient noise levels

Suburb	$LA_{eq,\ period}$ (dBA)		
	Day	Evening	Night Time
Casula	55	54	53
Glenfield	48	47	44
Wattle Grove	55	49	46

Note: Daytime 7:00am–6:00pm; Evening 6:00pm–10:00pm; Night time 10:00pm 7:00am.
Abbreviation: dBA: A-weighted decibel

5.1.2 Operational noise

For operational noise, the $LA_{eq,\ period}$ at sensitive receivers due to the operation of the Proposal are presented in **Table 5-3**. In addition, transient noise events associated with the operation of the site, including horns, tonal reversing alarms, pneumatic trailer brakes, and 'banging' noises associated with moving containers, may have the potential to cause sleep disturbance. The maximum noise levels (L_{Amax}) at sensitive receivers during night time due to the transient noise events associated with the operation of the Proposal are also presented in **Table 5-3**.

Table 5-3: Predicted operational noise levels from Proposal				
Receiver/Suburb	**$LA_{eq,\ period}$ (dBA)**			**LA_{max} (dBA)**
	Day	**Evening**	**Night Time**	**Night Time**
Casula	33	33	36	47
Glenfield	20	20	20	23
Wattle Grove	29	29	33	24
All Saints Senior College (S1)	20	20	22	N/A
Casula Powerhouse (S2)	24	24	27	N/A
MPE (I1)	60	60	60	N/A
DJLU (I2)	56	56	57	N/A
ABB (I3)	51	48	48	N/A
Notes: Daytime 7:00am–6:00pm; Evening 6:00pm–10:00pm; Night time 10:00pm 7:00am. Night time noise levels were predicted under adverse meteorology conditions. **Abbreviations:** dBA: A-weighted decibel. DJLU: Defence Joint Logistics Unit. MPW: Moorebank Precinct West				

Furthermore, the cumulative $LA_{eq,\ period}$ at sensitive receivers have been predicted by combining the computer noise models developed for each site. The cumulative L_{AMax} at sensitive receivers during night time due to the transient noise events associated with the operation of the cumulative Proposal have been taken as the higher value between the two sites.

The predicted cumulative operational noise levels are presented in **Table 5-4**.

Table 5-4: Predicted operational noise levels from the cumulative Proposal				
Receiver/Suburb	**$LA_{eq,\ period}$ (dBA)**			**LA_{max} (dBA)**
	Day	**Evening**	**Night Time**	**Night Time**
Casula	33	33	36	47
Glenfield	20	20	24	23
Wattle Grove	32	32	36	24
All Saints Senior College (S1)	29	29	34	N/A
Casula Powerhouse (S2)	24	24	27	N/A
DJLU (I2)	56	56	57	N/A
ABB (I3)	51	48	48	N/A
Notes: Daytime 7:00am–6:00pm; Evening 6:00pm–10:00pm; Night time 10:00pm 7:00am. Night time noise levels were predicted under adverse meteorology conditions. **Abbreviations:** dBA: A-weighted decibel DJLU: Defence Joint Logistics Unit				

5.1.3 Rail noise

Rail noise predictions are made for all trains travelling between the Proposal site and the SSFL. Previous assessments and approval of the SSFL are understood to account for freight movements generated by an intermodal terminal facility in the Moorebank area. Therefore, no assessment was undertaken of noise emissions from movements on the SSFL generated by the Proposal.

The predicted rail noise levels at sensitive receivers due to freight rail movements associated with the Proposal are presented in **Table 5-5**.

Table 5-5: Predicted rail noise levels due to freight rail movements associated with the Proposal

Receiver/Suburb	$LA_{eq, period}$ (dBA)			LA_{max} (dBA)
	Day	Evening	Night Time	Night Time
Casula	50	50	48	67
Glenfield	43	43	41	62
Wattle Grove	41	42	39	54
All Saints Senior College (S1)	48	48	47	N/A
Casula Powerhouse (S2)	43	43	42	N/A

Notes: Daytime 7:00am–6:00pm; Evening 6:00pm–10:00pm; Night time 10:00pm 7:00am.
Abbreviations: dBA: A-weighted decibel. DJLU: Defence Joint Logistics Unit.

5.2 Toxicity assessment

Exposure to noise is associated with direct auditory and non-auditory health effects, including cardiovascular disease, cognitive impairment, sleep disturbance, tinnitus, annoyance, and hearing impairment (WHO, 1999; WHO, 2011).

Epidemiological studies suggest a higher risk of cardiovascular diseases, including high blood pressure and myocardial infarction, in people chronically exposed to high levels of road or air traffic noise (Pacific Environment, 2015; WHO, 2011). High blood pressure is a major risk factor for cardiovascular disease and small increases in blood pressure from road traffic noise may impact on public health, particularly for the elderly. Sleep disturbance also contributes to cardiovascular risk with older people again the more susceptible risk group (Pacific Environment, 2015).

Children may be particularly vulnerable to the effects of noise on cognitive impairment and noise may interfere with learning at a critical developmental stage. Epidemiological studies show effects of chronic noise exposure on tasks involving central processing and language, such as reading, comprehension, memory and attention. Exposure during critical periods of learning at school could potentially impair development and have a lifelong effect on educational attainment (Pacific Environment, 2015). The WHO (2011) has defined cognitive impairment as 'Reduction in the ability in school-age children that occurs while noise exposure persists and will persist for some time after the cessation of the exposure'.

Sleep disturbance in one of the most common complaints raised by noise exposed communities and can have a major impact on health and quality of life (WHO (2011)). Studies have shown that noise affects sleep in terms of immediate effects (eg., arousal responses, sleep stage changes, awakenings, body movements, total wake time, autonomic responses), after effects (eg., sleepiness, daytime performance cognitive function deterioration) and long-term effects (eg., self-reported chronic sleep disturbance) (Pacific Environment, 2015).

The WHO has established guidelines for community noise to protect against the key health effects of annoyance, sleep disturbance, and cognitive impairment (WHO, 1999). The WHO guidelines are summarised in **Table 5-6**.

The WHO community noise guidelines apply to total noise including existing ambient noise, not just the increment from a particular source.

Table 5-6: WHO guidelines for community noise

Specific Environment	Critical health effect	$L_{Aeq, period}$ (dBA)	Time Base (hour)	L_{Amax} (dBA)
Outdoor Living Area	Serious annoyance, daytime and evening	55	16	--
	Moderate annoyance , daytime and evening	50	16	--
Dwelling, Indoor	Disturbance of speech intelligibility and moderate annoyance, daytime and evening	35	16	--
Inside Bedrooms (Indoor)	Sleep disturbance, night time	30	8	45
Outside Bedrooms (Outdoor)	Sleep disturbance, window open, night time	45	8	60
School/Preschool Classrooms, Indoor	Disturbance of speech intelligibility, information extraction, and message communications, daytime	35	During class	--
Preschool Bedrooms, Indoor	Sleep disturbance, sleep time	30	During sleep	45
School Playground, Outdoor	Annoyance, during play, daytime	55	During play	--

Abbreviations: dBA: A-weighted decibel. WHO: World Health Organization
--: Not Available.

5.3 Risk Characterisation

The risk characterisation was conducted by comparing the predicted noise levels to the corresponding health-based WHO guideline values. The ratio of the predicted noise level to the guideline is termed as hazard quotient (HQ). The HQ was estimated for each health effect listed in **Table 5-6**, at each applicable sensitive receiver, except that sleep disturbance is not applicable to the non-residential receivers because no people will sleep at those locations.

Sleep disturbance has been assessed using the night time noise levels while both annoyance and cognitive function have been assessed using the daytime (and evening in some cases) noise levels. Since the predicted noise levels have been modelled for outdoor receptors, the noise levels were reduced by 10 decibels (dB) when compared against the WHO guidelines for indoor environment to account for the attenuation of noise by structures. The maximum HQs for each of the three key health effect categories (i.e. annoyance, sleep disturbance, and cognitive impairment) at sensitive receivers are presented in this HRA.

A HQ of less than or equal to 1 is considered to be an acceptable level (enHealth 2012b). It should be noted that a HQ of greater than 1 does not necessarily mean that adverse health effects will be observed; it just means that further assessment is warranted.

To place the results of the noise HRA in context, **Table 5-8** presents the HQs for existing ambient noise in the three nearby suburbs. All HQs are greater than 1 for annoyance, sleep disturbance, and cognitive impairment in the three surrounding suburbs, indicating that the existing ambient noise levels already exceed the health-based WHO guidelines.

Table 5.7: Hazard quotients for existing ambient noise			
Suburb	**Annoyance**	**Sleep Disturbance**	**Cognitive Impairment**
	$LA_{eq, period}$	**$LA_{eq, period}$**	**$L_{Aeq, period}$**
Casula	1.3	1.4	1.3
Glenfield	1.1	1.1	1.1
Wattle Grove	1.3	1.2	1.3

Table 5-8 presents the HQs for operational noise associated with the Proposal at sensitive receivers. All HQs were less than 1 at the residential and school receivers, indicating that the operational noise from the Proposal does not pose an unacceptable risk to the health of these communities.

The HQs were greater than 1 for annoyance and cognitive impairment at the nearest industrial receivers. It is noted, however, that the HQs for existing ambient noise already exceed 1 for annoyance and cognitive impairment.

Table 5-8: Hazard quotients for operational noise from MPW Stage 2				
Receiver/Suburb	**Annoyance**	**Sleep Disturbance**		**Cognitive Impairment**
	$LA_{eq, period}$	**$LA_{eq, period}$**	**L_{Amax}**	**$L_{Aeq, period}$**
Casula	0.7	0.9	0.8	0.7
Glenfield	0.4	0.4	0.4	0.3
Wattle Grove	0.6	0.8	0.4	0.5
All Saints Senior College (S1)	0.4	N/A	N/A	0.3
Casula Powerhouse (S2)	0.4	N/A	N/A	0.4
MPE (I1)	1.4	N/A	N/A	1.4
DJLU (I2)	1.3	N/A	N/A	1.3
ABB (I	1.2	N/A	N/A	1.2
Abbreviations: N/A: Not Applicable DJLU: Defence Joint Logistics Unit MPW: Moorebank Precinct West				

Table 5-9 presents the HQs for cumulative operational noise from the cumulative Proposal. All HQs were less than or equal to 1 at the residential and educational receivers, indicating that the operational noise from the cumulative Proposal does not pose an unacceptable risk to the health of these communities.

The HQs were greater than 1 for annoyance and cognitive impairment at the nearest industrial receivers. It is noted, however, that the HQs for existing ambient noise already exceed 1 for annoyance and cognitive impairment.

