JHCPB Joint Venture

Potential Ventilation System Modifications - E10 Report

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Definitions and abbreviations

Abbreviation	Definition
CEMP	Construction Environmental Management Plan
CO	Carbon Monoxide
CSSI	Critical State Significant Infrastructure
DP&E	Department of Planning And Environment
EIS	Environmental Impact Statement
HCV	Heavy Commercial Vehicle
HDV	Heavy Duty Vehicle, with a mass of greater than 4.5 tonnes
Hydraulic Diameter	The hydraulic diameter is a commonly used term when handling flow in non-circular tubes and channels.
Jet fan niche	Localised increase in tunnel height where jet fans can be installed
LCV	Light Commercial Vehicle
M&E	Mechanical and Electrical
MCC	Motorway Control Centre
MCoA	Ministers Conditions of Approval
MOC	Motorway Operation Complex
NO_2	Nitrogen Dioxide
OMCS	Operations Management and Control Systems – the traffic control and management system and installations control and management system control system for the motorway
PCU	Passenger car unit – One passenger car corresponds to one passenger car unity. Typically, 2 or 3 PSU's correspond to one truck depending on the vehicle dimensions and speed
PIARC	Permanent International Association of Road Congresses
RIC	Rozelle Interchange
SPIR	Submissions and Preferred Infrastructure Report (Submissions Report) – This report details aspects of the EIS that have changed since the EIS was publicly displayed, and includes refinements to the concept design of the Project, in part to minimise its environmental impact, and identify and respond to issues raised and responded to in submissions
SVDS	Smoky Vehicle Detection System
TfNSW	Transport for New South Wales
TMCS	Traffic Management and Control System – the traffic control software within the OMCS responsible for all traffic control and relate traffic control and monitoring
WRTM	WestConnex Road Traffic Model

1. Executive Summary

The objective of this document is to demonstrate that the Rozelle Interchange (RIC) ventilation system has been designed and constructed such that it can be modified in the future, if required. The Minister for Planning granted approval for the project subject to SSI 7485 conditions of Approval including E10 which states:

> All tunnels must be designed and constructed so as to allow for future modification of the ventilation system if required. The Proponent must submit a report to the Secretary demonstrating how this will be allowed for prior to finalising detailed design.

2. Introduction

2.1. Background

WestConnex is one of the NSW Government's key infrastructure projects which aims to ease congestion, create jobs, and connect communities. Together with the other components of the WestConnex Program of Works and the proposed future Sydney Gateway, the WestConnex M4-M5 Link will facilitate improved connections between western Sydney, Sydney Airport and Port Botany and south and south-western Sydney, as well as better connectivity between the important economic centres along Sydney's Global Economic Corridor and local communities (refer to Figure 1). Due to its importance, the WestConnex M4-M5 Link project was declared to be critical state significant infrastructure (CSSI) by the Minister for Planning on 15 August 2017.

This Construction Environmental Management Plan (CEMP) has been prepared in accordance with the Conditions of Approval which were granted to the Project on 17 April 2018, as well as subsequent Approved Modification Reports.

The WestConnex M4-M5 Link is being delivered in two stages:

- Stage 1, the Mainline Tunnels which includes the construction and operation of the M4-M5 Link Tunnel between the New M4 at Haberfield and the New M5 at St Peters, and
- Stage 2, the Rozelle Interchange, which will connect the Stage 1 mainline tunnels to the surrounding surface road network and includes the construction and operation of (see Figure 1)
    - An interchange at Lilyfield and Rozelle, including a connection to the proposed future Western Harbour Tunnel and Beaches Link project, and
    - A tunnel connection between the Anzac Bridge and Victoria Road, east of Iron Cove Bridge.

This CEMP applies only to Stage 2 of the M4-M5 Link, the Rozelle Interchange Project (the Project), which is being managed by Roads and Maritime Services (RMS).

A detailed description of the Project is provided in Chapter 5 of the WestConnex M4-M5 Link Environmental Impact Statement (EIS).

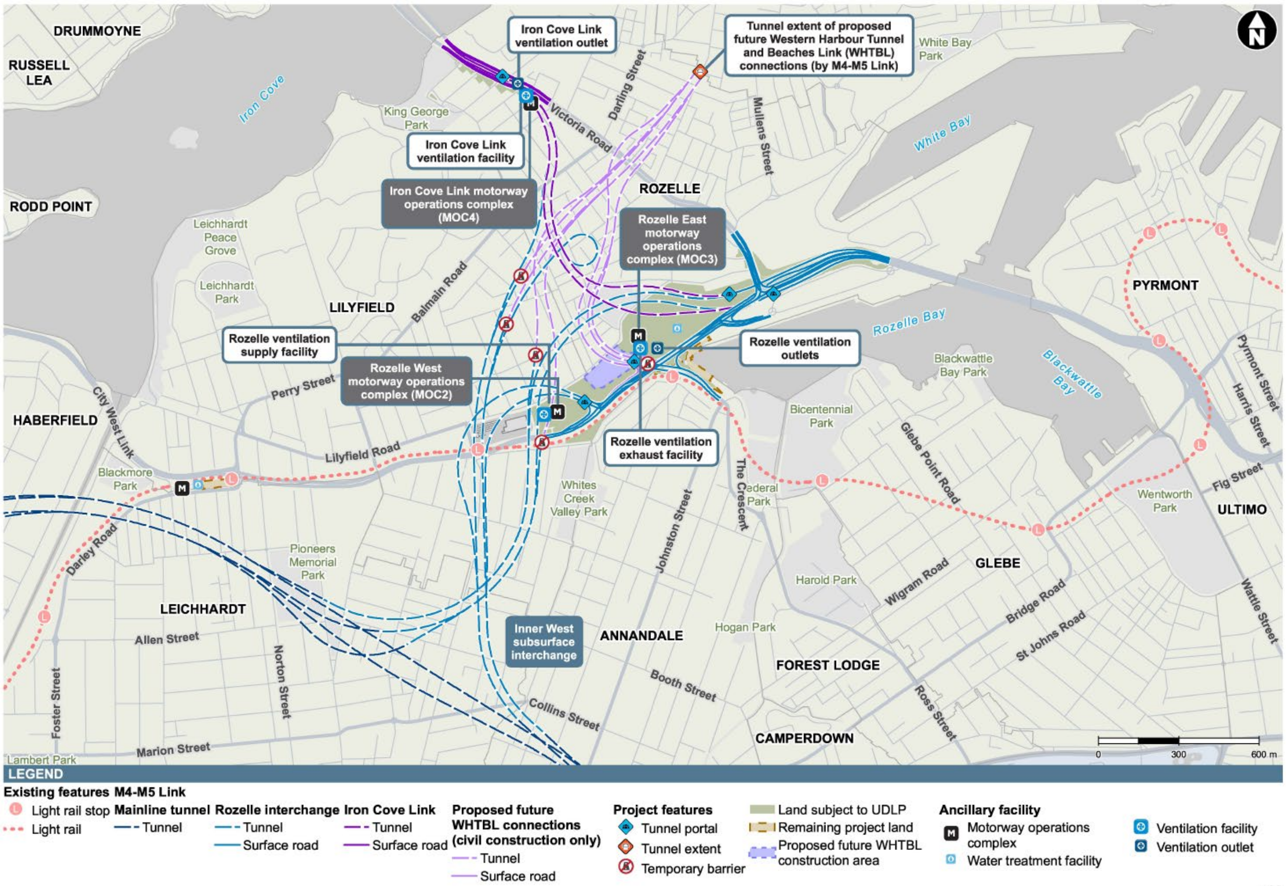

Figure 1 Map of RIC stage of WestConnex Project

2.2. Purpose

The purpose of this Potential Future Modification to Tunnel Ventilation System Report, is to demonstrate that the RIC ventilation system has been designed and constructed to allow for modification in the future, if required, under State Significant Infrastructure SSI 7485 Infrastructure Approval Condition E10 which states:

> *All tunnels must be designed and constructed so as to allow for future modification of the ventilation system if required. The Proponent must submit a report to the Secretary demonstrating how this will be allowed for prior to finalising detailed design.*

This report will review:

- A summary of the Project Environmental Impact Statement (EIS).
- The tunnel ventilation design.
- Potential future modifications.
- Analysis of the feasibility and impacts of the modifications.

