Appendix L - Ventilation report

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WESTCONNEX

NEW M5 VENTILATION REPORT

for WestConnex Delivery Authority
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Ref 1505

REVISION HISTORY			
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1	28 September 2015	First draft issue.	
2	20 October 2015	New M5 internal review addressed	
3	3 November 2015	Further internal comments addressed	
4	9 November 2015	Further internal comments addressed	
5	10 November 2015	Figures 11.35 to 11.40 added	

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EXECUTIVE SUMMARY

Stacey Agnew was commissioned by the WestConnex Delivery Authority (WDA), now transferred to Sydney Motorway Corporation (SMC), to model in-tunnel airflow, pollution levels and temperature resulting from traffic operations in the WestConnex New M5 project (the project) and the future M4-M5 Link project to Rozelle (which will be subject to separate assessment and planning approval).

This report documents the input data used in the tunnel ventilation simulation, and the predicted in-tunnel and vent outlet air flow, temperature and pollution levels for the New M5 project, and for the connected M4-M5 Link tunnel as far north as Rozelle.

Modelling was undertaken using the IDA Tunnel software by EQUA AB[1]. IDA Tunnel solves aerodynamic and thermodynamic equations to calculate the tunnel and outlet air flow and temperature over time, given the vehicle forcing and the vehicle heat generation within the surrounding ground heat sink. Pollutant generation and advection is computed based on the input fleet mix.

Data on traffic volume and fleet mix for the project were taken from the WestConnex Road Traffic Model (WRTM). The fleet mix based on registration type was then transformed in this work to be relevant to pollution generation. The traffic model within the simulation applies traffic continuity and realistic models on traffic flow versus speed, to predict the traffic density and speed throughout the tunnel. Airflows resulting from the modelled traffic scenarios, in combination with the vehicle emissions, determine the pollutant levels in the tunnel. The air flows and pollution levels are not substantially different between summer and winter condition, however there are substantial differences in tunnel and outlet air temperatures.

The important conclusion derived from these results is that the New M5 and M4-M5 Link tunnels would be self-ventilating for the predicted traffic. This is because the ‘piston effect’ of vehicles (without the aid of jet fans) drives sufficient air along the mainline tunnel to maintain pollutant levels below the specified design limits. Jet fans are still required to move smoke longitudinally during a tunnel fire (vehicles will be stopped) and any other exceptional stopped traffic events. Air exchange at the Kogarah intersection with the future Southern Extension is not required for in-tunnel pollution control. Similarly, mainline air exchange is not required at St Peters Interchange as the on and off-ramps provide sufficient exchange.

Plots of results are provided in Section 11 for free flowing and congested traffic. The detailed outputs for free flowing daily (24 hour) 2021 and 2031 traffic in summer and winter are provided in Appendices A, B and C. Appendix D gives the congested traffic outputs.

The congested traffic results are for steady state traffic demand where the traffic in the downstream tunnel segments is reduced to nominal limits of 20 km/h, 40 km/h and 60 km/h. Demand is increased in steps until capacity is exceeded. These congested case results are compared with the 80 km/h (free flowing) case.

Results show that in-tunnel pollution levels can still be maintained at levels below the limits which are anticipated to be imposed, without running mainline jet fans. The tabulated results for eastbound simulations show a number of jet fans running overnight. This is a result of a control policy to maintain minimum airspeeds, in this case 3 m/s. The pollution results show that minimum to be unnecessarily high and so the next iteration will use a lower minimum, likely requiring no mainline jet fans. For fire safety reasons it is recommended that normal operation traffic speeds below 20 km/h should be prevented using traffic management.

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[1] http://www.equa.se/en/tunnel/ida-tunnel/road-tunnels

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1 INTRODUCTION

NSW Roads and Maritime Services (Roads and Maritime) is seeking approval to construct and operate the New M5 (the project). The proposed works are described more fully in the main body of the EIS.

The project is a component of WestConnex, which is a proposal for a 33 kilometre motorway linking Sydney's west and south-west with Sydney Airport and the Port Botany precincts. The WestConnex project includes 21 kilometres of twin-bore tunnels, plus ramps. The individual components of WestConnex are:

- M4 Widening – Pitt Street at Parramatta to Homebush Bay Drive (planning approval granted and under construction)
- M4 East – Homebush Bay Drive, Homebush to Parramatta Road and City West Link (Wattle Street) at Haberfield (planning application lodged and subject to planning approval)
- New M5 – King Georges Road at Beverly Hills to St Peters (the subject of this report)
- King Georges Road Interchange Upgrade (planning approval granted and under construction)
- M4–M5 Link – Haberfield to Rozelle and then to St Peters (undergoing concept development and subject to planning approval)
- Southern Gateway (undergoing concept development and subject to planning approval).

A proposed Southern Extension from Arncliffe to Kogarah is currently being investigated by Transport for NSW. The Southern Extension would connect the New M5 to the southern and bayside suburbs of Sydney, and the proposed F6 extension..

This report addresses only the New M5 Project, considering also the effect of the future M4-M5 Link on the New M5 ventilation, and on emissions in the project area. The M4-M5 Link design is currently being developed and is subject to further design refinement. Modelling of the interchange at Rozelle includes a complete air break that effectively separates the tunnel ventilation systems either side of the interchange.

This report has been prepared to support the assessment of air quality for the environmental impact statement (EIS).

