NorthConnex

Building for the future

Australian Government

NSW NOW The new state of business

transurban

Volume 1

Environmental Impact Statement

Submissions and Preferred Infrastructure Report

Chapters 1 - 4

November 2014

RMS/Pub: 14.478 ISBN 978-1-925093-99-5

Roads and Maritime Services

NorthConnex

Submissions and preferred infrastructure report

NOVEMBER 2014

Prepared by
AECOM Australia Pty Ltd
Level 21, 420 George Street, Sydney NSW 2000, PO Box Q410, QVB Post Office NSW 1230, Australia
T +61 2 8934 0000 F +61 2 8934 0001 www.aecom.com
ABN 20 093 846 925

(blank page)

Contents

Volume 1

Volume 2

Volume 3

Volume 4

Appendices

(blank page)

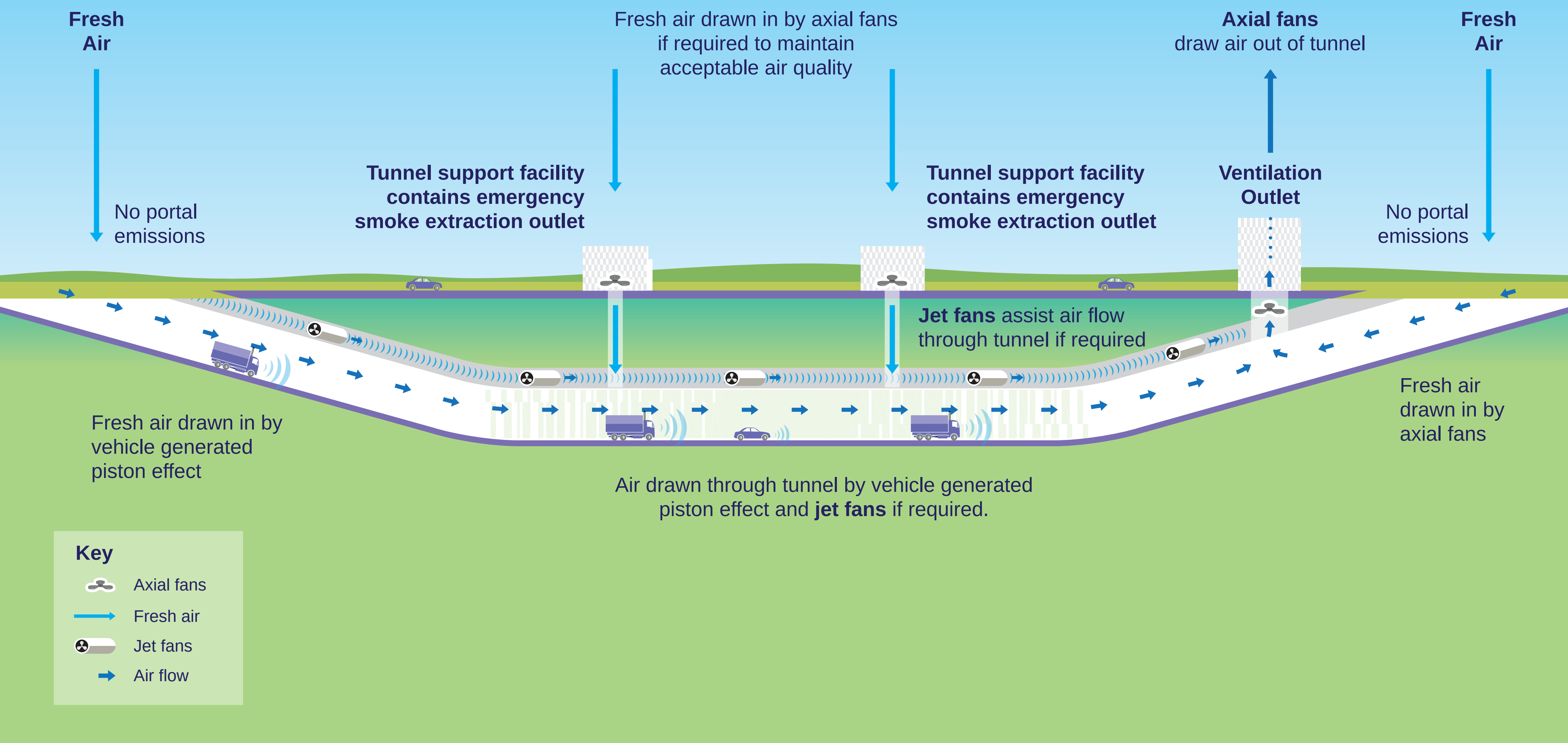
Glossary of terms and abbreviations

This section provides a list of terms and abbreviations used in this document.

A diagram showing the key components of the project is provided on the following page to assist in understanding and interpreting components of the project and its ventilation system.

(blank page)

Motorway Tunnel Ventilation



(blank page)

Term	Meaning
µg/m^3	Micrograms per cubic metre
A	
AADT	Average annual daily traffic. The total volume of traffic passing a roadside observation point over a period of a year, divided by the number of days per year. It is calculated from mechanically obtained axle counts.
Aboriginal cultural heritage	The tangible (objects) and intangible (dreaming stories, songlines, places) cultural practices and traditions associated with past and present day Aboriginal communities.
Aboriginal object	Any deposit, object or material evidence (not being a handicraft made for sale), including Aboriginal remains, relating to the Aboriginal habitation of NSW.
Acute noise levels	Road traffic noise levels received at private dwellings that are predicted to be greater than 65dB(A)$L_{eq(15hr)}$ (day) and 60dB(A)$L_{eq(9hr)}$ (night), as presented in Practice Note IV of the Environmental Noise Management Manual (RTA, 2001).
AHD	Australian Height Datum. The standard reference level used to express the relative height of various features. A height given in metres AHD is essentially the height above sea level. Mean sea level is set as zero elevation.
Airshed	Part of the atmosphere that shares a common flow of air and that is exposed to similar influences.
Alignment	The geometric layout (eg of a road tunnel) in plan (horizontal) and elevation (vertical).
Ambient	Used interchangeably with 'background' in this report. Ambient/background pollutant concentrations refer to the concentrations of pollutants in the air, which are generated by all local pollutant sources, i.e. the term refers to the general pollutant loads in the air.
Ancillary	A subordinate part or element.
ANZECC	Australian and New Zealand Environment and Conservation Council
Aquatic ecology	Flora and fauna that live in or on water for all or a substantial part of the life span (generally restricted to fresh/ inland waters).
Aquifer	Geologic formation, group of formations, or part of a formation capable of transmitting and yielding quantities of water.
Archaeology	The scientific study of human history, particularly the relics and cultural remains of the distant past.
ARI	Average recurrence interval. Used to describe the frequency or probability of floods occurring. (eg a 100 year ARI flood is a flood that occurs or is exceeded on average once every 100 years (100:1)).
Arterial roads	The main or trunk roads of the State road network.
Asphalt	A dense, continuously graded mixture of coarse and fine aggregates, mineral filler and bitumen usually produced hot in a mixing plant.
Axial fans	Fans typically used within the ventilation facility or tunnel support facility that pull air into or out of the main alignment tunnel.
B	
Background noise level	The ambient sound-pressure noise level in the absence of the sound under investigation exceeded for 90 per cent of the measurement period. Normally equated to the average minimum A-weighted sound pressure level.

Term	Meaning
Blasting	The use of explosives for excavating rock, demolition and other purposes.
Bore	A cylindrical drill hole sunk into the ground from which water is pumped for use or monitoring.
Borehole	A hole produced in the ground by drilling for the investigation and assessment of soil and rock profiles.
Bund	A small embankment designed to retain water.
C	
Cadastral	Showing the extent and ownership of land (generally on a map).
CALPUFF	An advanced air dispersion model.
Carriageway	The portion of a roadway used by vehicles including shoulders and ancillary lanes.
Catchment	The area from which a surface watercourse or a groundwater system derives its water.
CO	Carbon monoxide.
CO_2	Carbon dioxide.
CO_{2-e}	Carbon dioxide equivalent.
Compound site	Facilities used to support the operation of a construction site including (but not limited to) site offices, workshops, delivery areas, storage areas, staff vehicle parking, materials, plant and equipment.
Concentration (air quality)	Vehicles emit pollutants to the air, which are transported and diluted resulting in a volume of pollutant per volume of ambient air. Ambient air quality goals are expressed in terms of concentrations, which are measured in parts per million or micrograms per cubic metre.
Constructability	The ease with which structures can be built.
Construction footprint	The area required to construct the project, including underground components, above ground components and temporary ancillary construction facilities.
CSIRO	Commonwealth Scientific and Industrial Research Organisation.
CTMP	Construction Traffic Management Plan
Cumulative impacts	Impacts that, when considered together, have different and/or more substantial impacts than a single impact considered alone.
Cut	The material excavated from a cutting.
Cutting	Formation resulting from the construction of the road below existing ground level – the material is cut out or excavated.
D	
dB(A)	Decibels using the A-weighted scale measured according to the frequency of the human ear.
DEC	NSW Department of Environment and Conservation (now OEH and the EPA).
DECC	NSW Department of Environment and Climate Change (formerly DEC and now OEH and EPA).
DECCW	NSW Department of Environment, Climate Change and Water (formerly DEC, DECC and now OEH and the EPA).
Decibel	A scale unit used in the comparison of powers and levels of sound energy. Used for measuring noise.
Dewatering	The removal of water from solid material or soil by wet classification, centrifugation, filtration or similar solid-liquid separation processes.

Term	Meaning
DGRs	Director-General's Requirements. Requirements and specifications for an environmental impact statement prepared by the Secretary (formerly the Director-General) of the Department of Planning and Environment under section 115Y of the *Environmental Planning and Assessment Act 1979*.
Drainage	Natural or artificial means for the interception and removal of surface or subsurface water.
E	
Earthworks	All operations involved in loosening, excavating, placing, shaping and compacting soil or rock.
Ecosystem	A functional unit of energy transfer and nutrient cycling in a given place. It includes all relationships within the biotic community and between the biotic components of the system.
Emergency smoke extraction facility	A facility that is designed to maintain air quality in the tunnels in the unlikely event of an emergency. As a secondary feature, these facilities would also supply fresh air the tunnels during low speed, congested traffic conditions.
Emission factor	The rate of pollutants emitted in the exhaust of a vehicle, depending on the type of vehicles and the conditions under which it is driven.
EPA	NSW Environment Protection Authority.
F	
Fill	The material placed in an embankment.
Footprint	The extent of impact that a development makes on the land.
Fragmentation	The breaking up of continuous sections of ecosystems or landscape features.
Frequency (sound)	Similar to the pitch of a musical note in sound pressure fluctuations of cycles per second (Hertz). Most sounds comprise a composite of frequencies of varying sound-pressure levels in the range of 20 Hertz to 20,000 Hertz.
G	
Grade	The degree of inclination of a road or slope.
Grade separation	The separations of road, rail or other traffic so that crossing movements at intersections are at different levels. Opposite to 'at grade'.
Greenhouse gas (GHG)	Greenhouse gases are those gases which reduce the loss of heat from the earth's atmosphere by absorbing infrared radiation. Six greenhouse gases are recognised by the Kyoto Protocol: Carbon dioxide (CO_2), Methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). The emissions of greenhouse gases are reported in carbon dioxide equivalents (see above).
Groundwater	Water that is held in the rocks and soil beneath the earth's surface.
H	
ha	Hectare. Equivalent to 10,000 m^2.
Habitat	The place where a species, population or ecological community lives (whether permanently, periodically or occasionally). Habitats are measurable and can be described by their flora and physical components.
Heavy vehicle	A vehicle is classified as a Class 3 vehicle (a two axle truck) or larger, in accordance with the Austroads Vehicle Classification System.

Term	Meaning
Hills M2 Motorway integration works	The works to join the project to the Hills M2 Motorway extending from the southern interchange to Windsor Road interchange
Hydrocarbon	Any organic compound — gaseous, liquid or solid — consisting only of carbon and hydrogen.
Hydrogeology	The science of the distribution and movement of groundwater.
Hydrology	The study of rainfall and surface water runoff processes.
I	
Interchange	A grade separation of two or more roads with one or more interconnecting carriageways.
Integration works	Works to join existing roads to the project.
ISEPP	*State Environmental Planning Policy (Infrastructure) 2007.*
L	
Landscape character	The aggregate of built, natural and cultural aspects that make up an area and provide a sense of place. Includes all aspects of a tract of land – built, planted and natural topographical and ecological features.
LEP	Local Environmental Plan.
Light vehicle	A vehicle is classified as a Class 2 vehicle or smaller, in accordance with the Austroads Vehicle Classification System.
Local road	A road or street used primarily for access to abutting properties.
Longitudinal ventilation	The method of tunnel ventilation in which air is drawn along the carriageway of the tunnel, typically in the direction of traffic flow.
Lot	A parcel of land defined by measurement as a lot in a deposited plan (DP) or as a Crown portion or allotment.
M	
Macroinvertebrates	Macroinvertebrates are fauna with no backbone that can be seen with the naked eye (ie without the aid of a microscope or magnifying glass). Aquatic macroinvertebrates are those that spend all or part of their life cycles in water.
Macrophytes	Macrophytes are aquatic plants that can be seen with the naked eye. They can grow below, within or on top of the water.
Main alignment tunnels	The two underground tunnels forming the principal carriageways of the project.
Micrometre	One millionth of a metre (abbreviation µm).
Motorway	Fast, high volume controlled access roads. May be tolled or untolled.
Motorway control centre	A centre with facilities necessary for the monitoring, maintenance and control of tunnel services. Also known as a tunnel control centre facility.
Motorway operations complex	The combined facility near the southern interchange comprising the motorway control centre, workshops, the water treatment plant and the southern ventilation facility.
Mt	Million tonnes.
N	
Northern interchange	The connections of the project with the M1 Pacific Motorway (formerly known as the F3 Freeway) and Pennant Hills Road.
Northern ventilation facility	A component of the ventilation system located near the northern portal of the project for the extraction of in-tunnel air from the northbound tunnel.
NO_x	Oxides of nitrogen.
NO_2	Nitrogen dioxide.

Term	Meaning
NSW	New South Wales
O	
O_3	Ozone
OEH	NSW Office of Environment and Heritage.
P	
PACHCI	Procedure for Aboriginal Cultural Heritage Consultation and Investigation (Roads and Maritime Services, 2011).
PCU	Passenger car unit. A standard, consistent basis for accounting for the amount of space taken up by different size vehicles.
Peak oil	The predicted time when oil extraction reaches its maximum, after which oil extraction is anticipated to decline.
pH	A measure of acidity or alkalinity of a solution, numerically equal to 7 for neutral solution, increasing with increasing alkalinity and decreasing with increasing acidity. Originally stood for the words potential of hydrogen.
PIARC	Permanent International Association of Road Congresses.
Piezometer	Device used to measure the pressure of groundwater, or static pressure of a liquid.
Piston effect	Air flow in a tunnel that is generated by, and in the direction of, moving vehicles.
PM	Particulate matter.
$PM_{2.5}$	Particulate matter less than 2.5 micrometres in diameter.
PM_{10}	Particulate matter less than 10 micrometres in diameter.
Pollutant	Any measured concentration of solid or liquid matter that is not naturally present in the environment.
Portal	Where a tunnel emerges to the surface, being the entrance or exit of the main alignment tunnels, off-ramps or on-ramps.
(The) project	The NorthConnex project.
Q	
Quarry	An open pit from which stone, sand, gravel or fill is taken.
R	
Receiver	An environmental modelling term used to describe a map reference point where the impact is predicted. A sensitive receiver is a home, work place, school or other place where people spend some time.
Revegetation	To revegetate an area by direct seeding with non-native species or cover crops and / or native species using manual or mechanical means such as hydromulching, strawmulching and tractor seeding.
RNP	NSW Road Noise Policy (DECCW, 2011).
Roads and Maritime	Roads and Maritime Services of New South Wales.
RTA	Roads and Traffic Authority of NSW (now Roads and Maritime Services).
Runoff	That part of the rainfall on a catchment which flows as surface discharge past a specified point.
S	
Sediment	Material, both mineral and organic, that is being or has been moved from its site of origin by the action of wind, water or gravity and comes to rest either above or below water level.
Sediment/ sedimentation basins	An area where runoff water is ponded to allow sediment to be deposited.
Sedimentation	Deposition of sediment usually by water.

Term	Meaning
Sensitive receiver	A sensitive receiver, such as a residence, work place, school or other place where people spend some time. An elevated sensitive receiver is a point above ground level.
Site establishment works	Preliminary works carried out prior to the commencement of construction, including installation of environmental controls, demolition of existing structures, vegetation clearing and establishment of temporary construction facilities.
Shotcrete	Concrete applied to a surface through a pressure hose.
Shoulder	The portion of the carriageway beyond the traffic lanes adjacent to and flush with the surface of the pavement.
Southern interchange	The connections of the project with the Hills M2 Motorway and Pennant Hills Road.
Southern ventilation facility	A component of the ventilation system located near the southern portal of the project for the extraction of in-tunnel air from the southbound tunnel.
Spoil	Surplus excavated material.
SPTs	Standards Penetration Tests
Surface water	Water flowing or held in streams, rivers and other wetlands in the landscape.
T	
Terrestrial	Living or growing on land (ie a terrestrial plant or animal).
Threatened	As defined under the *Threatened Species Conservation Act 1994*, a species, population or ecological community that is likely to become extinct or is in immediate danger of extinction.
Tie-in works	The works to join the project to existing roads, such as the M1 Pacific Motorway.
U	
Urban design	The process and product of designing human settlements, and their supporting infrastructure, in urban and rural environments.
V	
Ventilation facility	Facilities for the mechanical removal of air from the main alignment tunnels, or mechanical introduction of air into the tunnels.
Ventilation offtake	The component of the ventilation system that connects the main alignment tunnel to the ventilation facility, and through which tunnel air is drawn prior to discharge via the ventilation outlet.
Ventilation outlet	Part of the tunnel’s ventilation system within the ventilation facility which contains axial fans to expel air from within the tunnels into the atmosphere.
W	
Water table	The surface of saturation in an unconfined aquifer at which the pressure of the water is equal to that of the atmosphere.
Waterway	Any flowing stream of water, whether natural or artificially regulated (not necessarily permanent).
Z	
Zoning	Zoning regulates land use within an environmental planning instrument (usually by different colour codes on a map accompanying a local environmental plan). Land use tables set out the various purposes for which land may or may not be used or developed in each zone.

Executive Summary

The NSW Government's State Infrastructure Strategy, State Plan and Long Term Master Plan identify the NorthConnex project as a priority to deliver improvements to the State's urban road network.

The proposed motorway includes a nine-kilometre tunnel linking Sydney's north to the Orbital road network and forms part of the National Highway route. It would provide a vital link for commuters and freight operators between the M1 Pacific Motorway at Wahroonga and the Hills M2 Motorway at West Pennant Hills. The project would deliver a high standard motorway to integrate with the regional transport network, keeping Sydney and the NSW economy moving. It would also improve road safety, noise and air pollution and ease congestion along Pennant Hills Road.

The NorthConnex project is a public private partnership with the NSW and Federal governments, Transurban and the M7 Westlink Shareholders (the Project Sponsors).

Project Benefits

The NorthConnex project is designed to:

- ✓ Provide the missing link in Sydney's motorway network and the National Land Transport Network between the M1 Pacific Motorway and the Sydney Orbital road network
- ✓ Save up to 15 minutes of travel time on opening compared to using Pennant Hills Road
- ✓ Bypass 21 sets of traffic lights along Pennant Hills Road
- ✓ Improve productivity and efficiency of intrastate and interstate freight movements through travel time savings and reduced operating costs
- ✓ Improve safety of motorists, cyclists and pedestrians on Pennant Hills Road through the reduction of around 5,000 heavy vehicles every day.
- ✓ Improve local amenities and connectivity for people living, working and travelling along Pennant Hills Road
- ✓ Provide opportunities for future public transport improvements and the reinvigoration of the Pennant Hills Road corridor.

Environmental Impact Statement

The NorthConnex environmental impact statement was placed on public exhibition from 15 July to 12 September 2014. During this extended 60 day period, the community, interest groups, local councils and relevant Government departments, were invited to provide submissions on the proposal for consideration by the Department of Planning and Environment as part of the planning process.

Interested parties were also invited to attend a number of information forums, meetings, displays and the community information centre where specialists in air quality, health assessment, tunnel design, noise and other project specifics were available to answer inquiries and record feedback.

A total of 1,518 submissions from 1,251 stakeholders were received by the Department of Planning and Environment. Five submissions were from government agencies and three from local government. Of the submissions received, 672 submissions (44 per cent) were anonymous and 605 (40 per cent) were standardised form letters. Each submission was read carefully and issues extracted for detailed consideration. **Chapter 7** and **Chapter 8** of this report present the issues raised in submissions and corresponding responses.

The subjects most commonly raised related to:

- Operational air quality.
- Project development and alternatives.
- Health impact.
- Planning and statutory requirements.
- Construction traffic impact.
- Consultation.
- Urban design, landscape character and visual impact.

Air quality was the issue most frequently raised in submissions, indicating that despite the effort given to assess and address this issue in the environmental impact statement the community remained concerned. Accordingly significant additional effort has been made during the preparation of this Submissions and Preferred Infrastructure Report to address this issue.