Table 5-9: Hazard quotients for cumulative operational noise from the cumulative Proposal

Receiver/Suburb	Annoyance	Sleep Disturbance		Cognitive Impairment
	$LA_{eq, period}$	$LA_{eq, period}$	L_{Amax}	$L_{Aeq, period}$
Casula	0.7	0.9	0.8	0.7
Glenfield	0.4	0.5	0.4	0.3
Wattle Grove	0.6	0.9	0.4	0.6
All Saints Senior College (S1)	0.5	N/A	N/A	0.5
Casula Powerhouse (S2)	0.5	N/A	N/A	0.4
DJLU (I2)	1.3	N/A	N/A	1.3
ABB (I3)	1.2	N/A	N/A	1.2

Abbreviations:
N/A: Not Applicable
DJLU: Defence Joint Logistics Unit
MPE: Moorebank Precinct East
MPW: Moorebank Precinct West

Table 5.10 presents the HQs for rail noise due to freight rail movements associated with the Proposal at sensitive receivers. HQs were greater than 1 for annoyance, sleep disturbance, and cognitive impairment in the suburbs of Casula and for sleep disturbance in the suburb of Glenfield. HQs were greater than 1 for cognitive impairment at All Saints Senior College.

Table 5.10: Hazard quotients for rail noise due to freight rail movements associated with the Proposal

Receiver/Suburb	Annoyance	Sleep Disturbance		Cognitive Impairment
	$LA_{eq, period}$	$LA_{eq, period}$	L_{Amax}	$L_{Aeq, period}$
Casula	1.1	1.3	1.3	1.1
Glenfield	0.9	1.0	1.2	0.9
Wattle Grove	0.9	1.0	1.0	0.9
All Saints Senior College (S1)	0.9	N/A	N/A	1.1
Casula Powerhouse (S2)	0.8	N/A	N/A	0.9

Abbreviations:
DJLU: Defence Joint Logistics Unit
MPW: Moorebank Precinct West

The WHO community noise guidelines apply to total noise, including the Proposal and existing ambient background, and therefore the total noise levels were also evaluated in this HRA. The decibel is a log scale unit, therefore the total noise levels were calculated as the logarithmic sum of the predicted noise levels from cumulative operation of the cumulative Proposal, rail, and existing ambient background.

The data presented in **Table 5.11** show that the difference between the total noise level and the existing ambient noise level would not be detected in any suburb, indicating that the Proposal related noise has a minimal impact on the noise in the local area.

Table 5.11: Predicted total noise levels (from operational, rail and existing ambient background noise)

Suburb	Daily $LA_{eq, period}$ (dBA)				
	Operational noise	**Rail noise**	**Operational + Rail noise**	**Existing Ambient**	**Total (Proposal + Existing Ambient)**
Casula	36	50	50	55	55
Glenfield	24	43	43	48	48
Wattle Grove	36	41	41	55	55

Abbreviations: dBA: A-weighted decibel. MPE: Moorebank Precinct East. MPW: Moorebank Precinct West

Table 5.12 presents the HQs for total noise from cumulative Proposal, rail, and existing ambient background in the three nearby suburbs. All HQs were greater than 1 for annoyance, sleep disturbance, and cognitive impairment in the three surrounding suburbs.

However, the HQs for total noise are similar to the HQs for existing ambient noise, indicating that the existing ambient noise is the major contributor to the total noise, and the Proposal related noise has a minimal impact on the noise in the local residential area.

Table 5.12: Hazard quotients for total noise levels from cumulative operation of MPW Stage 2 and MPE Stage 1, rail, and existing ambient background

Suburb	Annoyance	Sleep Disturbance	Cognitive Impairment
	$LA_{eq, period}$	$LA_{eq, period}$	$L_{Aeq, period}$
Casula	1.3	1.4	1.3
Glenfield	1.1	1.2	1.1
Wattle Grove	1.3	1.2	1.3

5.4 Summary of health risks from noise

A HRA has been conducted to investigate the impact of operational and rail noise associated with Proposal on the annoyance, sleep disturbance, and cognitive impairment in local communities by comparing the predicted noise levels against the WHO community noise guidelines.

The HRA indicates the following:

- The existing ambient noise levels alone exceed the WHO community guidelines.
- The noise from operation of Proposal, as well as cumulative Proposal meets the WHO community noise guidelines at all sensitive residential and educational receivers.
- A HQ greater than 1 was predicted for annoyance and cognitive impairment at the nearest industrial receivers.
- There are multiple exceedances of the WHO community noise guidelines on annoyance, sleep disturbance, and/or cognitive impairment in the local communities from the rail noise and total noise, however HQs for existing ambient noise already exceed in the area.

Based on the above results, all actions outlined in the Best Practice Review should be implemented to minimise the noise impacts, especially the rail noise, on the health of surrounding communities.

6. CONCLUSIONS

A HRA has been conducted to assess potential health risk posed by the air emission and noise from the Proposal to the surrounding communities. The MPW site is surrounded by the suburbs of Casula, Wattle Grove, Glenfield, and Moorebank in southwestern Sydney. A review of the demographics of the population and the baseline health status has found that there are no significant differences in the health indicators between these communities and the rest of Sydney and NSW that would make these communities more vulnerable to the effects of environmental factors, such as air pollution or noise from the Proposal.

The air quality HRA evaluated a range of health endpoints associated with the key air pollutants, including increases in mortality and morbidity as well as excess lifetime cancer risks. The results of the air quality HRA found that the increases in mortality and morbidity due to the Proposal and cumulative Proposal were low and in most cases were negligible. The excess lifetime cancer risks were below or within the acceptable risk range. Therefore, there are no significant adverse health effects expected in relation to short-term and long-term exposure to key air pollutants associated with the operation of the cumulative Proposal in the surrounding communities.

The noise HRA has been conducted to investigate the impact of operational and rail noise associated with Proposal on the annoyance, sleep disturbance, and cognitive impairment in local communities. Predicted noise levels are compared against the WHO community noise guidelines.

To place the results of the noise HRA in context the existing ambient noise levels were reviewed and found to already exceed the WHO community guidelines in residential areas.

The noise from the Proposal and cumulative Proposal meet the WHO community noise guidelines at all sensitive residential and education receivers. A HQ greater than 1 was predicted for annoyance and cognitive impairment at the nearest industrial receivers, however, the HQs for existing ambient noise already exceed 1 for annoyance and cognitive impairment.

There are a number of exceedances of the WHO community noise guidelines on annoyance, sleep disturbance, and/or cognitive impairment in the local communities from the rail noise due to freight rail movements associated with the Proposal. The total noise (cumulative Proposal plus existing background) exceeds the WHO community noise guidelines on annoyance, sleep disturbance, and cognitive impairment in all the three surrounding suburbs, however the Proposal related noise is expected to have a minimal additional impact on the noise in the local area above existing baseline levels.

Mitigation measures and monitoring are considered in the AQIA and Noise Impact Assessment, in accordance with the REMMs outlined in the MPW Concept Plan Approval.

7. REFERENCES

Attfield MD, Schleiff PL, Lubin JH, Blair A, Stewart PA, Vermeulen R, et al. 2012. The diesel exhaust in miners study: A cohort mortality study with emphasis on lung cancer. J Natl Cancer Inst 104:869–883.

Burgers M, Walsh S. 2002, Exposure Assessment and Risk Characterisation for the Development of a PM2.5 Standard, National Environment Protection Council. September.

Canadian Council of Ministers for the Environment (CCME). 2010. Canadian Soil Quality Guidelines, Carcinogenic and Other Polycyclic Aromatic Hydrocarbons (PAHs) (Environmental and Human Health Effects), Scientific Criteria Document (revised), Quebec.

Cesaroni G, Badaloni C, Gariazzo C, Stafoggia M, Sozzi R, Davoli M, et al. 2013. Long-term exposure to urban air pollution and mortality in a cohort of more than a million adults in Rome. Environ Health Perspect 121:324–331.

CHETRE. 2007. Health Impact Assessment – A Practical Guide - Centre for Health Equity Training, Research and Evaluation. University of New South Wales, Research Centre for Primary Health Care and Equity.

Crump. 2014. Meta-Analysis of Lung Cancer Risk from Exposure to Diesel Exhaust: Study Limitations. Environmental Health Perspectives Volume 122 Number 9, September.

enHealth. 2012a. Environmental Health Risk Assessment: Guidelines for Assessing Human Health Risks from Environmental Hazards. Department of Health and Ageing and enHealth Council, Commonwealth of Australia.

enHealth. 2012b. Exposure Factors Guide. enHealth Council.

EnRisks. 2014a. Technical Working Paper: Human Health Risk Assessment – Moorebank Intermodal Terminal. September.

EnRisks. 2014b. Technical Working Paper: Moorebank Intermodal Terminal Health Impact Assessment. September.

Environment Protection Authority. 2000. NSW Industrial Noise Policy. January.

Environment Protection and Heritage Council (EPHC). 2010. Expansion of the multi-city mortality and morbidity study. September.

Garshick E, Schenker MB, Muñoz A, Segal M, Smith TJ, Woskie SR, Hammond SK, Speizer FE. 1988. A retrospective cohort study of lung cancer and diesel exhaust exposure in railroad workers. Am Rev Respir Dis 137:820–825.

Garshick E, Laden F, Hart JE, Davis ME, Eisen EA, Smith TJ. 2012. Lung cancer and elemental carbon exposure in trucking industry workers. Environ Health Perspect 120:1301– 1306.

Health Effects Institute (HEI). 1999. Diesel Emissions and Lung Cancer: Epidemiology and Quantitative Risk Assessment. June. HEI. 2009. Extended follow-up and spatial analysis of the American Cancer Society study linking particulate air pollution and mortality. Research Report 140.

HEI. 2015. Diesel Emissions and Lung Cancer: An Evaluation of Recent Epidemiological Evidence for Quantitative Risk Assessment. November.

Hesterberg TW, Long CM, Sax SN, Lapin CA, McClellan RO, Bunn WB, Valberg PA. 2011. Particulate Matter in New Technology Diesel Exhaust (NTDE) is Quantitatively and Qualitatively Very Different from That Found in Traditional Diesel Exhaust (TDE). J Air Waste Manag Assoc. 61(9):894-913.

International Agency for Research on Cancer (IARC). 2012. Press Release No. 213. IARC: Diesel Engine Exhaust Carcinogenic. June.

Jalaudin B, Khalaj B, Sheppeard V, Morgan G. 2008. Air pollution and ED visits for asthma in Australian children: a case-crossover analysis. International Archives of Occupational and Environmental Health 81(8):967-74.

Katsouyanni K. 2006. APHEA Project: Air Pollution and Health: A European Approach. Epidemiology, Volume 17, Issue 6, p19.

Morfeld P and Spallek M. 2015. Diesel engine exhaust and lung cancer risks – evaluation of the meta-analysis by Vermeulen et al. 2014. J Occup Med Toxicol. 10: 31.

National Environment Protection Council (NEPC). 2011. Methodology for Setting Air Quality Standards in Australia.

NEPC. 2013. National Environmental Protection (Assessment of Site Contamination) Amended Measure. Guideline on Derivation of Health-Based Investigation Levels.