In ventilation terms, the New M5 project and the M4-M5 Link up to Rozelle are one system. The connected M4-M5 Link tunnels north of St. Peters will affect the ventilation and emissions within the New M5 project area. With the M4-M5 Link motorway surfacing at Rozelle, parts of the M4-M5 Link beyond Rozelle are not relevant to this assessment. If the Rozelle connection were later to be designed as an underground connection, some of the results may need to be revisited. With the surface interchange at Rozelle, and the inherently integrated ventilation operation south of Rozelle, there is a need for nomenclature to describe the functional tunnel sections quite separately from the WestConnex project scope descriptors. The overall schematic is shown in Figure 4.1. In this report we use the following terms:

- New M5 – the motorway tunnel from Beverly Hills to St Peters, including ramps which connect to that section. As above, New M5 is the scope of the EIS which this report is part of.
- SPI to Rozelle – that part of M4-M5 Link that connects New M5 at St Peters Interchange (SPI) to Rozelle, including ramps.
- M5 to Rozelle – the motorway tunnel from Beverly Hills to Rozelle, including ramps which connect to that section. This is the combination of the New M5 and SPI to Rozelle as one system.
- Southern Extension – the ramp which connects to the New M5 at Kogarah. This has also been known as the Southern Connector.

2 SCOPE

The aim of this report is to document the input data used in the tunnel ventilation simulation model, and the predicted in-tunnel and ventilation outlet air flow, temperature and pollution levels for the New M5 project, both before and after the future M4-M5 Link tunnel development. This report is focused on pollution estimation for EIS purposes, however the ventilation design for emergency response is also mentioned here.

The ventilation outputs for the New M5 project and SPI to Rozelle are included in Section 11, with appendices tabulating the numerical results in detail.

References to design inputs and assumptions in this report are listed in Table 2.1 below.

Table 2.1. Summary of design inputs and assumptions used in simulation.

Input	Value	Reference
NO_2 limits	0.5 ppm average	Section 6.1, Table 6.1
CO limits	87 ppm over 15 min. avg. 50 ppm over 30 min. avg.	Table 6.2

Extinction coefficient limits	0.005 /m	Table 6.2
Vertical alignment (New M5 and SPI to Rozelle)		Figure 4.2 and Figure 4.3
Cross section (New M5)	Beverly Hills to Kogarah: 100m^2 Kogarah to SPI off-ramp: 135 m^2 SPI to Rozelle: 100 m^2	Table 4.1
Vehicle sizes		Table 7.4
Fleet fuel mix		Figure 7.8
Fleet age profile		Figure 7.7
Traffic demand		Table 7.5 and Table 7.6
Ramp traffic splits (New M5)		Table 7.8 to Table 7.12
Vehicle aerodynamic drag coefficients		Table 8.2
Vehicle parameters for heat generation		Table 9.5
Vehicle emission factors, for NO_2, CO and PM.	PIARC (2012) Australian tables, with fleet taken to year 2020 for 2021 and 2031 traffic flows.	Table 9.1, Table 9.2, Table 9.4, Table 9.6, Table 9.7
Vehicle heat emission factors		Table 9.8

It is noted that the analysis conservatively adopts 2020 emission values for both 2021 and 2031 simulations. Ongoing work to re-estimate future emissions may, when complete, allow estimation of the degree of conservatism included through use of 2020 figures.

3 ALIGNMENT

Figure 4.1 is a schematic of the combined New M5 (red) and M4-M5 Link (blue). Also included in this schematic is the Southern Extension which may be added with the M4-M5 Link. The ramps which form the Arundel Interchange, shown as a dashed line in Figure 4.1, are not included in the ventilation model. Their provision is now part of M4-M5 Link project. With the distance of the Arundel Interchange from SPI, they will have little impact on New M5 air flows. To the extent that the Arundel Interchange will necessarily involve some exchange of tunnel air, omitting them from the New M5 assessment adds conservatism for estimating pollution flux into the westbound tube of New M5. There will be no impact on the eastbound tube of New M5.

The modelling is based on the reference design alignment. Vertical alignment of New M5 and the M4-M5 Link up to Rozelle is shown in Figure 4.2 and Figure 4.3. The western end adjacent to the portal reaches 4% gradient, while the St Peters off-ramp reaches 5% for a 450 m long section. Gradient in the majority of both tubes is between -1% and 1%.

While the impact assessment is for Stage 2 (the red tunnel sections in Figure 4.1), it necessarily also considers the combined effect on the Stage 2 environs after Stage 3 (the blue sections in Figure 4.1) is added.

4 CROSS SECTION

Table 4.1 gives tunnel airflow parameters based on the cross-section. The friction factor in Table 4.1 is the Darcy-Weisbach friction factor, used in the calculation of flows and pressures. The value noted is a value selected by SMC on the basis of experience with previous similar tunnels.

Table 4.1. Tunnel parameters.