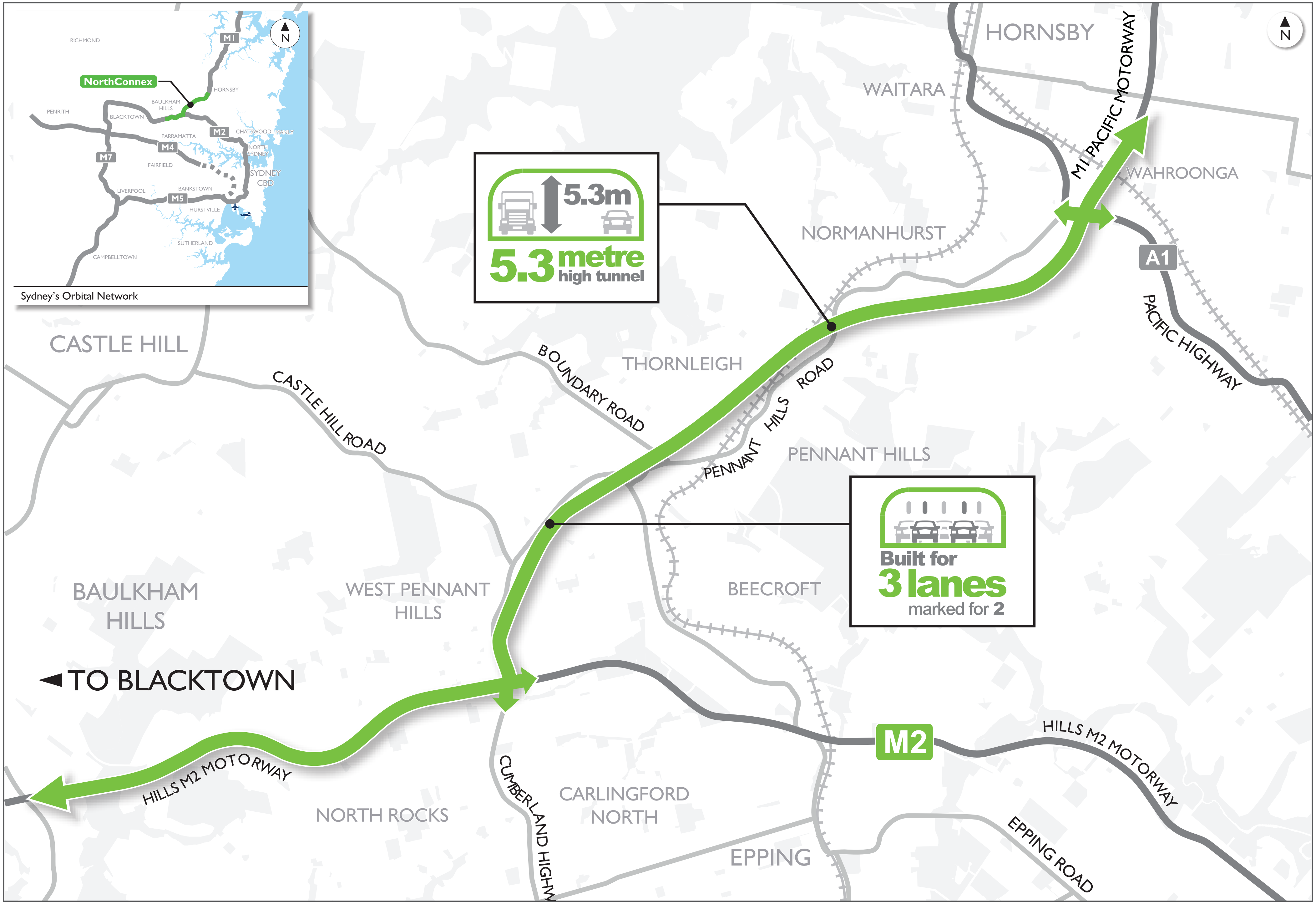
The air quality assessment prepared for the NorthConnex environmental impact statement demonstrated effective performance of the proposed tunnel ventilation system and ventilation outlets. It explains the effect on local air quality and demonstrates there will be an overall net improvement in air quality across the Pennant Hills Road corridor.

The predicted increase around each of the ventilation outlets, for all health outcomes including diesel emissions, would be very small and undetectable.

The air quality assessment also predicted a reduction in the health impacts along Pennant Hills Road due to the decrease in air pollution as a result of traffic, particularly heavy vehicles, using the tunnel.

The assessment considered the potential impact on the general population, as well as more sensitive members of the community including children, the elderly and those with existing respiratory issues.

For the first time for a road project in NSW, a comprehensive health risk assessment was also carried out in accordance with the *Environmental Health Risk Assessment: Guidelines for assessing human health risks from environmental hazards* (enHealth, 2012) and published as part of the environmental impact statement.



Linking Sydney's Orbital road network

(blank page)

From a health risk perspective, taking into account the total population affected by both increases and decreases in vehicle emissions (refer to Section 7.4 of the environmental impact statement) it has been calculated that the NorthConnex project would have a net health benefit.

The health risk assessment is conservative (potential benefits are under-predicted) as it was limited to air quality and did not include the expected improvement in health from a reduction in road incidents and fewer injuries/ fatalities as a result of the NorthConnex project. In a recent NRMA survey, Pennant Hills Road is the second worst road in New South Wales, experiencing around 360 crashes per year. Drivers would be five times less likely to be involved in a crash and about four times less likely to be involved in an injury crash using the NorthConnex project instead of Pennant Hills Road.

Submissions and Preferred Infrastructure Report

To prepare this Submissions and Preferred Infrastructure Report, Roads and Maritime has reviewed all submissions and prepared clarifications and responses to the issues raised. A range of amendments to the project have also been identified to reduce environmental impacts and address stakeholder and community concerns.

This information is set out in this Submissions and Preferred Infrastructure Report in the following format.

- Introduction - **Chapter 1**.
- Clarifications in response to issues raised in respect of air quality are documented in **Chapter 2** and **Chapter 3**.
- Clarifications in response to other issues are addressed in **Chapter 4**.
- A summary of community involvement is outlined in **Chapter 5**.
- A summary of submissions received is provided in **Chapter 6**.
- Issues raised in submissions from government, councils, peak groups and advisory organisations, schools, churches, hospitals and age care facilities and members of parliament are addressed in **Chapter 7**.
- Issues raised in community submissions are addressed in **Chapter 8**.
- Changes made to the project (since exhibition of the environmental impact statement) to reduce environmental impacts are described and assessed in **Chapter 9**.
- An updated summary of mitigation measures is provided in **Chapter 10**.
- Conclusions – **Chapter 11**.

Of particular note is **Chapter 2** which presents the reorganisation and consolidation of relevant material regarding air quality contained in Section 7.2 and Appendix G of the environmental impact statement. It comprehensively explains the air quality impact assessment for the project, including a description of the inputs, methodology and assumptions. Further detail has been provided where relevant to respond to specific issues raised in submissions on the environmental impact statement.

Changes to the project since exhibition of the EIS

As recognised in submissions made by key government agencies, all feasible and reasonable mitigation measures to reduce exposures to vehicle emissions within the tunnels and surrounding environment need to be identified and applied to the NorthConnex project.

This requirement is supported and further consideration of reasonable and feasible measures has been undertaken (refer to **Section 3.2** of this report). This has included an analysis of ventilation design alternatives considering:

- Ventilation outlet height.
- Ventilation outlet locations.
- Additional ventilation outlets.
- Ventilation flow rates.
- Air treatment systems (ie filtration).

This further analysis identified it was feasible to increase the height of the southern and the northern ventilation outlets by five metres. This would make both outlets 20 metres in height, measured from Pennant Hills Road and Bareena Avenue respectively.

It is therefore proposed to change the project design to increase the height of the southern and the northern ventilation outlets by five metres. This would optimise the performance of the outlets while maintaining the efficiency of the in-tunnel ventilation system.

The following additional changes to the project are also proposed to reduce environmental impacts and respond to community concerns:

- Amendments to the construction haulage routes for the southern interchange (C5), Trelawney Street (C7) and northern interchange (C9) compounds to reduce heavy vehicle impacts on local residential streets.
- An increase in bus movements at the Pioneer Avenue compound (C8), to minimise potential construction worker traffic and parking impacts on the surrounding road network.
- Additional property acquisition near the Wilson Road compound (C6), to improve the safety of access arrangements.
- Inclusion of a laydown area at the Junction Road compound (C11), to improve construction phase management and to minimise the requirement for out of hours deliveries to the site.

Descriptions and assessments of these changes to the project are provided in **Chapter 9** of this report.

Clarifications in response to submissions

Air quality and modelling

Submissions queried the veracity of assumptions and inputs applied to the air dispersion modelling, including background air quality, local topography, local meteorology, and the implications of drawing background concentrations of pollution into the tunnels. Clarification was also sought on whether the overall vehicle emissions would be reduced with the project or whether the NorthConnex project transferred emissions to areas around the outlets.

Chapter 2 of this report provides clarifications and interpretative discussion of the air quality impact assessment presented in the environmental impact statement. Information about the methodology, assumptions and inputs into the assessment are provide in a single, consolidated location.

The key areas of information, clarification and analysis are summarised below:

- **Background air quality data** - Air quality across Sydney is variable throughout the year and largely similar at different regional monitoring locations. While it is desirable to have site-specific background air quality data for an air quality impact assessment, it is rare that sufficient local data is available. An accepted alternative is the use of data from a monitoring location, demonstrated as representative of local conditions.

  In the case of the NorthConnex project, **Section 2.11** of this report presents further analysis of the background air quality data used in the air quality impact assessment, obtained from the Office of Environment and Heritage. This information has been validated using three local monitoring stations along the project corridor. The analysis demonstrates the data was appropriate for use as an alternative to site specific data, in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (DEC, 2005).

- **Topographical data** – Additional analysis has been carried out to compare the topographic data used in the meteorological and air dispersion modelling for th NorthConnex project, with high resolution 'LiDAR' topographic data (remote sensing technology that measures distance by illuminating a target laser and analysing the reflected light) collected along the project corridor. This analysis confirms the terrain data used in the assessment reflects local terrain conditions. Analysis using a screening level air dispersion model suggests the topographic data used in the assessment of the NorthConnex project may have produced slightly conservative estimates (over estimates) of air quality impacts.

- **Meteorological data** – Submissions questioned whether the regional metrological data appropriately represented localised weather conditions. The analysis of the air quality dispersion modelling meteorological data demonstrates peak air quality impacts will occur under moderate wind conditions rather than calm or still days. Therefore if there were more calm and low wind days around the outlets than predicted in the modelling, this would lead to less impact than currently estimated. A review and comparison of data from local amateur weather stations has also been completed. Hence the current modelling represents a realistic and conservative approach.

- **Vehicle emissions at portals** - Additional modelling has been carried out to account for background pollution being drawn into the tunnel entry portals. The additional modelling has demonstrated a negligible change in predicted air quality (refer to **Table 2-46** in **Section 2.8.3** of this report).

- **Overall reduction in emissions** as a result of the NorthConnex project - By providing a free-flowing motorway alternative to Pennant Hills Road, the NorthConnex project would reduce the total amount of vehicle emissions discharged into the atmosphere. Avoiding stop-start traffic congestion along Pennant Hills Road, it is estimated a heavy vehicle would emit 80 per cent less carbon monoxide, 70 per cent less oxides of nitrogen and 70 per cent less particulate matter (as PM_{10}). This demonstrates the NorthConnex project would reduce the quantity of emissions being generated along the Pennant Hills Road corridor.
- **Reduced emissions and improved dispersion** – the NorthConnex project would lead to improved air quality outcomes along the Pennant Hills Road corridor. This is achieved by reducing overall travel times along the motorway. The project would manage and disperse vehicle emissions in a controlled manner through a well-designed ventilation system and effective ventilation outlets. Rather than vehicle emissions being emitted at ground level with limited dispersion, the ventilation outlets would ensure effective atmospheric dispersion by discharge at high speeds (at up to about 70 km/h from the ventilation outlets).

Project design and scope

A number of submissions were seeking clarifications of the project design and scope.

This report provides minor clarifications of project design and scope issues. This includes the location of the ventilation off-take for the southern ventilation outlet. The offtake is a separate tunnel used to transport the air and emissions from the southbound tunnel to the ventilation outlet located in the motorway operations complex. Its purpose and location has now been clarified both in this report and through community consultation material and events.

Traffic forecasting

A number of submissions questioned whether the environmental impact statement had considered the impact if forecast traffic numbers have been underestimated.

Section 2.5.1 and Section 2.7.3 of this report provide further information and clarification to demonstrate that:

- The modelling of air quality and the design of the ventilation system was carried out using predicted traffic figures and a worst case scenario, which was described in the environmental impact statement as 'design analysis A'.
- There is a significant difference between forecast NorthConnex daily traffic volumes to the worst case traffic volumes (design analysis A). This provides an allowance for incidents, traffic mix and increased traffic. The graph on the following page shows the level of passenger car units (PCU) at different times of the day. A comparison of the forecast traffic against the worst case traffic figure (design analysis A) shows there is a significant margin of conservatism (a factor of more than two).
- The traffic scenario and air quality impacts using the traffic figures in design analysis A are very unlikely to eventuate.

- The performance of the ventilation system has been assessed and verified against the worst case traffic figures (design analysis A), based on a full tunnel using a range of vehicles speeds (80, 60, and 40 km/h) and stationary traffic. In all cases the in-tunnel air quality design criteria would be met by the proposed ventilation system.
- The air quality impact assessment presented in the environmental impact statement considers expected air quality performance based on forecast traffic volumes, as well as the design analysis A traffic figures. In both cases the project meets ambient air quality criteria.

In summary, this approach demonstrates that even if the NorthConnex project had more than twice the expected daily traffic volume than anticipated, the tunnel ventilation system would operate effectively and meet in-tunnel and out-of-tunnel air quality criteria.

In-tunnel air quality

A number of submissions questioned whether the tunnel ventilation system would achieve appropriate in-tunnel air quality.

The key to ensuring an effective, efficient and safe tunnel is the establishment of appropriate design criteria for in-tunnel air quality conditions. The ventilation system for the NorthConnex project has been designed and would be operated to meet the in-tunnel air quality criteria.

In-tunnel criteria are generally expressed in maximum concentration levels for a period of time. The expected travel time through the NorthConnex tunnels would be around seven minutes under normal operation at 80 km/h, nine minutes at 60 km/h and 14 minutes at 40 km/h.

The ventilation system would be automatically controlled using “real time” traffic data covering both vehicle mix and speed, and feedback from air quality sensors in the tunnel, to ensure in-tunnel conditions are managed effectively in accordance with the agreed criteria. Further, there would be specific ventilation modes developed to manage breakdown, congested and emergency situations.

Ventilation design

Submissions made by key government agencies state all feasible and reasonable mitigation measures be identified and applied to reduce exposure to vehicle emissions within the tunnels and surrounding environment. Community submissions have raised concerns about in-tunnel air treatment (filtration), ventilation outlet heights and ventilation outlet locations.

A key mitigation measure to reduce human exposure to vehicle emissions is to design the tunnel infrastructure to minimise the creation of emissions by vehicles using it. Emission quantities will vary depending on traffic mix, quantity, speed and gradient. Roads with free-flowing traffic in and out of the tunnel, together with flat grades, will create the least amount of emissions.

The NorthConnex design provisions to mitigate emissions within the tunnel include:

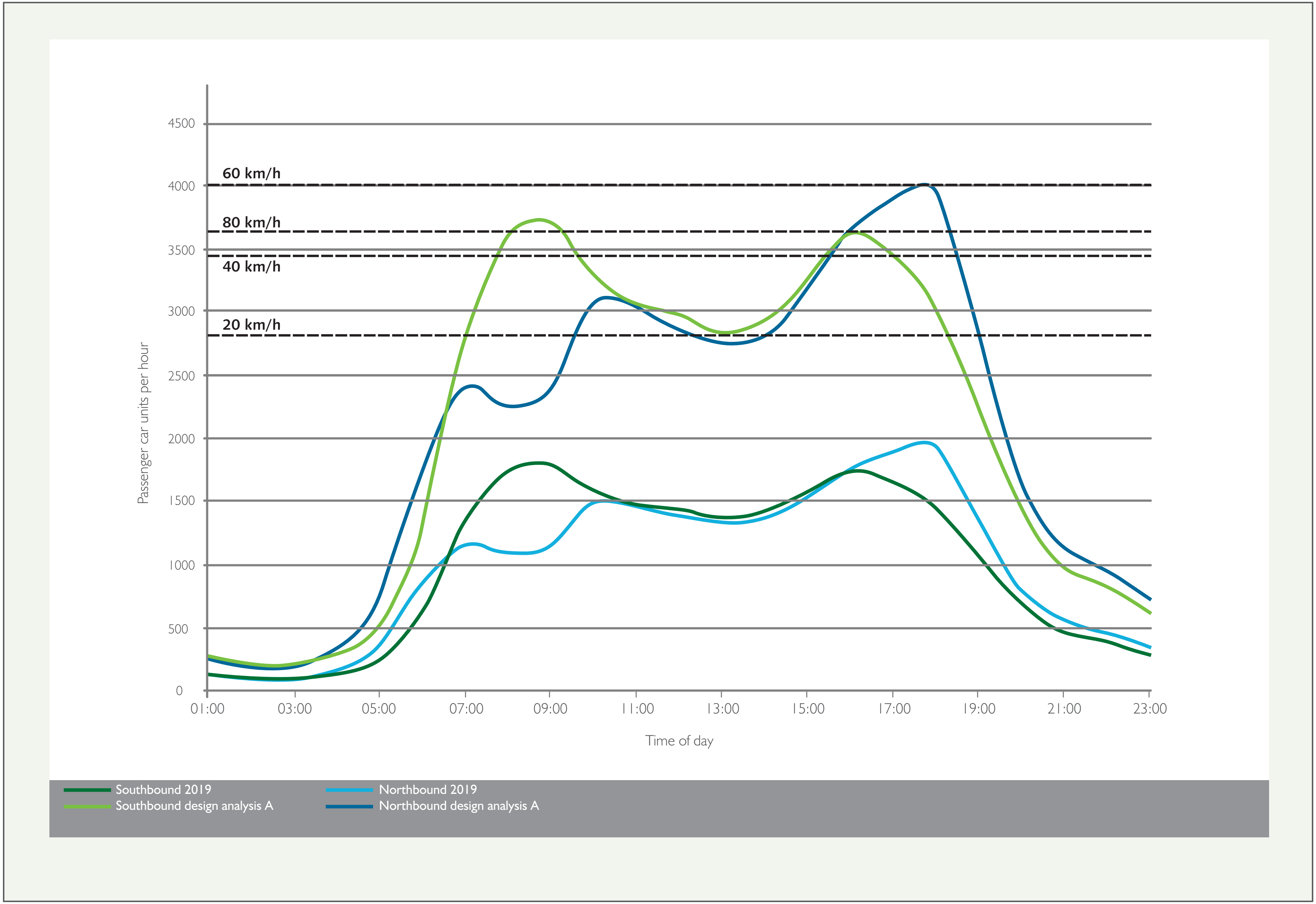
- **Minimal gradients** - The NorthConnex tunnels would be very flat (around eight kilometres with a grade of around 1.5 per cent south to north), with short entry and exit ramps of around four per cent. By way of comparison, the M5 East tunnel has a grade of up to eight per cent on the western exit, which causes trucks to slow down and increase emissions. The NorthConnex project alignment, with motorway-to-motorway connections at both ends, ensures efficient operation of vehicles in the tunnel and minimises emissions generated. This results in significantly less emissions than equivalent vehicles using Pennant Hills Road.
- **Large tunnel cross-section** – the NorthConnex project has a very large tunnel cross-sectional area. This allows a greater air flow along the tunnel.
- **Low air velocity** - Good engineering practice for longitudinally ventilated tunnels, is to limit maximum air velocity to 10 metres per second (m/s) (36 km/h). For the NorthConnex project, the maximum air volume vertically exhausted from the tunnel is $700m^3/s$. Of this maximum air flow volume, $600m^3/s$ is drawn along the full length of the tunnel from the entrance portal with a further $100m^3/s$ drawn in from the adjacent exit portal. The 100 m^3/s ensures the zero portal emissions criterion is met. Therefore, air velocities along the tunnel resulting from the $600m^3/s$ flow will be around 8 m/s (29 km/h) – well within the maximum limit.
- **Increased height** - The significantly higher NorthConnex tunnel, 5.3 metres versus the 4.6 metres in the M5 East, also minimises the risk of overheight incidents blocking the tunnel, ensuring free-flowing traffic is not disrupted by oversized heavy vehicles. Evidence of this is Westlink M7 Motorway which has a minimum overpass bridge headroom of 5.3 metres.
- **Smoky vehicle cameras** – These would be installed to automatically detect vehicles with excessive exhaust smoke, with penalties applying to offenders. A similar initiative is in place for the M5 East tunnel and has resulted in a reduction of smoky vehicles using the tunnel.

Analysis of alternatives to further improve air quality

In addition to the infrastructure provisions, an analysis of ventilation design alternatives has been carried out (refer to **Section 3.2** of this report), as summarised below:

Ventilation outlet heights - Further analysis was carried out to assess the implications of increasing the ventilation outlets by two, five, 10 or 15 metres. The analysis considered the change in the ventilation outlet performance and the impacts to the community.

It found that increasing the height by five metres would improve performance while not unduly increasing adverse visual impact. This is a feasible and reasonable means of optimising the dispersion of emissions while maintaining performance of the in-tunnel ventilation system.



Design analysis A (PCU) relative to traffic design capacity

(blank page)

The project scope has therefore been amended to include this increase with further assessment of environmental impacts presented in **Section 9.2** of this report.

Ventilation outlet locations – Relocating the outlet, as demonstrated through the additional analysis of environmental impacts including air quality, health, visual amenity, land and cost, offers no significant improvement in environmental outcomes, notably in relation to out-of-tunnel air quality. Given this, the additional environmental impact, property acquisition requirements and engineering constraints are not considered appropriate.

Additional ventilation outlets – These would improve in-tunnel and ambient air quality outcomes but would introduce significant additional environmental and land use impacts that would outweigh any minor air quality benefits.