National Health and Medical Research Council (NHMRC) Approach to Hazard Assessment for Air Quality, 2006.

Office of Environmental Health Hazard Assessment. 1998. Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant. Appendix III, Part B: Health Risk Assessment for Diesel Exhaust. May.

Ostro B. 2004. Outdoor Air Pollution: Assessing the environmental burden of disease at national and local levels., World Health Organisation.

Pacific Environment. 2015. Moorebank Precinct East (MPE) (formerly SIMTA) Intermodal Terminal Facility - Stage 1 Health Risk Assessment (SSD-6766). April.

Ramboll Environ. 2016. Moorebank Precinct West Stage 2 Proposal - Air Quality Impact Assessment. July.

Silverman DT, Attfield MD. 2012. Response to: 'The Diesel Exhaust in Miners Study: A nested case-control study of lung cancer and diesel exhaust' and 'The Diesel Exhaust in Miners Study: A cohort mortality study with emphasis on lung cancer.' J Natl Cancer Inst 104:1848–1849.

Simpson R, Williams G, Petroeschevsky A, Best T, Morgan G, Denison L, Hinwood A, Neville G, Neller A. 2005. The short-term effects of air pollution on hospital admissions in four Australian cities. Aust N Z J Public Health. Jun;29(3):205-12.

South Western Sydney Local Health District (SWSLHD). 2014. Liverpool Local Government Area Health Profile 2014.

United States Environmental Protection Agency (USEPA). 1989. Risk assessment guidance for Superfund, Vol I. Human health evaluation manual (Part A) Interim final report, EPA/540/1-89/002, Washington, DC.

USEPA. 1991. Risk assessment guidance for Superfund, Vol I. Human health evaluation manual, Part B, Development of risk-based preliminary remediation goals. EPA/540/R-92/003, Washington, DC.

USEPA. 2002. Health Assessment Document for Diesel Engine Exhaust. EPA/600/8-90/057F. May.

USEPA. 2005. Particulate Matter Health Risk Assessment for Selected Urban Area. Office of Air Quality Planning and Standards.

USEPA. 2009. Risk Assessment Guidance for Superfund, Volume I: Human Health Evaluation Manual, (Part F, Supplemental Guidance for Inhalation Risk Assessment), Washington, D.C.

USEPA. 2010. Quantitative Health Risk Assessment for Particulate Matter, Office of Air Quality Planning and Standards.

USEPA. 2012. Provisional Assessment of Recent Studies on Health Effects of Particulate Matter Exposure, National Center for Environmental Assessment RTP Division, Office of Research and Development.

Vermeulen R, Silverman DT, Garshick E, Vlaanderen J, Portengen L, Steenland K. 2014. Exposure-response estimates for diesel engine exhaust and lung cancer mortality based on data from three occupational cohorts. Environ Health Perspect 122:172–177.

Wilkinson-Murray. 2016. MPW Stage 2 Noise and Vibration Impact Assessment. June.

World Health Organization (WHO). 1996. Diesel fuel and exhaust emissions. Environmental Health Criteria 171. Geneva.

WHO. 1999. Guidelines for Community Noise. April.

APPENDIX A
CALCULATION OF INCREASED ANNUAL INCIDENCE FOR MORTALITY AND MORBIDITY ENDPOINTS

Table A-1 Calculation of Increased Annual Incidence for Mortality and Morbidity Endpoints - PM10 (Proposal)

Endpoint:	Mortality - All Causes	Mortality - All Causes	Mortality - Cardiovascular Disease	Hospital Admissions - Respiratory Disease	Hospital Admissions - Cardiac Disease	Hospital Admissions - Pneumonia and Bronchitis	Hospital Admissions - Respiratory Disease	ED Visits Asthma
Exposure Period:	Annual Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
Age Group:	30+ years	All ages	All ages	65+ years	65+ years	65+ years	15-64 years	1-14 years
β (Exposure Response Function per 1 µg/m^3 Increase in PM_{10}):	0.004	0.002	0.002	0.003	0.002	0.0013	0.003	0.015
Baseline Health Incidence Rate (per person)	0.01065	0.005289	0.00155	0.04476	0.09159	0.01236	0.00899	0.00804
Casula								
Total Population:	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696
% Population in Assessment Age-Group	49%	100%	100%	10%	10%	10%	67%	23%
Average EPC within the Suburb (µg/m^3):	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01
Increased Annual Incidence (case per year):	0.05	0.02	0.01	0.03	0.04	0.004	0.04	0.06
Glenfield								
Total Population:	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558
% Population in Assessment Age-Group	67%	100%	100%	14%	14%	14%	67%	19%
Average EPC within the Suburb (µg/m^3):	8.6E-02	8.6E-02	8.6E-02	8.6E-02	8.6E-02	8.6E-02	8.6E-02	8.6E-02
Increased Annual Incidence (case per year):	0.02	0.007	0.002	0.01	0.02	0.001	0.01	0.01
Moorebank								
Total Population:	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595
% Population in Assessment Age-Group	60%	100%	100%	13%	13%	13%	66%	22%
Average EPC within the Suburb (µg/m^3):	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01	2.3E-01
Increased Annual Incidence (case per year):	0.04	0.02	0.005	0.03	0.04	0.004	0.03	0.04
Wattle Grove								
Total Population:	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192
% Population in Assessment Age-Group	45%	100%	100%	5%	5%	5%	69%	26%
Average EPC within the Suburb (µg/m^3):	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01
Increased Annual Incidence (case per year):	0.03	0.02	0.005	0.01	0.02	0.001	0.03	0.05
Total Increased Annual Incidence (case per year) - All Suburbs	**0.1**	**0.07**	**0.02**	**0.08**	**0.1**	**0.01**	**0.1**	**0.2**

Abbreviations:
µg/m^3: microgram per cubic meter
ED: Emergency Department
EPC: Exposure Point Concentration
MPW: Moorebank Precinct West
PM: Particulate Matter

Table A-2 Calculation of Increased Annual Incidence for Mortality and Morbidity Endpoints - PM2.5 (Proposal)

Endpoint:	Mortality - All Causes	Mortality - Cardiopulmonary	Mortality - Ischemic Heart Disease	Mortality - Lung Cancer	Mortality - All Causes	Mortality - Cardiovascular Disease	Hospital Admissions - Respiratory Disease	Hospital Admissions - Cardiac Disease	Hospital Admissions - Cardiovascular Disease	Hospital Admissions - Ischemic Heart Disease	Hospital Admissions - COPD	Hospital Admissions - Pneumonia and Bronchitis	Hospital Admissions - Respiratory Disease	ED Visits Asthma
Exposure Period:	Annual Average	Annual Average	Annual Average	Annual Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
Age Group:	30+ years	30+ years	30+ years	30+ years	All ages	All ages	65+ years	65+ years	65+ years	65+ years	65+ years	65+ years	15-64 years	1-14 years
β (Exposure Response Function per 1 µg/m³ Increase in $PM_{2.5}$):	0.006	0.014	0.024	0.014	0.0023	0.0013	0.004	0.005	0.003	0.004	0.004	0.005	0.003	0.0015
Baseline Health Incidence Rate (per person)	0.01065	0.0049	0.00067	0.00035	0.00529	0.001551	0.04476	0.09159	0.09159	0.03331	0.01489	0.01236	0.00899	0.00804
Casula														
Total Population:	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696
% Population in Assessment Age-Group	49%	49%	49%	49%	100%	100%	10%	10%	10%	10%	10%	10%	67%	23%
Average EPC within the Suburb (µg/m³):	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01
Increased Annual Incidence (case per year):	0.07	0.07	0.02	0.005	0.03	0.004	0.04	0.1	0.06	0.03	0.01	0.01	0.04	0.006
Glenfield														
Total Population:	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558
% Population in Assessment Age-Group	67%	67%	67%	67%	100%	100%	14%	14%	14%	14%	14%	14%	67%	19%
Average EPC within the Suburb (µg/m³):	8.3E-02	8.3E-02	8.3E-02	8.3E-02	8.3E-02	8.3E-02	8.3E-02	8.3E-02	8.3E-02	8.3E-02	8.3E-02	8.3E-02	8.3E-02	8.3E-02
Increased Annual Incidence (case per year):	0.03	0.03	0.007	0.002	0.008	0.001	0.02	0.04	0.02	0.01	0.005	0.005	0.01	0.001
Moorebank														
Total Population:	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595
% Population in Assessment Age-Group	60%	60%	60%	60%	100%	100%	13%	13%	13%	13%	13%	13%	66%	22%
Average EPC within the Suburb (µg/m³):	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01
Increased Annual Incidence (case per year):	0.06	0.07	0.02	0.005	0.02	0.003	0.04	0.1	0.06	0.03	0.01	0.01	0.03	0.004
Wattle Grove														
Total Population:	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192
% Population in Assessment Age-Group	45%	45%	45%	45%	100%	100%	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%	69%	26%
Average EPC within the Suburb (µg/m³):	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01	1.9E-01
Increased Annual Incidence (case per year):	0.04	0.05	0.01	0.003	0.02	0.003	0.01	0.04	0.02	0.01	0.005	0.005	0.03	0.005
Total Increased Annual Incidence (case per year) - All Suburbs	**0.2**	**0.2**	**0.05**	**0.02**	**0.07**	**0.01**	**0.1**	**0.3**	**0.2**	**0.08**	**0.04**	**0.04**	**0.1**	**0.02**

Abbreviations:
µg/m³: microgram per cubic meter
COPD: Chronic Obstructive Pulmonary Disease
ED: Emergency Department
EPC: Exposure Point Concentration
MPW: Moorebank Precinct West
PM: Particulate Matter

Table A-3 Calculation of Increased Annual Incidence for Mortality and Morbidity Endpoints - NO2 (Proposal)