3. Summary of EIS

3.1. General

Transport for NSW (formally NSW Roads and Maritime Services), authorised the preparation and submission of the following documents as part of the Project approval process:

- August 2017 M4-M5 Environmental Impact Statement (EIS); and
- M4-M5 Submissions and Preferred Infrastructure Report (SPIR).

The EIS identified that the air quality outcomes for the M4-M5 Link were influenced by several elements, including:

- Air quality;
- Traffic predictions; and
- Tunnel ventilation design.

Specific sections of the EIS relating to the M4-M5 Link Stage 2 project that are outlined in this document include:

- Volume 1A
  - Chapter 8 – Traffic and transport
  - Chapter 9 – Air quality
- Volume 2B
  - Appendix H – Technical working paper: Traffic and transport
- Volume 2C
  - Appendix I – Technical working paper: Air quality

3.2. Air quality

3.2.1. General

Air quality is covered in chapter 9 of the EIS. This chapter describes the methodology used to assess the impacts of the M4-M5 Link project on regional, local, and in-tunnel air quality, the results of that assessment and proposed mitigation measures to avoid or reduce the impacts. Appendix I (Technical working paper: Air quality) of the EIS, provides greater detail of the monitoring and modelling methodologies and results.

The assessment considers the potential air quality impacts during construction and operation of the Project. Consideration is also given to the potential cumulative impacts of the Project with the other components of the WestConnex program of works and any related projects within proximity to the M4-M5 Link and operational within 10 years of opening.

The assessment includes detailed analysis of the predicted air quality inside the mainline tunnels, including entry and exit ramps, during the operation of the Project.

The design and assessment of the Project has benefited from data from the design and operation of existing Sydney tunnels. This has enabled evaluation of emissions models for both in tunnel and external emissions modelling. Recent air quality assessments for surface roads and tunnels in Australia and New Zealand were reviewed to identify the methodologies, tools and findings that could inform the M4-M5 Link assessment. These assessments are presented in Annexure D of Appendix I (Technical working paper: Air quality). The findings include details of the pollutants considered, the sources of emission factors, the dispersion models applied, and the approaches used to assess construction impacts.

3.2.2. Air Quality Considerations

Section 3 of Appendix I (Technical working paper: Air quality) of the EIS discusses the air quality considerations for the project. Section 3 explores the main aspects of traffic-related emissions and air pollution, including the air quality issues that are associated specifically with road tunnels.

Section 3.2.1 of Appendix I states that road traffic is the main source of several important air pollutants in Australian cities. Many different air pollutants are associated with road vehicles. Pollutants that are emitted directly into the air are termed ‘primary’ pollutants. Regarding local air quality and health, as well as the quantity emitted, the most significant primary pollutants from road vehicles are:

- Carbon monoxide (CO)
- Nitrogen oxides (NOX)
- Particulate matter (PM). The two metrics that are most used are PM10 and PM2.5
- Hydrocarbons (HC). The term ‘hydrocarbons’ covers a wide range of compounds which contain carbon and hydrogen.
- Volatile organic compounds (VOC) are also often used, particularly when there is a reference to fuel evaporation.

Other pollutants, notably ozone (O_3) and important components of airborne particulate matter, are formed through chemical reactions in the atmosphere. These are termed ‘secondary’ pollutants. Most of the NO_2 in the atmosphere is also secondary in nature.

Air pollution in road tunnels is discussed in section 3.2.4 of Appendix I (Technical working paper: Air quality) of the EIS which covers in-tunnel pollution, portal emissions, and ventilation outlet emissions as discussed in the following sections.

3.2.2.1. In-tunnel air pollution

The impacts on health are related to the concentration of pollutants in the tunnel and the amount of time spent in the tunnel. The more time spent travelling in a tunnel with elevated pollutant concentrations, the greater the exposure time which, in turn, would increase the risk of effects (National Health and Medical Research Council). Ensuring that in-tunnel air quality remains within acceptable levels is the key consideration for tunnel ventilation design. Visibility is also a significant safety concern for tunnel design.

Visibility is reduced by the scattering and absorption of visible light by airborne particles. The amount of scattering or absorption is dependent upon particle size, composition, and density (Permanent International Association of Road Congresses (PIARC), 2012).

3.2.2.2. Portal emissions

In most road tunnels around the world emissions are released from the portals. One of the potential advantages of tunnels is the opportunity to site portals so that emissions in sensitive areas are avoided. However, this can often be challenging in densely populated urban settings. In Sydney, several urban tunnels have therefore been designed in such a way that portal emissions are avoided. In line with this approach, the Project is currently designed such that there are no emissions from the tunnel portals during normal operations.

3.2.2.3. Ventilation outlet emissions

Tunnel portal emissions are avoided through the extraction of air via elevated ventilation outlets, and these provide an effective means of dispersing the polluted air from a tunnel. Ventilation outlets work by taking advantage of the turbulent mixing in the atmosphere, and the fact that wind speed generally increases with height. The concentrations of pollutants at locations of potential exposure are determined by the emission rates of the pollutants and the effectiveness of the ventilation system at harnessing the dispersive capacity of the atmosphere.

The concentrations of pollutants at ground level are progressively reduced as the height of the outlet increases. A combination of the design height of the outlet and the amount of fresh air that is mixed with the polluted air from the tunnel can be used to ensure appropriate dilution before the exhaust plume contacts the ground, and good design can ensure compliance with local air quality standards, (PIARC, 2008).

The temperature of the air leaving tunnel ventilation outlets is also an important determinant of the dispersion of pollutants. Plumes with higher temperatures have higher buoyancy, which generally means that the plume is carried higher into the atmosphere, resulting in improved dispersion. The temperature of the plume is influenced by the number of vehicles moving through the tunnels, as some of the heat from the vehicle exhaust would be carried through to the ventilation outlets.

To achieve zero emissions from a portal, the polluted air from the section of tunnel between a ventilation outlet and the portal must be extracted from the ventilation outlet. This requires that the air in the tunnel section is drawn back against air flow induced by vehicle aerodynamic drag (piston effect). Given this requirement for pushing air in the opposite direction to the traffic flow, positioning ventilation outlets close to tunnel exit portals has been found to be the most cost-effective and energy-efficient approach, as this minimises the distance over which this ‘reverse flow’ is needed. However, the use of ventilation outlets to avoid portal emissions does have implications:

- An increase in the required throughput of ventilation air, which can increase the design size and capital cost of the ventilation system.
- An increase in the operational cost (and energy use) of the ventilation system, as it must be operated continuously regardless of traffic or pollutant levels in the tunnel.

Ventilation outlets can also be deliberately sited away from dense residential areas to address community concern about the impact. However, this can considerably increase the construction, maintenance and running costs of a tunnel for no significant gain in air quality, and such designs are very rare outside Australia.

3.2.3. Air Quality Criteria

The criteria for analysing the air quality considers the Ambient (outdoor) air quality, in-tunnel air quality, and the visibility and particulate matter within the tunnel.

3.2.2.1. Ambient Air Quality

Compliance with ambient air quality standards is an essential consideration during road project design and operation. An ambient air quality standard defines a metric relating to the concentration of an air pollutant in the ambient air. Standards are usually designed to protect human health, including sensitive people such as children, the elderly and people suffering from respiratory disease. The standards may also relate to other adverse effects such as damage to buildings and vegetation.

The form of an air quality standard is typically a concentration limit for a given averaging period (e.g. annual mean, 24-hour mean), which may be stated as a ‘not-to-be-exceeded’ value or with some exceedances permitted. Several different averaging periods may be used for the same pollutant to address long-term and short-term exposure.

Air pollutants are often divided into 'criteria' pollutants and 'air toxics, criteria pollutants tend to be ubiquitous, i.e. found everywhere, and emitted in relatively large quantities, and their health effects relatively well known. Air toxics are gaseous or particulate organic pollutants that are present in the air in low concentrations, but are defined on the basis that they are, for example, highly toxic or last a long time in the environment to be a hazard to humans, plants, or animal life.