Lanes	Flow area (m^2)	Hydraulic diameter (m)	Friction factor
1	60	7.7	0.035
2	80	8.9	0.035
3	100	10.0	0.035
4	135	10.5	0.035

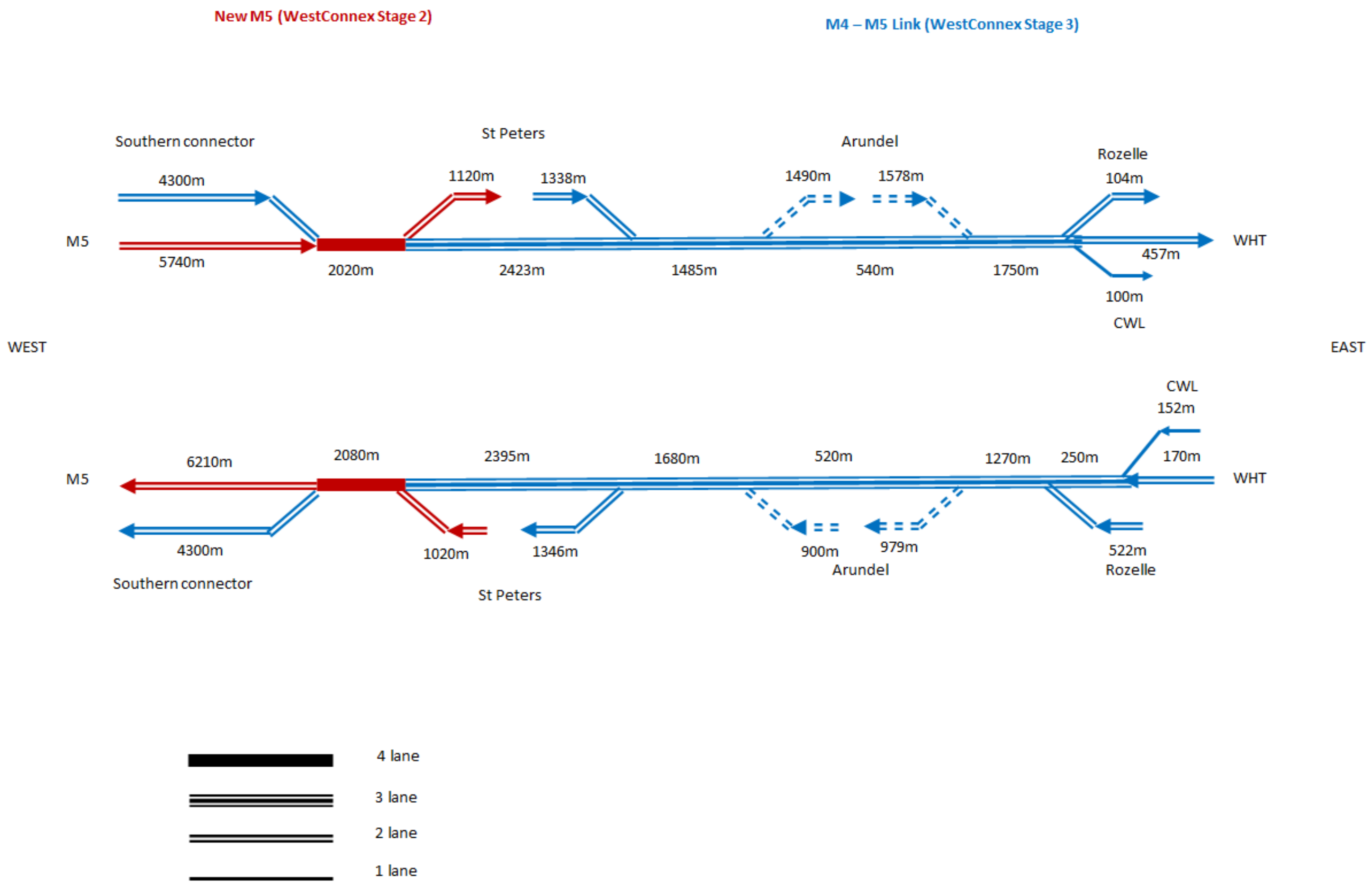

Figure 4.1. Schematic layout of WestConnex New M5 and M4-M5 Link projects up to Rozelle. The "4 lane" section will be marked and operated as 2 lanes for the New M5 project, but will have a cross section excavated for 4 lanes and a breakdown lane. This is acknowledged in the aerodynamic modelling.

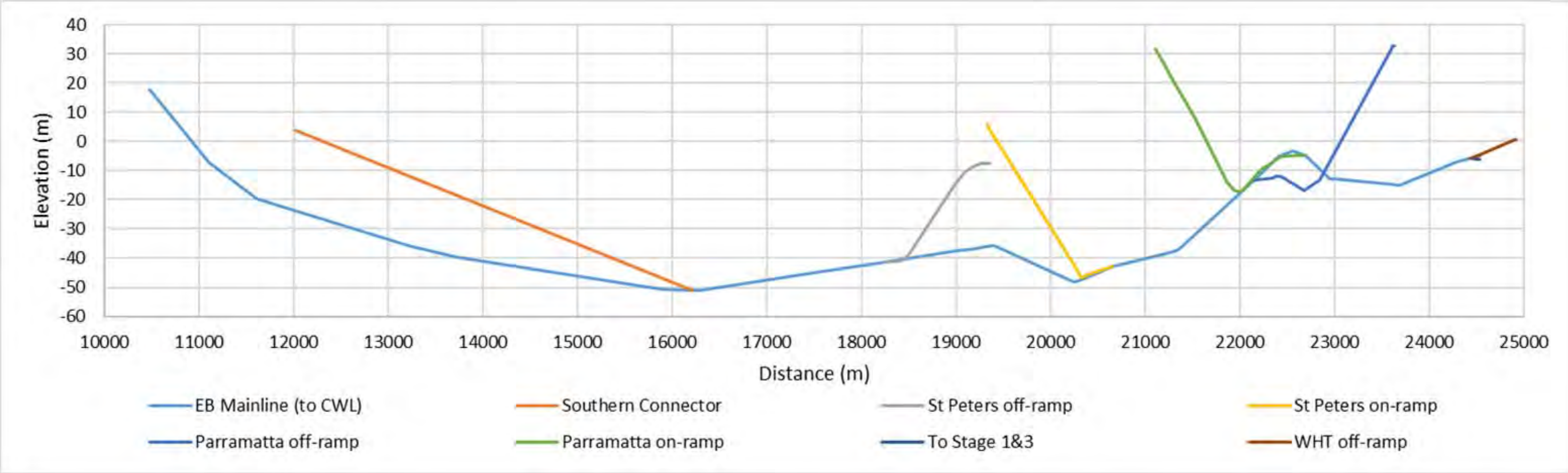

Figure 4.2. Eastbound vertical alignment of New M5 and the M4-M5 Link up to Rozelle.