Endpoint:	Mortality - All Causes	Mortality - Cardiovascular	Mortality - Respiratory	Mortality - All Causes	Mortality- Respiratory	Mortality - Cardiovascular Disease	Hospital Admissions - Respiratory Disease	Hospital Admissions - Cardiovascular Disease	Hospital Admissions - Respiratory Disease	ED Visits Asthma
Exposure Period:	Annual Average	Annual Average	Annual Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
Age Group:	30+ years	30+ years	30+ years	All ages	All ages	All ages	65+ years	65+ years	15-64 years	1-14 years
β (Exposure Response Function per 1 µg/m^3 Increase in NO_2):	0.0028	0.0028	0.0028	0.001	0.0023	0.001	0.003	0.0014	0.001	0.0006
Baseline Health Incidence Rate (per person)	0.01065	0.002987	0.00050	0.00529	0.00050	0.001551	0.04476	0.09159	0.00899	0.00804
Casula										
Total Population:	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696
% Population in Assessment Age-Group	49%	49%	49%	100%	100%	100%	10%	10%	67%	23%
Average EPC within the Suburb (µg/m^3):	4.4E+00	4.4E+00	4.4E+00	4.4E+00	4.4E+00	4.4E+00	4.4E+00	4.4E+00	4.4E+00	4.4E+00
Increased Annual Incidence (case per year):	0.9	0.3	0.04	0.3	0.07	0.1	0.9	0.9	0.4	0.07
Glenfield										
Total Population:	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558
% Population in Assessment Age-Group	67%	67%	67%	100%	100%	100%	14%	14%	67%	19%
Average EPC within the Suburb (µg/m^3):	2.7E+00	2.7E+00	2.7E+00	2.7E+00	2.7E+00	2.7E+00	2.7E+00	2.7E+00	2.7E+00	2.7E+00
Increased Annual Incidence (case per year):	0.4	0.1	0.02	0.1	0.02	0.03	0.4	0.4	0.1	0.02
Moorebank										
Total Population:	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595
% Population in Assessment Age-Group	60%	60%	60%	100%	100%	100%	13%	13%	66%	22%
Average EPC within the Suburb (µg/m^3):	6.7E+00	6.7E+00	6.7E+00	6.7E+00	6.7E+00	6.7E+00	6.7E+00	6.7E+00	6.7E+00	6.7E+00
Increased Annual Incidence (case per year):	0.9	0.3	0.04	0.3	0.06	0.08	0.9	0.8	0.3	0.05
Wattle Grove										
Total Population:	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192
% Population in Assessment Age-Group	45%	45%	45%	100%	100%	100%	5.2%	5.2%	69%	26%
Average EPC within the Suburb (µg/m^3):	5.8E+00	5.8E+00	5.8E+00	5.8E+00	5.8E+00	5.8E+00	5.8E+00	5.8E+00	5.8E+00	5.8E+00
Increased Annual Incidence (case per year):	0.6	0.2	0.03	0.2	0.05	0.07	0.3	0.3	0.3	0.06
Total Increased Annual Incidence (case per year) - All Suburbs	**2.9**	**0.8**	**0.1**	**1.0**	**0.2**	**0.3**	**2.5**	**2.4**	**1.1**	**0.2**

Abbreviations:
µg/m^3: microgram per cubic meter
ED: Emergency Department
EPC: Exposure Point Concentration
MPW: Moorebank Precinct West
NO_2: Nitrogen Dioxide

Table A-4 Calculation of Increased Annual Incidence for Mortality and Morbidity Endpoints - SO2 (Proposal)

Endpoint:	Mortality - All Causes	Mortality- Respiratory	Mortality - Cardiovascular Disease	Hospital Admissions - Respiratory Disease	ED Visits Asthma
Exposure Period:	24-Hour Average	24-Hour Average	24-Hour Average	1-Hour Maximum	24-Hour Average
Age Group:	All ages	All ages	All ages	15-64 years	1-14 years
β (Exposure Response Function per 1 µg/m^3 Increase in SO_2):	0.0006	0.0013	0.0008	0.002	0.008
Baseline Health Incidence Rate (per person)	0.00529	0.00050	0.001551	0.00899	0.00804
Casula					
Total Population:	14,696	14,696	14,696	14,696	14,696
% Population in Assessment Age-Group	100%	100%	100%	67%	23%
Average EPC within the Suburb (µg/m^3):	2.4E-02	2.4E-02	2.4E-02	2.4E-02	2.4E-02
Increased Annual Incidence (case per year):	0.001	0.0002	0.0004	0.004	0.005
Glenfield					
Total Population:	7,558	7,558	7,558	7,558	7,558
% Population in Assessment Age-Group	100%	100%	100%	67%	19%
Average EPC within the Suburb (µg/m^3):	1.0E-02	1.0E-02	1.0E-02	1.0E-02	1.0E-02
Increased Annual Incidence (case per year):	0.0003	0.00005	0.0001	0.001	0.001
Moorebank					
Total Population:	7,595	7,595	7,595	7,595	7,595
% Population in Assessment Age-Group	100%	100%	100%	66%	22%
Average EPC within the Suburb (µg/m^3):	2.8E-02	2.8E-02	2.8E-02	2.8E-02	2.8E-02
Increased Annual Incidence (case per year):	0.0007	0.0001	0.0003	0.002	0.003
Wattle Grove					
Total Population:	8,192	8,192	8,192	8,192	8,192
% Population in Assessment Age-Group	100%	100%	100%	69%	26%
Average EPC within the Suburb (µg/m^3):	2.9E-02	2.9E-02	2.9E-02	2.9E-02	2.9E-02
Increased Annual Incidence (case per year):	0.0008	0.0002	0.0003	0.003	0.004
Total Increased Annual Incidence (case per year) - All Suburbs	**0.003**	**0.0006**	**0.001**	**0.01**	**0.01**

Abbreviations:
µg/m^3: microgram per cubic meter
ED: Emergency Department
EPC: Exposure Point Concentration
MPW: Moorebank Precinct West
SO_2: Sulfur Dioxide

Table A-5 Calculation of Increased Annual Incidence for Mortality and Morbidity Endpoints - CO (Proposal)

Endpoint:	Mortality - All Causes	Hospital Admissions - Cardiac Disease	Hospital Admissions - Cardiovascular Disease
Exposure Period:	8-Hour Average	8-Hour Average	8-Hour Average
Age Group:	30+ years	65+ years	65+ years
β (Exposure Response Function per 1 μg/m^3 Increase in CO):	0.000001	0.000003	0.0000014
Baseline Health Incidence Rate (per person)	0.01065	0.09159	0.01236
Casula			
Total Population:	14,696	14,696	14,696
% Population in Assessment Age-Group	49%	10%	10%
Average EPC within the Suburb (μg/m^3):	2.4E+00	2.4E+00	2.4E+00
Increased Annual Incidence (case per year):	0.0002	0.001	0.00006
Glenfield			
Total Population:	7,558	7,558	7,558
% Population in Assessment Age-Group	67%	14%	14%
Average EPC within the Suburb (μg/m^3):	1.2E+00	1.2E+00	1.2E+00
Increased Annual Incidence (case per year):	0.00006	0.0003	0.00002
Moorebank			
Total Population:	7,595	7,595	7,595
% Population in Assessment Age-Group	60%	13%	13%
Average EPC within the Suburb (μg/m^3):	3.3E+00	3.3E+00	3.3E+00
Increased Annual Incidence (case per year):	0.0002	0.0009	0.00005
Wattle Grove			
Total Population:	8,192	8,192	8,192
% Population in Assessment Age-Group	45%	5.2%	5.2%
Average EPC within the Suburb (μg/m^3):	3.0E+00	3.0E+00	3.0E+00
Increased Annual Incidence (case per year):	0.0001	0.0004	0.00002
Total Increased Annual Incidence (case per year) - All Suburbs	**0.0005**	**0.003**	**0.0002**

Abbreviations:

μg/m^3: microgram per cubic meter
CO: Carbon Monoxide
EPC: Exposure Point Concentration
MPW: Moorebank Precinct West

Table A-6 Calculation of Increased Annual Incidence for Mortality and Morbidity Endpoints - PM10 (Cumulative Operation of MPW Stage 2 and MPE Stage 1)

Endpoint:	Mortality - All Causes	Mortality - All Causes	Mortality - Cardiovascular Disease	Hospital Admissions - Respiratory Disease	Hospital Admissions - Cardiac Disease	Hospital Admissions - Pneumonia and Bronchitis	Hospital Admissions - Respiratory Disease	ED Visits Asthma
Exposure Period:	Annual Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
Age Group:	30+ years	All ages	All ages	65+ years	65+ years	65+ years	15-64 years	1-14 years
β (Exposure Response Function per 1 µg/m^3 Increase in PM_{10}):	0.004	0.002	0.002	0.003	0.002	0.0013	0.003	0.015
Baseline Health Incidence Rate (per person)	0.01065	0.005289	0.00155	0.04476	0.09159	0.01236	0.00899	0.00804
Casula								
Total Population:	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696
% Population in Assessment Age-Group	49%	100%	100%	10%	10%	10%	67%	23%
Average EPC within the Suburb (µg/m^3):	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01	2.2E-01
Increased Annual Incidence (case per year):	0.07	0.03	0.01	0.04	0.06	0.005	0.06	0.09
Glenfield								
Total Population:	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558
% Population in Assessment Age-Group	67%	100%	100%	14%	14%	14%	67%	19%
Average EPC within the Suburb (µg/m^3):	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01
Increased Annual Incidence (case per year):	0.03	0.01	0.004	0.02	0.03	0.003	0.02	0.03
Moorebank								
Total Population:	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595
% Population in Assessment Age-Group	60%	100%	100%	13%	13%	13%	66%	22%
Average EPC within the Suburb (µg/m^3):	3.2E-01	3.2E-01	3.2E-01	3.2E-01	3.2E-01	3.2E-01	3.2E-01	3.2E-01
Increased Annual Incidence (case per year):	0.06	0.03	0.007	0.04	0.06	0.005	0.04	0.06
Wattle Grove								
Total Population:	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192
% Population in Assessment Age-Group	45%	100%	100%	5%	5%	5%	69%	26%
Average EPC within the Suburb (µg/m^3):	3.8E-01	3.8E-01	3.8E-01	3.8E-01	3.8E-01	3.8E-01	3.8E-01	3.8E-01
Increased Annual Incidence (case per year):	0.06	0.03	0.01	0.02	0.03	0.003	0.06	0.1
Total Increased Annual Incidence (case per year) - All Suburbs	**0.2**	**0.1**	**0.03**	**0.1**	**0.2**	**0.02**	**0.2**	**0.3**

Abbreviations:
µg/m^3: microgram per cubic meter
ED: Emergency Department
EPC: Exposure Point Concentration
MPE: Moorebank Precinct East
MPW: Moorebank Precinct West
PM: Particulate Matter

Table A-7 Calculation of Increased Annual Incidence for Mortality and Morbidity Endpoints - PM2.5 (Cumulative Operation of MPW Stage 2 and MPE Stage 1)