Ventilation flow rates – The average in-tunnel air quality levels for particulate matter and nitrogen dioxide are well within acceptable limits for both free-flowing and slow moving traffic. There is an opportunity to further improve the in-tunnel air quality levels by drawing additional air into the tunnel through the tunnel support facilities at Trelawney Street and Wilson Road. This operation would be adopted to optimise in-tunnel air quality to ensure the proposed design criteria is met at all times.

Air treatment systems – Filtration can be used to reduce particulate matter and with more recent technology, nitrogen dioxide levels if acceptable in-tunnel or external air quality criteria cannot be met by conventional ventilation systems.

The NorthConnex project has carried out analysis of the environmental, land use, engineering and cost implications of a filtration treatment system (refer to **Section 3.2** of this report). The analysis of the availability, sustainability and efficiency of such technology (refer to **Section 3.1** of this report) has been completed. The conclusions are:

- Most tunnels achieve acceptable air quality criteria without filtration. Less than one per cent of tunnels in the world use filtration to reduce particulate matter or nitrogen dioxide levels to maintain acceptable in-tunnel or external air quality. No tunnels in Australia use filtration to meet their air quality criteria.
- In some international tunnels where filtration systems are installed they are seldom used.
- According to a CETU Study (2010), there are around 60 tunnels with filtration worldwide, eight are in Norway (where there are more than 900 road tunnels) and 45 are in Japan (where there are 8,000 tunnels).
- In Norway, filtration systems are required for the high dust concentration related to the use of studded tyres and large amounts of sand and salt dispersed in winter.
- In Japan, they are required to address the high number of diesel powered cars, the high percentage of heavy vehicles and poor local air quality.
- Other tunnels with filtration systems in Spain, Italy, France, Austria, Vietnam and South Korea, have specific local conditions that have to be managed, including poor external air quality, poor fleet and local geographical conditions.
- In Australia, there was a trial system in the M5 East Motorway that was not found to be effective. This trial was not on the outlets, it was used to manage air being recycled between the westbound and eastbound tunnels, and in-tunnel air quality.

- The technology around tunnel air filtering systems for nitrogen dioxide is relatively new and any benefit has yet to be sufficiently measured.
- The majority of tunnel air filtration systems are primarily "to improve visibility in the tunnels where visibility is affected by particulate pollution, or to minimise the need for fresh air renewal in very long tunnels. These systems are rarely used solely for environmental purposes" (CETU 2010).
- NorthConnex in-tunnel air quality levels, which are comparable to best practice and accepted elsewhere in Australia and throughout the world, would be achieved without filtration. As the conventional ventilation system is effective, there would be little benefit in providing an in-tunnel filtration system.
- If in-tunnel air quality levels could not be achieved with the proposed NorthConnex ventilation system, the most effective solution would be the introduction of additional ventilation outlets and additional air supply locations. This is a proven solution and more sustainable and reliable than tunnel filtration systems.
- Incorporating filtration to the ventilation outlets would have negligible benefit and require a significant increase in the size of the tunnel facilities to accommodate the equipment. It would result in increased project size, community footprint, and capital cost. The energy usage would be substantial and does not represent a sustainable approach. Further, the air leaving the outlet is not highly concentrated with pollutants (as demonstrated by the air quality assessment) since it must be of a quality to be acceptable for tunnel users. Any predicted impact on local air quality is very small even without a filtration system.

In summary, the provision of a tunnel filtration system does not represent a feasible and reasonable mitigation measure and is not being proposed.

Tunnel safety

The air quality forum held on 29 July 2014, and submissions received from the community queried the impact of an in-tunnel fire as a concern.

Section 2.7.2 of this report provides a more detailed analysis of the potential for in-tunnel fire incidents, including consideration of incident rates in other road tunnels. It demonstrates the likelihood of an in-tunnel fire incident is very low, taking into account the design of the project, exclusion of dangerous goods traffic from the tunnel and the use of emergency infrastructure and response procedures. It also discusses the low consequence of in-tunnel fires and how these potential consequences would be further reduced through the emergency management systems included in the project design. The outlets would be designed to meet the requirements of AS1668 with respect to ensuring the safe and effective dispersion of smoke in the event of a fire.

In summary, the likelihood of significant fire incidents in the tunnel is low. In the rare event of a significant fire incident, smoke would be 'scrubbed' by the in-tunnel fire suppression deluge system before effective dispersion via the tunnel support systems. The risk to human health is at worse, no higher than uncontrolled dispersion of smoke from a fire incident on the surface.

Noise and vibration

Further project design development around the southern interchange near Coral Tree Drive, has identified the need for more consideration of noise mitigation measures for residents in this area. **Section 4.4** of this report presents additional analysis of operational traffic noise impacts for residents along Coral Tree Drive, and identifies:

- The need for a two-noise barrier configuration next to the connection between the NorthConnex project and the Hills M2 Motorway.
- An additional six properties in addition to those identified in the environmental impact statement who would be eligible for consideration of at-property acoustic treatments.

Ongoing consultation with the Department of Planning and Environment as part of the assessment for the NorthConnex project, and concerns raised in several submissions have identified the need for more details of the construction noise mitigation and management measures to be presented.

Section 4.5 of this report provides more information and includes:

- Details of predicted noise impact around construction sites, including the level of noise impact and the number of residents potentially affected by the impact.
- Site and property specific noise mitigation and management commitments, taking into account the predicted level of noise impact. These mitigation and management measures have been modelled on similar approaches taken for the North West Rail Link and the Hills M2 Motorway upgrade projects.

Operational air quality

In addition to the clarification of air dispersion modelling presented in **Chapter 2** of this report, several submissions, including those from the key government agencies, have raised concerns relating to the air quality impact assessment. Many relate to testing the sensitivity of the air quality impact assessment to changes in modelling assumptions, including:

- Traffic forecasts.
- Vehicle fleet and fuel mix.
- Vehicle speed in the tunnel, including congested conditions.

The environmental impact statement considered forecast traffic scenarios in 2019 and 2029, as well as a worst-case traffic scenario based on the maximum traffic design capacity of the main tunnels ('Design Analysis A'). Further information is provided in relation to forecast traffic volumes and Design Analysis A as part of the response to the submission from the Environmental Protection Authority (EPA) (refer to **Section 7.1** of this report). This information demonstrates and confirms the range of conceivable potential traffic volumes that may use the tunnels has been considered in the EIS, and acceptable environmental outcomes would be achieved.

Clarifications of assumptions around the vehicle fleet and fuel mix have been provided in response to concerns raised in the submissions from the EPA and Ku-ring-gai Council. In particular, further analysis has been carried out around potential changes in the petrol-diesel mix of the vehicle fleet. This analysis demonstrated changes in petrol-diesel mix assumptions would have a minor impact on in-tunnel and ambient air quality. This analysis is considered to be conservative since it does not take into account future declines in vehicle fleet emissions from 2020, including the proposed introduction of Euro 6 standards for heavy-duty diesel engines in Australia from 2017.

As a consequence, a more conservative set of assumptions around petrol-diesel mix have been applied to the additional air dispersion modelling done for the five metre height increases of the southern and northern ventilation outlets (refer to **Section 9.2** of this report).

Further discussion has been provided in **Section 2.5** to demonstrate the NorthConnex project has been designed to operate as a free-flowing motorway connection with an average traffic speed of 80 km/h. The likelihood of low traffic speeds (40 km/h or less) or congested traffic conditions have been minimised through project design and operational measures and procedures. These operational strategies would be implemented as part of the design development phase to ensure in-tunnel air quality is managed within acceptable levels in the unlikely event of a drop in traffic speed or congestion in the tunnel.

Project development and alternatives

Concerns raised in relation to the project development and alternatives included strategic planning and evolution of the project.

Further discussion of scope and findings of the F3 to Sydney Orbital Link Study (SKM, 2004) and the subsequent Pearlman Review of that report is provided in the relevant parts of **Section 8.1** and **Section 8.2** of this report.

Planning and statutory requirements

Submissions have queried the scope and level of detail of the assessments presented in the environmental impact statement, particularly, compliance with the environmental assessment requirements issued by the Secretary of the Department of Planning and Environment.

Where relevant in **Chapter 7** and **Chapter 8** of this report, further discussion and demonstration of the adequacy of the environmental impact statement has been provided, with reference to the Secretary's environmental assessment requirements and current impact assessment guidelines and policies. In each case, the environmental impact statement has been demonstrated an appropriate, robust and conservative assessment of the potential impacts of the NorthConnex project during construction and operation.

Further statutory concerns raised in public submissions include the duration of the public exhibition period and declaration of the project as critical State Significant Infrastructure.

A discussion of these matters is provided in **Chapter 8** of this report, noting these matters are the responsibility of the Department of Planning and Environment, or otherwise dictated by the requirements of the *Environmental Planning and Assessment Act 1979*.

Construction traffic impact

The major construction traffic issue raised in submissions related to the potential impact of heavy vehicles on the surrounding road network. Of particular concern was the use of local residential streets for heavy vehicle movements.

In response, heavy vehicle access routes during construction have been reviewed and revised. This has principally focused on those construction sites where the use of local residential streets was originally contemplated:

- The southern interchange compound (C5).
- Trelawney Street compound (C7).
- The northern interchange compound (C9).

Construction traffic access arrangements at these sites have been changed to avoid the need to use local residential streets. As a result, construction traffic and noise impacts are expected to improve. Further information about these changes is presented in **Section 9.4** of this report.

Consultation

Submissions have raised various concerns relating to community consultation, particularly the adequacy and extent of consultation activities during development of the project and preparation of the environmental impact statement. Submissions suggested the level of consultation had not been sufficient.

Chapter 5 of this report provides a detailed summary of community and stakeholder consultation carried out in relation to the NorthConnex project. This summary demonstrates that the outcomes of consultation activities were used to inform the project and its assessment in a meaningful way.

Urban design, landscape character and visual amenity

Key concerns raised in submissions in relation to urban design, landscape character and visual amenity, principally relate to the appearance of operational infrastructure (including the ventilation outlets, motorway operations complex and tunnel support facilities at Wilson Road and Trelawney Street). Concerns relating to landscaping in and around these sites, and along the Hills M2 Motorway and M1 Pacific Motorway were also raised.

As identified in the environmental impact statement and in **Section 8.13** of this report, further consideration of urban design and landscaping would be done as part of the detailed design for the NorthConnex project. It is recognised minimising the visual impacts and optimising integration into the surrounding landscape will be an important focus.

The Technical Working Paper: Urban Design (Appendix I of the environmental impact statement) provides urban design and landscape plans for the NorthConnex project. These will be further developed as part of detailed design and documented in an

Urban Design and Landscape Plan. As identified in the Community Communication Framework (Appendix D of the environmental impact statement), the Urban Design and Landscape Plan would be developed in consultation with the community and relevant local councils.

Land use and property impacts

Key concerns raised in submissions relating to land use and property impacts included property acquisition, compensation and property values.

As detailed in the environmental impact statement and in **Section 8.20** of this report, the need for acquisition of properties has been minimised. A key feature of the NorthConnex project has been a design and construction methodology that requires relatively little space, is largely within the existing road corridor, and as a consequence, has a relatively low level of property acquisitions compared to other road projects. All properties directly affected are subject to acquisition and compensation in accordance with the *Land Acquisition (Just Terms Compensation) Act 1991*. Discussions with affected property owners in relation to acquisition arrangements started when the project was announced on 16 March 2014.

Compensation or acquisition of other properties not directly affected by the project is not proposed, based on the demonstration in the environmental impact statement that the potential impacts would be within acceptable limits.

Section 8.20 of this report provides further information on the potential impacts of major infrastructure projects on property prices and recent residential property sales activity along the project. Based on this information and the demonstration of acceptable environmental and land use impact presented in the environmental impact statement, there is no technical basis or evidence of negative changes in property values as a result of the project.

Social and economic impacts

Concerns relating to social and economic impacts have principally focused on dust, traffic and noise generated during construction and operation. These concerns are discussed broadly in **Section 8.15** of this report, and in specific detail in relevant (air, noise, traffic) sections of the report. The environmental impact statement and this report have demonstrated amenity impacts can be mitigated and managed within acceptable limits. As a consequence, social and economic impact is anticipated to be minimal.

As presented in the environmental impact statement, the NorthConnex project is expected to lead to significant social and economic improvements along the Pennant Hills Road corridor during operation as a result of reduced congestion and improvements to travel time, air quality, noise, and road safety., The project is also expected to provide wider economic benefits through it's contribution to improving the efficient movement of freight in NSW.

Next steps

All stakeholders and members of the community who made a submission on the NorthConnex environmental impact statement (if contact details have not been withheld) will receive a letter to confirm the release of the report and details of where they can find a response to their submission. The project team will also provide information on the project website (www.northconnex.com.au) and distribute a community update to inform the local community.

The Department of Planning and Environment will assess this project, including information provided in the environmental impact statement, concerns raised in submissions and responses provided in this report and the proposed changes to the project to reduce environmental impacts described and assessed in the preferred infrastructure report.

The Department will then make a recommendation to the Minister for Planning, who will make a decision on whether to approve the project and any conditions applied if the project is approved.

(blank page)

1 Introduction

1.1 The project

Roads and Maritime Services (Roads and Maritime) proposes to construct and operate a tolled motorway, known as the NorthConnex project, linking the M1 Pacific Motorway at Wahroonga to the Hills M2 Motorway at Carlingford in northern Sydney (the project). The project would deliver a high standard motorway that integrates with the regional transport network.

The NorthConnex project comprises the following key features:

- Twin motorway tunnels up to around nine kilometres in length with two lanes in each direction. The tunnels would be constructed with provision for a possible third lane in each direction if required in the future.
- A northern interchange with the M1 Pacific Motorway and Pennant Hills Road, including sections of tunnel for on-ramps and off-ramps, which would also facilitate access to and from the Pacific Highway.
- A southern interchange with the Hills M2 Motorway and Pennant Hills Road, including sections of tunnel for on-ramps and off-ramps.
- Integration works with the Hills M2 Motorway including alterations to the eastbound carriageway to accommodate traffic leaving the Hills M2 Motorway to connect to the project travelling northbound, and the provision of a new westbound lane on the Hills M2 Motorway extending through to the Windsor Road off-ramp.
- Tie-in works with the M1 Pacific Motorway extending to the north of Edgeworth David Avenue.
- A motorway operations complex located near the southern interchange on the corner of Eaton Road and Pennant Hills Road that includes operation and maintenance facilities.
- Two tunnel support facilities incorporating emergency smoke extraction outlets and substations.
- Ancillary facilities for motorway operation, such as electronic tolling facilities, signage, ventilation systems and fire and life safety systems including emergency evacuation infrastructure.
- Modifications to service utilities and associated works at surface roads near the two interchanges and operational ancillary facilities.
- Modifications to local roads, including widening of Eaton Road near the southern interchange and repositioning of the Hewitt Avenue cul-de-sac near the northern interchange.
- Ancillary temporary construction facilities and temporary works to facilitate the construction of the project.

The regional context of the project is shown in **Figure 1-1**. An overview of the project in the local context is shown in **Figure 1-2**. A detailed description of the project is available in Chapter 5 of the NorthConnex project environmental impact statement.

1.2 Statutory context

On 25 October 2013 the NorthConnex project was declared by the Minister for Planning to be State significant infrastructure and critical State significant infrastructure under sections 115U (4) and 115V of the *Environmental Planning and Assessment Act 1979*. Roads and Maritime is seeking approval for the project under Part 5.1 of that Act.

In accordance with the requirements of the *Environmental Planning and Assessment Act 1979*, an environmental impact statement was prepared to assess the potential impacts of the project. This was submitted to the Department of Planning and Environment in July 2014 and placed on public exhibition for a period of sixty days.

1.3 Purpose of the document

During the exhibition of the environmental impact statement, 1,518 submissions were made. The Secretary (formerly the Director-General) of the Department of Planning and Environment provided copies of the submissions to Roads and Maritime.

In accordance with section 115Z of the *Environmental Planning and Assessment Act 1979*, the Secretary required Roads and Maritime to respond to the issues raised in these submissions in a submissions report. The Secretary also advised that if there are any proposed changes to the project to minimise its environmental impact or to address issues raised in submissions, a preferred infrastructure report would be required. This NorthConnex Submissions and Preferred Infrastructure Report document has been prepared to fulfil both of these requirements.

This report presents the following information:

- A number of clarifications to information presented in the environmental impact statement in relation to air quality (**Chapter 2**).
- Further discussion of in-tunnel air treatment technologies and a review of feasible and reasonable ventilation design options and alternatives to minimise in-tunnel and ambient exposures to vehicle emissions (**Chapter 3**).
- A number of clarifications to information presented in the environmental impact statement in relation to the scope and design of the project, and noise issues (**Chapter 4**).
- Details of the community involvement activities carried out for the project during the public exhibition period (**Chapter 5**).
- A summary of the submissions received during the public exhibition period (**Chapter 6**).
- Responses to the issues raised in submissions received from government agencies and local councils (**Chapter 7**).
- Responses to the issues raised in submissions received from the local community (**Chapter 8**).
- Changes made to the project as presented in the environmental impact statement to further minimise its environmental impact and / or in response to issues raised in submissions (**Chapter 9**).
- A revised summary of mitigation measures, to those presented in the EIS, which have been updated to reflect responses to issues raised in submissions and changes made to the project (**Chapter 10**).

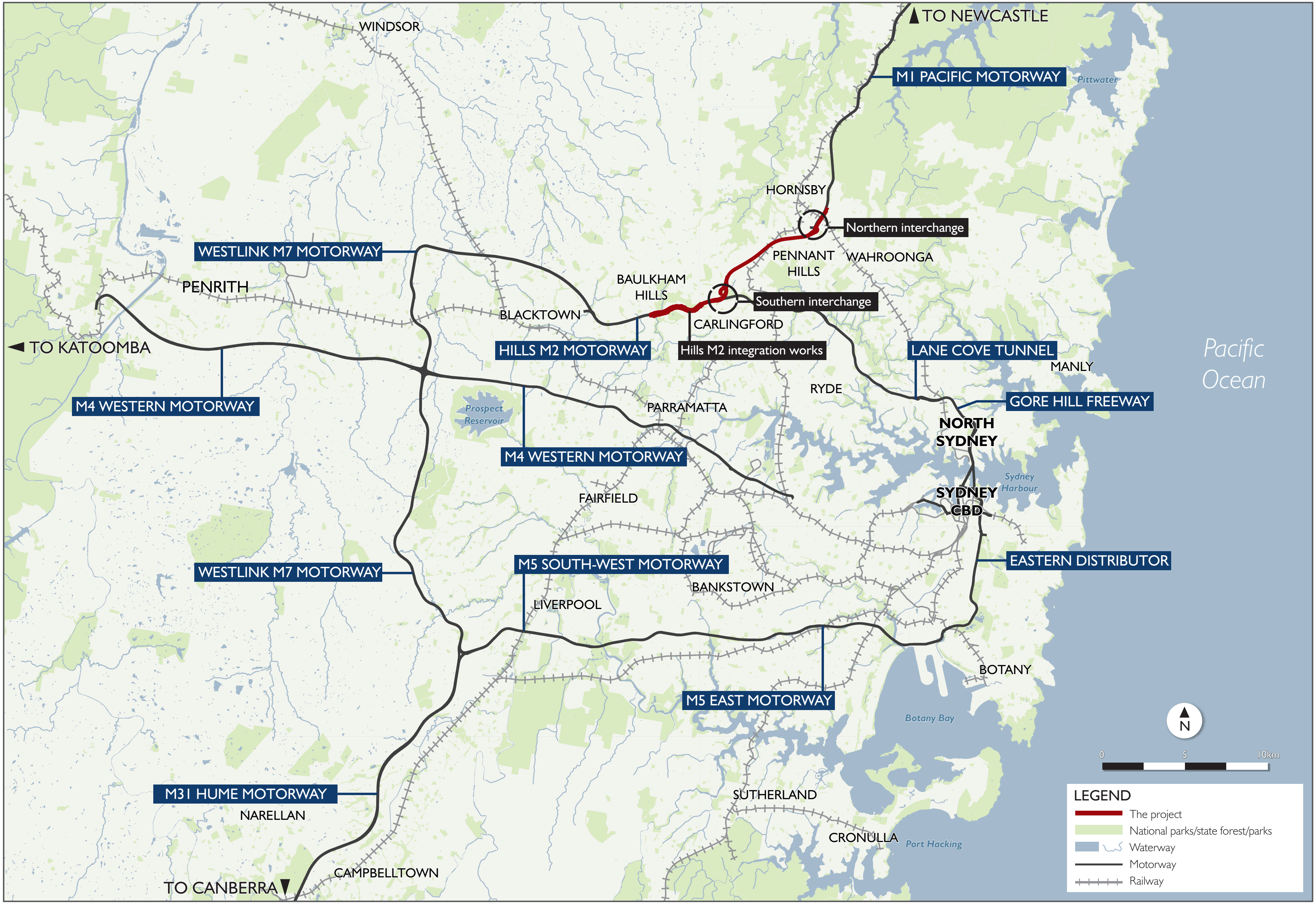


Figure 1-1 Regional context of the project

(Blank page)