The following table has been taken from section 9.2.3 of the EIS and is for the air quality criteria applicable to the Project assessment. The Australian states and territories manage emissions and air quality. In NSW the statutory methods used for assessing air pollution from stationary sources are listed in the NSW EPA Approved Methods (NSW EPA 2016).

These criteria include the latest (2016) update of the NSW EPA Approved Methods for particulate matter. The NSW EPA Approved Methods specify air quality criteria for many other substances, including air toxics. The SEARs for the Project require an evaluation of volatile organic compounds including the group known as BTEX compounds i.e. benzene, toluene, ethylbenzene, and xylenes.

Table 1 Air quality criteria applicable to the project assessment

Pollutant/metric	Concentration	Averaging period	Source
Criteria pollutants			
CO	30 mg/m^3	1 hour	NSW EPA (2016)
	10 mg/m^3	8 hours (rolling)	NSW EPA (2016)
Nitrogen dioxide (NO_2)	246 μg/m^3	1 hour	NSW EPA (2016)
	62 μg/m^3	1 year	NSW EPA (2016)
Particulate matter less than or equal to 10 micrometre	50 μg/m^3	24 hours	NSW EPA (2016)
	25 μg/m^3	1 year	NSW EPA (2016)
Particulate matter less than or equal to 2.5 micrometre diameter ($PM_{2.5}$)	25 μg/m^3	24 hours	NSW EPA (2016)
	20 μg/m^3 (goal by 2025)	*24 hours*	NEPC[a] (2016)
	8 μg/m^3	1 year	NSW EPA (2016)
	7 μg/m^3 (goal by 2025)	*1 year*	NEPC (2016)
Air toxics			
Benzene	0.029 mg/m^3	1 hour	NSW EPA (2016)
PAHs (as b(a)p)[b]	0.0004 mg/m^3	1 hour	NSW EPA (2016)
Formaldehyde	0.02 mg/m^3	1 hour	NSW EPA (2016)
1,3-butadiene	0.04 mg/m^3	1 hour	NSW EPA (2016)

Notes:
(a) National Environment Protection Council
(b) Polycyclic aromatic hydrocarbon as benzo(a)pyrene

3.2.2.2. In-tunnel Air Quality

The air quality criteria used to assess and manage air quality in tunnels have changed in recent years due to significant changes in vehicle emissions. Traditionally, CO was the key criterion used to protect the health of tunnel users.

Following reductions in CO in vehicle emissions, there is relatively more NO_2 in tunnel air than in the past. NO_2 is a respiratory irritant with identified health effects at levels that may be encountered in road tunnels.

An extensive review of the scientific literature commissioned by NSW Health found some evidence of health effects from short-term exposure to NO_2 concentrations between 0.2 and 0.5 ppm. No health effects were identified from short-term (20– 30 minutes) exposure of NO_2 levels below 0.2 ppm in this review. For the operating years of the Project, NO_2 would be the pollutant that determines the required airflow and drives the design of the tunnel ventilation system for in-tunnel pollution. DP&E issued a report in January 2015 that included discussion on this topic for the NorthConnex project. The Secretary's Environmental Assessment Report for the NorthConnex project states:

> *'The Department considers that nitrogen dioxide (NO_2) is now the key pollutant of concern for in-tunnel air quality. While carbon monoxide has historically been the basis for in-tunnel criteria in NSW and internationally, improvements in modern vehicle technology mean that NorthConnex will comply with existing health-based carbon monoxide standards. By contrast, vehicle emissions of NO_2 have fallen less quickly, and uptake of diesel vehicles (which produce more NO_2 than petrol-based vehicles) has risen … Accordingly, it is recommended that the Proponent's design criteria for NO_2 of 0.5 ppm (averaged over 15 minutes) be applied as an average across the tunnel under all operating conditions.'*

Air quality data for recently constructed Sydney tunnels is available at the following websites;

M4E Air Quality – https://www.linkt.com.au/sydney/using-toll-roads/about-sydney-toll-roads/westconnex-m4/tunnel-air-quality

M8 Air Quality – https://www.linkt.com.au/sydney/using-toll-roads/about-sydney-toll-roads/westconnex-m8/tunnel-air-quality

NorthConnex Air Quality – https://www.linkt.com.au/sydney/using-toll-roads/about-sydney-toll-roads/northconnex/tunnel-air-quality

The air quality within these tunnels operates well below specified limits thus, the ventilation design is proven to be more than adequate. The table below outlines the Ministers Conditions of Approval (MCoA) E3 for the M4-M5 Link project in tunnel air quality limits.

Table 2 In-tunnel average limits along length of tunnel

Pollutant	Concentration Limit	Units of measurement	Averaging period
CO	87	ppm	Rolling 15-minute
CO	50	ppm	Rolling 30-minute
NO_2	0.5	ppm	Rolling 15-minute

3.2.2.3. Visibility and particulate matter

Visibility is an important consideration in the design of a road tunnel ventilation system. As per section 9.2.3 of the EIS, the visibility is required to be greater than the minimum vehicle stopping distance at the design speed.

Visibility is reduced by the scattering and absorption of light by particles suspended in the air. The measurement of visibility in a tunnel is based on the concept that a light beam reduces in intensity as it passes through air containing particles or other pollutants. The amount of light scattering, or absorption, in road tunnels is principally dependent on the composition, diameter and density of the particles in the air.

Section 9.2.3 of the EIS explains that particles that affect visibility are generally in a size range of 0.4 to 1.0 micrometres (µm). A coefficient of light extinction is used as an indicator of the particulate matter concentration in the tunnel. The operational extinction coefficient limit of 0.005 m^{-1} specified in condition of approval E5 may result in tunnel emissions being visible under congested conditions, but not at sufficient levels to produce hazy conditions (PIARC 2012).

3.3. Traffic and transport

3.3.1 General

Traffic and transport are covered in chapter 8 (Traffic and transport), and Appendix H (Technical Working Paper: Traffic and Transport) of the EIS. Appendix H covers most data and analysis where chapter 8 discusses the assessment methods, environment, and impacts.

3.3.2 Traffic Models

Chapter 8 of Appendix H (Technical Working Paper: Traffic and Transport) details the traffic demand changes forecast by the WestConnex Road Traffic Model (WRTM) and performance in a ‘without project’ scenario using forecast AM and PM peak hour traffic volumes for 2023 and 2033. Section 4.2.1 of Appendix H explains that the WRTM was developed in the following stages:

- A review of the available transport planning models and data was undertaken to determine the optimal models and data to provide an appropriate foundation for the WRTM.
- Base and future population and employment data for metropolitan Sydney was sourced from Transport for NSW Transport Performance and Analytics, which are available at five-year intervals.
- Available toll choice modelling techniques were assessed in the current Sydney context where multiple competing toll roads cover a substantial portion of the developed Greater Sydney metropolitan area.
- Project specific Value of Travel Time Savings (VTTS) surveys of drivers’ willingness to pay tolls were undertaken to inform the toll choice modelling to enable the model to best reflect current driver behaviour in the specific context of the WestConnex component projects.
- Existing road infrastructure was reviewed for the base year. A set of future road infrastructure projects for the modelled Sydney metropolitan area for future years was developed and is consistent with its current funding and planning policies.
- The WRTM project model was developed and calibrated to current observed travel behaviour, then validated against 2012 Sydney-wide travel behaviour from a series of traffic count and travel time surveys. It was then adjusted to reflect driver behaviour on Sydney’s toll roads as indicated by the VTTS surveys. The model calibration and validation processes maintained a specific focus and refinement in the area of the WestConnex

program of works. The WRTM comprises separate weekday time period sub-models, with average one hour peak multi-class traffic assignments run for:

  - AM period: 07:00 AM – 09:00 AM
  - Daytime inter-peak: 09:00 AM – 03:00 PM
  - PM period: 03:00 PM – 06:00 PM
  - Evening off-peak: 06:00 PM – 07:00 AM

- The WestConnex program of works was coded into the WRTM future year models
- Future demands were estimated by applying future year traffic growth forecast by the STM to the WRTM to produce the most likely or future base case scenario. Traffic estimates were produced by the WRTM for the years 2021, 2026 and 2031. The demands for 2023 (assumed year of opening) were then determined by interpolating between the 2021 and 2026 demands. The demands for 2033 (assumed year of opening plus 10 years) were determined by extrapolating the demands from the 2026 and 2031 demand matrices. This produced vehicle demands by time for an average weekday at each year and vehicle class for toll assessment.