Endpoint:	Mortality - All Causes	Mortality - Cardiopulmonary	Mortality - Ischemic Heart Disease	Mortality - Lung Cancer	Mortality - All Causes	Mortality - Cardiovascular Disease	Hospital Admissions - Respiratory Disease	Hospital Admissions - Cardiac Disease	Hospital Admissions - Cardiovascular Disease	Hospital Admissions - Ischemic Heart Disease	Hospital Admissions - COPD	Hospital Admissions - Pneumonia and Bronchitis	Hospital Admissions - Respiratory Disease	ED Visits Asthma
Exposure Period:	Annual Average	Annual Average	Annual Average	Annual Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
Age Group:	30+ years	30+ years	30+ years	30+ years	All ages	All ages	65+ years	65+ years	65+ years	65+ years	65+ years	65+ years	15-64 years	1-14 years
β (Exposure Response Function per 1 µg/m^3 Increase in $PM_{2.5}$):	0.006	0.014	0.024	0.014	0.0023	0.0013	0.004	0.005	0.003	0.004	0.004	0.005	0.003	0.0015
Baseline Health Incidence Rate (per person)	0.01065	0.0049	0.00067	0.00035	0.00529	0.001551	0.04476	0.09159	0.09159	0.03331	0.01489	0.01236	0.00899	0.00804
Casula														
Total Population:	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696
% Population in Assessment Age-Group	49%	49%	49%	49%	100%	100%	10%	10%	10%	10%	10%	10%	67%	23%
Average EPC within the Suburb (µg/m^3):	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01	2.1E-01
Increased Annual Incidence (case per year):	0.1	0.1	0.02	0.007	0.04	0.006	0.06	0.1	0.09	0.04	0.02	0.02	0.06	0.008
Glenfield														
Total Population:	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558
% Population in Assessment Age-Group	67%	67%	67%	67%	100%	100%	14%	14%	14%	14%	14%	14%	67%	19%
Average EPC within the Suburb (µg/m^3):	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01	1.5E-01
Increased Annual Incidence (case per year):	0.05	0.05	0.01	0.004	0.01	0.002	0.03	0.07	0.04	0.02	0.009	0.01	0.02	0.003
Moorebank														
Total Population:	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595
% Population in Assessment Age-Group	60%	60%	60%	60%	100%	100%	13%	13%	13%	13%	13%	13%	66%	22%
Average EPC within the Suburb (µg/m^3):	3.1E-01	3.1E-01	3.1E-01	3.1E-01	3.1E-01	3.1E-01	3.1E-01	3.1E-01	3.1E-01	3.1E-01	3.1E-01	3.1E-01	3.1E-01	3.1E-01
Increased Annual Incidence (case per year):	0.09	0.1	0.02	0.007	0.03	0.005	0.05	0.1	0.08	0.04	0.02	0.02	0.04	0.006
Wattle Grove														
Total Population:	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192
% Population in Assessment Age-Group	45%	45%	45%	45%	100%	100%	5.2%	5.2%	5.2%	5.2%	5.2%	5.2%	69%	26%
Average EPC within the Suburb (µg/m^3):	3.5E-01	3.5E-01	3.5E-01	3.5E-01	3.5E-01	3.5E-01	3.5E-01	3.5E-01	3.5E-01	3.5E-01	3.5E-01	3.5E-01	3.5E-01	3.5E-01
Increased Annual Incidence (case per year):	0.08	0.09	0.02	0.006	0.04	0.006	0.03	0.07	0.04	0.02	0.009	0.009	0.05	0.009
Total Increased Annual Incidence (case per year) - All Suburbs	**0.3**	**0.3**	**0.08**	**0.02**	**0.1**	**0.02**	**0.2**	**0.4**	**0.3**	**0.1**	**0.05**	**0.06**	**0.2**	**0.03**

Abbreviations:
µg/m^3: microgram per cubic meter
COPD: Chronic Obstructive Pulmonary Disease
ED: Emergency Department
EPC: Exposure Point Concentration
MPE: Moorebank Precinct East
MPW: Moorebank Precinct West
PM: Particulate Matter

Table A-8 Calculation of Increased Annual Incidence for Mortality and Morbidity Endpoints - NO2 (Cumulative Operation of MPW Stage 2 and MPE Stage 1)

Endpoint:	Mortality - All Causes	Mortality - Cardiovascular	Mortality - Respiratory	Mortality - All Causes	Mortality- Respiratory	Mortality - Cardiovascular Disease	Hospital Admissions - Respiratory Disease	Hospital Admissions - Cardiovascular Disease	Hospital Admissions - Respiratory Disease	ED Visits Asthma
Exposure Period:	Annual Average	Annual Average	Annual Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
Age Group:	30+ years	30+ years	30+ years	All ages	All ages	All ages	65+ years	65+ years	15-64 years	1-14 years
β (Exposure Response Function per 1 µg/m^3 Increase in NO_2):	0.0028	0.0028	0.0028	0.001	0.0023	0.001	0.003	0.0014	0.001	0.0006
Baseline Health Incidence Rate (per person)	0.01065	0.002987	0.00050	0.00529	0.00050	0.001551	0.04476	0.09159	0.00899	0.00804
Casula										
Total Population:	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696	14,696
% Population in Assessment Age-Group	49%	49%	49%	100%	100%	100%	10%	10%	67%	23%
Average EPC within the Suburb (µg/m^3):	6.1E+00	6.1E+00	6.1E+00	6.1E+00	6.1E+00	6.1E+00	6.1E+00	6.1E+00	6.1E+00	6.1E+00
Increased Annual Incidence (case per year):	1.3	0.4	0.06	0.5	0.1	0.1	1.2	1.2	0.5	0.1
Glenfield										
Total Population:	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558	7,558
% Population in Assessment Age-Group	67%	67%	67%	100%	100%	100%	14%	14%	67%	19%
Average EPC within the Suburb (µg/m^3):	4.5E+00	4.5E+00	4.5E+00	4.5E+00	4.5E+00	4.5E+00	4.5E+00	4.5E+00	4.5E+00	4.5E+00
Increased Annual Incidence (case per year):	0.7	0.2	0.03	0.2	0.04	0.05	0.6	0.6	0.2	0.03
Moorebank										
Total Population:	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595	7,595
% Population in Assessment Age-Group	60%	60%	60%	100%	100%	100%	13%	13%	66%	22%
Average EPC within the Suburb (µg/m^3):	9.0E+00	9.0E+00	9.0E+00	9.0E+00	9.0E+00	9.0E+00	9.0E+00	9.0E+00	9.0E+00	9.0E+00
Increased Annual Incidence (case per year):	1.2	0.3	0.06	0.4	0.08	0.1	1.2	1.1	0.4	0.07
Wattle Grove										
Total Population:	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192	8,192
% Population in Assessment Age-Group	45%	45%	45%	100%	100%	100%	5.2%	5.2%	69%	26%
Average EPC within the Suburb (µg/m^3):	1.0E+01	1.0E+01	1.0E+01	1.0E+01	1.0E+01	1.0E+01	1.0E+01	1.0E+01	1.0E+01	1.0E+01
Increased Annual Incidence (case per year):	1.1	0.3	0.05	0.4	0.1	0.1	0.6	0.5	0.5	0.1
Total Increased Annual Incidence (case per year) - All Suburbs	**4.3**	**1.2**	**0.2**	**1.4**	**0.3**	**0.4**	**3.6**	**3.5**	**1.7**	**0.3**

Abbreviations:
µg/m^3: microgram per cubic meter
ED: Emergency Department
EPC: Exposure Point Concentration
MPE: Moorebank Precinct East
MPW: Moorebank Precinct West
NO_2: Nitrogen Dioxide

Table A-9 Calculation of Increased Annual Incidence for Mortality and Morbidity Endpoints - SO2 (Cumulative Operation of MPW Stage 2 and MPE Stage 1)

Endpoint:	Mortality - All Causes	Mortality- Respiratory	Mortality - Cardiovascular Disease	Hospital Admissions - Respiratory Disease	ED Visits Asthma
Exposure Period:	24-Hour Average	24-Hour Average	24-Hour Average	1-Hour Maximum	24-Hour Average
Age Group:	All ages	All ages	All ages	15-64 years	1-14 years
β (Exposure Response Function per 1 µg/m^3 Increase in SO_2):	0.0006	0.0013	0.0008	0.002	0.008
Baseline Health Incidence Rate (per person)	0.00529	0.00050	0.001551	0.00899	0.00804
Casula					
Total Population:	14,696	14,696	14,696	14,696	14,696
% Population in Assessment Age-Group	100%	100%	100%	67%	23%
Average EPC within the Suburb (µg/m^3):	2.4E-02	2.4E-02	2.4E-02	2.4E-02	2.4E-02
Increased Annual Incidence (case per year):	0.001	0.0002	0.0004	0.004	0.005
Glenfield					
Total Population:	7,558	7,558	7,558	7,558	7,558
% Population in Assessment Age-Group	100%	100%	100%	67%	19%
Average EPC within the Suburb (µg/m^3):	1.1E-02	1.1E-02	1.1E-02	1.1E-02	1.1E-02
Increased Annual Incidence (case per year):	0.0003	0.00005	0.0001	0.001	0.001
Moorebank					
Total Population:	7,595	7,595	7,595	7,595	7,595
% Population in Assessment Age-Group	100%	100%	100%	66%	22%
Average EPC within the Suburb (µg/m^3):	2.8E-02	2.8E-02	2.8E-02	2.8E-02	2.8E-02
Increased Annual Incidence (case per year):	0.0007	0.0001	0.0003	0.003	0.003
Wattle Grove					
Total Population:	8,192	8,192	8,192	8,192	8,192
% Population in Assessment Age-Group	100%	100%	100%	69%	26%
Average EPC within the Suburb (µg/m^3):	3.0E-02	3.0E-02	3.0E-02	3.0E-02	3.0E-02
Increased Annual Incidence (case per year):	0.0008	0.0002	0.0003	0.003	0.004
Total Increased Annual Incidence (case per year) - All Suburbs	**0.003**	**0.0006**	**0.001**	**0.01**	**0.01**

Abbreviations:

µg/m^3: microgram per cubic meter
ED: Emergency Department
EPC: Exposure Point Concentration
MPE: Moorebank Precinct East
MPW: Moorebank Precinct West
SO_2: Sulfur Dioxide

Table A-10 Calculation of Increased Annual Incidence for Mortality and Morbidity Endpoints - CO (Cumulative Operation of MPW Stage 2 and MPE Stage 1)

Endpoint:	Mortality - All Causes	Hospital Admissions - Cardiac Disease	Hospital Admissions - Cardiovascular Disease
Exposure Period:	8-Hour Average	8-Hour Average	8-Hour Average
Age Group:	30+ years	65+ years	65+ years
β (Exposure Response Function per 1 μg/m^3 Increase in CO):	0.000001	0.000003	0.0000014
Baseline Health Incidence Rate (per person)	0.01065	0.09159	0.01236
Casula			
Total Population:	14,696	14,696	14,696
% Population in Assessment Age-Group	49%	10%	10%
Average EPC within the Suburb (μg/m^3):	3.4E+00	3.4E+00	3.4E+00
Increased Annual Incidence (case per year):	0.0003	0.001	0.00009
Glenfield			
Total Population:	7,558	7,558	7,558
% Population in Assessment Age-Group	67%	14%	14%
Average EPC within the Suburb (μg/m^3):	2.2E+00	2.2E+00	2.2E+00
Increased Annual Incidence (case per year):	0.0001	0.0006	0.00004
Moorebank			
Total Population:	7,595	7,595	7,595
% Population in Assessment Age-Group	60%	13%	13%
Average EPC within the Suburb (μg/m^3):	4.7E+00	4.7E+00	4.7E+00
Increased Annual Incidence (case per year):	0.0002	0.001	0.00008
Wattle Grove			
Total Population:	8,192	8,192	8,192
% Population in Assessment Age-Group	45%	5.2%	5.2%
Average EPC within the Suburb (μg/m^3):	5.7E+00	5.7E+00	5.7E+00
Increased Annual Incidence (case per year):	0.0002	0.0007	0.00004
Total Increased Annual Incidence (case per year) - All Suburbs	**0.0008**	**0.004**	**0.0002**