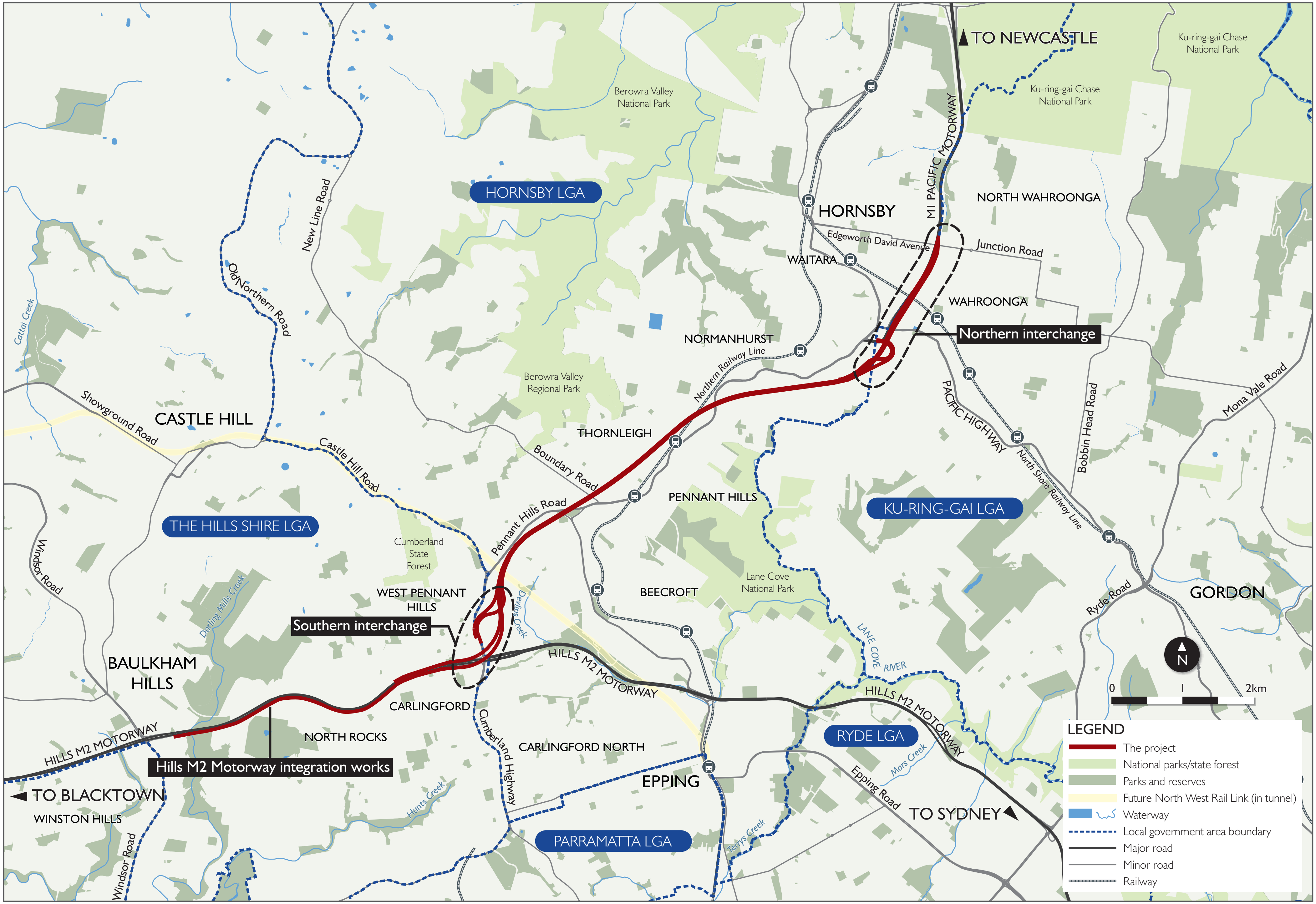


Figure 1-2 Local context of the project

(Blank page)

2 Clarifications – Air quality

This chapter presents the reorganisation and consolidation of relevant material regarding air quality previously contained in Section 7.2 and Appendix G of the environmental impact statement. In particular, it seeks to explain in a clear and consolidated way, the air quality impact assessment for the project, including a description of the inputs, methodology and assumptions. Further detail has been provided where relevant to respond to specific issues raised in submissions on the environmental impact statement. Additional sensitivity testing of modelling assumptions has also been included.

Chapter 3 of this report includes discussion of ventilation design options and alternatives and an assessment of feasible and reasonable measures that could be applied to the project to further reduce in-tunnel and ambient exposures to vehicle emissions.

Chapter 9 of this report details several changes that have been made to the project in order to further reduce environmental impacts. These changes include increasing the height of the northern and southern ventilation outlets by five metres.

2.1 Purpose of this chapter

The reorganisation and consolidation of relevant air quality information previously presented in the environmental impact statement in this chapter aims to:

- Address the criticism in some submissions about the presentation, clarity and robustness of the air quality impact assessment presented in the environmental impact statement.
- Reproduce the air quality impact assessment methodology originally presented in the technical working paper: air quality for the NorthConnex project, with clarifications of methodology, assumptions and inputs where relevant.
- Include further information around methodology, assumptions and inputs in response to specific issues raised in submissions on the environmental impact statement, including issues raised by the Environment Protection Authority, NSW Health and other community members and stakeholders.
- Provide further sensitivity testing of modelling assumptions to demonstrate the robust and conservative nature of the air quality impact assessment, consistent with typical environmental impact assessment practice and policy in New South Wales.
- Indicate where methodology, assumptions and inputs have been updated as part of the further air quality impact assessment conducted for an increase in ventilation outlet heights by five metres (refer to **Section 9.2** of this report).
- Provide a single, consolidated description and explanation of the methodology, assumptions and inputs into the air quality impact assessment for the NorthConnex project.

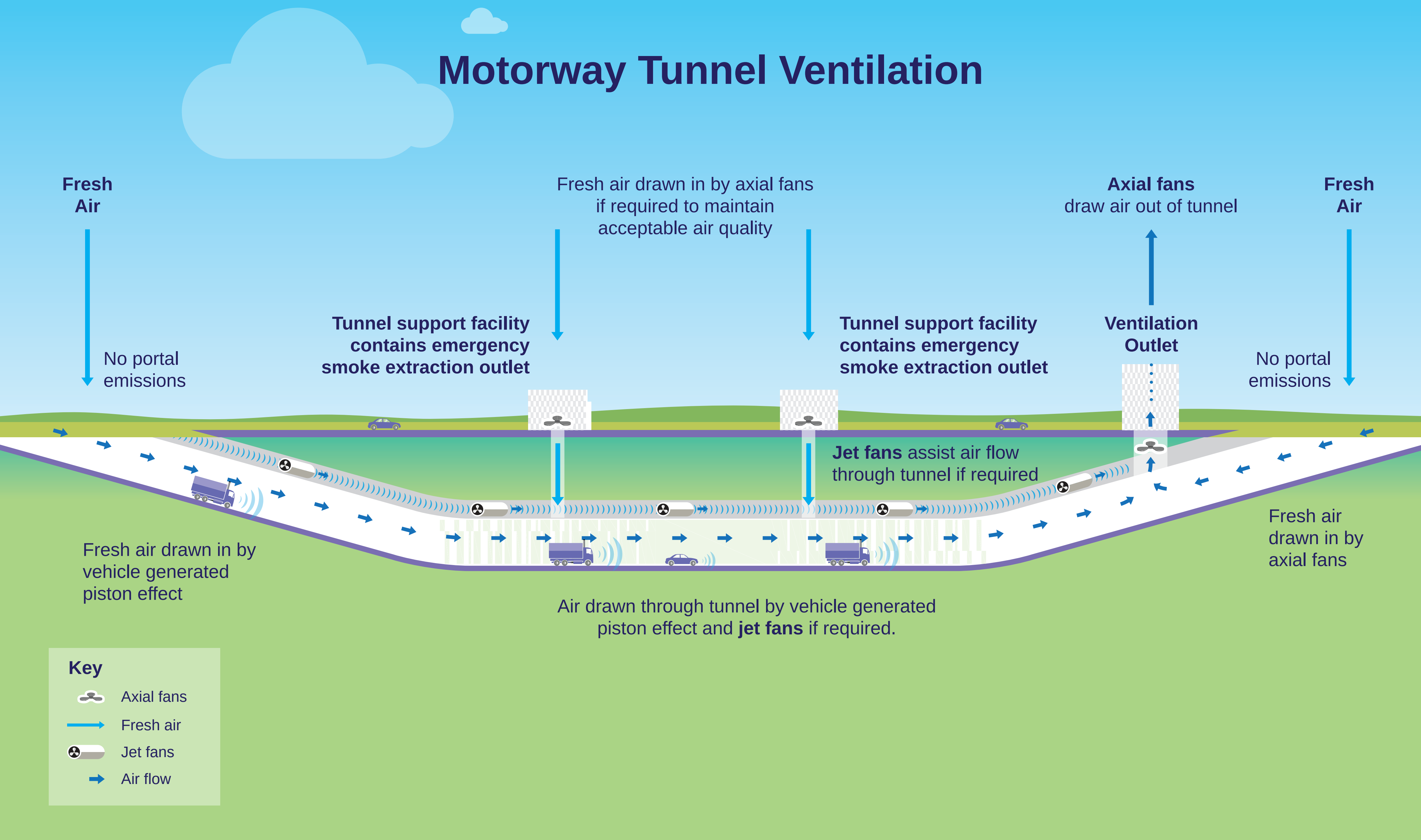
2.2 Chapter outline

This chapter includes information and discussion in relation to:

- The purpose of this chapter (refer to **Section 2.1**).
- Changes since the exhibition of the environmental impact statement (refer to **Section 2.3**).
- The components of the project relevant to air quality (refer to **Section 2.4**).
- The ventilation system design criteria that have been applied to the project (refer to **Section 2.5**).
- The assessment philosophy and approach to conservatism in the air quality impact assessment (refer to **Section 2.6**).
- Traffic volumes and assessment scenarios (refer to **Section 2.7**).
- The methodology used to calculate the emissions inventories for the project (refer to **Section 2.8**).
- In-tunnel air quality (refer to **Section 2.9**).
- Meteorological data and modelling (refer to **Section 2.10**).
- Ambient air quality (refer to **Section 2.11**).
- Local and regional terrain (refer to **Section 2.12**).
- Dispersion modelling (refer to **Section 2.13**).
- Post-processing of dispersion modelling outputs (refer to **Section 2.14**).
- The operational air quality impact assessment of the project (refer to **Section 2.15**).
- Construction air quality (refer to **Section 2.16**).

A diagram illustrating the key components of the project ventilation system is provided on the following page to assist in interpreting the text in **Section 2.4** and **Section 2.5**.

Motorway Tunnel Ventilation



(blank page)

2.3 Changes since the exhibition of the environmental impact statement

This chapter principally reflects the methodology, assumptions and inputs applied to the air quality impact assessment presented in the environmental impact statement, with further discussion and clarification of the methodology, assumptions and inputs where required to respond to issues raised in submissions. This further discussion and clarification has been provided as supplementary information and has not altered the approach taken to the modelling and assessment of air quality impacts as presented in the environmental impact statement.

In response to issues raised in submissions, and as detailed further in **Section 3.2** of this report, a review of ventilation options and alternatives has been conducted to identify feasible and reasonable measures to further minimise in-tunnel and ambient exposures to vehicle emissions. This review has concluded that an increase in the height of the northern and southern ventilation outlets by five metres is both feasible and reasonable. Accordingly, the height of both ventilation outlets has been increased by five metres (refer to **Section 9.2** of this report).

Increasing the height of the ventilation outlets has necessitated further operational air quality modelling and impact assessment. This has provided an opportunity to update some aspects of the air quality impact assessment methodology, assumptions and inputs to take into consideration comments received in response to the exhibition of the environmental impact statement. Broadly, these updates have included:

- Increasing the resolution of the receiver grid applied around each ventilation outlet (ie reduced receiver spacing) (refer to **Section 2.13.1**).
- Applying higher resolution topographic data (refer to **Section 2.12**).
- Revising future projections of vehicle fleet fuel mix, to reflect an increased use of diesel fuel in the future) (refer to **Section 2.7**).
- Amending the ozone limiting method equation to take into account a NO_2:NO_x ratio of 16 per cent, as recommended by the Environment Protection Authority (refer to **Section 2.14**).

Further detail of each of these updates in methodology, assumptions and inputs has been included in this chapter, where relevant.

2.4 Project description

Chapter 5 of the environmental impact statement provides description and details of the project.

In response to issues raised in public submissions and to further reduce the environmental impacts of the project, a series of amendments to the project have been made. Details of these amendments are provided in **Chapter 9** of this report.

The key amendment relevant to air quality is the increases in the northern and southern ventilation outlet heights by five metres. An impact assessment of this amendment for both the northern and southern ventilation outlets is provided in **Section 9.2** of this report, including the outcomes of air quality modelling using the methodology, assumptions and inputs detailed in this chapter.

The project involves the construction and operation of twin motorway tunnels up to around nine kilometres in length with two lanes in each direction. A description of the main design and operational features of the project relevant to the air quality assessment is provided in the following sections.

2.4.1 Road grade and tunnel design

The main alignment tunnels would have an absolute maximum grade of four per cent to maintain consistent traffic speeds and to minimise emissions.

The main alignment tunnels would be a minimum of 10.5 metres in width and a minimum of 5.3 metres in height. Each main alignment carriageway would consist of two lanes with a minimum posted speed limit of 80 kilometres per hour. Each lane would be 3.5 metres wide with the shoulder on the left hand side being 2.5 metres wide and the shoulder on the right hand side being one metre wide.

At opening of the project, each carriageway would be line marked for two lanes. If a decision is made to include a third lane in the spare physical capacity of the main alignment tunnels in the future, a separate assessment and approvals process would be conducted.

2.4.2 Ventilation system and facilities

The tunnel ventilation system would be operated to maintain appropriate air quality during both normal operation and emergency conditions (refer to **Section 2.5** for a discussion of ventilation system design criteria).

During operation, the ventilation system would draw fresh air into the tunnels via the entry portals and emit air from within the tunnels via two ventilation facilities. One of the ventilation facilities would be located near the northern tunnel portal and one would be located near the southern tunnel portal. The most energy efficient location for ventilation outlets is close to the main alignment tunnel portals. This is because vehicles travelling through the tunnels create a piston effect, which draws air into the tunnel and pushes it forward in the direction of traffic flow. Locating the ventilation outlets near the main alignment tunnel exit portals maximises the benefit of the piston effect and minimises the need for additional energy consumption to operate tunnel jet fans to draw air through the tunnels and to transport the exhaust air from the tunnel to the ventilation outlets. This approach provides ongoing environmental and cost benefits through the reduction in energy consumption and greenhouse gas emissions during tunnel operation.

The locations of ventilation outlets for the project were determined with consideration of proximity to the main alignment tunnel exit portals, and other factors including land use and access, land acquisition requirements, geology, engineering and construction constraints, potential landscape and visual impacts, and the location of other major infrastructure.

The project has been designed to have no portal emissions under normal operating conditions. Portal emissions may, however, be considered in the future, but would be subject to appropriate assessment and approval at the relevant time.

During emergency conditions, which are expected to occur infrequently (on average less than once per year), the ventilation system would extract smoke from the tunnel where required. The extracted smoke may be emitted from one or more of the following locations:

- Southern ventilation facility.
- Wilson Road tunnel support facility.
- Trelawney Street tunnel support facility.
- Northern ventilation facility.
- The tunnel portals.

The southern emergency smoke extraction outlet would be located on the corner of Wilson Road and Pennant Hills Road (at the Wilson Road tunnel support facility), and the northern emergency smoke extraction outlet would be located on the corner of Trelawney Street and Pennant Hills Road (at the Trelawney Street tunnel support facility). Key components of the project's ventilation system are summarised in **Table 2-1**.

Tunnel ventilation equipment would all be electrically powered, with power supplied from the grid via a project supply substation.

Table 2-1 Key ventilation system components

Component	Description
Jet fans	• Jet fans would be mounted in pairs, with each pair separated by a distance of around 90 metres. • A total of around 65 jet fans would be installed in the northbound tunnel and ramps and around 60 jet fans in the southbound tunnel and ramps. • Jet fans would be located throughout the tunnel and would operate as required to maintain in tunnel air quality requirements.
Emergency smoke extraction outlets	• Each tunnel support facility would have a minimum exhaust capacity of around 400 cubic metres per second to generate a net flow of around five metres per second along the tunnel (equivalent to 18 kilometres per hour). • Each tunnel support facility would consist of four horizontally mounted bidirectional axial fans, each with an exhaust capacity of around 135 cubic metres per second. • Emergency smoke extraction requirements could be achieved with three fans, with the fourth fan on standby. • During low traffic conditions, the tunnel support facilities may be used to supply additional fresh air to the tunnels if necessary to maintain acceptable in-tunnel air quality.
Ventilation facilities	• Two ventilation outlets would be required – one near each of the northern and southern main alignment tunnel portals. • Each ventilation outlet would have a maximum exhaust capacity of around 700 cubic metres per second. • The ventilation outlets would be serviced by five horizontally-mounted axial fans, each with an exhaust capacity of around 175 cubic metres per second. • Total ventilation requirements could be achieved with four fans, with the fifth fan on standby. During normal operation, however, all five fans would likely be operated at reduced capacity. • The ventilation facilities would maintain exit velocities from around 13 m/s to around 19 m/s under normal operating conditions. • The southern ventilation facility would have an outlet at around 20 metres in height, and a building height of seven metres when measured from Pennant Hills Road (note that the total height of the ventilation has been increased by five metres from the 15 metre height considered in the environmental impact statement. This change in ventilation outlet height is considered in more detail in **Section 9.2**). • The northern ventilation facility would have an outlet at around 20 metres in height and a building height of around seven metres when measured from the neighbouring land (note that the total height of the ventilation has been increased by five metres from the 15 metre height considered in the environmental impact statement. This change in ventilation outlet height is considered in more detail in **Section 9.2**).

The tunnel ventilation system would be operated in three principal modes:

- Normal traffic conditions.
- Low speed / congested conditions.
- Emergency conditions.

Operation of the ventilation system under each of these conditions is detailed in the following sections.

Normal traffic conditions

During normal operation, the tunnel would be longitudinally ventilated; that is, fresh air would be drawn into the tunnel from the entry portals and moved through the tunnels by a vehicle-generated piston effect (the suction created behind a moving vehicle, which pulls air into and through the tunnel) and pushed towards the tunnel exit portals. Tunnel air, which would contain vehicle exhaust emissions, would be drawn upwards into the ventilation outlets located near the main alignment portals via ventilation fans and discharged to the atmosphere.

For the tunnel off-ramps, air would be drawn from the portal back down the ramp, for extraction via the ventilation facility. This would require jet fans (used to accelerate the movement of air through the tunnel) to maintain the air flow against the direction of traffic flow. A similar approach would be applied to parts of the main alignment tunnels close to the exit portals to prevent portal emissions during normal and slow speed/ congested traffic conditions.

Air from within the tunnels, containing vehicle emissions, would be extracted from the tunnels prior to reaching the exit portals. Tunnel air would be removed via a ventilation take off and transferred to the ventilation facility via a vertical shaft. The air would then be discharged from the ventilation facility to the atmosphere.

Low speed/ congested traffic conditions

The piston effect of vehicle movements would be less pronounced during low speed traffic conditions. Under these conditions, the tunnel jet fans would be used as required to assist air flow. Additional fresh air intake may also be required, which would be achieved using the reverse flow operation of the axial fans in the two emergency smoke extraction points to draw in fresh air. The operation of axial fans in the ventilation facilities would be increased as required to ensure that acceptable air quality is maintained in the tunnels and to achieve acceptable dispersion of tunnel air following discharge to the atmosphere.

Emergency conditions

The two emergency smoke extraction outlets would principally function to maintain air quality in the tunnels in the event of a fire incident.

During smoke control, air would be extracted from the tunnel and transferred by operation of the jet fans to the closest emergency smoke extraction outlet, ventilation facility or portal. The smoke would then be discharged from the facility to the atmosphere.

The emergency smoke extraction outlets are expected to operate in smoke extraction mode infrequently and only during an emergency. Such operation would be for a short duration while emergency services and tunnel fire and life safety systems bring the situation under control. Further information about the potential for and management of in-tunnel fire events is provided in **Section 2.7.2**.

These facilities would also operate as required to supply fresh air the tunnels during low speed traffic conditions (discussed above).

2.5 Ventilation system design criteria

The project's ventilation system has been designed to achieve specified in-tunnel air quality outcomes for traffic volumes up to and including the maximum traffic throughput capacity of the project's main alignment tunnels. The ventilation system design criteria are provided in Table 7-95 of the environmental impact statement and are reproduced below. **Table 2-2** provides additional explanatory comments to provide context to the likely operational mode of the project relative to average traffic speeds and ventilation system design criteria.

Table 2-2 Ventilation system design criteria

Average traffic speed (km/h)	Operational mode	CO design criteria (15 minute)	NO_2 design criteria (15 minute)	Visibility (extinction coefficient)
80	Normal traffic conditions. Vehicles are moving freely with no congestion effects	50 ppm (57.5 mg/m^3)	0.5 ppm (0.94 mg/m^3)	<0.005 m^{-1}
60		50 ppm (57.5 mg/m^3)	0.5 ppm (0.94 mg/m^3)	<0.005 m^{-1}
40	Congested traffic conditions. Vehicles have slowed as a result of traffic congestion, caused by a vehicle accident or incident. Congestion management measures would be implemented as average traffic speeds fall towards 40 km/h.	60 ppm (69 mg/m^3)	0.8 ppm (1.51 mg/m^3)	<0.005 m^{-1}
0 to 20	Significantly congested traffic conditions. Vehicles have slowed significantly as a result of traffic congestion, caused by a vehicle accident or incident. Congestion management measures would be in place.	87 ppm (100 mg/m^3)	1.0 ppm (1.88 mg/m^3)	<0.005 m^{-1}

In applying the ventilation system design criteria outlined in **Table 2-2**:

- The carbon monoxide (CO) ventilation design criterion has been applied as **a 15-minute exposure standard** for a motorist using the project tunnels (with no allowance made for the mitigating effects of closing vehicle windows or recirculating vehicle air). For likely average traffic speeds through the main alignment tunnels, in-tunnel exposure durations would be less than 15 minutes, and as such, exposure to ambient air before and/ or after travel through a main alignment tunnel has also been taken into account when assessing motorist exposures. In the case of CO, ambient air has been assumed to be 5 ppm CO (5.73 mg/m^3 or equivalently 5,730 µg/m^3), which is higher than monitored background air quality data (refer to **Section 2.11**). For an example of a motorist travelling at an average speed of 80 kilometres per hour (ie an in-tunnel journey of around 6.75 minutes), the motorist's exposure to CO would be:
    - Around 6.75 minutes within the main alignment tunnel, with gradually increasing in-tunnel concentrations of CO from the tunnel entry portal to the ventilation offtake near the tunnel exit portal. The concentrations of CO experienced by the motorist within the main alignment tunnel would depend on the traffic volumes/ traffic mix at the time of the tunnel journey.
    - The remaining 8.25 minutes (to total 15 minutes) with exposure to ambient air, being assumed to be a constant 5 ppm (5.73 mg/m^3 or equivalently 5,730 µg/m^3) for the design and sizing of the ventilation system.
- The nitrogen dioxide (NO_2) ventilation design criterion has also been applied as **a 15-minute exposure standard**, and assessed in a similar way as outlined above for CO. For the purpose of taking into account background air quality, exposures prior to and following a journey through the project tunnels has been assumed to occur at 1 ppm NOx (1.88 mg/m^3 or equivalently 1,880 µg/m^3). Comparison with the monitored background air quality data (refer to **Section 2.11**) shows that this assumption overestimates likely ambient concentrations of NOx.
- The visibility design criterion has been applied as **an in-tunnel air quality standard**, applicable at all locations along the project tunnels, irrespective of potential motorist exposures.