Traffic demand data contained within this traffic and transport assessment was taken from the WRTM, following assessment of the model calibration and validation by independent peer reviewers and agreement that the model is suitable for this purpose.

Section 9.2.7 of the EIS explains the modelling scenarios and their relevant description in detail. There are seven expected traffic scenarios included in the operational air quality assessment as summarised in Figure 2 of the EIS shown below. The scenarios considered future changes over time in the composition and performance of the vehicle fleet, as well as predicted traffic volumes, the distribution of traffic on the network and vehicle speeds. The results from the modelling of these scenarios were also used in the health risk assessment for the project. The NorthConnex project is also included in the WRTM traffic assumptions for traffic forecasts for the years 2023 and 2033.

Scenario code	Scenario description	Inclusions									
		Existing network	WestConnex projects				Other projects				
			M4 Widening	M4 East	New M5	M4-M5 Link[a]	KGRIU[b]	Sydney Gateway	WHT[c]	Beaches Link	F6 Extension
2015-BY	2015 – Base Year (existing conditions)	✓	-	-	-	-	-	-	-	-	-
2023-DM	2023 – Do Minimum (no M4-M5 Link)	✓	✓	✓	✓	-	✓	-	-	-	-
2023-DS	2023 – Do Something (with M4-M5 Link)	✓	✓	✓	✓	✓	✓	-	-	-	-
2023-DSC	2023 – Do Something Cumulative (with M4-M5 Link and some other projects)	✓	✓	✓	✓	✓	✓	✓	✓	-	-
2033-DM	2033 – Do Minimum (no M4-M5 Link)	✓	✓	✓	✓	-	✓	-	-	-	-
2033-DS	2033 – Do Something (with M4-M5 Link)	✓	✓	✓	✓	✓	✓	-	-	-	-
2033-DSC	2033 – Do Something Cumulative (with M4-M5 Link and all other projects)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

Notes:
(a) Includes Rozelle interchange and Iron Cove Link
(b) KGRIU = King Georges Road Interchange Upgrade
(c) WHT = Western Harbour Tunnel (a component of the Western Harbour Tunnel and Beaches Link project)

Figure 2 EIS Traffic Modelling Scenarios

3.3.3 Modelling Scenarios

Section 4.2.1 of Appendix H (Technical Working Paper: Traffic and Transport) defines the following scenarios:

Base case (2015)

Current road network with no new projects or upgrades. For the operational modelling, 2015 was adopted as the base case to match the year of traffic survey data collection and represents road network conditions prior to the start of construction of the M4 Widening, M4 East, KGRIU and the New M5 projects.

Operation 'do minimum' or 'without project' (2023)

The 'do minimum' or 'without project' scenario assumes that NorthConnex, M4 Widening, M4 East, KGRIU and New M5 are complete, but that the third stage of the WestConnex program of works, the M4-M5 Link, has not been built. It is called 'do minimum' rather than 'do nothing' as it assumes that ongoing improvements would be made to the broader road and public transport network including some new infrastructure and intersection improvements to improve capacity and cater for traffic growth.

Operation 'with project' (2023)

With the 2023 'do minimum' projects completed and the M4-M5 Link complete and open to traffic.

Operation 'cumulative' (2023)

With the 2023 'do minimum' projects completed, the M4-M5 Link complete and open to traffic, and in addition, the proposed future Sydney Gateway and the Western Harbour Tunnel component of the proposed future Western Harbour Tunnel and Beaches Link complete and operational

Operation 'do minimum' or 'without project' (2033)

a future network including NorthConnex, M4 Widening, M4 East, KGRIU and New M5 and some upgrades to the broader road and public transport network over time to improve capacity and cater for traffic growth but does not include the M4-M5 Link.

Operation 'with project' (2033)

With the 2033 'do minimum' projects completed and the M4-M5 Link complete and open to traffic

Operation 'cumulative' (2033)

With the 2033 'do minimum' projects completed, the M4-M5 Link complete and open to traffic, and in addition, the proposed future Sydney Gateway, Western Harbour Tunnel and Beaches Link and F6 Extension complete and operational. Bandwidth plots used in this assessment are produced directly from WRTM for 2012 and future years in five-year intervals. Therefore, the bandwidth plots in this report use 2012 as a proxy for 2015, 2021 as a proxy for 2023, and 2031 as a proxy for 2033.

3.3.4 Traffic Predictions

3.3.4.1 Traffic Data from models

Section 5.4 of Appendix H (Technical Working Paper: Traffic and Transport) explains the surrounding roads of the Rozelle Interchange and investigates the current and future capacity and performance. The following data shows the expected traffic growth presented from the EIS.

For the 2023 Scenario:

Network measure	2023 'without project'	2023 'with project'	Percentage change
All vehicles			
Total traffic demand (veh)	22,087	25,327	15%
Total vehicle kilometres travelled in network (km)	57,775	73,188	27%
Total time travelled approaching and in network (hr)	5,355	6,308	18%
Total vehicles arrived	21,621	23,799	10%
Total number of stops	302,654	274,030	-9%
Average per vehicle in network			
Average vehicle kilometres travelled in network (km)	2.7	3.1	15%
Average time travelled in network (mins)	10.1	9.8	-2%
Average number of stops	12.3	10.1	-18%
Average speed (km/h)	15.9	18,8	18%
Unreleased vehicles			
Unreleased demand (veh)	1,278	2,309	-
% of total traffic demand	6%	9%	-

Figure 3 Rozelle interchange network performance – AM peak hour (2023 'without project' vs 'with project' scenario)

Network measure	2023 'without project'	2023 'with project'	Percentage change
All vehicles			
Total traffic demand (veh)	24,694	28,109	14%
Total vehicle kilometres travelled in network (km)	61,136	80,108	31%
Total time travelled approaching and in network (hr)	4,896	5,091	4%
Total vehicles arrived	21,854	24,261	11%
Total number of stops	146,986	179,138	22%
Average per vehicle in network			
Average vehicle kilometres travelled in network (km)	2.8	3.3	18%
Average time travelled in network (mins)	8.3	7.9	-4%
Average number of stops	5.9	6.4	8%
Average speed (km/h)	20.3	25.1	23%
Unreleased vehicles			
Unreleased demand (veh)	2,684	2,655	–
% of total traffic demand	11%	9%	–

Figure 4 Rozelle interchange network performance – PM peak hour (2023 'without project' vs 'with project' scenario)

2033 Scenario:

Network measure	2033 'without project'	2033 'with project'	Percentage change
All vehicles			
Total traffic demand (veh)	24,307	28,023	15%
Total vehicle kilometres travelled in network (km)	59,866	77,690	30%
Total time travelled approaching and in network (hr)	7,041	7,221	3%
Total vehicles arrived	22,682	25,794	14%
Total number of stops	314,527	272,544	-13%
Average per vehicle in network			
Average vehicle kilometres travelled in network (km)	2.6	3.0	14%
Average time travelled in network (mins)	10.3	9.3	-9%
Average number of stops	12.0	9.2	-23%
Average speed (km/h)	15.4	19.4	26%
Unreleased vehicles			
Unreleased demand (veh)	2,233	2,719	–
% of total traffic demand	9%	10%	–

Figure 5 Rozelle interchange network performance – AM peak hour (2033 'without project' vs 'with project' scenario)

Network measure	2033 'without project'	2033 'with project'	Percentage change
All vehicles			
Total traffic demand (veh)	26,528	30,259	14%
Total vehicle kilometres travelled in network (km)	60,908	86,924	43%
Total time travelled approaching and in network (hr)	6,146	5,286	-14%
Total vehicles arrived	22,679	27,082	19%
Total number of stops	151,862	92,817	-39%
Average per vehicle in network			
Average vehicle kilometres travelled in network (km)	2.7	3.2	20%
Average time travelled in network (mins)	8.2	6.1	-25%
Average number of stops	5.9	3.1	-47%
Average speed (km/h)	19.7	31.3	59%
Unreleased vehicles			
Unreleased demand (veh)	3,591	2,974	–
% of total traffic demand	14%	10%	–

Figure 6 Rozelle interchange network performance – PM peak hour (2033 'without project' vs 'with project' scenario)

This data indicates an increase in traffic is to be expected which is important not only to the efficiency of the project but also the air quality design. It is often believed that an increase in the number of vehicles using the tunnels will increase the emissions to be maintained however, as explained in previous sections, this is not the case and will be analysed below.