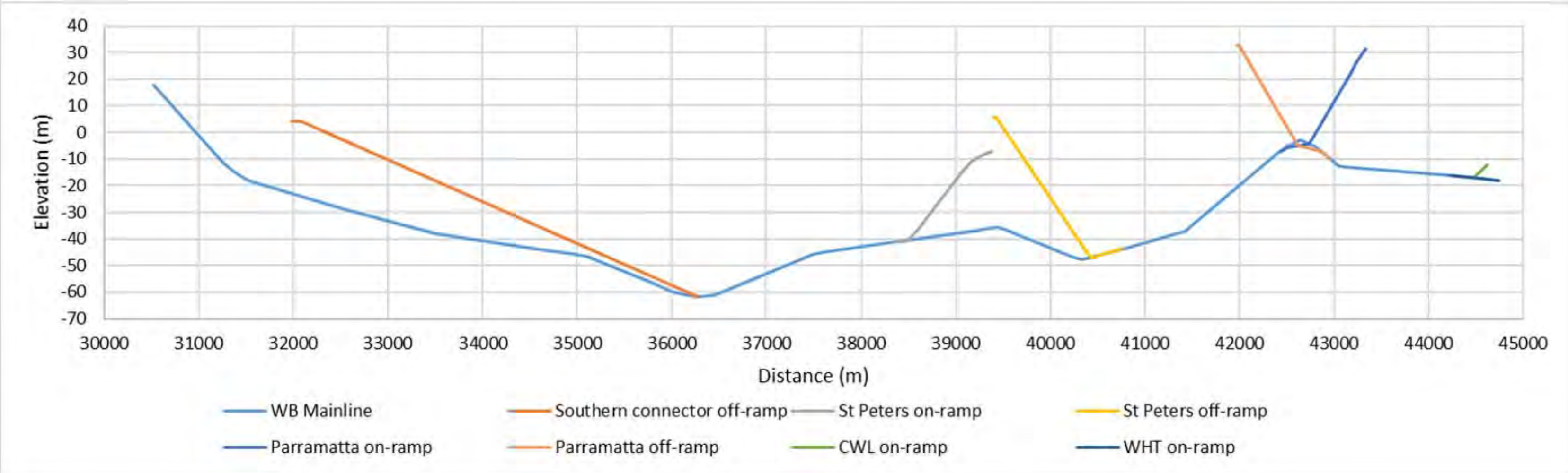

Figure 4.3. Westbound vertical alignment of New M5 and the M4-M5 Link up to Rozelle.

5 VENTILATION SCHEMES

The ventilation schemes for the New M5 and M4-M5 Link were developed to satisfy the anticipated conditions of approval. They have the capacity to generate net portal inflow at all portals. The schemes to satisfy those objectives are described below.

5.1 New M5

One particular reference ventilation scheme is considered for New M5, for which Figure 5.1 is the ventilation schematic of the tunnels. The blind stub tunnels on the eastern end of both mainline tubes are mined in preparation for the M4-M5 Link.

Extraction points are located near the St Peters Interchange (SPI) off-ramp portal on the eastbound tube and at the west portal of the westbound tube. Their role is to extract all of the airflow induced by the vehicle flow, plus sufficient additional air to ensure net inflow at each of the exit portals, nominally at 1 m/s. Eastbound air exchange is allowed for at Kogarah with an extraction point adjacent to the future Southern Extension junction, followed by a supply air station.

The fans in the main ventilation stations which exhaust or supply air to and from the tunnels are large axial flow fans. In different documents, they may be called vent station fans, extraction fans, supply fans, air exchange fans, or axial fans, all of which are correct descriptions. The use of the term “axial” is confusing as the jet fans mounted inside the tunnel are also axial fans but perform quite differently. Jet fans are smaller fans (up to about 1.6 m diameter) which are mounted under the tunnel ceiling. By accelerating a high speed stream of air which them mixes with the tunnel air, the jet fans transfer momentum to promote (or retard) the tunnel air flow.

Under most circumstances, the piston effect of vehicles along the tunnel will be sufficient to create on-ramp inflow without the aid of jet fans.

Jet fans are provided in the main tube to augment the longitudinal air flow in the event of fire. The same jet fans would assist, if required, to augment the tunnel air flow during congested traffic, to comply with the pollution limits.

5.2 New M5 with M4-M5 Link

The ventilation scheme for the combined system up to Rozelle, including part of the M4-M5 Link tunnels, is shown in Figure 5.2. The off-ramps at City West Link, Western Harbour Tunnel, Rozelle and SPI have air extraction points close to the daylight portals, ensuring portal inflow airspeed at nominally 1 m/s. The flows from City West Link and Rozelle extraction points may be combined to discharge to the atmosphere though a single outlet. The air extracted from the southbound SPI off-ramp will be discharged through a northern SPI ventilation outlet.