Abbreviations:
μg/m^3: microgram per cubic meter
CO: Carbon Monoxide
EPC: Exposure Point Concentration
MPE: Moorebank Precinct East
MPW: Moorebank Precinct West

APPENDIX B
CALCULATION OF EXCESS LIFETIME CANCER RISK

Table B-1 Calculation of Excess Lifetime Cancer Risks (Proposal)

Chemical:	DPM	Benzene	1,3-Butadiene	PAHs (as BaP TEQ)
URF ($\mu g/m^3$)$^{-1}$	0.0003	0.000029	0.00017	0.0011
URF Source:	Cal/EPA (2016)	Cal/EPA (2016)	Cal/EPA (2016)	Cal/EPA (2016)

Suburb	Receptor Location	Receptor Type	Annual Average GLC ($\mu g/m^3$)								MAF [a]	EPC ($\mu g/m^3$)				Inhalation Intake Factor [b]	Excess Lifetime Cancer Risk			
			MPW Stage 2 (IMT Facility)				MPW Stage 2 (Warehousing)													
			DPM	Benzene	1,3-Butadiene	PAHs (as BaP TEQ)	DPM	Benzene	1,3-Butadiene	PAHs (as BaP TEQ)		DPM	Benzene	1,3-Butadiene	PAHs (as BaP TEQ)					
Casula	Lakewood Crescent	Residential	2.3E-01	6.7E-03	1.4E-03	1.2E-06	4.8E-02	7.4E-03	3.1E-03	2.5E-07	1.0	2.8E-01	1.4E-02	4.6E-03	1.4E-06	0.50	4.2E-05	2.1E-07	3.9E-07	7.7E-10
Casula	St Andrews Boulevard	Residential	3.1E-01	9.1E-03	1.9E-03	1.5E-06	7.5E-02	1.2E-02	4.9E-03	3.9E-07	1.0	3.8E-01	2.1E-02	6.8E-03	1.9E-06	0.50	5.8E-05	3.0E-07	5.8E-07	1.0E-09
Casula	Buckland Road	Residential	3.3E-01	9.8E-03	2.1E-03	1.6E-06	9.2E-02	1.4E-02	6.1E-03	4.9E-07	1.0	4.2E-01	2.4E-02	8.2E-03	2.1E-06	0.50	6.4E-05	3.5E-07	6.9E-07	1.1E-09
Casula	Dunmore Crescent	Residential	2.0E-01	5.7E-03	1.3E-03	9.7E-07	5.1E-02	8.0E-03	3.4E-03	2.7E-07	1.0	2.5E-01	1.4E-02	4.6E-03	1.2E-06	0.50	3.8E-05	2.0E-07	3.9E-07	6.8E-10
Casula	Leacocks Lane	Residential	3.1E-02	8.0E-04	1.9E-04	1.4E-07	6.0E-03	9.4E-04	4.0E-04	3.2E-08	1.0	3.7E-02	1.7E-03	5.9E-04	1.8E-07	0.50	5.5E-06	2.5E-08	5.0E-08	9.7E-11
Casula	Leacocks Lane Mid	Residential	4.5E-02	1.1E-03	2.8E-04	2.2E-07	8.0E-03	1.2E-03	5.3E-04	4.2E-08	1.0	5.3E-02	2.3E-03	8.0E-04	2.6E-07	0.50	8.0E-06	3.4E-08	6.8E-08	1.4E-10
Casula	Slessor Road	Residential	8.8E-02	1.8E-03	5.3E-04	4.2E-07	1.3E-02	2.0E-03	8.4E-04	6.7E-08	1.0	1.0E-01	3.8E-03	1.4E-03	4.9E-07	0.50	1.5E-05	5.5E-08	1.2E-07	2.7E-10
Casula	Maple Grove Retirement Village	Residential	2.7E-02	7.1E-04	1.7E-04	1.3E-07	5.1E-03	8.0E-04	3.4E-04	2.7E-08	1.0	3.2E-02	1.5E-03	5.0E-04	1.5E-07	0.50	4.8E-06	2.2E-08	4.3E-08	8.4E-11
Casula	All Saints Catholic College	Residential/School	4.2E-02	1.1E-03	2.6E-04	2.0E-07	7.9E-03	1.2E-03	5.2E-04	4.2E-08	1.0	5.0E-02	2.3E-03	7.8E-04	2.4E-07	0.50	7.4E-06	3.3E-08	6.6E-08	1.3E-10
Casula	Casula High School	Residential/School	2.4E-02	6.5E-04	1.5E-04	1.1E-07	4.6E-03	7.3E-04	3.1E-04	2.4E-08	1.0	2.9E-02	1.4E-03	4.6E-04	1.4E-07	0.50	4.3E-06	2.0E-08	3.9E-08	7.6E-11
Casula	Casula Primary School	Residential/School	7.2E-02	2.0E-03	4.4E-04	3.5E-07	1.6E-02	2.6E-03	1.1E-03	8.7E-08	1.0	8.8E-02	4.5E-03	1.5E-03	4.3E-07	0.50	1.3E-05	6.6E-08	1.3E-07	2.4E-10
Casula	Casula Powerhouse Arts Centre	Recreational	5.4E-02	1.3E-03	3.3E-04	2.5E-07	1.0E-02	1.6E-03	6.6E-04	5.2E-08	1.3	6.7E-02	3.4E-03	1.2E-03	3.2E-07	0.024	4.8E-07	2.4E-09	4.9E-09	8.4E-12
Glenfield	Canterbury Road	Residential	4.7E-02	1.1E-03	2.9E-04	2.2E-07	7.6E-03	1.2E-03	5.0E-04	4.0E-08	1.0	5.5E-02	2.3E-03	7.9E-04	2.6E-07	0.50	8.2E-06	3.3E-08	6.7E-08	1.5E-10
Glenfield	Ferguson Street	Residential	4.9E-02	1.1E-03	3.0E-04	2.3E-07	7.8E-03	1.2E-03	5.2E-04	4.1E-08	1.0	5.7E-02	2.4E-03	8.2E-04	2.8E-07	0.50	8.6E-06	3.4E-08	7.0E-08	1.5E-10
Glenfield	Goodenough Street	Residential	6.4E-02	1.4E-03	3.9E-04	3.0E-07	9.5E-03	1.5E-03	6.3E-04	5.0E-08	1.0	7.3E-02	2.9E-03	1.0E-03	3.5E-07	0.50	1.1E-05	4.2E-08	8.6E-08	1.9E-10
Glenfield	Cambridge Avenue	Residential	6.1E-02	1.4E-03	3.7E-04	2.9E-07	9.4E-03	1.5E-03	6.2E-04	5.0E-08	1.0	7.1E-02	2.9E-03	1.0E-03	3.4E-07	0.50	1.1E-05	4.1E-08	8.5E-08	1.9E-10
Glenfield	Glenwood Public School	Residential/School	2.7E-02	6.7E-04	1.7E-04	1.3E-07	4.6E-03	7.2E-04	3.0E-04	2.4E-08	1.0	3.2E-02	1.4E-03	4.7E-04	1.5E-07	0.50	4.8E-06	2.0E-08	4.0E-08	8.4E-11
Glenfield	Glenfield Public School	Residential/School	3.5E-02	8.4E-04	2.1E-04	1.6E-07	5.8E-03	9.1E-04	3.8E-04	3.0E-08	1.0	4.1E-02	1.7E-03	6.0E-04	1.9E-07	0.50	6.1E-06	2.5E-08	5.1E-08	1.1E-10
Glenfield	Hurlstone Agricultural School	Residential/School	2.9E-02	7.0E-04	1.8E-04	1.4E-07	4.9E-03	7.6E-04	3.2E-04	2.6E-08	1.0	3.4E-02	1.5E-03	5.0E-04	1.6E-07	0.50	5.0E-06	2.1E-08	4.2E-08	8.9E-11
Glenfield	Glenfield Rise Development	Residential	2.1E-01	5.9E-03	1.3E-03	9.7E-07	3.1E-02	4.9E-03	2.1E-03	1.6E-07	1.0	2.4E-01	1.1E-02	3.4E-03	1.1E-06	0.50	3.7E-05	1.6E-07	2.9E-07	6.2E-10
Glenfield	Playground Learning Centre	Residential	1.2E-01	3.4E-03	7.6E-04	5.7E-07	1.9E-02	3.0E-03	1.3E-03	1.0E-07	1.0	1.4E-01	6.4E-03	2.0E-03	6.7E-07	0.50	2.1E-05	9.3E-08	1.7E-07	3.7E-10
Moorebank	Anzac Road	Residential	3.1E-01	8.6E-03	1.9E-03	1.4E-06	4.4E-02	6.9E-03	2.9E-03	2.3E-07	1.0	3.5E-01	1.6E-02	4.8E-03	1.7E-06	0.50	5.3E-05	2.3E-07	4.1E-07	9.2E-10
Moorebank	Anzac Road	Commercial/Industrial	3.1E-01	8.6E-03	1.9E-03	1.4E-06	4.4E-02	6.9E-03	2.9E-03	2.3E-07	1.3	3.7E-01	1.8E-02	5.8E-03	1.8E-06	0.094	1.0E-05	4.9E-08	9.3E-08	1.8E-10
Moorebank	Church Road	Residential	1.1E-01	3.1E-03	6.7E-04	5.7E-07	1.8E-02	2.9E-03	1.2E-03	9.7E-08	1.0	1.3E-01	5.9E-03	1.9E-03	6.6E-07	0.50	1.9E-05	8.6E-08	1.6E-07	3.6E-10
Moorebank	New DNSDC Facility	Commercial/Industrial	3.3E-02	8.0E-04	2.0E-04	1.6E-07	5.5E-03	8.6E-04	3.6E-04	2.9E-08	1.3	4.0E-02	1.9E-03	6.9E-04	1.9E-07	0.094	1.1E-06	5.3E-09	1.1E-08	2.0E-11
Wattle Grove	Wallcliff Court	Residential	9.4E-02	2.4E-03	5.8E-04	4.3E-07	1.5E-02	2.3E-03	9.7E-04	7.7E-08	1.0	1.1E-01	4.7E-03	1.6E-03	5.1E-07	0.50	1.6E-05	6.8E-08	1.3E-07	2.8E-10
Wattle Grove	Corryton Court	Residential	1.3E-01	3.3E-03	7.8E-04	5.7E-07	1.9E-02	3.0E-03	1.3E-03	1.0E-07	1.0	1.4E-01	6.3E-03	2.0E-03	6.7E-07	0.50	2.2E-05	9.2E-08	1.7E-07	3.7E-10
Wattle Grove	Martindale Court	Residential	1.4E-01	3.8E-03	8.6E-04	6.3E-07	2.1E-02	3.3E-03	1.4E-03	1.1E-07	1.0	1.6E-01	7.0E-03	2.2E-03	7.5E-07	0.50	2.4E-05	1.0E-07	1.9E-07	4.1E-10
Wattle Grove	Yallum Court	Residential	1.1E-01	2.9E-03	7.0E-04	5.2E-07	1.7E-02	2.7E-03	1.1E-03	9.1E-08	1.0	1.3E-01	5.6E-03	1.8E-03	6.1E-07	0.50	1.9E-05	8.2E-08	1.6E-07	3.3E-10
Wattle Grove	Wattle Grove Public School	Residential/School	1.0E-01	2.7E-03	6.3E-04	4.7E-07	1.6E-02	2.5E-03	1.0E-03	8.3E-08	1.0	1.2E-01	5.1E-03	1.7E-03	5.5E-07	0.50	1.8E-05	7.5E-08	1.4E-07	3.0E-10
Wattle Grove	St Marks Coptic College	Residential/School	7.8E-02	2.1E-03	4.8E-04	3.6E-07	1.2E-02	1.9E-03	8.1E-04	6.5E-08	1.0	9.1E-02	4.0E-03	1.3E-03	4.3E-07	0.50	1.4E-05	5.8E-08	1.1E-07	2.3E-10
Wattle Grove	Wattle Grove Long Day Care Centre	Residential	3.0E-01	8.6E-03	1.9E-03	1.5E-06	8.4E-02	1.3E-02	5.5E-03	4.4E-07	1.0	3.9E-01	2.2E-02	7.4E-03	1.9E-06	0.50	5.8E-05	3.1E-07	6.3E-07	1.0E-09
Wattle Grove	Wattle Grove Long Day Care Centre	Recreational	3.0E-01	8.6E-03	1.9E-03	1.5E-06	8.4E-02	1.3E-02	5.5E-03	4.4E-07	1.3	4.1E-01	2.6E-02	9.2E-03	2.1E-06	0.024	3.0E-06	1.8E-08	3.7E-08	5.4E-11