3.3.4.2 Emissions

Section 9.5.4 of the EIS explains the contribution of road transport to air pollution over time. The projections of sectoral emissions show that the road transport contribution to emissions of CO, VOCs and NOx has decreased over several decades and is projected to continue to decrease substantially between 2011 and 2036 due to improvements in emission control technology.

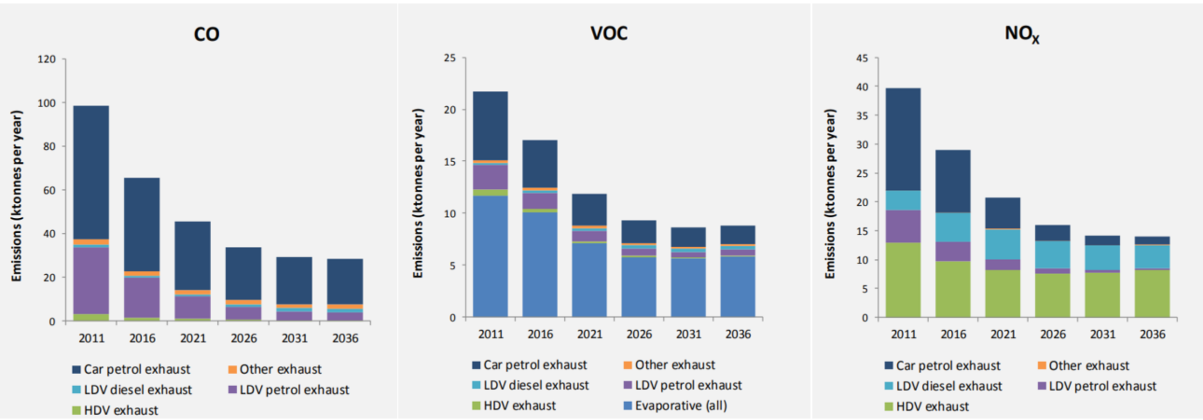

Figure 7 Predicted Emissions.

These figures indicate that a decline in vehicle emissions is to be expected upon the completion of the M4-M5 Link project. As stated previously, previous tunnel projects have shown that the air quality is well within their limits. Additionally, the emission control technology is expected to reduce the number of emissions produced from fleet using the tunnels.

4. Tunnel ventilation system design

4.1. General

As per section 9.4.1 of the EIS, the Project ventilation system is designed for coordinated operation with adjacent tunnel projects (i.e. the WestConnex M4 East and New M5 projects and the proposed future Western Harbour Tunnel and Beaches Link project), with complete or partial air exchange at project boundaries when necessary, to ensure in-tunnel air quality is maintained throughout the tunnel network.

Section 9.10.2 of the EIS explains several reasons that a tunnel must be ventilated. The main reasons are:

- Control of the internal environment. It must be safe and comfortable to drive through the tunnel. Vehicle emissions must be sufficiently diluted so as not to be hazardous during normal operation, or when traffic is moving slowly or stationary.
- Protection of the external environment. Ventilation, and the dispersion of pollutants, is the most widely used method for minimising the impacts of tunnels on ambient air quality. Collecting emissions and venting them via elevated ventilation outlets has been proven to be an efficient way of dispersing pollutants.
- Emergency situations. When a fire occurs in a tunnel, the ventilation system controls the heat and smoke in the tunnel to permit safe evacuation of occupants. Ventilation control is also used to provide the emergency services with a safe route to deal with the fire and to rescue any trapped or injured persons.

4.2. Tunnel Geometry

Pollutant concentrations can fluctuate a great deal on short timescales, and substantial concentration gradients can occur in the vicinity of sources such as busy roads. Meteorological conditions and local topography are also very important; cold nights and clear skies can create temperature inversions, trapping air pollution near ground level, and local topography can increase the frequency and strength of these inversions. In the case of particulate matter, dust storms, natural bush fires, and planned burning activities are often associated with the highest concentrations (State of the Environment Committee 2011).

The topography of the land in an area plays an important role in the dispersion of air pollutants. It steers winds, generates turbulence and large-scale eddies, and generates drainage flows at night and upslope flows during the day. Terrain data for Sydney was obtained from the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) website.

The terrain along the project corridor varies from an elevation of around 10 metres Australian Height Datum (AHD) at the western end of the M4-M5 Link to an elevation of around 14 metres AHD at the Rozelle interchange and 10 metres at St Peters, at the southern end. The uniformity of the terrain, and the lack of major geographical obstacles to wind flow, is assessed to support good dispersion and airflow throughout the study area.

4.3. Rozelle Interchange ventilation design.

The ventilation system comprises of two principal components: the longitudinal ventilation system of the carriageway with extraction at a vertical ventilation outlet near the end of each carriageway as shown in Figure 8 below.

Figure 8 shows the basic function of the tunnel ventilation system, to draw in fresh air and exhaust “vitiated air”, a mix of fresh air and vehicle emissions, whilst ensuring there are no pollutants emitted from any of the tunnel portals. The movement of vehicles through a tunnel drives air flow, called the 'piston-effect', drawing fresh air in through the tunnel entrance, diluting the vehicle exhaust emissions. In short tunnels (up to around 500 metres long) this volume of fresh air is usually adequate to manage in-tunnel air quality. In longer tunnels such as this project, under some circumstances, additional air may need to be forced through the tunnel by fans to dilute emissions and maintain appropriate air quality.

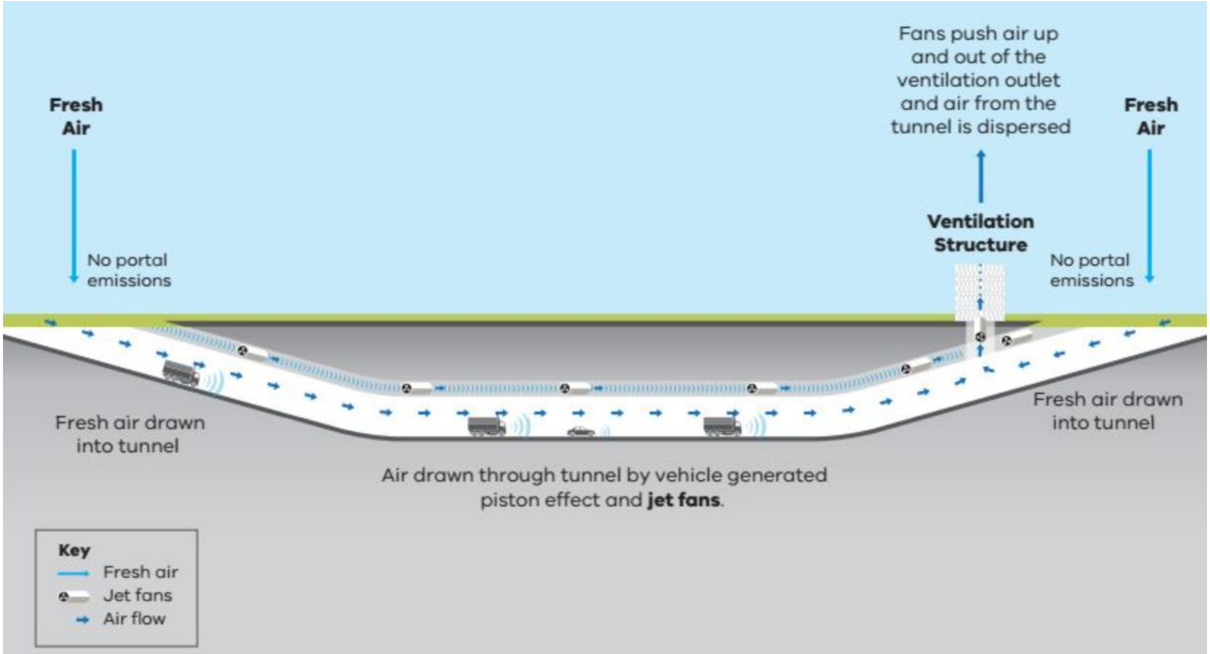

Figure 8 Longitudinal Ventilation System Schematic

The tunnel ventilation system on the RIC project is made up of several components that are automatically controlled to meet the normal and emergency ventilation requirements of the system. These components include:

- Jet fans – for longitudinal airflow control within the tunnel.
- Axial fans – for extraction or supply of air within the ventilation facilities.
- Attenuators – to limit the transmission of noise within the ventilation facilities.
- Dampers – to control the flow path of air.
- Air quality sensors – to provide feedback to the control system.
- Air velocity sensors – to provide feedback to the control systems

4.3.1. Jet fans

Jet Fans are required within the road tunnels to maintain minimum airflow rates for pollutant dilution and to manage smoke in the event of a fire. A schematic of jet fans is shown in Figure 9 below which has been developed based on the following:

- A minimum of 10 hydraulic diameters between banks.
- A minimum of five (5) hydraulic diameters from tunnel merge or diverge sections or an exhaust or supply point, including the start of a tunnel section.
- Generally jet fans are to be installed in no more than banks of three (3). Except for single lane tunnel sections where they will be installed in no more than banks of two (2).
- Jet Fans are to be approximately 100-150m in from a portal to limit noise breakout.

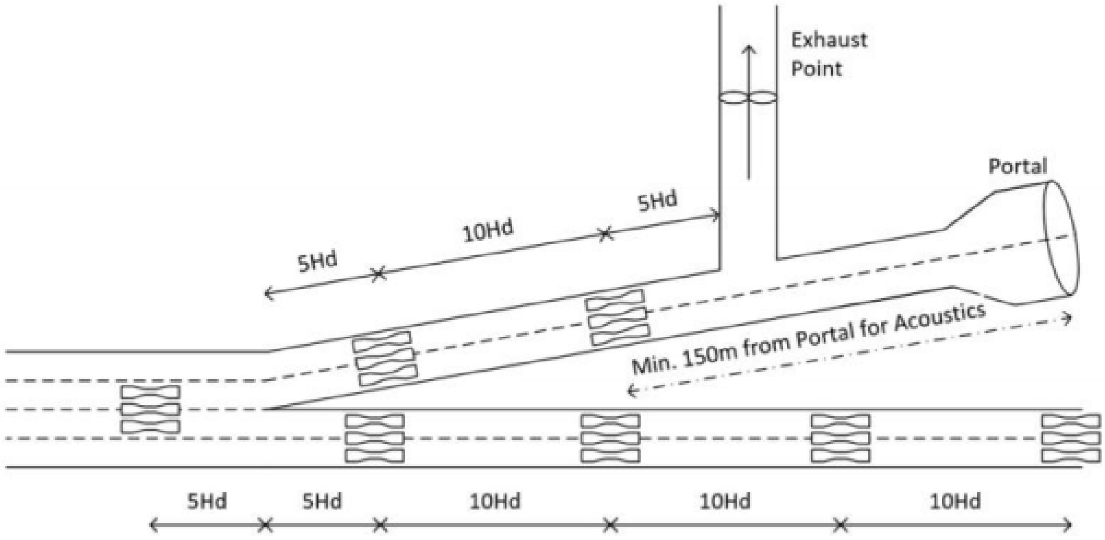

Figure 9 Jet fan spacing strategy

The system has been designed to accommodate the same jet fan unit design throughout the tunnel to ensure consistency across the design, improving maintenance activities and consolidating the provision of spare equipment. A total of 132 Jet Fans are utilised across the Project with the above layout constraints. This design includes the allowance of 1 additional fan per tunnel section for redundancy.

4.3.2. Ventilation Facilities

The MCoA for the M4-M5 Link project requires the ventilation system prevent portal emissions during Normal traffic operations, captures smoke in the event of a fire incident and provides a full air exchange between the RIC and the WHT. The design of the ventilation facilities is summarised below.

Table 3 Ventilation facility description

Ventilation Facility	Location	Type	Requirement
Rozelle Interchange Ventilation facilities.			
VF01	Iron Cove Link	Exhaust 4 duty (+1 redundancy) fans	Required to prevent portal emissions at Iron Cove Link portal and capture smoke in the event of a fire.
VF02	WHT North Bound	Exhaust 6 duty (+1 redundancy) fans	Required to provide an air exchange between RIC and WHT and capture smoke in the event of a fire.
VF03	WHT North Bound	Supply 5 duty (+1 redundancy) fans	Required to provide an air exchange between RIC and WHT.
VF04	Anzac Bridge Link	Exhaust 7 duty (+1 redundancy) fans	Required to prevent portal emissions at Anzac Bridge portal and capture

Ventilation Facility	Location	Type	Requirement
			smoke in the event of a fire.
VF05	M5 to CWL	Exhaust 2 duty (+1 redundancy) fans	Required to prevent portal emissions at CWL portal and capture smoke in the event of a fire.

Like the Jet fan design, the 5 ventilation facilities across the RIC are designed with a +1 redundant fan.

As per section 2.4.3 of Appendix I (Technical working paper: Air Quality) of the EIS, the tunnel ventilation system would operate in two modes:

- Normal traffic conditions, including worst case and low speed traffic; and
- Major incident (emergency) conditions including major accident and fire scenarios.

In-tunnel air quality, traffic volumes and average traffic speeds through the project tunnels are constantly monitored by operators in the Motorway Control Centre where any decisions regarding the operation of the RIC ventilation system is made in real time.

Operating procedures would be developed and applied to the operation of the ventilation system, including triggers for intervention in the case of elevated concentrations of vehicle emission in the project tunnels, congested traffic conditions or incidents, breakdowns, or emergencies.

The operating procedures would include:

- Actions to manage the operation of the ventilation system, including increased ventilation rates using jet fans within the tunnel, and potential introduction of additional fresh air into the tunnels through the ventilation supply facilities.
- Actions to manage traffic volumes and average traffic speeds through the project tunnels if required for in-tunnel air quality reasons or during incidents, breakdowns, or emergencies within or downstream of the project tunnels.
- Incident, breakdown, and emergency response actions.

Under normal traffic conditions (i.e. when traffic flow within the tunnel is at capacity and travelling at the posted speed limit of 80 kilometres per hour), the main alignment tunnels would be longitudinally ventilated. Fresh air would be drawn into the main alignment tunnels from the entry portals and from vehicles travelling through the tunnel, generating a ‘piston’ effect pushing air towards the tunnel exit portals. Under normal traffic conditions, the tunnels would effectively ‘self-ventilate’, as the piston effect generated from moving vehicles exceeds the fresh air demand, thereby removing the need for additional ventilation from jet fans to move air through the tunnels.

Low speed conditions are when traffic speeds slow towards 40 kilometres per hour or less, typically due to a traffic incident, the piston effect associated with traffic movement is reduced. Traffic management measures (such as reducing speed limits, ramp, and lane closures) would be imposed to manage the incident and restore as far as practicable free flowing traffic. Under these conditions, longitudinal ventilation may require additional support to move air through the tunnels. Jet fans may be used to aid the movement of air in the same direction that the traffic is flowing (except at exit portals, where the jet fans direct the flow of air in the opposite direction to traffic flow) to provide the fresh air demand required to meet the relevant air quality criteria from the MCoA.