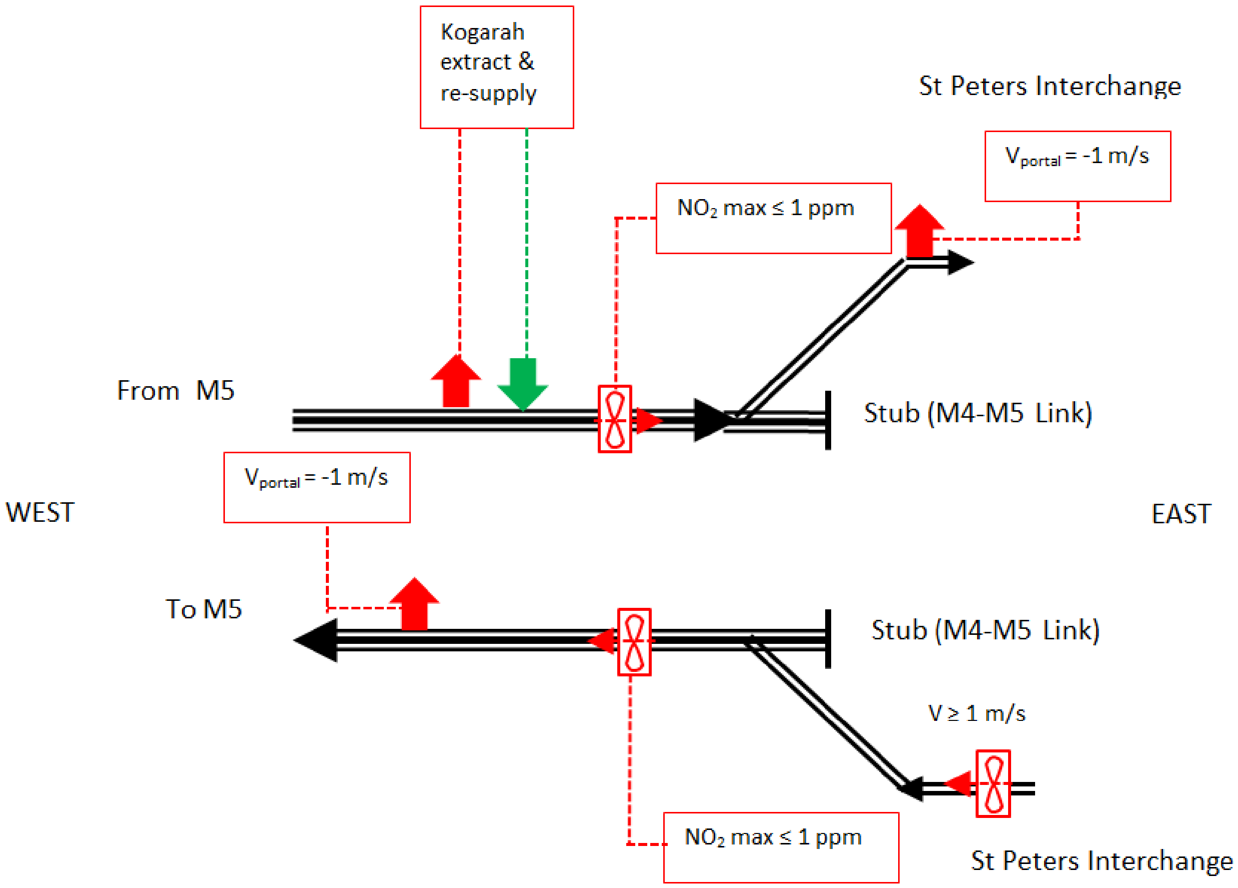

Figure 5.1. Ventilation scheme for New M5.