As noted above, background concentrations of CO and NO_x outside the project tunnels have been assumed to be constant and above monitored background values. This is a conservative assumption because a higher assumed exposure to CO and NO_x outside the project tunnels means that a motorist must be exposed to lower concentrations in the project tunnels (than if a lower background concentration outside the project tunnels had been assumed) in order for the ventilation design criteria to be met (as exposure standards). This approach will have led to a slight over-design in the ventilation system capacity to maintain lower-than-required in-tunnel concentrations of CO and NO_x. This slight over-design provides additional latent ventilation capacity in the event that it is ever required and is considered to be a prudent approach to the design and management of a road tunnel ventilation system.

2.5.1 Design capacity of the project's ventilation system

The total number of vehicles (measured as a standard passenger car unit) that can pass a fixed point in a motorway lane per hour is dependent on the average speed of traffic. 'Passenger car units' is a standard, consistent basis for measuring the 'space' taken up by different size vehicles. For example:

- A standard passenger vehicle is one passenger car unit.
- An articulated truck is 2.9 passenger car units.
- A truck and dog is two passenger car units.

This relationship between the theoretical motorway lane 'throughput capacity' and average traffic speed is illustrated in **Figure 2-1**. The figure shows that:

- A maximum motorway lane capacity of 2,000 passenger car units per lane per hour is achievable at an average traffic speed of 60 km/h. This means that 2,000 passenger car units could pass a fixed monitoring point on a motorway lane every hour if traffic is travelling at 60 km/h.
- At an average traffic speed of 80 km/h per hour, a greater stopping distance is required between vehicles. Because of this, only 1,740 passenger car units would pass the same fixed point on a motorway lane per hour.
- At an average speed of 40 km/h, a shorter stopping is required between vehicles, but the vehicles are moving more slowly. Because of this, only 1,849 passenger car units would pass the same fixed point on a motorway lane per hour. For 20 km/h, this figure would drop further to only 1,419 passenger car units per hour.

For the two lane configuration of each of the project's main alignment tunnels, this means that for a fixed point, the following maximum vehicle throughputs could be accommodated:

- A maximum of 3,480 passenger car units per hour (two lanes) at 80 km/h.
- A maximum of 4,000 passenger car units per hour (two lanes) at 60 km/h.
- A maximum of 3,698 passenger car units per hour (two lanes) at 40 km/h.

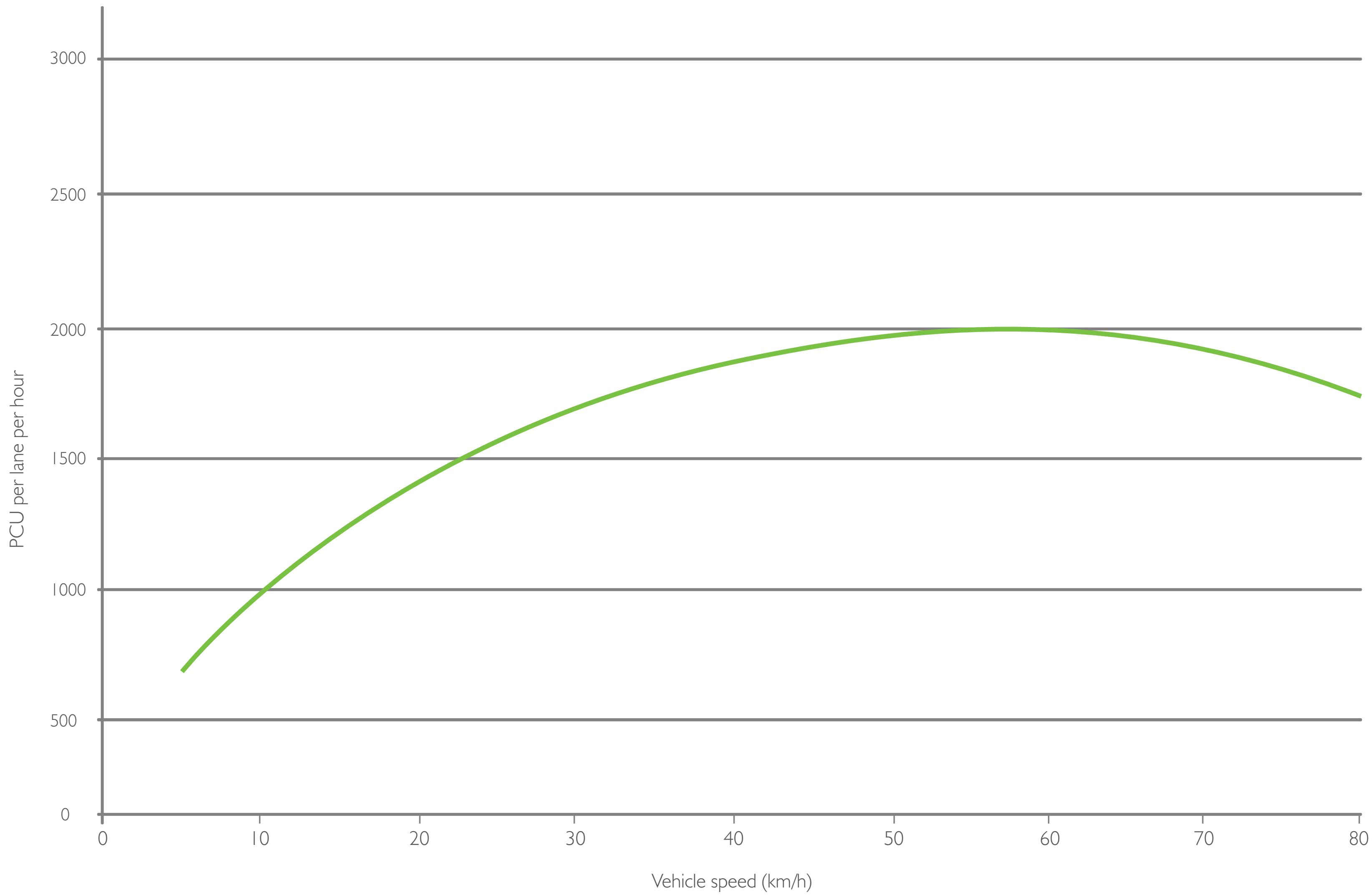


Figure 2-1 Relationship between motorway lane capacity and average traffic speed

(blank page)

By virtue of the physical capacity of a motorway lane to allow traffic to pass, the 'worst case' in-tunnel vehicle emissions scenarios for the project would occur whenever the maximum throughput of traffic is experienced at the relevant average traffic speed, as listed above. As part of the ventilation design process for the project, these 'worst case' vehicle emissions scenarios have been analysed and the ventilation system sized to provide sufficient air flow to ensure that in-tunnel concentrations of emissions do not exceed the design criteria specified in **Table 2-2**.

Table 2-3 summarises calculated in tunnel air quality (ventilation design calculations) at the ventilation offtake and at the tunnel mid point for the northbound and southbound main alignment tunnels for the maximum physical throughput capacity at each nominated average traffic speed.

The values shown in the table are in-tunnel concentrations at the relevant point (as distinct from motorist exposures). Therefore some of the concentrations listed in the table at the ventilation offtake are higher in magnitude than the ventilation system design criteria. The project ventilation would nonetheless comply with the ventilation system design criteria when factors including averaging period and the distinction between exposure standards and in-tunnel concentrations are taken into account.

The calculations conducted for the values presented in **Table 2-3** are:

- Based on the theoretical maximum physical throughput capacity of the main alignment tunnels at average traffic speeds of 80 km/h, 60 km/h and 40 km/h.
- Based on the project's ventilation design to achieve these criteria.
- Independent of year (as they are based in the maximum traffic throughput of a motorway lane), but have conservatively applied the Permanent International Association of Road Congresses (2012) emission factors for 2019 (rather than lower emissions factors for a later year). Emissions from vehicles after this year are expected to be no worse than in 2019, and likely to improve over time, based on current trends, with improved vehicle and fuel efficiency.

As noted in the environmental impact statement, vehicle throughput would be actively managed once traffic speeds fall to 40 km/h or lower in order to manage motorist exposure levels and to maintain in-tunnel air quality within acceptable limits

It is proposed to develop a proactive and adaptive management approach to ensure that ventilation design criteria are not exceeded in the project tunnels. This approach would be developed during the detailed design phase of the project, and implemented from the commencement of operation.

Table 2-3 Summary of road tunnel design and operational criteria (visibility)

Average traffic speed	Carbon monoxide			Nitrogen dioxide			Visibility (PM_{10})		
	Design criterion (15-minute)	Maximum concentration at tunnel mid point	Maximum concentration at ventilation offtake	Design criterion (15-minute)	Maximum concentration at tunnel mid point	Maximum concentration at ventilation offtake	Design criterion	Maximum concentration at tunnel mid point	Maximum concentration at ventilation offtake
Northbound main alignment tunnel									
80 km/h	**50 ppm (57.3 mg/m^3)**	8.4 ppm (9.6 mg/m^3)	11.8 ppm (13.5 mg/m^3)	**0.5 ppm (0.94 mg/m^3)**	0.40 ppm (0.75 mg/m^3)	0.78 ppm (1.47 mg/m^3)	**<0.005 m^{-1} (1.06 mg/m^3)**	0.0026 m^{-1} (0.55 mg/m^3)	0.0045 m^{-1} (0.96 mg/m^3)
60 km/h	**50 ppm (57.3 mg/m^3)**	8.9 ppm (10.2 mg/m^3)	12.8 ppm (14.7 mg/m^3)	**0.5 ppm (0.94 mg/m^3)**	0.43 ppm (0.81 mg/m^3)	0.84 ppm (1.58 mg/m^3)	**<0.005 m^{-1} (1.06 mg/m^3)**	0.0029 m^{-1} (0.62 mg/m^3)	0.0050 m^{-1} (1.06 mg/m^3)
40 km/h	**60 ppm (68.7 mg/m^3)**	10.1 ppm (11.6 mg/m^3)	13.1 ppm (15.0 mg/m^3)	**0.8 ppm (1.51 mg/m^3)**	0.51 ppm (0.96 mg/m^3)	0.83 ppm (1.56 mg/m^3)	**<0.005 m^{-1} (1.06 mg/m^3)**	0.0034 m^{-1} (0.72 mg/m^3)	0.0050 m^{-1} (1.06 mg/m^3)
Southbound main alignment tunnel									
80 km/h	**50 ppm (57.3 mg/m^3)**	7.2 ppm (8.2 mg/m^3)	10.0 ppm (11.5 mg/m^3)	**0.5 ppm (0.94 mg/m^3)**	0.21 ppm (0.40 mg/m^3)	0.48 ppm (0.90 mg/m^3)	**<0.005 m^{-1} (1.06 mg/m^3)**	0.0021 m^{-1} (0.45 mg/m^3)	0.0039 m^{-1} (0.83 mg/m^3)
60 km/h	**50 ppm (57.3 mg/m^3)**	8.3 ppm (9.5 mg/m^3)	12.0 ppm (13.7 mg/m^3)	**0.5 ppm (0.94 mg/m^3)**	0.27 ppm (0.51 mg/m^3)	0.61 ppm (1.14 mg/m^3)	**<0.005 m^{-1} (1.06 mg/m^3)**	0.0027 m^{-1} (0.57 mg/m^3)	0.0050 m^{-1} (1.06 mg/m^3)
40 km/h	**60 ppm (68.7 mg/m^3)**	10.2 ppm (11.7 mg/m^3)	12.9 ppm (14.8 mg/m^3)	**0.8 ppm (1.51 mg/m^3)**	0.43 ppm (0.80 mg/m^3)	0.69 ppm (1.30 mg/m^3)	**<0.005 m^{-1} (1.06 mg/m^3)**	0.0035 m^{-1} (0.68 mg/m^3)	0.0050 m^{-1} (1.06 mg/m^3)

Note: in-tunnel air quality should be considered and assessed at the tunnel mid point. The maximum concentration at the ventilation offtake is relevant to and has been considered in the assessment of ambient air quality.

2.5.2 Compliance with design criteria and operational monitoring

Application of the ventilation design criteria listed in **Table 2-2** as operational performance criteria would be impractical because of the nature of some of those criteria as 15-minute average motorist exposure standards. To apply exposure standards as operational performance criteria would:

- Require knowledge of motorist exposures while outside the project tunnels (to account for a full 15 minute exposure in cases where tunnel travel times are less than 15 minutes).
- Require knowledge of exposure mitigation and its efficacy, such as the implications of closing vehicle windows (if they exist) and recirculating air.
- Involve a calculation with several inputs, which is less desirable than continuous monitoring for comparison to an in-tunnel concentration standard.

As a consequence, it is proposed that in-tunnel concentration limits be set to ensure acceptable in-tunnel air quality and as compliance standards for operation of the project. It is proposed that these in-tunnel concentration limits be set as a time-based average, measurable at the mid point of the main alignment tunnels. While in practice concentration limits could be developed and applied to any location within the project tunnels, the tunnel mid point is considered most practical and useful as an indication of average conditions along the tunnel length and well placed to provide tunnel operators with a practical measure of tunnel performance.

Table 2-3 indicates expected maximum in-tunnel concentrations (as an hourly average based on maximum theoretical traffic throughput) at the mid points of the project tunnels and the maximum in-tunnel concentrations at the ventilation offtakes.

2.6 Assessment philosophy and conservatism

2.6.1 Approach taken to the assessment

The air quality impact assessments conducted for the NorthConnex project, as presented in the environmental impact statement and in this report, have been pursued with a deliberate intention to provide a conservative assessment of potential impacts during construction and operation. In this context, the concept of a 'conservative assessment' has been applied through the selection and application of assessment methodologies, assumptions and inputs that would tend to overestimate the likely environmental impacts of the project. This approach is not unusual, and a similar philosophy has been historically applied to other major infrastructure and other development proposals in New South Wales.

In applying a conservative approach to the assessment of air quality and other impacts from the project, the intention has been to err on the side of overestimating likely impacts without unreasonably exaggerating or otherwise skewing the predictions. By demonstrating that a conservative overestimate of impacts is acceptable, it can be confidently predicted that actual impacts likely to be experienced in reality would also lie within acceptable limits.

A reasonable level of conservatism in the air quality impact assessment is desirable for the following reasons:

- It assists in accommodating some uncertainty in the series of assumptions and inputs into the overall environmental impact assessment. The various models and assessments conducted for the project build on each other in many areas (for example, the traffic forecast model, which informs the air quality impact assessment, which in turn informs the human health risk assessment), and each model/ assessment includes its own suite of assumptions and inputs. By selecting assumptions and inputs in each assessment that would produce a conservative outcome from the relevant model/ assessment, the uncertainty in each assumption/ input and the risk that changes in an assumption/ input may significantly affect the outcomes of the relevant assessment(s) are largely mitigated. That is, if assumed conditions or assessment inputs are different in reality, it is more likely than not that the net effect of different conditions would remain within the conservative assessment outcomes pursued through the environmental impact assessment process.
- It provides a broader 'environmental impact envelope' within which the detailed design of the project can be finalised and within which the project can be implemented. It is undesirable for the extent of potential environmental impacts from the project to be too narrowly defined at this point in the development of the project design, noting that there remains scope for the design of the project to be refined prior to implementation. A conservative assessment approach provides flexibility for ongoing design refinements within an approved environmental envelope (subject to approval of the project and conditions of approval that may be applied by the Minister for Planning), and reduces the risk that additional environmental impact assessments would be required for each minor design refinement between approval of the project and its final implementation.

However, it is recognised that conservatism in the air quality impact assessment may lead to some potentially undesirable outcomes that need to be mitigated and managed, such as:

- Risk of overstatement of potential air quality impacts and associated human health risks, which may contribute to concerns by the local community and other stakeholders about the impacts of the project. The potential community and stakeholder concern raised in submissions has led to additional effort to clearly explain the level of conservatism in the assessment and to provide interpretation and context for conservative results that have been presented. Full details of community and stakeholder engagement activities are provided in **Chapter 5** of this report.
- Overstatement of potential air quality impacts and associated human health risks may also lead to additional or more stringent conditions of approval than necessary, including in relation to mitigation, monitoring and management of air quality. The mitigation, monitoring and management measures required and proposed for the project in light of predicted air quality and other impacts have been reviewed and confirmed as feasible and reasonable.
- Overstatement of vehicle contributions to local air quality may similarly lead to overstating the benefit where vehicle emissions are reduced by project (along surface roads, such as Pennant Hills Road). These benefits have been reviewed and appropriately qualified.

2.6.2 Assumptions and conservatism

The assumptions applied to the air quality impact assessment for the project that have the most influence on the outcomes of the assessment are discussed in this section. This discussion is provided to clarify the level of uncertainty and conservatism in the assessment (and consequently, the total conservatism in the predicted air quality impacts of the project). A full summary of key assumptions and conservatism is provided in **Table 2-4** at the end of this section.

Emission factors

The air quality impact assessment has been based on emission factors published by the Permanent International Association of Road Congresses (PIARC), which were used to calculate emissions from vehicles within the project tunnels and on surface roads. Details of these calculations are provided in **Section 2.8**, including inherent conservatism in the PIARC emissions factors where relevant.

Key areas of uncertainty and conservatism in PIARC emissions factors can be summarised as follows:

- The PIARC emission factors were developed for the purpose of tunnel ventilation design, and as such have been developed to include a design safety margin.
- A recent study conducted on the Lane Cove Tunnel (PEL, September 2014) (refer to **Section 2.8.1**) included an analysis of in-tunnel air quality calculated using PIARC emission factors and in-tunnel air quality monitoring data. This analysis indicated that for the conditions in the Lane Cove Tunnel, the PIARC emission factors overestimated CO by 1.3 to 1.7 times, NO_X by 1.6 to 1.8 times, and $PM_{2.5}$ by 2.8 to 4.4 times.
- PIARC provides adjustment factors up to the year 2020 to account for expected continuous improvement in engine technologies and emissions. As this assessment considered traffic in the years 2019 and 2029, the 2020 adjustment factors were conservatively used for predicting traffic emissions in the 2029 case. That is, the air quality impact assessment has not factored in any improvement in vehicle efficiencies or fuel standards beyond 2020.

Background air quality

The approach taken to determine background air quality in and around the project is detailed in **Section 2.11**.

Sufficient air quality monitoring data in proximity to the project’s ventilation outlets was not available for the air quality impact assessment for the project and as such an alternative method has been applied to gain representative ambient background air quality values. The method, in summary, was that hourly monitoring data from Lindfield and Prospect monitoring stations (operated by the Office of Environment and Heritage) were combined and the highest monitored concentration of each pollutant on an hourly basis was selected as part of the background (ambient) air quality data set for the assessment. The use of the highest monitored concentrations compared to simply the data from a single nearest station, as is common practice for assessments in NSW, resulted in a total average for all pollutants above the average from either individual station.

A review of ambient monitoring data against the monitoring data collected from monitoring stations installed along the project corridor has been conducted and is provided in **Section 2.11** (for the period January 2014 to August 2014, inclusive). The review shows a good correlation between the two sets of data, with the monitoring data from the stations operated by the Office of Environment and Heritage trending towards the upper end of the project monitoring data (ie the data used in the air quality impact assessment tends to be at the higher end of observed air quality along the project corridor). The review confirms that the ambient background data used in the assessment is likely to be consistent with local pollution trends in the project area and is appropriate for use in the assessment.

Surface road contributions

Section 2.14.1 of this report details how project contributions, background contributions and cumulative concentrations of air pollutants have been calculated. In broad terms, the approach taken in the air quality impact assessment for the project applied the following definitions:

- ‘Project contributions’ have been taken to be those changes in air quality directly attributable to the operation of the project’s ventilation outlets.
- ‘Background contributions’ have been taken to be all other air quality contributions, including pollutant levels in ambient air in the region and contributions from surface roads (which includes both increases and decreases in road contributions as an indirect consequence of operation of the project). The approach to determining ‘background contributions’ for the purpose of the air quality impact assessments is detailed further below.
- ‘Cumulative concentrations’ have been taken to be the sum of the project contribution and the background contribution for a particular receiver location.

An alternative approach to calculating and assigning project and background air quality contributions is also analysed in **Section 2.14.1**. This alternative approach includes changes in air quality as a result in changes to surface traffic as part of the ‘project contribution’ rather than the ‘background contribution’ (as was done in the air quality assessment for the project).