Major incidents are when traffic is stopped in the tunnel. In this case, the jet fans are to be used to increase the air flow to protect vehicle occupants and emergency services personnel from a build-up of emissions. Drivers would be requested, via the public address system, to turn off vehicle engines to further reduce emissions if there is an extended delay while the incident is cleared.

4.3.3. Traffic Management and Vehicle Enforcement Provisions

There are several measures that assist in maintaining air quality within the tunnel that are not part of the ventilation system. These are:

- NSW Cleaner Vehicles and Fuels Strategy (Department of Environment and Climate Change, 2008) including vapour recovery at service station, stricter emissions levels, alternative fuels, and the Diesel Retrofit Program.
- Smoky Vehicle Detection Program – an initiative under the NSW Cleaner Vehicles and Fuel Strategy which aims to reduce vehicle emissions by ensuring that owners properly maintain their vehicles. A smoky vehicle is regarded as any motor vehicle that emits visible smoke continuously for over 10 seconds. Under NSW environmental legislation, it is an offence for a vehicle to emit visible air impurities for more than 10 seconds.
    - Sections of the WestConnex tunnels include provisions for the implementation of the Smoky Vehicle Detection System (SVDS). The SVDS uses several photo electronic devices and sophisticated software to trigger the detection and subsequent photographing and identification of medium to heavy diesel-powered vehicles emitting visible particulates in their exhaust gases (smoky vehicles). The detection system is restricted to identifying those with a gross vehicle mass of 4.5 tonnes or greater, all of which are required by law in NSW to have vertical exhaust stacks. The system is designed to reduce emissions from the in-service fleet and is a source of emissions design control program.
- Adoption of Australian Design Rules governing on-road motor vehicle emission limits which have been progressively tightened based on United States and European standards, this includes traffic management devices such as ramp metering of the on-ramps, lane closure medians external to the tunnel to limit the amount of traffic entering the tunnel in the case of heavy congestion and slow traffic.
- The Traffic Management Control System (TMCS) is part of the Operations Management and Control Systems (OMCS) and is the system responsible for all traffic related control and monitoring. The TMCS devices are designed to be operated manually and/or automatically and can be used to manage traffic in a way which controls air quality. The TMCS will be used in accordance with the Tunnel Ventilation Incident Response and Traffic Management System Integration Protocol.

5. Modification Concepts

5.1. Considerations for ventilation modifications

Notwithstanding the robust design of the ventilation system of the RIC project, the intent is to consider what modifications or additional improvements are capable of being provided so that the air quality limits can be maintained, if there are repeated exceedances of air quality limits.

These modifications to the overall tunnel ventilation design have potential effects on several other tunnel systems, and potentially impacts to the tunnel civil design if additional space is required. The ventilation system, power distribution system and control system are intimately linked, so changes made to the ventilation system will have an impact on these other systems. For example, an increase in the number of jet fans within the tunnel increases the overall power demand, and potentially an increase in the size of the power reticulation system. A classification of the potential future modification is therefore useful.

Future modifications are expected to be required because of 'unpredicted events.' Potential future modifications to the tunnel ventilation system have been classified into different categories:

- Operational – Reconfiguration of system usage and controls: those accomplished by reconfiguration of the existing design.
- Additional equipment – Provision of additional components, such as jet fans, with potential impacts on existing M&E systems.
- Expansion or conversion of existing installations – Provision of substantial additional system components: those accomplished by significant construction of additional system components and altering the civil works.
- Additional treatment – Installation of filtration either for in-tunnel air, or outlet air, or both to target specific issues with air quality.

Any modification or modifications implemented may require an adjustment of the ventilation operational controls and/or emergency mode controls. This can only be assessed based on the actual design of the modification.

5.2. Constraints on potential modification

The constraints associated with the civil and associated services design also need to be considered. Several of these are either impracticable or unreasonable to alter. Examples include:

- The cross-sectional area of the tunnel mainline carriageways and tunnel ramps.
- The cross-sectional area of the ventilation outlet.
- The cross-sectional area of the ventilation inlets.
- Potential constraints on the spatial enlargement for additional equipment. Plus, a detailed assessment would be required on any additional attenuation of the building fabric that may be required from a change in equipment, or equipment operational scenarios.
- The available capacity of the energy supply from the Utility Network.
- Within the Motorway energy network supply what provisions are made for spare capacity, and then spare conduits to provide additional HV power between substations.
- From the Substations supply what provisions are made for spare capacity, and then spare conduits to provide additional LV power from the substations.
- Geological constraints limiting the spacing of longitudinal jet fans due to in-tunnel noise limitations (for audibility and intelligibility) and proximity to existing tunnel devices.

5.3. Assessment methodology

The assessment of each of the potential modifications will provide a high-level review as follows:

- Can the proposed modification be readily implemented?
- Identification of potential constraints or limitations that arise from the ventilation system design and the overall motorway design. What are the technical constraints on future implementation?
- A broad qualitative ranking of costs. This has been assessed only as low, medium, or high with potential timeframes and additional approvals that may be required.
- Can the current ventilation system design be modified or augmented in the future and outline in what form?
- A qualitative assessment on the capability to implement the potential modification.
- This broad assessment has been provided with each potential modification described.

6. Potential Modifications

6.1. General

The ventilation system is expected to be more than adequate to keep the air quality within limits. Past performance of air quality monitoring in similar tunnels demonstrates that the air quality rarely approaches the limits.

Future modifications are only expected to be required in the occurrences of 'Unpredicted Events'. Potential future modifications to the tunnel ventilation system have been classified into different categories:

- Operational;
- Additional equipment;
- Expansion or conversion of existing installations; and
- Additional treatment.

Several potential modifications have been identified that can improve the air quality if systemic exceedances in the air quality criteria occurs due to the operation of the tunnel. These include:

- Installation and operation of higher capacity or additional jet fans;
- Additional Capacity of Axial Fans;
- Tunnel Air Filtration; and
- Modification of Air Quality Goals.

The following factors have been considered in the analysis of their feasibility:

1. Effectiveness (estimated) on tunnel ventilation;
2. Impact to (tunnel) operation;
3. Technical constraints and limitations (feasibility); and
4. Cost.

The analyses in the below section are high level and indicative only. A full analysis of all relevant factors will need to be undertaken by the parties that are contemplating making modifications to the ventilation system if the unlikely need arises.

6.2. Potential Modification #1 – Higher Capacity or additional Jet Fans

This potential modification would require the provision of additional jet fans, or jet fans with increased capacity, within the tunnels to improve longitudinal air flow control. Additional fans may be required if the assumed design criteria change significantly. That is, the fleet mix increases the vehicle emissions, or the number of vehicles changes.

This report outlines that an expected increase in traffic demand is to be expected and has been accounted for in the design of the RIC.

6.2.1. Increasing the size of the jet fans:

With the application of a new jet fan size, the longitudinal ventilation capacity (thrust) can be increased. This will marginally reduce the concentration of pollution in the tunnel; however, it will require extensive cabling and coordination works to locate the larger units on site.

6.2.2. New jet fan niches:

Additional jet fan niches can be constructed, where further jet fans can be installed. This offers the benefit of a localised increase of longitudinal vent capacity. This option is limited to certain areas of the tunnel since some tunnel sections do not offer enough space to provide additional niches due to other already existing M&E equipment.

6.2.3. Assessment

Upgrade of the jet fan type involves installing a larger unit into the tunnel to increase the thrust. The existing jet fan is a 1250mm diameter unit. Theoretically in some locations where the soffit height is larger, a 1400mm diameter banana jet fan may be installed. Where a larger capacity jet fan can be installed, this may result in a 25% improvement in the individual thrust of the jet fan. An upgrade to the electrical switch room and cables from the circuit breaker would be required due to the extra power demand for the 1400mm diameter jet fan/s. Subject to design, power from a substation (above ground or within the tunnel) would be required, and longer lengths of cable from the surface to within the tunnel, with an increased cable size. The current RIC ventilation design is to limit negative impacts to fan performance. Jet fans were placed to avoid any areas of local enlargements such as merge/diverge caverns, breakdown bays and large cut and cover structures, however, fans may also be added to these locations to improve ventilation. It should also be noted that the jet fan design allows for a (+1) redundancy fan throughout the tunnel.