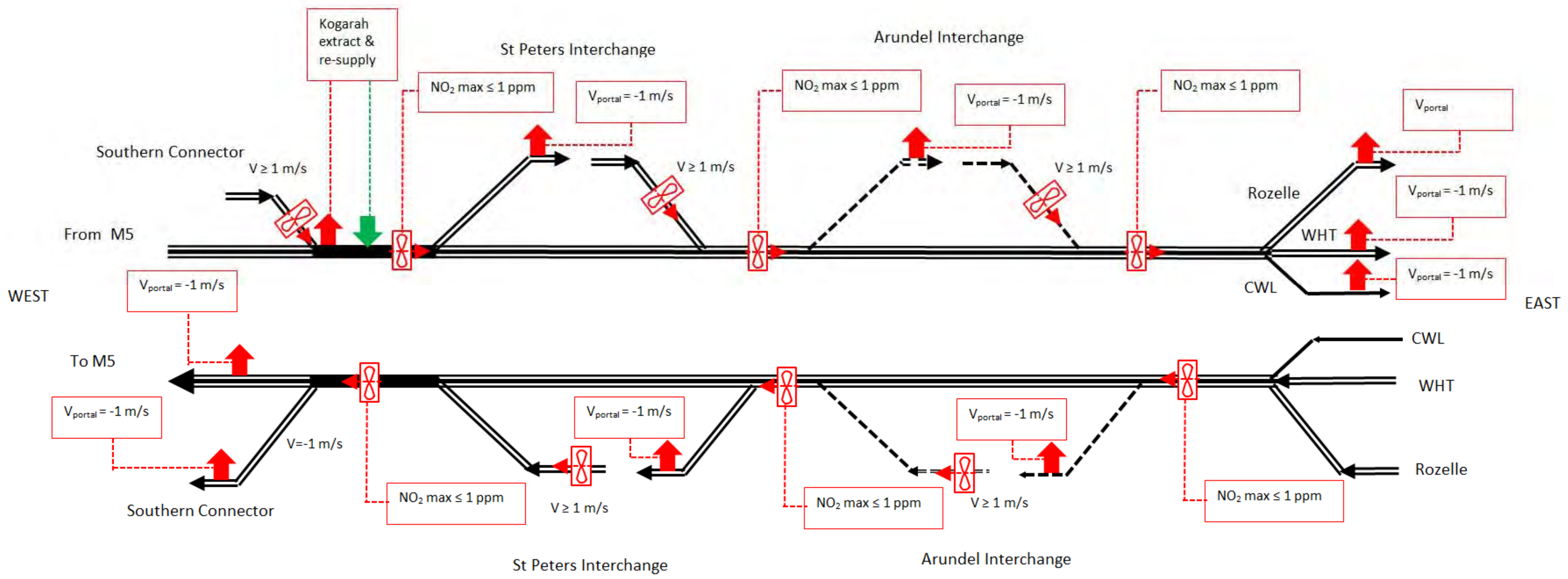

Figure 5.2. Ventilation scheme for New M5 including M4-M5 Link up to Rozelle.

5.3 Fire ventilation

Except for short sections at exit portals, prior to an incident the air will be flowing strongly with the traffic. At the onset of a fire, any exit portal flow against traffic will be reversed, with the flow direction maintained for the majority of the tunnel. Exit portal inflows can be reversed quickly by turning off the ventilation station fans which extract the tunnel air prior to the portal.

Jet fans maintain an air flow in the traffic direction in order to prevent people held behind the fire from being affected by smoke. Sufficient jet fans will be provided to control backlayering of the smoke at the fire-site.

Under normal operation, traffic control measures will be applied to ensure that the traffic speed in the tunnel does not drop below 20 km/h for any significant period. This will ensure that, if a vehicle ignites, the smoke movement does not overtake downstream traffic.

Depending on the fire location, the smoke may be discharged through the normal ventilation outlet, using the ventilation station fans. The alternative is to drive the smoke out the exit portal. The non-incident tube will be closed to traffic and the airflow in that tube will be reversed using jet fans. This is to ensure that smoke issuing from a portal is not drawn into the adjacent portal of the non-incident tube. The jet fans will also be used to maintain the non-incident tube at a higher pressure than the incident tube, to prevent smoke flow through cross passages.

6 POLLUTION CRITERIA

6.1 In-tunnel air quality

The three pollutants assessed in-tunnel are nitrogen dioxide (NO_2), carbon monoxide (CO) and particulate matter (PM). For the operating years of the WestConnex project, NO_2 will be the pollutant that determines the required airflow and drives the design of ventilation for in-tunnel pollution.

The NSW Department of Planning and Environment issued a report that included discussion on this topic for the NorthConnex project in January 2015. From the Secretary's Environmental Assessment Report[2] for the NorthConnex project:

> *"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."*

The Environmental Assessment Report refers to 'average across the tunnel'. It is understood that this is a spatial average along the tunnel from entry portal to exit portal. This spatial average is a proxy for the average level experienced by motorists while travelling through the tunnel. For constant vehicle speed, the two are identical. Whereas the spatial average can be estimated readily from tunnel instruments and so is a practical measure, exposure estimates in congested traffic require the progress of motorists to be monitored, which is not practical from a control or regulatory perspective.

If the pollutant level increases linearly from nearly zero at the entry to the maximum near the exit, then the spatial average level is half the peak level. Because most urban road tunnels, including WestConnex, have portals higher than the general tunnel, pollutant generation is higher when climbing toward the exit, biasing the exposure towards the end of the tunnel trip. This means that the average level is somewhat less than half the peak level near the exit. With an average NO_2 limit of 0.5 ppm, a peak limit of 1.0 ppm is used as a useful initial reckoning tool, acknowledging that it will generally be slightly conservative.

The NO_2 limits as proposed by the NorthConnex Proponent and as recommended in the Secretary's Environmental Assessment Report (SEAR) are contained in Table 6.1 and Table 6.2.

[2] NSW Government Planning and Environment, State Significant Infrastructure Assessment: NorthConnex M1-M2 project SSI 6136, Secretary's Environmental Assessment Report, Section 115ZA of the Environmental Planning and Assessment Act 1979, January 2015.

Table 6.1. NO_2 limits from NorthConnex.

Traffic speed along the whole tube	Proposed limit on NO_2 as an average over the whole tunnel and over 15 minutes	
	NorthConnex Proponent	NorthConnex Environmental Assessment Report
60 – 80 km/h	0.5 ppm	0.5 ppm
40 km/h	0.8 ppm	0.5 ppm
0 – 20 km/h	1.0 ppm	0.5 ppm

Table 6.2. Pollutant limits summary from NorthConnex.

In-Tunnel Air Quality — Limits

E2 The tunnel ventilation system must be designed and operated so that the average concentration of CO and NO_2, calculated along the length of the tunnel, does not exceed the concentration limit specified for that pollutant in **Table 5**.

Table 5 – 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

E3 The tunnel ventilation system must be designed and operated so that the concentration of CO as measured at any single point in the tunnel must not exceed the concentration limit specified for that pollutant in **Table 6** under all conditions (including congested conditions).