An assessment of the two methodologies for a series of receiver locations has been conducted (refer to **Section 2.14.1**). The assessment demonstrates that for most of the time (more than 99.95 per cent of the time when considering maximum cumulative concentrations of NO_2 (one hour) and PM_{10} (24 hour)), the methodology applied in the environmental impact statement and in this report calculates higher predicted cumulative impacts (project and background contributions) than the alternative method. This analysis also confirms that the air quality impact assessments for the project are over-estimating cumulative air quality impacts.

Traffic forecasts and assessment scenarios

In addition to assessing air quality impacts under forecast traffic volumes in 2019 and 2029, the environmental impact statement includes an assessment of a 'worst case' scenario (design analysis A). Details of scenarios that have been assessed for the project, and an explanation of how design analysis A represents a credible worst case scenario are provided in **Section 2.7.3**.

One of the key assumptions applied as part of design analysis A is that the theoretical maximum traffic throughput capacity of the project will be reached during the peak hour. The theoretical maximum traffic throughput capacity (4,000 passenger car units per hour) is around 2.1 times the peak forecast traffic volumes in 2019 and around 1.6 times the peak forecast traffic volumes in 2029. This means that actual traffic volumes would need to be around 110 per cent higher than traffic forecasts in 2019 or around 60 per cent higher than traffic in forecasts in 2029. Based on traffic forecasts using the Cube strategic model, the triggers that may lead to this level of variance in traffic volumes (demography, land use, major additions to the road network, traffic generating developments) are not expected within the timeframes considered as part of the assessment of the project.

The environmental impact statement demonstrates that design analysis A would comply with applicable ambient air quality criteria and advisory reporting standards. The analysis presented in **Section 2.5** also demonstrates that the project's ventilation system has been designed to achieve specified in-tunnel air quality criteria at the maximum traffic throughput capacity of the main alignment tunnels (as has been assumed in the peak hour for design analysis A).

Dispersion modelling

Discussion of modelling packages used in the air quality impact assessment is provided in **Section 2.13**.

The atmosphere is a complex, physical system, and the movement of air in a given location is dependent on a number of variables, including temperature, topography and land use, as well as larger-scale synoptic processes. Dispersion modelling is a method of simulating the movement of air pollutants in the atmosphere using mathematical equations. The model equations necessarily involve the current understanding of the complex environmental interactions and chemical reaction processes involved, available input data, processing time and data storage limitations. The model configuration particularly affects model predictions during certain meteorological conditions and source emission types. For example, the prediction of pollutant dispersion under low wind speed conditions (typically defined as those less than 1 m/s) or for low-level, non-buoyant sources, is problematic for most dispersion models. To accommodate these effects, the model is configured to provide conservative estimates of pollutant concentrations at particular locations. While the models, when used appropriately and with high quality input data, can provide very good indications of the scale of pollutant concentrations and the likely locations of the maximum concentrations occurring, their outputs should not be considered to be representative of exact pollutant concentrations at any given location or point in time.

Summary of assumptions and conservatism

The key methods and assumptions for the air quality impact assessment are summarised in **Table 2-4**, and discussed in more detail in the relevant following sections of this report.

Table 2-4 Summary of key methods and assumptions applied to the air quality impact assessment

Issue	Comment
General method	The air quality modelling and impact assessment were conducted in accordance with relevant guidance documents (DEC, 2005; Barclay and Scire, 2011).
Emissions inventory	
Project contribution	The project contribution has been considered to be ventilation outlet emissions only. Surface road emissions have been included as background pollutant concentrations. A review of a comparison method applying the impact from change in traffic as project contribution has been completed (refer to **Section 2.14.1**).
Portal emissions	The assessment has been conducted assuming zero emissions from the tunnel portals; that is, all vehicle emissions have been assumed to be vented via the tunnel ventilation outlets near the end of each tunnel.
Outlet heights	The ventilation emission points had been assumed to be 15 metres above ground (for the assessment presented in the environmental impact statement). These have been increased by five metres (to 20 metres) as part of this report in response to issues raised in submissions and based on an analysis of feasible and reasonable measures to minimise exposures to vehicle emissions (refer to **Section 3.2**).
Volumetric flow rates	Volumetric flow rates (VFRs) were initially calculated for each hourly predicted traffic flow rates. This volumetric flow rate was then assigned to one of the "VSO Running Levels", which defined the conditions under which the ventilation stations will be operated. The running level above the predicted volumetric flow rate was adopted for each hour. Rates were based on a minimum VFR of 300 Nm^3/s which would correspond with periods of the lowest traffic volumes in the project tunnels and a maximum design capacity of 700 Nm^3/s (four fans operating at a maximum capacity of 175 Nm^3/s each).
Hourly varying emission rates	The emissions from the ventilation outlets would be directly proportional to the hourly traffic volumes in each tunnel. The emission rates and concentrations would both vary in accordance with these traffic volumes, as well as the ventilation outlet volumetric flow rates (fan rates). As such, all scenarios incorporated the use of hourly varying emission rates and volumetric flows to reflect the expected traffic volumes.
Emission factors source	PIARC emission factors have been used for particulate matter, NO_x and CO. As these factors have been development or the purpose of ventilation design, they include engineering safety factors (ie they overestimate likely emissions). The emission factors published in the National Pollutant Inventory (NPI) (DEWHA, 2008) have also been used to estimate emissions of other pollutants (refer to **Section 2.8**).
PIARC adjustment factors	PIARC adjustment factors for 2019 and 2020 have been used to estimate emissions for 2019 and 2029 modelling scenarios (refer to **Section 2.8**). Adjustment factors are only available up to 2020 – the use of 2020 factors for 2029 is expected to result in overestimation of 2029 emissions and resultant ground level pollutant concentrations due to expected improvements in vehicle emissions over time (EPA, 2012b).

Issue	Comment
Particulate matter ratio (PM_{10}:$PM_{2.5}$)	The NPI provides emission factors for a variety of different vehicle types and fuels. The ratios of PM_{10} to $PM_{2.5}$ emissions have been calculated for the various vehicle types assessed (refer to **Section 2.8**). The ratios for cars and light duty vehicles (LDVs) have been averaged to provide an average ratio of $PM_{2.5}$ to PM_{10} for non-heavy duty vehicles (HDVs) (0.93). This ratio has then been multiplied by the PM_{10} emissions calculated using the PIARC emission factors to estimate $PM_{2.5}$ emission rates. A similar process has been followed for HDVs, where the ratio of $PM_{2.5}$ to PM_{10} was calculated to be 0.95.
VOCs and PAHs emission factors	Emissions of VOCs and PAHs have been similarly calculated using the carbon monoxide emission rates (refer to **Section 2.8**). The ratios of NPI emission factors for these pollutants and carbon monoxide have been calculated. The carbon monoxide emission rates calculated from the PIARC carbon monoxide emission factors were then multiplied by the calculated ratios to estimate emission rates of VOCs and PAHs.
Traffic forecast data	The forecast traffic volumes presented in the Technical Working Paper: Traffic and Transport (Appendix E of the environmental impact statement) have been used in the air quality impact assessment.
Fleet distribution – general	The current Australian fleet distribution relating to the number of diesel-powered passenger vehicles and the fleet mix (proportion of LDV to HDV) data have been obtained from the motor vehicle census prepared by the Australian Bureau of Statistics (ABS, 2013). This data has been compared with vehicle registration data from Roads and Maritime Services and confirmed to be representative of the NSW vehicle fleet (refer to **Section 2.8**). Diesel-engine passenger cars have been shown to make up approximately eight per cent of the current Australian fleet, and this value has been used in the emission calculations. It is also noted that the infiltration of diesel-powered passenger cars into the Australian market and fleet mix since 2008 has risen by over 100 per cent. While the use of diesel-powered vehicles is likely to continue to increase in future years, no assumptions regarding future trends were made for the assessment presented in the environmental impact statement. The current ratio of petrol to diesel vehicles (2013) has therefore been used for both 2019 and 2029 in the assessment presented in the environmental impact statement. Emissions from passenger cars /LDVs have been calculated separately for all pollutants, and then summed with the emissions from HDVs to provide total pollutant emission rates. As part of this report, the heights of the project's ventilation outlets have been increased by five metres. Further air quality impact assessment for this amendment to the project has applied updated assumptions around petrol/ diesel fuel mix. In particular, the growth in diesel-fuelled vehicle has been extrapolated to 2019 and 2029 (refer to **Section 2.8**), rather than assuming a constant petrol/ diesel distribution to identify sensitivity to changes in fuel mix in the future.

Issue	Comment
Fleet distribution – heavy vehicles	The percentage of heavy vehicles in the total traffic volumes using the project tunnels has been forecast to be around 28 per cent in 2019 and around 25 per cent in 2029. These traffic forecasts for the project have assumed that 95 per cent of through heavy vehicles travelling along the Pennant Hills Road corridor would be directed into the project tunnels with the implementation of regulatory measures (to require heavy vehicles to use the tunnels). A sensitivity analysis has been conducted of the implications should the proportion of heavy vehicles increase by 10 per cent (refer to **Section 2.9.2** and **Table 2-48**).
Fleet distribution – proportion of diesel vehicles	As stated above, the fleet distribution has been sourced from ABS data. The environmental impact statement fleet distribution applied the 2013 composition to the 2019 and 2029 assessment scenarios, while in this report a linear extrapolation from 2008 and 2013 ABS data has been applied to determine the fleet mix in 2019 and 2029. This extrapolation resulted in a future increase in diesel vehicles. Refer to **Section 2.8** for more details.
Surface road particulate matter calculations	Surface road dispersion modelled has employed the CAL3QHCR model, which doesn't include $PM_{2.5}$ as a modelling species. To address this issue, the concentrations of PM_{10} calculated by the CAL3QHCR model have been multiplied by 0.95 (the maximum ratio of $PM_{2.5}$ to PM_{10} calculated for the project tunnel emissions (refer to **Section 2.8**) to estimate $PM_{2.5}$ concentrations at each receiver location.
Tunnel emissions calculation - parameters	Predicted pollutant emissions from vehicles within the project tunnels have been calculated taking into account the number of vehicles each hour, the speed and the fleet composition (refer to **Section 2.8**). The vertical design alignment of the tunnel has also been taken into account, and each main alignment tunnel has been split into a series of sections to calculate the differing emissions resulting from gradient changes along the lengths of the tunnels. Gradient data for the emission calculations have been obtained from the design documents.
Tunnel emission calculation	It has been assumed that there are no portal emissions. The total tunnel emissions have been calculated based on the sum of each tunnel section's emissions, factoring in the length of each section, the time taken for vehicles in the tunnel to pass through each section, the density of vehicles in the tunnel and the respective gradients. Hourly emission rates in grams per second have been generated for the identified pollutants of concern for each individual tunnel for the expected traffic flows in the assessment years 2019 and 2029.
Portal in-take air	Pollutant loads in portal intake air was not considered in the environmental impact statement dispersion modelling. A screening assessment has been undertaken as part of this report and demonstrates that pollutant loads in portal intake air do not significantly alter the outcomes of the air quality impact assessment.
Variable exit temperature	Variable temperatures have been calculated using average seasonal temperature differences between the Lane Cove Tunnel emissions and ambient air. The hourly seasonal average temperature differences have then been applied to the temperature data predicted for the project's ambient environment to calculate the estimated temperatures of emissions from the ventilation outlets.
Exit diameter of the	The air dispersion modelling has assumed time-varying ventilation outlet diameters to maintain required discharge velocity.

Issue	Comment
ventilation outlets	
Forecast traffic data	Twenty-four hour Annual Average Weekday Traffic (AAWT) flows have been used in the air quality assessment. The use of 24 hour AAWT data, rather than the use of 24 hour Annual Average Daily Traffic (AADT), is considered to be a conservative approach in the assessment as AAWT data only take into account the weekday traffic volumes, which are typically busier than weekend traffic volumes. Traffic forecasts have assumed that 95 per cent of heavy vehicles travelling along the Pennant Hills Road corridor would utilise the project tunnels, and have accommodate anticipated growth in heavy vehicle numbers.
Pollutant concentrations	
NO_2 calculation – ozone limiting method	The Ozone Limiting Method (OLM) endorsed for use in the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (DEC, 2005a) has been used to calculate the conversion of NO_X to NO_2. The air quality impact assessment presented in the environmental impact statement has applied the OLM equation using the equation published in the Approved Methods guideline (refer to **Section 2.14.2**). Based on further advice from the Environment Protection Authority in its submission on the environmental impact statement, the published OLM equation has been modified to reflect a NO_2:NO_x ratio in vehicle exhaust of 16 per cent (on average). The amended OLM equation has been applied to the further modelling and assessment of the increased ventilation outlet height (refer to **Section 2.15.1**).
VOC calculation	The total VOC concentrations have been speciated using the profile (i.e. the types of pollutants) provided in OEH (2012) and the mass fraction for the project fleet determined by the human health risk assessment for the project. For passenger cars, sixty per cent of fuel used has been assumed to be E10. This percentage represents the target for petrol sold in New South Wales under the *Biofuels Act 2007*. For the purpose of this speciation, the composition of VOCs in vehicle emissions has been assumed to remain the same over time. The mass fraction percentages have been multiplied by the 99.9th percentile predicted total VOC ground level concentrations.
PAHs and VOCs - background	For PAHs and VOCs, cumulative assessment using background data is not required by the Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (DEC, 2005a). Furthermore, background data are not available to conduct a cumulative assessment of these pollutants.
Contemporaneous assessment	A contemporaneous assessment pairs the project emissions to background pollutant concentrations occurring at the same point in time. Assessing the total predicted ground level concentrations using a contemporaneous approach provides a more realistic estimation of the likely total pollutant concentrations at any point in time than simply adding the two maximum values.

Issue	Comment
Background data	
Background data source	Pollutant concentrations measured at Prospect and Lindfield were taken to be indicative of ambient pollutant concentrations throughout the project area. For PM_{10}, $PM_{2.5}$ and NO_2, the ambient concentrations were determined by taking the maximum of the concentrations predicted by CAL3QHCR and those measured by the Office of Environment and Heritage at its Lindfield and Prospect monitoring stations. This was done for each receiver for each hour modelled. Data from the Office of Environment and Heritage monitoring stations has been compared with data collected from the ambient monitoring stations installed along Pennant Hills Road and this is discussed in **Section 2.11.3**.
Background PM_{10} to $PM_{2.5}$ ratio	As $PM_{2.5}$ is not monitored at either the Lindfield or Prospect monitoring stations, $PM_{2.5}$ concentrations have been estimated from the monitored PM_{10} concentrations using a PM_{10} to $PM_{2.5}$ ratio calculated from Sydney monitoring stations that recorded both particulate matter fractions. Monitoring data from Liverpool, Chullora, Earlwood and Richmond for the period 2009 to 2011 have been used. The PM_{10} to $PM_{2.5}$ ratios have been calculated for each of the monitoring stations for each hour of the day. These ratios have then been averaged across the monitoring stations for each hour of the day, and the maximum of those averages has been adopted as the conversion ratio for the assessment, which was 0.35. This ratio has been applied to the combined PM_{10} monitoring data from Lindfield/Prospect to estimate hourly $PM_{2.5}$ concentrations. Based on experience, the ratio is typically between 0.3 and 0.4, so this value is considered to be acceptable.
Meteorological Data	
Data source	Meteorological data have been sourced from five local surface meteorological stations located in the Sydney basin (Lindfield, Terrey Hills, Richmond RAAF Base, Prospect and Sydney Airport), operated by the Bureau of Meteorology (BOM) and the Office of Environment and Heritage. These measured data have been used in conjunction with MM5 prognostic model data (refer to **Section 2.10**).
Modelled time period	The dispersion modelling has been conducted for a three year period (January 2009 – December 2011).
Terrain/land use	
Terrain data source	NASA SRTM three arc-second (or around 90 metre resolution) data has been used for the terrain data in the environmental impact statement (refer to **Section 2.12**). The further modelling and assessment of the increased ventilation outlet height (refer to **Section 2.15.1**) has used 5m resolution Land and Property Information (LPI) data.
Land use data source	Land use data within the study area has been derived from the Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES).

(blank page)

2.7 Traffic volumes and assessment scenarios

2.7.1 Forecast traffic volumes

Full details of traffic forecasts and the assessment of potential traffic impacts of the project are included in Section 7.1 of the environmental impact statement and the Technical Working Paper: Traffic and Transport (Appendix E of the environmental impact statement). Outputs from those assessments relevant to the operational air quality impact assessment are summarised in this section.

Forecast traffic data for the project, including the project tunnels and the surrounding surface road network, has been generated through a strategic transport model of Sydney's major road network using the Cube Voyager software platform. Cube is the most widely used software package in the world for transport planning.

The Cube model used to develop traffic forecast data for the NorthConnex project has taken into account factors including existing and future land use, anticipated changes to the major road network, existing and future travel demands, existing and future tolling structures, and motorist behaviours. Further details of these assumptions and inputs are provided in Section 5.2 of the Technical Working Paper: Traffic and Transport (Appendix E of the environmental impact statement).

It is relevant to note that the Cube model has taken into account factors that are outside the scope of the NorthConnex project, and as a consequence, not all forecast changes in traffic on the surface road network are necessarily fully or partially a consequence of the project itself. Importantly, anticipated potential changes in the tolling structure applicable to the Westlink M7 Motorway have been taken into account in traffic forecasts across the surface road network. These potential changes in tolling structure are outside the scope of the NorthConnex project, and are not subject to assessment under the *Environmental Planning and Assessment Act 1979* because the Westlink M7 Motorway would continue to operate within the terms of its existing planning and environmental approvals. Notwithstanding, traffic forecasts presented in the Technical Working Paper: Traffic and Transport (Appendix E of the environmental impact statement) show changes in the distribution of traffic on the surface road network as a result of changes to the Westlink M7 Motorway tolling structure which are independent of any effect attributable to the NorthConnex project itself.

With respect to potential traffic changes on the surface road network, it is also important to recognise that a key objective of the project has been to ensure that there is no deterioration in the performance of the surface road network. That is, design and construct tenderers were directed to design the project in a manner that minimised adverse impacts (ie significant increases in traffic volumes) on the surface road network as a consequence of the project. This outcome has been achieved, and traffic forecasts for the surface road network presented in the Technical Working Paper: Traffic and Transport (Appendix E of the environmental impact statement) and summarised in the following sections, show few areas of increased traffic volumes and no deterioration in road network performance when considering measures such as level of service. This is also reflected in the limited need for surface road network enhancements to accommodate the project.

Traffic forecasts for the project tunnels

The number of vehicles within the northbound and southbound tunnels would vary throughout a 24-hour period and, subsequently, the level of pollutant emissions associated with vehicle movements would vary. Forecast hourly traffic data, including heavy vehicle percentages and vehicle speeds for each main alignment tunnel for the opening year of the tunnel and 10 years after opening (2019 and 2029, respectively), are shown graphically in **Figure 2-2** and **Figure 2-3**. The figures illustrate the forecast increase in traffic flows between 2019 and 2029 assessment years for the northbound and southbound tunnels.

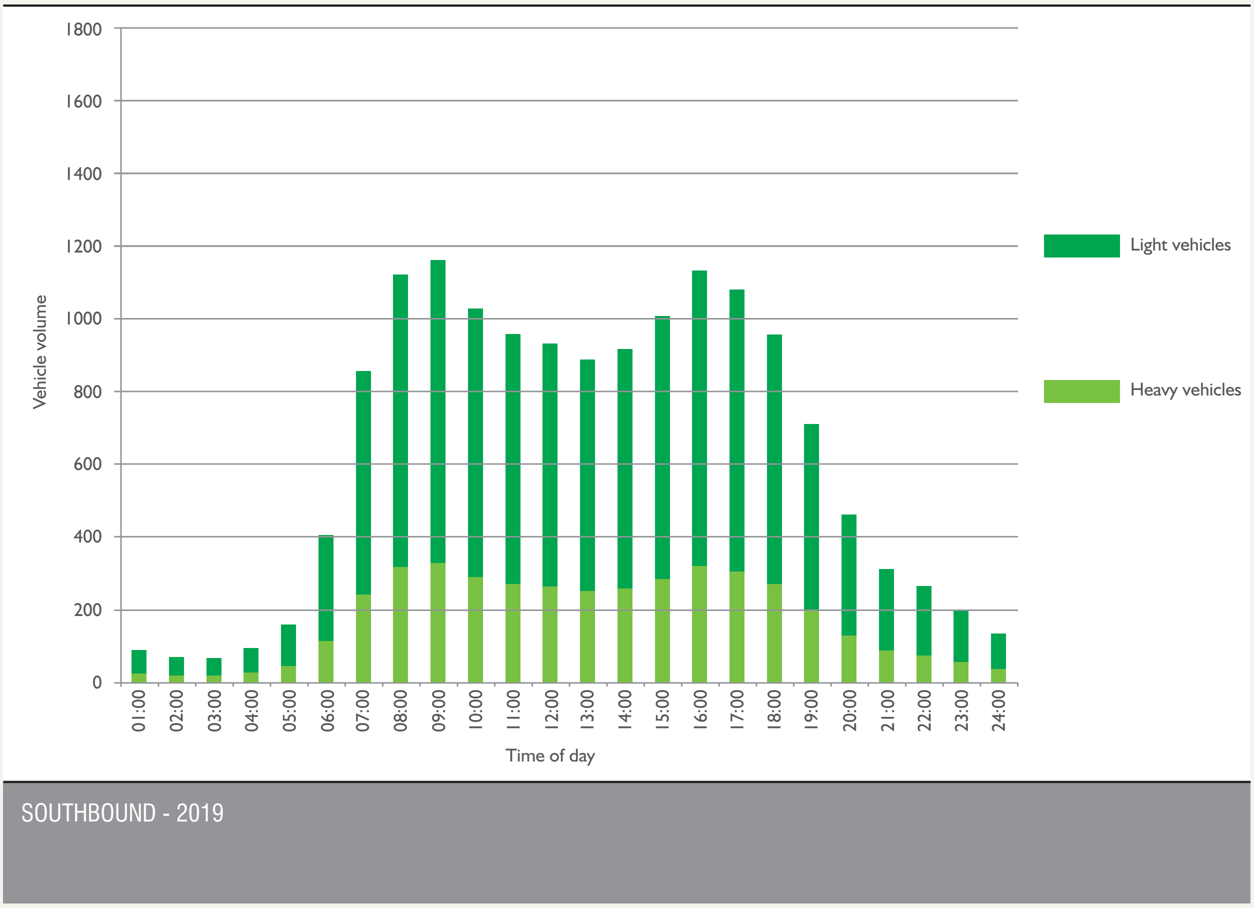
For 2019, the predicted percentage of heavy vehicles varied hourly, and ranged from 28.0 per cent to 28.5 percent for the northbound tunnel and from 27.8 per cent to 28.6 per cent in the southbound tunnel.