Maximum Residential/School Receptors	**6.4E-05**	**3.5E-07**	**6.9E-07**	**1.1E-09**
Maximum Recreational Receptor	**3.0E-06**	**1.8E-08**	**3.7E-08**	**5.4E-11**
Maximum Commercial/Industrial Receptor	**1.0E-05**	**4.9E-08**	**9.3E-08**	**1.8E-10**

Abbreviations and Notes:
$\mu g/m^3$: microgram per cubic meter
BaP: Benzo(a)pyrene
Cal/EPA: California Environmental Protection Agency
DPM: Diesel Particulate Matter
EPC: Exposure Point Concentration
GLC: Ground Level Concentration
IMEX: Import Export
IMT: Intermodal Terminal
MAF: Modeling Adjustment Factor
MPW: Moorebank Precinct West
PAH: Polycyclic Aromatic Hydrocarbon
TEQ: Toxicity Equivalent
URF: Unit Risk Factor

[a] The MPW State 2 warehousing would operate 18 hours per day, while the model predicted GLCs were annualized over 24 hours per day. Therefore, the annual average GLCs were lower than the actual air concentrations emitted from the source. Commercial/industrial and recreational receptors may not be continuously exposed to chemicals in air, and using annual average GLCs instead of the actual air concentrations as EPCs for these human receptors may underestimate the risk. Therefore, the annual average GLCs for MPW State 2 warehousing were adjusted back to the actual air concentrations by multiplying a MAF (calculated as 24 hours/18 hours = 1.3).

[b] Exposure time (ET) was assumed to be 24 hours per day, 8 hours per day, and 4 hours per day for residential/school, commercial/industrial, and recreational receptors, respectively. Exposure frequency (EF) was assumed to be 365 days per year, 240 days per year, and 104 days per year for residential/school, commercial/industrial, and recreational receptors, respectively. Exposure duration (ED) was assumed to be 35 years, 30 years, and 35 years for residential/school, commercial/industrial, and recreational receptors, respectively. Inhalation Intake Factor was calculated as ET x EF x ED/CF/AT, where AT is averaging time for cancer risk (i.e. 70 years or 25550 days), and CF is conversion factor (24 hours/day).

Source:
California Environmental Protection Agency (Cal/EPA) Office of Environmental Health Hazard Assessment (OEHHA). 2016. OEHHA Toxicity Criteria Database. Available at: http://oehha.ca.gov/tcdb/index.asp

Table B-2 Calculation of Excess Lifetime Cancer Risks (Cumulative Operation of MPW Stage 2 and MPE Stage 1)

	Chemical:	DPM	Benzene	1,3-Butadiene	PAHs (as BaP TEQ)
	URF ($\mu g/m^3$)$^{-1}$	0.0003	0.000029	0.00017	0.0011
	URF Source:	Cal/EPA (2016)	Cal/EPA (2016)	Cal/EPA (2016)	Cal/EPA (2016)