Table 6 – In-tunnel single point exposure limits

Pollutant	Concentration Limit	Units of measurement	Averaging period
CO	200	ppm	Rolling 3–minute

E4 The tunnel ventilation system must be designed and operated so that the visibility in the tunnel does not exceed the level specified in **Table 7**.

Table 7 — In-tunnel visibility limits along length of tunnel

Parameter	Average extinction co-efficient Limit	Units of measurement	Averaging period
Visibility	0.005	m^{-1}	Rolling 15–minute

6.2 Interaction of traffic and pollution limits

The risk of harm from pollutants is treated like any other risk; we seek to reduce it to a level that is as low as reasonably practicable. The risk is taken as being as low as reasonably practicable when the cost of making further risk reduction is disproportionate to the benefit of the further risk reduction achieved.

It is the extreme congestion cases that determine the ventilation provisions and hence they have a strong influence on cost in tunnels. In a risk context, we might allow higher pollution levels in rare events, if catering to the same level for those events were to cause high costs. This is particularly so if the pollution limits are set at the low end of the band in which health effects might start to be significant. There is no sharp transition from un-harmful to harmful as NO_2 levels rise. In a review for the NorthConnex project, Todoroski[3] noted that the available literature "*…indicates an upper bound above 4 ppm may not be reasonable to manage potential health effects, and that the potential upper bound for NO_2 levels could reasonably lie in the range 0.5 to 4 ppm*".

In this context, the Proponent's limits initially proposed for NorthConnex in Table 6.1 had merit. Risk was to be rationally managed with a slight increase in level for rare slow speed events. However, the information that was not available to the NorthConnex environmental assessment was the likely frequency of the very slow speed traffic. Without the risk context given by probability of the low speed traffic scenario, no concession on pollution limit was made for low speed cases. Further, it was found that the design could comply with the same criterion at speeds right down to 20 km/h, and so there was insufficient incentive to substantiate the view that such slow traffic would be rare, with the project accepting the more stringent constant NO_2 criterion.

The NorthConnex outcome did not deny the risk context, but simply responded to the lack of frequency data available and to the design opportunities. Consequently, it does not form a precedent for avoiding the risk context on WestConnex should the data become available. However, the New M5 design and procurement process has not completed documented expectations of low speed traffic frequency in a way that could be used to justify a different in-tunnel NO_2 limit for low speed scenarios. Consequently, the New M5 project has adopted an NO_2 limit of 0.5 ppm as a spatial and time average for all design traffic cases.

With the adopted approach to the NO_2 limit perhaps embodying an element of risk conservatism, it is undesirable to introduce yet more conservatism in the calculation of the low speed traffic cases. It is simple to base a spreadsheet calculation on traffic travelling at maximum density for a given constant speed along a whole tube. This can be applied as a screening method, and is sometimes applied as a design method, however it is considered to be an over-simplification and does not reflect realistic traffic flow.

Traffic obeys rules of continuity in that vehicles are not lost or created at intersections. Continuity of flow means that, at any intersection where the number of lanes changes, the traffic speed and density cannot be the same in all legs connected to the intersection. That means that a uniform congestion assumption must be unrealistically conservative for any tunnel with intersections, which includes New M5 and M4-M5 Link. Further, real driver behaviour generates waves in the traffic speed; moving the traffic further from idealised congestion where the traffic is assumed to travel at a constant speed.

In the present work, the limiting traffic flow for the congested cases has been treated realistically. Congested cases have been modelled with unlimited inflow traffic demand, and speed restrictions placed in downstream sections to limit flow to the nominated speeds. In the tunnel behind the blockage, the traffic behaves as modelled by IDA Tunnel (Chapter 10), including obeying continuity.

[3] Todoroski Air Sciences; Independent Air Quality Review NorthConnex (M1-M2) Project SSI-6136, 12th January 2015.

7 TRAFFIC

7.1 Demand

7.1.1 Normal and regulatory traffic demand

Traffic for "normal" operation is the predicted weekday traffic demand. The traffic data provided indicates that the peak in this traffic flow falls short of the theoretical maximum 2200 pcu/lane.h ("pcu" is "passenger car units", a measure used to standardise road capacity for different traffic mixes). To cover the possibility of the traffic being under-predicted, a limiting traffic case was sought, relating to the maximum capacity of the tunnel. For the purposes of this limiting case ventilation design, the normal daily traffic demand was scaled to increase the demand to so that the peak traffic flow reached in the most congested parts of the tunnel is 2200 pcu/lane.h. This scaled daily demand is referred to in this report as "regulatory case" or just "regulatory" daily traffic demand.

7.1.2 Congested traffic

Congested cases have been generated by applying speed limits (20, 40, 60 & 80 km/h) in critical sections which are likely to cause traffic to back-up in the tunnel. Using the regulatory daily traffic demand with the ramp inflows and outflows held in the same proportions as the normal peak hour traffic, some parts of the tunnel network will saturate before others. The ventilation system model incorporates the aerodynamic response to the locally saturated traffic in order to correctly assess the tunnel air flow and temperature as well as pollution levels.

7.1.3 Breakdown scenario

In order to attend to and remove a broken down vehicle, tunnel operators may close one lane upstream of the disabled vehicle to clear a path for the road patroller. With one lane closed, the number of vehicles in the tunnel will decrease and the average speed will not fall as far as it would without the lane closure, maintaining some benefit from the piston effect. If the breakdown occurs near the exit of the tunnel, and the operators were to take no action, the traffic would bank up and over time might look like that in the congested scenario above. With normal operator control, the traffic case will be less onerous than the congested case.