For 2029, the percentage of heavy vehicles ranged from 24.5 per cent to 25.0 per cent in the northbound tunnel and from 24.5 per cent to 25.2 per cent in the southbound tunnel over the course of a 24 hour period.

These traffic forecasts for the project have assumed that 95 per cent of through heavy vehicles travelling along the Pennant Hills Road corridor would be directed into the project tunnels with the implementation of regulatory measures (to require heavy vehicles to use the tunnels). There is therefore a very low potential for heavy vehicles using the project to exceed these heavy vehicle percentages.

Forecast traffic data have been consistently presented in the environmental impact statement and associated technical specialist studies through figures such as **Figure 2-2** and **Figure 2-3**, rather than detailed tables of forecast traffic numbers, based on the commercial sensitivities of this information. If required, actual forecast traffic numbers can be provided to relevant regulatory agencies for internal assessment purposes.

A significant investment is proposed in the NorthConnex project. The commercial viability of this investment is dependent on forecast traffic volumes expected to use the project being reasonable and realistic. Because of this, the Cube model and its outputs have been interrogated in detail to confirm that the project is viable prior to seeking design and construct tenders or lodging an application for environmental planning approval.



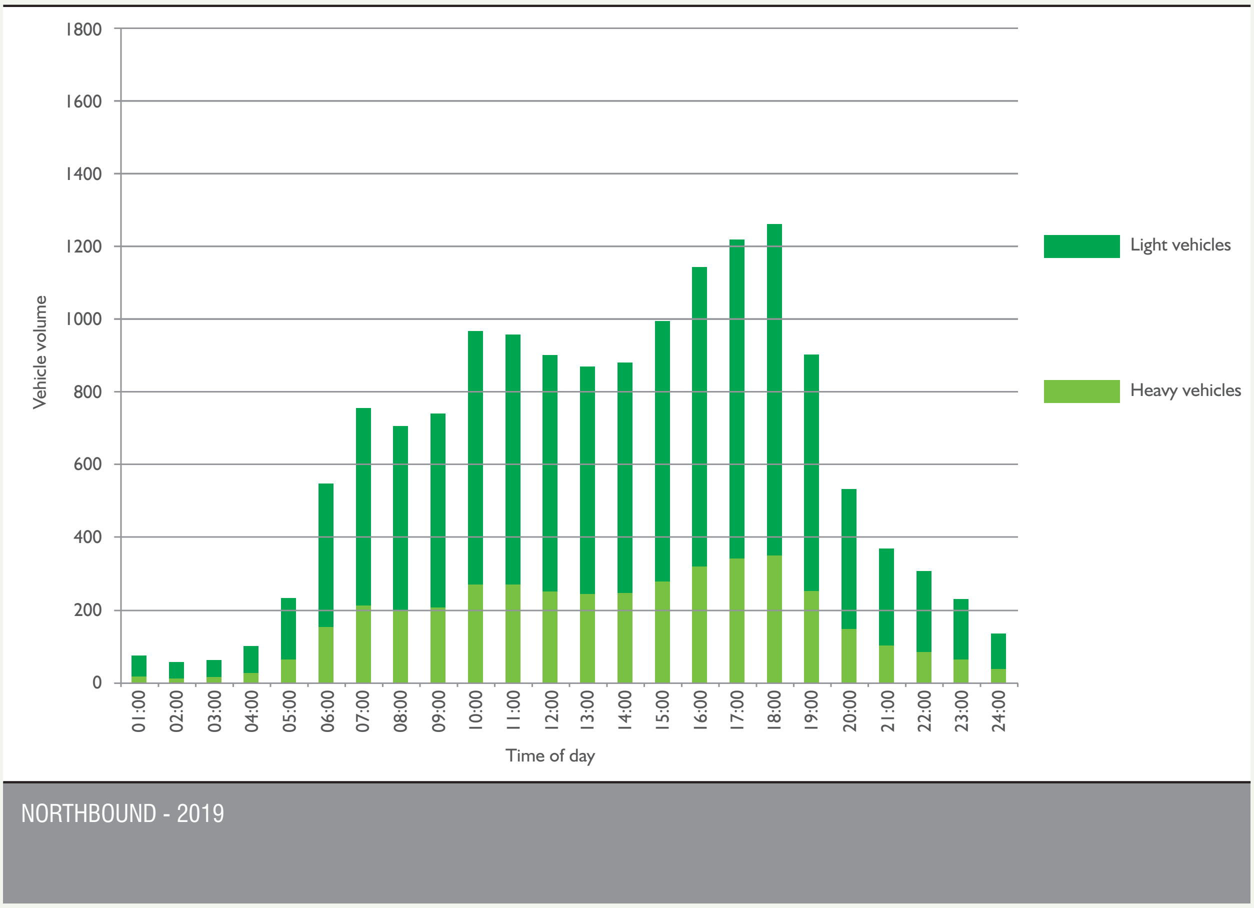
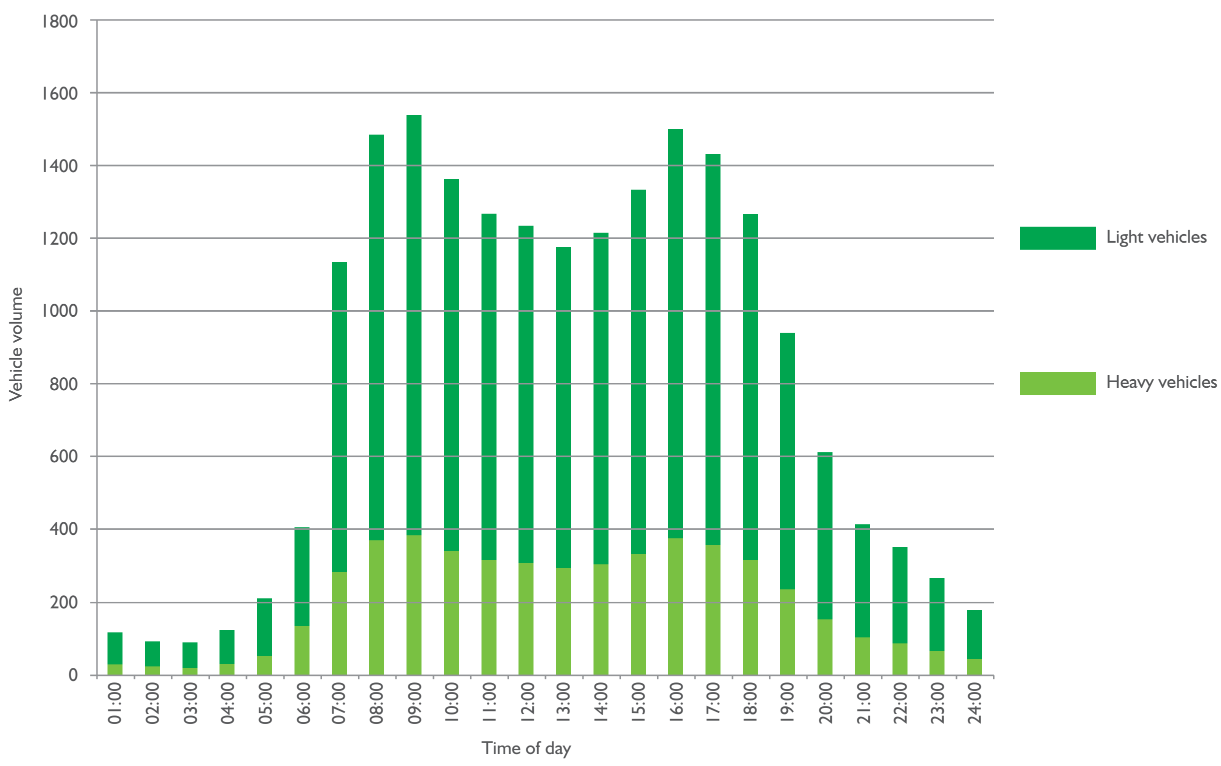
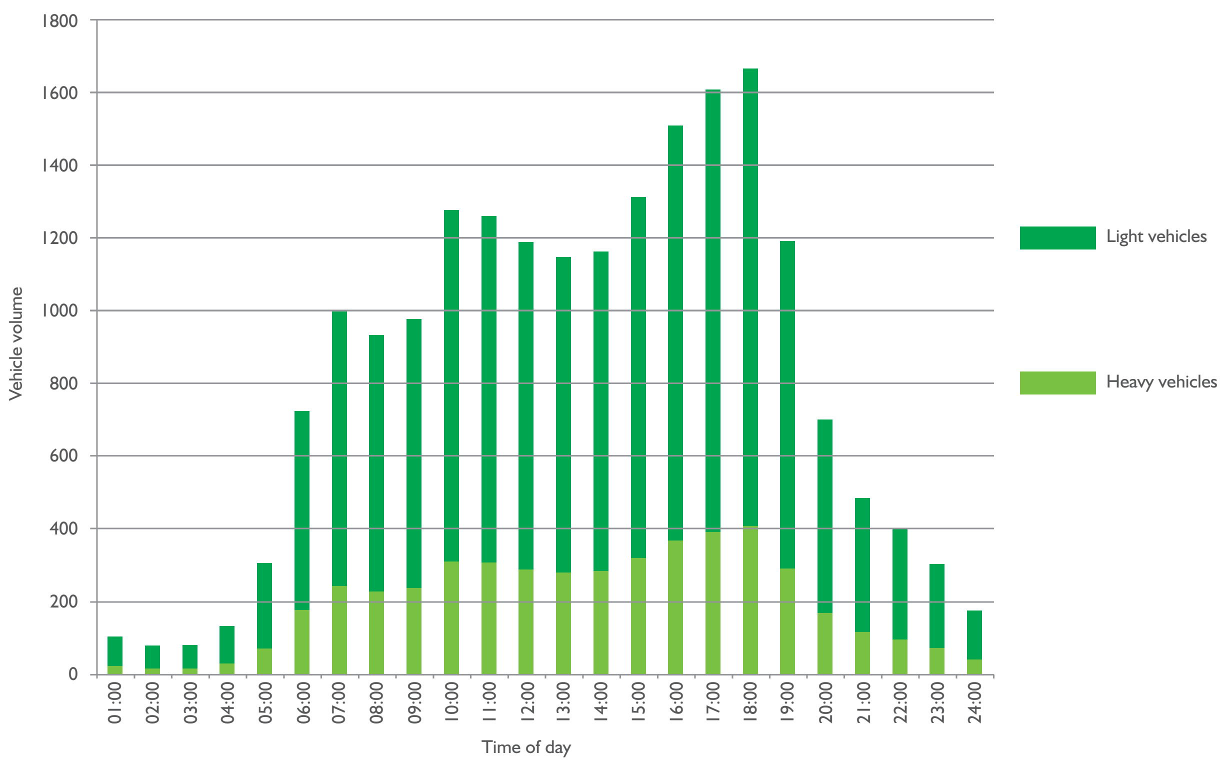


Figure 2-2 2019 hourly traffic flows

(blank page)



SOUTHBOUND - 2029



NORTHBOUND - 2029

Figure 2-3 2029 hourly traffic flows

(blank page)

Traffic forecasts for the surface road network

Section 7.1 of the environmental impact statement and the Technical Working Paper: Traffic and Transport (Appendix E of the environmental impact statement) present the outcomes of traffic forecasts for surface roads around the project. The section summarises data relevant to the air quality impact assessment.

The project would affect traffic volumes, and associated vehicle emissions, along the following surface roads:

- Major roads connecting to and around the project, including:
  - Direct impacts on the Hills M2 Motorway, through road capacity changes associated with the Hills M2 Motorway integration works, and indirectly through induced and redistributed traffic flows.
  - Direct impacts on the M1 Pacific Motorway through road capacity changes associated with the M1 Pacific Motorway tie-in works, and indirectly through induced and redistributed traffic flows.
- Direct impacts on Pennant Hills Road, through road capacity changes associated with roadworks at Pearces Corner, and indirectly by providing an alternative traffic route through the corridor.
- Other major arterial roads in the region, indirectly through induced and redistributed traffic flows. This includes the Pacific Highway, which connects to the project via Pennant Hills Road and/ or the M1 Pacific Motorway.

While there is potential for the project to contribute to changes in traffic flows along local streets during operation, these potential changes are considered minor in nature and in the context of traffic changes on the surrounding major arterial road network.

The following sections summarise the forecast changes in surface traffic volumes as a result of the project in 2019 and 2029. Data is presented for total vehicles, as well as for light vehicles and heavy vehicles. To assist in interpretation of traffic data, the change in surface traffic volumes has been expressed as a percentage and visually highlighted as summarised in **Table 2-5**.

Table 2-5 Shading for forecast changes in surface traffic

Increases in traffic	Decreases in traffic
Less than one per cent increase	Less than one per cent increase
From one to 10 per cent increase	From one to 10 percent decrease
From 10 to 50 per cent increase	From 10 to 50 per cent decrease
More than 50 per cent increase	More than 50 per cent decrease

Note that the traffic data presented in this section is summarised (refer to the Technical Working Paper: Traffic and Transport for the full traffic data set and impact assessment), nor does it represent all of the data used for the assessment of air quality changes associated with surface roads (refer to **Section 2.8.3** of this report). The traffic data presented in this section are intended to provide context to the extent and relative magnitude of changes in surface traffic as a result of the project, and as a consequence the extent and relative magnitude of changes in traffic-related air quality. This context has been used to define and justify the scope of the air quality impact assessment as it relates to surface traffic changes (refer to **Section 2.7.2** of this report).

Major roads connecting to the project

Major roads connecting to the project include the Hills M2 Motorway, the M1 Pacific Motorway, Pennant Hills Road and the Pacific Highway near the intersection with Pennant Hills Road and the M1 Pacific Motorway. Traffic forecasts on these major connecting roads are summarised in **Table 2-6**, **Table 2-7**, **Table 2-8** and **Table 2-9** respectively. Data is shown for the peak hours in 2019 and 2029, with a breakdown by vehicle type (total vehicles, light vehicles and heavy vehicles) and calculated change in vehicle numbers (as a percentage change).

The data in the tables show that:

- For the Hills M2 Motorway:
  - In 2019, there is forecast to be a slight reduction in traffic volumes in the AM peak (generally less than six per cent) and a moderate increase in the PM peak (generally up to around 15 per cent). The most pronounced changes are forecast in heavy vehicle numbers to the east of Pennant Hills Road, which are forecast to fall by around 39 per cent (westbound, AM peak) and 25 per cent (eastbound PM peak). The most significant increase in heavy vehicles is forecast to occur in the eastbound direction in the PM peak (around 21 per cent increase).
  - In 2029, there is forecast to be a slight increase in total vehicles and light vehicle numbers in the AM peak (less than 10 per cent), with the exception of the westbound direction east of Pennant Hills Road which shows a forecast decrease in vehicle numbers (both light and heavy vehicles). A similar trend is shown in the PM peak traffic forecasts (increases in total and light vehicle numbers up to around 20 per cent), with the exception of the eastbound direction east of Pennant Hills Road, which shows a slight decrease (around seven per cent). The most significant changes in vehicle numbers can be seen in heavy vehicles, and particularly during the AM peak. During the AM peak in an eastbound direction, and during the PM peak in both an eastbound and westbound direction, heavy vehicles numbers are forecast to increase. The westbound direction in the AM peak is forecast to experience a significant reduction in heavy vehicle numbers (around 60 per cent reduction east of Pennant Hills Road, and around 25 per cent west of Pennant Hills Road).

- For the M1 Pacific Motorway:
  - There is generally negligible change in vehicle numbers in both peaks in 2019 and 2029. This outcome is not unexpected given the design of the project and the location of the M1 Pacific Motorway in the broader road network. The M1 Pacific Motorway is the principal route connecting the Central Coast, Newcastle and the north of New South Wales to Sydney, with no other practical alternative. All traffic travelling between Sydney and the north currently uses the motorway, and will continue to do so in the future. The NorthConnex project connects to the end of the M1 Pacific Motorway, and does not create new entry/ exit points along the motorway north of Sydney (other than the connection to the end of the motorway). Traffic forecasts show a very small redistribution of traffic on the M1 Pacific Motorway in 2019 associated with the new interchange connection, and no change in 2029.

- For Pennant Hills Road:
  - Traffic forecasts indicate an almost comprehensive reduction in traffic volumes along Pennant Hills Road in the AM and PM peaks in 2019 and 2029. The most significant reductions are apparent in heavy vehicle numbers which in many cases show a forecast drop of around 50 to 80 per cent.
  - The key exception is the southern portion of Pennant Hills Road, where traffic is forecast to be redistributed as a consequence of access/ egress arrangements for the project. The most pronounced change in traffic can be seen in heavy vehicles traveling northbound on Pennant Hills Road between North Rocks Road and the Hills M2 Motorway (ie south of the southern interchange) in the PM peak. Forecast increases in heavy vehicle numbers in this area are around 120 to 180 per cent. In relative terms these forecast changes are significant, however, the absolute numbers of heavy vehicles (less than 200 in the PM peak) are low.

- For the Pacific Highway near the connection with the project:
  - In 2019, traffic volumes are generally forecast to decrease (by up to 20 per cent) in the AM peak. The exception is northbound east of the M1 Motorway (ie traffic from the Pacific Highway travelling towards the project) where a moderate increase in total vehicles is anticipated (up to 10 per cent). Heavy vehicle numbers are forecast to increase by around 30 per cent, but this is a consequence of the relative change (from 120 to 160 heavy vehicles in the peak hour) rather than a significant absolute heavy vehicle volume. Forecast changes in traffic are more pronounced in the PM peak, with reductions in total vehicles of up to around 60 per cent in the southbound direction north of Pennant Hills Road and increases in total vehicles of up to around seven per cent in the southbound direction east of the M1 Pacific Motorway. Forecast significant increases in heavy vehicle numbers (up to around 170 per cent in the northbound direction north of Pennant Hills Road) are the result of a significant relative change in vehicle numbers (from 30 to 80 in the PM peak) rather than indicating a significant increase in the absolute number of vehicles
  - In 2029, forecast traffic in the AM peak is anticipated to fall north of Pennant Hills Road (by up to around 10 per cent for total and light vehicle counts) and increase to the east of the M1 Pacific Motorway (by around 10 per cent for total vehicle numbers). The most significant change is forecast to occur in heavy vehicle numbers east of the M1 Pacific Motorway, where increases of around 30 to 50 per cent are forecast. In the PM peak, traffic volumes are forecast to increase in most cases (by up to around 15 per cent for total and light vehicle numbers) with the exception of southbound north of Pennant Hills Road where traffic numbers are forecast to fall by a similar degree. The most significant relative change is anticipated in heavy vehicles northbound north of Pennant Hills Road and southbound east of the M1 Pacific Motorway (by around 230 per cent and 100 per cent, respectively).