Suburb	Receptor Location	Receptor Type	Annual Average GLC ($\mu g/m^3$)												MAF [a]	EPC ($\mu g/m^3$)				Inhalation Intake Factor [b]	Excess Lifetime Cancer Risk			
			MPW Stage 2 (IMT Facility)				MPW Stage 2 (Warehousing)				MPE Stage 1 (IMEX Facility)													
			DPM	Benzene	1,3-Butadiene	PAHs (as BaP TEQ)	DPM	Benzene	1,3-Butadiene	PAHs (as BaP TEQ)	DPM	Benzene	1,3-Butadiene	PAHs (as BaP TEQ)		DPM	Benzene	1,3-Butadiene	PAHs (as BaP TEQ)		DPM	Benzene	1,3-Butadiene	PAHs (as BaP TEQ)
Casula	Lakewood Crescent	Residential	2.3E-01	6.7E-03	1.4E-03	1.2E-06	4.8E-02	7.4E-03	3.1E-03	2.5E-07	8.5E-02	3.0E-03	6.4E-04	2.2E-06	1.0	3.7E-01	1.7E-02	5.2E-03	3.6E-06	0.50	5.5E-05	2.5E-07	4.4E-07	2.0E-09
Casula	St Andrews Boulevard	Residential	3.1E-01	9.1E-03	1.9E-03	1.5E-06	7.5E-02	1.2E-02	4.9E-03	3.9E-07	1.1E-01	3.8E-03	8.2E-04	2.8E-06	1.0	4.9E-01	2.5E-02	7.7E-03	4.7E-06	0.50	7.4E-05	3.6E-07	6.5E-07	2.6E-09
Casula	Buckland Road	Residential	3.3E-01	9.8E-03	2.1E-03	1.6E-06	9.2E-02	1.4E-02	6.1E-03	4.9E-07	1.3E-01	4.6E-03	9.9E-04	3.3E-06	1.0	5.6E-01	2.9E-02	9.1E-03	5.4E-06	0.50	8.3E-05	4.2E-07	7.8E-07	3.0E-09
Casula	Dunmore Crescent	Residential	2.0E-01	5.7E-03	1.3E-03	9.7E-07	5.1E-02	8.0E-03	3.4E-03	2.7E-07	1.2E-01	4.0E-03	8.5E-04	2.7E-06	1.0	3.7E-01	1.8E-02	5.5E-03	3.9E-06	0.50	5.6E-05	2.6E-07	4.7E-07	2.2E-09
Casula	Leacocks Lane	Residential	3.1E-02	8.0E-04	1.9E-04	1.4E-07	6.0E-03	9.4E-04	4.0E-04	3.2E-08	1.9E-02	6.1E-04	1.3E-04	4.0E-07	1.0	5.5E-02	2.4E-03	7.2E-04	5.8E-07	0.50	8.3E-06	3.4E-08	6.1E-08	3.2E-10
Casula	Leacocks Lane Mid	Residential	4.5E-02	1.1E-03	2.8E-04	2.2E-07	8.0E-03	1.2E-03	5.3E-04	4.2E-08	3.4E-02	1.1E-03	2.4E-04	6.9E-07	1.0	8.7E-02	3.4E-03	1.0E-03	9.5E-07	0.50	1.3E-05	4.9E-08	8.9E-08	5.2E-10
Casula	Slessor Road	Residential	8.8E-02	1.8E-03	5.3E-04	4.2E-07	1.3E-02	2.0E-03	8.4E-04	6.7E-08	8.3E-02	2.5E-03	5.8E-04	1.6E-06	1.0	1.8E-01	6.3E-03	2.0E-03	2.1E-06	0.50	2.8E-05	9.1E-08	1.7E-07	1.1E-09
Casula	Maple Grove Retirement Village	Residential	2.7E-02	7.1E-04	1.7E-04	1.3E-07	5.1E-03	8.0E-04	3.4E-04	2.7E-08	1.9E-02	6.5E-04	1.4E-04	4.3E-07	1.0	5.1E-02	2.2E-03	6.4E-04	5.8E-07	0.50	7.7E-06	3.1E-08	5.5E-08	3.2E-10
Casula	All Saints Catholic College	Residential/School	4.2E-02	1.1E-03	2.6E-04	2.0E-07	7.9E-03	1.2E-03	5.2E-04	4.2E-08	2.8E-02	8.9E-04	2.0E-04	6.0E-07	1.0	7.8E-02	3.2E-03	9.8E-04	8.4E-07	0.50	1.2E-05	4.6E-08	8.3E-08	4.6E-10
Casula	Casula High School	Residential/School	2.4E-02	6.5E-04	1.5E-04	1.1E-07	4.6E-03	7.3E-04	3.1E-04	2.4E-08	1.6E-02	5.3E-04	1.1E-04	3.5E-07	1.0	4.4E-02	1.9E-03	5.7E-04	4.8E-07	0.50	6.7E-06	2.8E-08	4.8E-08	2.7E-10
Casula	Casula Primary School	Residential/School	7.2E-02	2.0E-03	4.4E-04	3.5E-07	1.6E-02	2.6E-03	1.1E-03	8.7E-08	4.7E-02	1.6E-03	3.5E-04	1.1E-06	1.0	1.4E-01	6.2E-03	1.9E-03	1.5E-06	0.50	2.0E-05	9.0E-08	1.6E-07	8.2E-10
Casula	Casula Powerhouse Arts Centre	Recreational	5.4E-02	1.3E-03	3.3E-04	2.5E-07	1.0E-02	1.6E-03	6.6E-04	5.2E-08	3.8E-02	1.2E-03	2.7E-04	8.0E-07	1.3	1.0E-01	4.6E-03	1.5E-03	1.1E-06	0.024	7.4E-07	3.2E-09	6.0E-09	2.9E-11
Glenfield	Canterbury Road	Residential	4.7E-02	1.1E-03	2.9E-04	2.2E-07	7.6E-03	1.2E-03	5.0E-04	4.0E-08	4.8E-02	1.6E-03	3.4E-04	9.8E-07	1.0	1.0E-01	3.9E-03	1.1E-03	1.2E-06	0.50	1.5E-05	5.6E-08	9.7E-08	6.8E-10
Glenfield	Ferguson Street	Residential	4.9E-02	1.1E-03	3.0E-04	2.3E-07	7.8E-03	1.2E-03	5.2E-04	4.1E-08	5.2E-02	1.7E-03	3.7E-04	1.1E-06	1.0	1.1E-01	4.1E-03	1.2E-03	1.3E-06	0.50	1.6E-05	5.9E-08	1.0E-07	7.3E-10
Glenfield	Goodenough Street	Residential	6.4E-02	1.4E-03	3.9E-04	3.0E-07	9.5E-03	1.5E-03	6.3E-04	5.0E-08	7.3E-02	2.4E-03	5.2E-04	1.4E-06	1.0	1.5E-01	5.3E-03	1.5E-03	1.8E-06	0.50	2.2E-05	7.6E-08	1.3E-07	9.9E-10
Glenfield	Cambridge Avenue	Residential	6.1E-02	1.4E-03	3.7E-04	2.9E-07	9.4E-03	1.5E-03	6.2E-04	5.0E-08	6.3E-02	2.0E-03	4.5E-04	1.2E-06	1.0	1.3E-01	4.9E-03	1.4E-03	1.6E-06	0.50	2.0E-05	7.1E-08	1.2E-07	8.7E-10
Glenfield	Glenwood Public School	Residential/School	2.7E-02	6.7E-04	1.7E-04	1.3E-07	4.6E-03	7.2E-04	3.0E-04	2.4E-08	2.7E-02	9.3E-04	2.0E-04	5.7E-07	1.0	5.9E-02	2.3E-03	6.7E-04	7.3E-07	0.50	8.9E-06	3.4E-08	5.7E-08	4.0E-10
Glenfield	Glenfield Public School	Residential/School	3.5E-02	8.4E-04	2.1E-04	1.6E-07	5.8E-03	9.1E-04	3.8E-04	3.0E-08	3.4E-02	1.2E-03	2.5E-04	7.2E-07	1.0	7.5E-02	2.9E-03	8.4E-04	9.1E-07	0.50	1.1E-05	4.2E-08	7.2E-08	5.0E-10
Glenfield	Hurlstone Agricultural School	Residential/School	2.9E-02	7.0E-04	1.8E-04	1.4E-07	4.9E-03	7.6E-04	3.2E-04	2.6E-08	2.8E-02	9.4E-04	2.0E-04	5.9E-07	1.0	6.2E-02	2.4E-03	7.0E-04	7.5E-07	0.50	9.2E-06	3.5E-08	6.0E-08	4.1E-10
Glenfield	Glenfield Rise Development	Residential	2.1E-01	5.9E-03	1.3E-03	9.7E-07	3.1E-02	4.9E-03	2.1E-03	1.6E-07	1.8E-01	6.3E-03	1.3E-03	4.5E-06	1.0	4.2E-01	1.7E-02	4.7E-03	5.6E-06	0.50	6.3E-05	2.5E-07	4.0E-07	3.1E-09
Glenfield	Playground Learning Centre	Residential	1.2E-01	3.4E-03	7.6E-04	5.7E-07	1.9E-02	3.0E-03	1.3E-03	1.0E-07	8.5E-02	3.0E-03	6.3E-04	2.1E-06	1.0	2.3E-01	9.4E-03	2.7E-03	2.8E-06	0.50	3.4E-05	1.4E-07	2.3E-07	1.5E-09
Moorebank	Anzac Road	Residential	3.1E-01	8.6E-03	1.9E-03	1.4E-06	4.4E-02	6.9E-03	2.9E-03	2.3E-07	1.3E-01	4.6E-03	9.9E-04	3.5E-06	1.0	4.9E-01	2.0E-02	5.8E-03	5.2E-06	0.50	7.3E-05	2.9E-07	5.0E-07	2.8E-09
Moorebank	Anzac Road	Commercial/Industrial	3.1E-01	8.6E-03	1.9E-03	1.4E-06	4.4E-02	6.9E-03	2.9E-03	2.3E-07	1.3E-01	4.6E-03	9.9E-04	3.5E-06	1.3	5.0E-01	2.3E-02	6.8E-03	5.2E-06	0.094	1.4E-05	6.1E-08	1.1E-07	5.4E-10
Moorebank	Church Road	Residential	1.1E-01	3.1E-03	6.7E-04	5.7E-07	1.8E-02	2.9E-03	1.2E-03	9.7E-08	5.5E-02	1.9E-03	4.1E-04	1.4E-06	1.0	1.8E-01	7.9E-03	2.3E-03	2.0E-06	0.50	2.8E-05	1.1E-07	2.0E-07	1.1E-09
Moorebank	New DNSDC Facility	Commercial/Industrial	3.3E-02	8.0E-04	2.0E-04	1.6E-07	5.5E-03	8.6E-04	3.6E-04	2.9E-08	3.3E-02	1.1E-03	2.3E-04	6.8E-07	1.3	7.3E-02	3.0E-03	9.2E-04	8.7E-07	0.094	2.1E-06	8.3E-09	1.5E-08	9.0E-11
Wattle Grove	Wallcliff Court	Residential	9.4E-02	2.4E-03	5.8E-04	4.3E-07	1.5E-02	2.3E-03	9.7E-04	7.7E-08	1.6E-01	6.0E-03	1.2E-03	3.5E-06	1.0	2.7E-01	1.1E-02	2.7E-03	4.0E-06	0.50	4.1E-05	1.5E-07	2.3E-07	2.2E-09
Wattle Grove	Corryton Court	Residential	1.3E-01	3.3E-03	7.8E-04	5.7E-07	1.9E-02	3.0E-03	1.3E-03	1.0E-07	1.9E-01	6.9E-03	1.4E-03	4.2E-06	1.0	3.3E-01	1.3E-02	3.4E-03	4.9E-06	0.50	5.0E-05	1.9E-07	2.9E-07	2.7E-09
Wattle Grove	Martindale Court	Residential	1.4E-01	3.8E-03	8.6E-04	6.3E-07	2.1E-02	3.3E-03	1.4E-03	1.1E-07	1.7E-01	6.2E-03	1.3E-03	4.0E-06	1.0	3.3E-01	1.3E-02	3.5E-03	4.7E-06	0.50	5.0E-05	1.9E-07	3.0E-07	2.6E-09
Wattle Grove	Yallum Court	Residential	1.1E-01	2.9E-03	7.0E-04	5.2E-07	1.7E-02	2.7E-03	1.1E-03	9.1E-08	2.0E-01	7.5E-03	1.5E-03	4.4E-06	1.0	3.3E-01	1.3E-02	3.3E-03	5.0E-06	0.50	5.0E-05	1.9E-07	2.8E-07	2.8E-09
Wattle Grove	Wattle Grove Public School	Residential/School	1.0E-01	2.7E-03	6.3E-04	4.7E-07	1.6E-02	2.5E-03	1.0E-03	8.3E-08	1.5E-01	5.4E-03	1.1E-03	3.3E-06	1.0	2.6E-01	1.1E-02	2.8E-03	3.8E-06	0.50	4.0E-05	1.5E-07	2.3E-07	2.1E-09
Wattle Grove	St Marks Coptic College	Residential/School	7.8E-02	2.1E-03	4.8E-04	3.6E-07	1.2E-02	1.9E-03	8.1E-04	6.5E-08	9.3E-02	3.4E-03	6.9E-04	2.1E-06	1.0	1.8E-01	7.4E-03	2.0E-03	2.6E-06	0.50	2.8E-05	1.1E-07	1.7E-07	1.4E-09
Wattle Grove	Wattle Grove Long Day Care Centre	Residential	3.0E-01	8.6E-03	1.9E-03	1.5E-06	8.4E-02	1.3E-02	5.5E-03	4.4E-07	1.7E-01	5.9E-03	1.3E-03	4.0E-06	1.0	5.6E-01	2.8E-02	8.7E-03	5.9E-06	0.50	8.3E-05	4.0E-07	7.4E-07	3.3E-09
Wattle Grove	Wattle Grove Long Day Care Centre	Recreational	3.0E-01	8.6E-03	1.9E-03	1.5E-06	8.4E-02	1.3E-02	5.5E-03	4.4E-07	1.7E-01	5.9E-03	1.3E-03	4.0E-06	1.3	5.8E-01	3.2E-02	1.0E-02	6.1E-06	0.024	4.2E-06	2.2E-08	4.2E-08	1.6E-10

Maximum Residential/School Receptors	**8.3E-05**	**4.2E-07**	**7.8E-07**	**3.3E-09**
Maximum Recreational Receptor	**4.2E-06**	**2.2E-08**	**4.2E-08**	**1.6E-10**
Maximum Commercial/Industrial Receptor	**1.4E-05**	**6.1E-08**	**1.1E-07**	**5.4E-10**

Abbreviations and Notes:
$\mu g/m^3$: microgram per cubic meter
BaP: Benzo(a)pyrene
Cal/EPA: California Environmental Protection Agency
DPM: Diesel Particulate Matter
EPC: Exposure Point Concentration
GLC: Ground Level Concentration
IMEX: Import Export
IMT: Intermodal Terminal
MAF: Modeling Adjustment Factor
MPE: Moorebank Precinct East
MPW: Moorebank Precinct West
PAH: Polycyclic Aromatic Hydrocarbon
TEQ: Toxicity Equivalent
URF: Unit Risk Factor

[a] The MPW State 2 warehousing would operate 18 hours per day, while the model predicted GLCs were annualized over 24 hours per day. Therefore, the annual average GLCs were lower than the actual air concentrations emitted from the source. Commercial/industrial and recreational receptors may not be continuously exposed to chemicals in air, and using annual average GLCs instead of the actual air concentrations as EPCs for these human receptors may underestimate the risk. Therefore, the annual average GLCs for MPW State 2 warehousing were adjusted back to the actual air concentrations by multiplying a MAF (calculated as 24 hours/18 hours = 1.3).

[b] Exposure time (ET) was assumed to be 24 hours per day, 8 hours per day, and 4 hours per day for residential/school, commercial/industrial, and recreational receptors, respectively. Exposure frequency (EF) was assumed to be 365 days per year, 240 days per year, and 104 days per year for residential/school, commercial/industrial, and recreational receptors, respectively. Exposure duration (ED) was assumed to be 35 years, 30 years, and 35 years for residential/school, commercial/industrial, and recreational receptors, respectively. Inhalation Intake Factor was calculated as ET x EF x ED/CF/AT, where AT is averaging time for cancer risk (i.e. 70 years or 25550 days), and CF is conversion factor (24 hours/day).

Source:
California Environmental Protection Agency (Cal/EPA) Office of Environmental Health Hazard Assessment (OEHHA). 2016. OEHHA Toxicity Criteria Database. Available at: http://oehha.ca.gov/tcdb/index.asp