Estimated effect:	*medium*
Impact to operations:	*high*
Feasibility:	*medium*
Cost:	*medium*

6.3. Potential Modification #2 – Higher Capacity of Axial Fans

This potential modification would require the provision of larger capacity axial fans in the ventilation facilities.

Larger capacity axial fans may be required if the assumed design criteria changed significantly. This would only occur if the fleet mix significantly increased producing more emissions. A higher airflow rate would then be required to dilute and safely disperse vehicle emissions.

Vent tunnels have been designed to facilitate additional ventilation capacity through potential installation of higher capacity axial fans with minimal to no additional excavation. There is limited M&E in vent tunnels to inhibit additional works.

As noted previously in this report, the population is expected to grow between the years 2023 and 2033 indicating that an increase in the number of fleet using the tunnels is expected. however, due to technological improvements, the emissions from the fleet is reducing.

6.3.1. Utilisation of redundant fan

There are 5 ventilation facilities throughout the RIC, all equipped with a redundant fan, which could be used, if available (design of power supply allows for approximately 20% additional power). This option can only be considered as a temporary solution and cannot be relied upon for a permanent state of operation, since it cannot be guaranteed that the redundant fan is available at any time.

6.3.2. Operate ventilation fans beyond nominal speed

The ventilation equipment can be operated beyond the nominal speed (design of power supply allows for approximately 20% additional power). This option should only be considered as a temporary solution and cannot be relied upon for a permanent state of operation, since the design life of the equipment may be shortened.

6.3.3. Assessment

It may be possible to make use of all fans within the ventilation facilities however, this cannot be considered a permanent solution. Using the fans beyond nominal speeds is also a temporary fix as this could reduce the design life of the fans and surrounding structures.

It should also be noted that like the jet fan design, the axial fans are already designed with a (+1) redundancy fan.

Estimated effect:	*medium*
Impact to operations:	*high*
Feasibility:	*medium*
Cost:	*medium*

6.4. Potential Modification #3 – Tunnel Air Filtration

Tunnel filtration is a means of addressing vehicle emissions. It is a broad concept, but can be summarised as these two methods of air cleansing:

- Electrostatic Precipitation of particulate matters.
- Chemical treatment of gaseous pollutants.

These filtration types have mixed success, with electrostatic precipitation used widely to address issues with visibility in road tunnels. The limitations to filtration systems are that they target specific pollutants, however, are not able to remove all tunnel pollutants. It may address specific air quality issues; however, it is not a complete treatment. For the purposes of assessment, it is assumed that any of the ventilation facilities would provide a filtration system that provides a take-off point and resupply point as required.

As noted throughout this report, the emissions from traffic have been modelled for the increase in traffic and past performance shows that although the amount of traffic using the tunnels will increase, the emissions are expected to decrease over time.

6.4.1. Assessment

As per section E.8.2 of Appendix I (Technical working paper: Air Quality) of the EIS, the provision of a tunnel filtration system does not represent a feasible and reasonable mitigation measure and is not being proposed. The reasons for this are as follows:

- In-tunnel air pollutant levels, which are comparable to best practice and accepted elsewhere in Australia and throughout the world, would be achieved without filtration.
- Emissions from the ventilation outlets of the M4-M5 Link tunnel would have a negligible impact on existing ambient pollutant concentrations.
- Of the systems that have been installed, the majority have subsequently been switched off or are currently being operated infrequently. Where the operation of in-tunnel air treatment systems has been discontinued or reduced, the reasons have been that the technology has proved to be less effective than predicted, the forecast traffic volumes have not eventuated, or there have been reductions in vehicle emissions.
- Incorporating filtration with the ventilation outlets would 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 also be substantial and does not represent a sustainable approach.

If in-tunnel air quality criteria could not be achieved with the proposed 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.

Estimated effect:	*low*
Impact to operations:	*medium*
Feasibility:	*medium*
Cost:	*high*

6.5. Potential Modification #4 – Modification of MCoA Requirements

The tunnel air quality limits are limits prescribed by the minister in consultation with the EPA during the approval of the SSI. Ventilation goals are put in place to prevent the ventilation limits from being exceeded. During design of the tunnel ventilation system, the goals are set to minimise the pollution in the tunnel and are programmed into the control system.

Once operational traffic flows become established and air quality data examined, in the event that fleet emissions continue to improve and air quality trends are positive, the following modifications can be implemented to reduce power consumption:

1. Optimisation of ventilation goals with corresponding set-points and limits.
2. Allow for portal emissions or increase the air-quality thresholds to optimise power consumption based on actual traffic and emissions, once the tunnel is under operation.

6.5.1. Assessment

Optimisation of the ventilation system normally occurs during commissioning; however, major gains can be made after the tunnel is opened for traffic and the operator has become comfortable with the operation of the ventilation system.

The most gains can be made with the allowance for partial or complete portal emissions. This requires approval from the Secretary and evidence of a substantial decrease in overall emissions that may be possible with a change in vehicle fleet.

Past projects including the M4 East, M8, and NorthConnex, where the air quality is available to the public, display much cleaner air quality than predicted and suitable for the consideration of portal emissions. If portal emissions are possible, this would dramatically reduce axial and jet fan usage, which reduces the power consumption and need for maintenance. In addition, some fans (axial fans and jet fans) may be decommissioned following the reassessment of emergency ventilation requirements.

Estimated effect:	*high*
Impact to operations:	*very-low*
Feasibility:	*medium*
Cost:	*very-low*

7. Potential modifications summary

Several modifications to the ventilation design have been identified and discussed that can improve the air quality if systemic exceedances in the air quality criteria occurs due to the operation of the tunnel. These include:

- Installation and operation of higher capacity or additional jet fans;
- Additional Capacity of Outlet Axial Fans;

- Tunnel Air Filtration; and
- Modification of Air Quality Goals.

The feasibility of each potential modification has been discussed above, and a high-level summary of the impacts assessed for each modification has been summarised in the below. The ranking goes from 1 (best) to 4 (worst) based on a combination of the effectiveness, operational impact, feasibility, and cost of the modifications.

Table 4 Comparison Table

Potential Future Modification	Effectiveness	Impact to operations	Feasibility	Cost	Rank
Higher Capacity or Additional Jet Fans	Medium	High	Medium	Medium	3
Additional Capacity of Axial Fans	Med-High	Medium	Med-High	Low	2
Tunnel Air Filtration	Low	Medium	Medium	High	4
Modification of Air Quality Goals	High	Very-low	Medium	Very-low	1

8. Conclusion

This document demonstrates that the RIC ventilation system has been designed and constructed such that it can be modified in the future, if required. The Minister for Planning granted approval for the project subject to conditions of Approval including E10 which states:

> *All tunnels must be designed and constructed so as to allow for future modification of the ventilation system if required. The Proponent must submit a report to the Secretary demonstrating how this will be allowed for prior to finalising detailed design.*

The current RIC ventilation design is expected to operate to keep the air quality within the limits provided by the MCoA outlined previously in this report. If the need should arise for additional ventilation requirement, potential modifications were investigated.

Throughout this report, there have been 4 potential future modifications to the ventilation design considered. These modifications included higher capacity jet fans, additional capacity of axial fans, tunnel air filtration, and the modification of air quality goals.

Modifications to the tunnel ventilation system have been considered and assessed within this report. It is demonstrated that the ventilation system has been designed and constructed to allow for future modification, if required in accordance with E10 requirements.

The modifications within Section 7 of this report may be implemented in the future in the unlikely event that the project is found to be a significant contributor to exceedances of in-tunnel, ventilation outlet or ambient air quality goals and/or limits. Alternatively, the modifications could be implemented in the event that the air quality is found to be consistently below limits. The modifications identified within Section 7 would require design and modelling, and would cause disruption if implemented, but have not been excluded by the design and construction of the Project. The ventilation system, as designed for the approved Project, does not preclude any of the potential modification options identified in this Report.