Table 2-6 Hills M2 Motorway – forecast peak hour traffic (mid block) with and without the project in 2019 and 2029

Road	Total vehicles Without project	Total vehicles With project	Total vehicles % change because of project	Light vehicles Without project	Light vehicles With project	Light vehicles % change because of project	Heavy vehicles Without project	Heavy vehicles With project	Heavy vehicles % change because of project
2019 AM peak									
Hills M2 Motorway (east of Pennant Hills Road) eastbound	4,530	4,280	-5.5%	4,190	3,960	-5.5%	340	320	-5.9%
Hills M2 Motorway (east of Pennant Hills Road) westbound	2,200	2,190	-0.5%	2,020	2,080	+3.0%	180	110	-38.9%
Hills M2 Motorway (west of Pennant Hills Road) eastbound	4,730	4,550	-3.8%	4,250	4,090	-3.8%	480	460	-4.2%
Hills M2 Motorway (west of Pennant Hills Road) westbound	2,990	3,030	+1.3%	2,730	2,760	+1.1%	260	270	+3.8%
2019 PM peak									
Hills M2 Motorway (east of Pennant Hills Road) eastbound	2,790	2,510	-10.0%	2,590	2,360	-8.9%	200	150	-25.0%
Hills M2 Motorway (east of Pennant Hills Road) westbound	4,620	4,820	+4.3%	4,290	4,540	+5.8%	330	280	-15.2%
Hills M2 Motorway (west of Pennant Hills Road) eastbound	3,430	3,650	+6.4%	3,140	3,300	+5.1%	290	350	+20.7%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
Hills M2 Motorway (west of Pennant Hills Road) westbound	4,570	5,180	+13.3%	4,120	4,700	+14.1%	450	480	+6.7%
2029 AM peak									
Hills M2 Motorway (east of Pennant Hills Road) eastbound	4,690	4,830	+3.0%	4,490	4,540	+1.1%	200	290	+45.0%
Hills M2 Motorway (east of Pennant Hills Road) westbound	2,470	2,160	-12.6%	2,140	2,020	-5.6%	330	140	-57.6%
Hills M2 Motorway (west of Pennant Hills Road) eastbound	5,150	5,440	+5.6%	4,860	4,970	+2.3%	290	470	+62.1%
Hills M2 Motorway (west of Pennant Hills Road) westbound	3,480	3,510	+0.9%	3,030	3,170	+4.6%	450	340	-24.4%
2029 PM peak									
Hills M2 Motorway (east of Pennant Hills Road) eastbound	3,040	2,850	-6.3%	2,840	2,640	-7.0%	200	210	+5.0%
Hills M2 Motorway (east of Pennant Hills Road) westbound	5,030	5,710	+13.5%	4,700	5,320	+13.2%	330	390	+18.2%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
Hills M2 Motorway (west of Pennant Hills Road) eastbound	3,880	4,400	+13.4%	3,520	3,930	+11.6%	360	470	+30.6%
Hills M2 Motorway (west of Pennant Hills Road) westbound	5,020	5,980	+19.1%	4,530	5,480	+21.0%	490	500	+2.0%

Table 2-7 M1 Pacific Motorway – forecast peak hour traffic (mid block) with and without the project in 2019 and 2029

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
2019 AM peak									
M1 Pacific Motorway between Ku-ring-gai Chase Road and Windy Banks interchange northbound	1,850	1,820	-1.6%	1,580	1,550	-1.9%	270	270	0%
M1 Pacific Motorway between Ku-ring-gai Chase Road and Windy Banks interchange southbound	4,210	4,160	-1.2%	3,920	3,860	-1.5%	290	300	+3.4%
2019 PM peak									
M1 Pacific Motorway between Ku-ring-gai Chase Road and Windy Banks interchange northbound	4,330	4,240	-2.1%	4,060	3,960	-2.5%	270	280	+3.7%
M1 Pacific Motorway between Ku-ring-gai Chase Road and Windy Banks interchange southbound	2,230	2,230	0%	2,000	1,980	-10.0%	230	250	+8.7%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
2029 AM peak									
M1 Pacific Motorway between Ku-ring-gai Chase Road and Windy Banks interchange northbound	1,930	1,930	0%	1,610	1,610	0%	320	320	0%
M1 Pacific Motorway between Ku-ring-gai Chase Road and Windy Banks interchange southbound	4,980	4,980	0%	4,620	4,620	0%	360	360	0%
2029 PM peak									
M1 Pacific Motorway between Ku-ring-gai Chase Road and Windy Banks interchange northbound	4,920	4,920	0%	4,580	4,580	0%	340	340	0%
M1 Pacific Motorway between Ku-ring-gai Chase Road and Windy Banks interchange southbound	2,340	2,340	0%	2,030	2,030	0%	310	310	0%

Table 2-8 Pennant Hills Road – forecast peak hour traffic (mid block) with and without the project in 2019 and 2029

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
2019 AM peak									
Pennant Hills Road, North Rocks Road to Hills M2 Motorway, northbound	1,770	1,770	0%	1,590	1,610	+1.3%	180	160	-11.1%
Pennant Hills Road, North Rocks Road to Hills M2 Motorway, southbound	2,450	2,390	-2.4%	2,320	2,240	-3.4%	130	150	+15.4%
Pennant Hills Road, Hills M2 Motorway to Castle Hill Road, northbound	2,680	2,330	-13.1%	2,330	2,140	-8.2%	350	190	-45.7%
Pennant Hills Road, Hills M2 Motorway to Castle Hill Road, southbound	3,470	3,080	-11.2%	3,220	2,990	-7.1%	250	90	-64.0%
Pennant Hills Road, Castle Hill Road to Beecroft Road, northbound	2,830	2,610	-7.8%	2,540	2,470	-2.8%	290	140	-51.7%
Pennant Hills Road, Castle Hill Road to Beecroft Road, southbound	2,410	2,150	-10.8%	2,200	2,080	-5.4%	210	70	-66.7%
Pennant Hills	3,770	3,430	-9.0%	3,430	3,260	-5.0%	340	170	-50.0%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
Road, Beecroft Road to Comenarra Parkway, northbound									
Pennant Hills Road, Beecroft Road to Comenarra Parkway, southbound	3,590	3,240	-9.7%	3,380	3,130	-7.4%	210	110	-47.6%
Pennant Hills Road, Comenarra Parkway to Pacific Highway, northbound	2,430	2,240	-7.8%	2,140	2,100	-1.9%	290	140	-51.7%
Pennant Hills Road, Comenarra Parkway to Pacific Highway, southbound	2,610	2,170	-16.9%	2,340	2,100	-10.3%	270	70	-74.1%
2019 PM peak									
Pennant Hills Road, North Rocks Road to Hills M2 Motorway, northbound	2,130	1,760	-17.4%	2,080	1,620	-22.1%	50	140	+180%
Pennant Hills Road, North Rocks Road to Hills M2 Motorway, southbound	2,120	1,890	-10.8%	1,980	1,730	-12.6%	140	160	+14.3%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
Pennant Hills Road, Hills M2 Motorway to Castle Hill Road, northbound	3,830	3,490	-8.8%	3,640	3,420	-6.0%	190	70	-63.2%
Pennant Hills Road, Hills M2 Motorway to Castle Hill Road, southbound	3,280	2,830	-13.7%	2,970	2,660	-10.4%	310	170	-45.2%
Pennant Hills Road, Castle Hill Road to Beecroft Road, northbound	2,610	2,190	-16.1%	2,450	2,170	-11.4%	160	20	-87.5%
Pennant Hills Road, Castle Hill Road to Beecroft Road, southbound	2,540	2,220	-12.6%	2,250	2,090	-7.1%	290	130	-55.2%
Pennant Hills Road, Beecroft Road to Comenarra Parkway, northbound	3,870	3,560	-8.0%	3,690	3,530	-4.3%	180	30	-83.3%
Pennant Hills Road, Beecroft Road to Comenarra Parkway, southbound	3,160	2,600	-17.7%	2,830	2,480	-12.4%	330	120	-63.6%
Pennant Hills Road, Comenarra	3,060	2,760	-9.8%	2,890	2,650	-8.3%	170	110	-35.3%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
Parkway to Pacific Highway, northbound									
Pennant Hills Road, Comenarra Parkway to Pacific Highway, southbound	3,280	1,830	-44.2%	2,970	1,750	-41.1%	310	80	-41.9%
2029 AM peak									
Pennant Hills Road, North Rocks Road to Hills M2 Motorway, northbound	2,050	2,090	+2.0%	1,810	1,900	+5.0%	240	190	-20.8%
Pennant Hills Road, North Rocks Road to Hills M2 Motorway, southbound	3,010	2,750	-8.6%	2,840	2,560	-9.9%	170	190	+11.8%
Pennant Hills Road, Hills M2 Motorway to Castle Hill Road, northbound	2,870	2,460	-14.3%	2,470	2,220	-10.1%	400	240	-40.0%
Pennant Hills Road, Hills M2 Motorway to Castle Hill Road, southbound	3,940	3,640	-7.6%	3,620	3,490	-3.6%	320	150	-53.1%
Pennant Hills Road, Castle Hill Road to Beecroft	3,070	2,740	-10.7%	2,750	2,570	-6.5%	320	170	-46.9%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
Road, northbound									
Pennant Hills Road, Castle Hill Road to Beecroft Road, southbound	2,630	2,330	-11.4%	2,370	2,230	-5.9%	260	100	-61.5%
Pennant Hills Road, Beecroft Road to Comenarra Parkway, northbound	4,180	3,720	-11.0%	3,750	3,470	-7.5%	430	250	-41.9%
Pennant Hills Road, Beecroft Road to Comenarra Parkway, southbound	4,210	3,710	-11.9%	3,930	3,620	-7.9%	280	90	-67.9%
Pennant Hills Road, Comenarra Parkway to Pacific Highway, northbound	2,630	2,490	-5.3%	2,290	2,310	+0.9%	340	180	-47.1%
Pennant Hills Road, Comenarra Parkway to Pacific Highway, southbound	3,000	2,550	-15.0%	2,690	2,430	-9.7%	310	120	-61.3%
2029 PM peak									
Pennant Hills Road, North Rocks Road to Hills M2 Motorway,	2,480	2,150	-13.3%	2,420	2,020	-16.5%	60	130	+116.7%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
northbound									
Pennant Hills Road, North Rocks Road to Hills M2 Motorway, southbound	2,500	2,530	+1.2%	2,280	2,340	+2.6%	220	190	-13.6%
Pennant Hills Road, Hills M2 Motorway to Castle Hill Road, northbound	4,290	3,840	-10.5%	4,050	3,720	-8.1%	240	120	-50.0%
Pennant Hills Road, Hills M2 Motorway to Castle Hill Road, southbound	2,990	3,140	+5.0%	2,620	2,950	+12.6%	370	190	-48.6%
Pennant Hills Road, Castle Hill Road to Beecroft Road, northbound	2,730	2,350	-13.9%	2,560	2,290	-10.5%	170	60	-64.7%
Pennant Hills Road, Castle Hill Road to Beecroft Road, southbound	2,740	2,470	-9.9%	2,400	2,270	-5.4%	340	200	-41.2%
Pennant Hills Road, Beecroft Road to Comenarra Parkway, northbound	4,320	3,930	-9.0%	4,080	3,870	-5.1%	240	60	-75.0%
Pennant Hills Road, Beecroft	3,400	2,810	-17.4%	2,990	2,620	-12.4%	410	190	-53.7%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
Road to Comenarra Parkway, southbound									
Pennant Hills Road, Comenarra Parkway to Pacific Highway, northbound	3,370	3,080	-8.6%	3,140	2,940	-6.4%	230	140	-39.1%
Pennant Hills Road, Comenarra Parkway to Pacific Highway, southbound	3,680	2,030	-44.8%	3,300	1,880	-43.0%	380	150	-60.5%

Table 2-9 Pacific Highway – forecast peak hour traffic (mid block) with and without the project in 2019 and 2029

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
2019 AM peak									
Pacific Highway, north of Pennant Hills Road, northbound	1,570	1,420	-9.6%	1,470	1,340	-8.8%	100	80	-20.0%
Pacific Highway, north of Pennant Hills Road, southbound	1,230	1,000	-18.7%	1,150	920	-20.0%	80	80	0%
Pacific Highway, east of M1 Pacific Motorway, northbound	1,720	1,890	+9.9%	1,600	1,730	+8.1%	120	160	+33.3%
Pacific Highway, east of M1 Pacific Motorway, southbound	3,170	3,060	-3.5%	3,000	2,900	-3.3%	170	160	-5.9%
2019 PM peak									
Pacific Highway, north of Pennant Hills Road, northbound	1,330	1,360	+2.3%	1,300	1,280	-1.5%	30	80	+166.7%
Pacific Highway, north of Pennant Hills Road, southbound	4,270	1,680	-60.7%	4,200	1,630	-61.2%	70	50	-28.6%
Pacific Highway, east of M1 Pacific Motorway, northbound	3,110	3,050	-1.9%	3,030	2,970	-2.0%	80	80	0%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
Pacific Highway, east of M1 Pacific Motorway, southbound	1,850	1,980	+7.0%	1,790	1,880	+5.0%	60	100	+66.7%
2029 AM peak									
Pacific Highway, north of Pennant Hills Road, northbound	1,650	1,590	-3.6%	1,570	1,500	-4.7%	80	90	+12.5%
Pacific Highway, north of Pennant Hills Road, southbound	1,290	1,140	-11.6%	1,200	1,050	-12.5%	90	90	0%
Pacific Highway, east of M1 Pacific Motorway, northbound	1,960	2,170	+10.7%	1,800	1,950	+8.3%	160	220	+37.5%
Pacific Highway, east of M1 Pacific Motorway, southbound	3,370	3,390	+0.6%	3,240	3,190	-1.5%	130	200	+53.8%
2029 PM peak									
Pacific Highway, north of Pennant Hills Road, northbound	1,330	1,500	+12.8%	1,300	1,400	+7.7%	30	100	+233.3%
Pacific Highway, north of Pennant Hills Road, southbound	1,700	1,560	-8.2%	1,630	1,500	-8.0%	70	60	-14.3%
Pacific Highway, east of M1 Pacific	3,110	3,290	+5.8%	3,030	3,200	+5.6%	80	90	+12.5%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
Motorway, northbound									
Pacific Highway, east of M1 Pacific Motorway, southbound	1,850	2,110	+14.1%	1,790	1,990	+11.2%	60	120	+100.0%

Other major roads in the area

Traffic data for other major roads around the project corridor are provided in **Table 2-10**. Given the volumes of traffic on these roads and/ or the minor level of traffic volume changes as a consequence of the project, traffic data have been provided as daily traffic volumes (annual weekly daily traffic (AWDT)).

Table 2-10 shows that the relative change in traffic volume (either increase or decrease) would in most cases be less than 10 per cent (and frequently less than five per cent) as a consequence of the project.

(blank page)

Table 2-10 Other major roads – forecast average weekly daily traffic (mid block) with and without the project in 2019 and 2029

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
2019									
Pacific Highway, Pennant Hills Road to Woolcott Avenue, northbound	17,700	17,950	+1.41%	16,650	16,800	+0.90%	1,050	1,150	+9.52%
Pacific Highway, Pennant Hills Road to Woolcott Avenue, southbound	21,000	19,850	-5.48%	20,450	19,400	-5.13%	550	450	-18.18%
Pacific Highway, M1 Pacific Motorway interchange to Redleaf Avenue, northbound	36,450	36,950	+1.37%	33,550	34,200	+1.94%	2,900	2,750	-5.17%
Pacific Highway, M1 Pacific Motorway interchange to Redleaf Avenue, southbound	39,350	40,350	+2.54%	34,800	35,300	+1.44%	4,550	5,050	+10.99%
Pacific Highway, North of Bobbin Head Road, northbound	36,550	33,700	-7.80%	33,700	30,950	-8.16%	2,850	2,750	-3.51%
Pacific Highway, North of Bobbin Head Road,	32,100	29,250	-8.88%	28,150	25,550	-9.24%	3,950	3,700	-6.33%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
southbound									
Castle Hill Road, New Line Road to Edward Bennett Drive, eastbound	19,100	17,800	-6.81%	18,350	17,250	-5.99%	750	550	-26.67%
Castle Hill Road, New Line Road to Edward Bennett Drive, westbound	16,650	14,650	-12.01%	15,900	14,950	-5.97%	750	700	-6.67%
Boundary Road, North of Pennant Hills Road, eastbound	18,650	16,200	-13.14%	17,550	15,150	-13.68%	1,100	1,050	-4.55%
Boundary Road, North of Pennant Hills Road, westbound	12,200	13,050	+6.97%	11,100	11,850	+6.76%	1,100	1,200	+9.09%
Beecroft Road, Hills M2 Motorway interchange to Cheltenham Road, northbound	25,900	27,000	+4.25%	24,600	25,550	+3.86%	1,300	1,450	+11.54%
Beecroft Road, Hills M2 Motorway interchange to Cheltenham Road, southbound	19,400	20,250	+4.38%	18,600	19,350	+4.03%	800	900	+12.50%
Beecroft Road, South of Hills M2 Motorway, northbound	23,500	23,850	+1.49%	22,400	22,600	+0.89%	1,100	1,250	+13.64%
Beecroft Road,	16,000	15,750	-1.56%	15,550	15,300	-1.61%	450	450	0%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
South of Hills M2 Motorway, southbound									
North Rocks Road, West of Pennant Hills Road, eastbound	18,100	18,050	-0.28%	16,900	16,850	-0.30%	1,200	1,200	0%
North Rocks Road, West of Pennant Hills Road, westbound	14,600	14,150	+3.08%	13,950	13,250	-5.02%	650	900	+38.46%
Carlingford Road, East of Pennant Hills Road, eastbound	14,700	14,400	-2.04%	14,250	13,950	-2.11%	450	450	0%
Carlingford Road, East of Pennant Hills Road, westbound	22,050	21,450	-2.72%	21,300	20,700	-2.82%	750	750	0%
Lane Cove Road, South of Hills M2 Motorway, northbound	32,350	29,600	-8.50%	29,700	27,050	-8.92%	2,650	2,550	-3.77%
Lane Cove Road, South of Hills M2 Motorway, southbound	27,950	25,950	-7.16%	25,500	23,650	-7.25%	2,450	2,300	-6.12%
Epping Road, West of Delhi Road, northbound	49,400	47,150	-4.55%	45,950	43,650	-5.01%	3,450	3,500	+1.45%
Epping Road, West of Delhi Road,	33,750	32,750	-2.96%	31,450	30,400	-3.34%	2,300	2,350	+2.17%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
southbound									
Pennant Hills Road, Marsden Road to Carlingford Road, northbound	31,500	30,850	-2.06%	28,250	27,550	-2.48%	3,250	3,300	+1.54%
Pennant Hills Road, Marsden Road to Carlingford Road, southbound	42,950	41,700	-2.91%	37,700	36,000	-4.51%	5,250	5,700	+8.57%
Emert Street, North of Great Western Highway, northbound	27,150	25,900	-4.60%	24,450	23,000	-5.93%	2,700	2,900	+7.41%
Emert Street, North of Great Western Highway, southbound	34,000	32,600	-4.12%	30,550	28,700	-6.06%	3,450	3,900	+13.04%
2029									
Pacific Highway, Pennant Hills Road to Woolcott Avenue, northbound	23,000	22,800	-0.87%	21,800	21,350	-2.06%	1,200	1,450	+20.83%
Pacific Highway, Pennant Hills Road to Woolcott Avenue, southbound	23,000	19,500	-15.22%	22,350	18,950	-15.21%	650	550	-15.38%
Pacific Highway, M1 Pacific	40,700	41,350	+1.60%	37,100	37,900	+2.16%	3,600	3,450	-4.17%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
Motorway interchange to Redleaf Avenue, northbound									
Pacific Highway, M1 Pacific Motorway interchange to Redleaf Avenue, southbound	43,450	43,900	+1.04%	38,000	38,200	+0.53%	5,450	5,900	+8.26%
Pacific Highway, North of Bobbin Head Road, northbound	38,600	36,800	-4.66%	35,150	33,450	-4.84%	3,450	3,350	-2.90%
Pacific Highway, North of Bobbin Head Road, southbound	34,750	31,650	-8.92%	29,950	27,350	-8.68%	4,800	4,300	-10.42%
Castle Hill Road, New Line Road to Edward Bennett Drive, eastbound	21,950	21,100	-3.87%	21,000	20,300	-3.33%	950	800	-15.79%
Castle Hill Road, New Line Road to Edward Bennett Drive, westbound	19,300	19,150	-0.78%	18,250	18,150	-0.55%	1,050	1,000	-4.76%
Boundary Road, North of Pennant Hills Road, eastbound	20,800	19,250	-7.45%	19,400	18,000	-7.22%	1,400	1,250	-10.71%
Boundary Road, North of Pennant	13,100	14,200	+8.40%	11,700	12,650	+8.12%	1,400	1,550	+10.71%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	**With project**	**% change because of project**	**Without project**	**With project**	**% change because of project**	**Without project**	**With project**	**% change because of project**
Hills Road, westbound									
Beecroft Road, Hills M2 Motorway interchange to Cheltenham Road, northbound	28,600	31,100	+8.74%	26,750	28,950	+8.22%	1,850	2,050	+10.81%
Beecroft Road, Hills M2 Motorway interchange to Cheltenham Road, southbound	20,750	22,900	+10.36%	19,750	21,750	+10.13%	1,000	1,150	+15.00%
Beecroft Road, South of Hills M2 Motorway, northbound	25,350	26,600	+4.93%	23,750	24,850	+4.63%	1,600	1,750	+9.38%
Beecroft Road, South of Hills M2 Motorway, southbound	16,300	16,600	+1.84%	15,700	16,000	+1.91%	600	600	0%
North Rocks Road, West of Pennant Hills Road, eastbound	18,550	18,650	+0.54%	17,350	17,400	+0.29%	1,200	1,250	+4.17%
North Rocks Road, West of Pennant Hills Road, westbound	14,950	14,900	-0.33%	14,250	13,750	-3.51%	700	1,150	+64.29%
Carlingford Road, East of Pennant Hills Road, eastbound	16,550	16,550	0%	15,950	16,000	+0.31%	600	550	-8.33%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
Carlingford Road, East of Pennant Hills Road, westbound	24,050	24,100	+0.21%	23,150	23,250	+0.43%	900	850	-5.56%
Lane Cove Road, South of Hills M2 Motorway, northbound	36,800	34,800	-5.43%	33,550	31,700	-5.51%	3,250	3,100	-4.62%
Lane Cove Road, South of Hills M2 Motorway, southbound	33,000	31,400	-4.85%	29,700	28,500	-4.04%	3,300	2,900	-12.12%
Epping Road, West of Delhi Road, northbound	55,450	54,550	-1.62%	51,300	50,300	-1.95%	4,150	4,250	+2.41%
Epping Road, West of Delhi Road, southbound	36,900	36,850	-0.14%	34,100	34,050	-0.15%	2,800	2,800	0%
Pennant Hills Road, Marsden Road to Carlingford Road, northbound	33,900	34,100	+0.59%	30,350	30,450	+0.33%	3,550	3,650	+2.82%
Pennant Hills Road, Marsden Road to Carlingford Road, southbound	45,200	45,150	-0.11%	39,700	38,950	-1.89%	5,500	6,200	+2.73%
Emert Street, North of Great Western Highway, northbound	32,100	32,050	-0.16%	29,050	28,600	-1.55%	3,050	3,450	+13.11%

Road	Total vehicles			Light vehicles			Heavy vehicles		
	Without project	With project	% change because of project	Without project	With project	% change because of project	Without project	With project	% change because of project
Emert Street, North of Great Western Highway, southbound	38,350	38,600	+0.65%	34,350	33,900	-1.31%	4,000	4,700	+17.50%