That is; the foreseeable breakdown scenario is no more onerous than the congested case. The congested case results may be applied to the breakdown scenario, including some conservatism. Given the low frequency of occurrence, the added conservatism in breakdown cases will not be significant.

7.2 Vehicle classification

Fleet characterization used in the WestConnex Road Traffic Model (WRTM) needed to be modified for ventilation design calculations based on PIARC[4] emission factors (or for any method that treats the fleet according to its makeup by emissions characteristics). For current purposes, the WRTM over-estimates the fraction of light duty vehicles (LDV) and heavy goods vehicles (HGV) in two ways.

Firstly, the WRTM split of vehicle classifications in the WRTM traffic data was produced using automatic number plate recognition, based on the type of registration (private or commercial). In this way, a courier's Hyundai i30 (small hatch-back) would be a light duty

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[4] Road Tunnels: Vehicles, Emissions and Air Demand for Ventilation. Document 2012R05EN, Permanent International Association of Road Congresses (PIARC) Technical Committee C4 Road Tunnels Operation. December 2012.

vehicle, and a VW Multivan (large carrier) could be a passenger car if privately owned. When PIARC definitions of passenger cars (PC), light duty vehicles (LDV) and heavy goods vehicles (HGV) are applied to traffic in the WestConnex corridors, the fleet typically has 10% to 20% LDVs, compared with the estimate of 35% to 55% commercial vehicles published from the WRTM.

Secondly, the WRTM traffic predictions assign all vehicles in Austroads Classes 3–12 to be HGVs. Some of the Class 3 vehicles should be removed from the HGV classification and included in the LDV fraction for the purpose of emissions assessment.

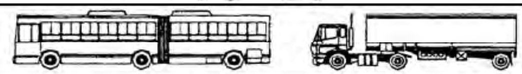
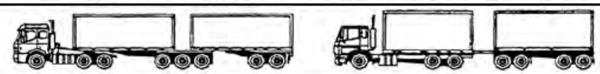
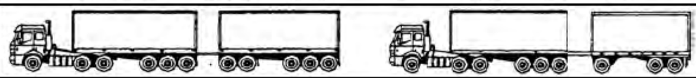
This section revises the WRTM fleet fractions to follow PIARC definitions of PC, LDV and HGV. The following sub-sections describe the data sources and methodology used to re-categorise the fleet for the purpose of ventilation design, with the conclusion on fleet mix given in Section 7.2.5.

There are four possible additional sources of information to characterise the WestConnex fleet:

- NSW Roads and Maritime Services fixed counting network data;
- weigh-in-motion (WIM) stations in the relevant corridors, weighing passing vehicles;
- typical values published by PIARC, and;
- noted fleet compositions in the Sydney air-shed more generally[5].

Data from the first source references Austroads vehicle classifications, which are shown in Figure 7.1.

[5] Personal communication, Paul Boulter, Pacific Environment.

Level 1 Length (indicative)	Level 2 Axles and Axle Groups		Level 3 Vehicle Type	AUSTROADS Classification		
Type	Axles	Groups	Typical Description	Class	Parameters	Typical Configuration
					LIGHT VEHICLES	
Short up to 5.5m		1 or 2	**Short** Sedan, Wagon, 4WD, Utility, Light Van, Bicycle, Motorcycle, etc	1	d(1) ≤ 3.2m and axles = 2	
Medium 5.5m to 14.5m	3, 4 or 5	3	**Short - Towing** Trailer, Caravan, Boat, etc	2	groups = 3 d(1) ≥ 2.1m, d(1) ≤ 3.2m, d(2) ≥ 2.1m and axles = 3, 4 or 5	
					HEAVY VEHICLES	
	2	2	**Two Axle Truck or Bus**	3	d(1) > 3.2m and axles = 2	
	3	2	**Three Axle Truck or Bus**	4	axles = 3 and groups = 2	
	> 3	2	**Four Axle Truck**	5	axles > 3 and groups = 2	
Long 11.5m to 19.0m	3	3	**Three Axle Articulated** Three axle articulated vehicle, or Rigid vehicle and trailer	6	d(1) > 3.2m, axles = 3 and groups = 3	
	4	> 2	**Four Axle Articulated** Four axle articulated vehicle, or Rigid vehicle and trailer	7	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 4 and groups > 2	
	5	> 2	**Five Axle Articulated** Five axle articulated vehicle, or Rigid vehicle and trailer	8	d(2) < 2.1m or d(1) < 2.1m or d(1) > 3.2m axles = 5 and groups > 2	
	≥ 6	> 2	**Six Axle Articulated** Six axle articulated vehicle, or Rigid vehicle and trailer	9	axles = 6 and groups > 2 or axles > 6 and groups = 3	
Medium Combination 17.5m to 36.5m	> 6	4	**B Double** B Double, or Heavy truck and trailer	10	groups = 4 and axles > 6	
	> 6	5 or 6	**Double Road Train** Double road train, or Medium articulated vehicle and one dog trailer (M.A.D.)	11	groups = 5 or 6 and axles > 6	
Large Combination Over 33.0m	> 6	> 6	**Triple Road Train** Triple road train, or Heavy truck and three trailers	12	groups > 6 and axles > 6	

Definitions:
Group: Axle group, where adjacent axles are less than 2.1m apart
Groups: Number of axle groups
Axles: Number of axles (maximum axle spacing of 10.0m)

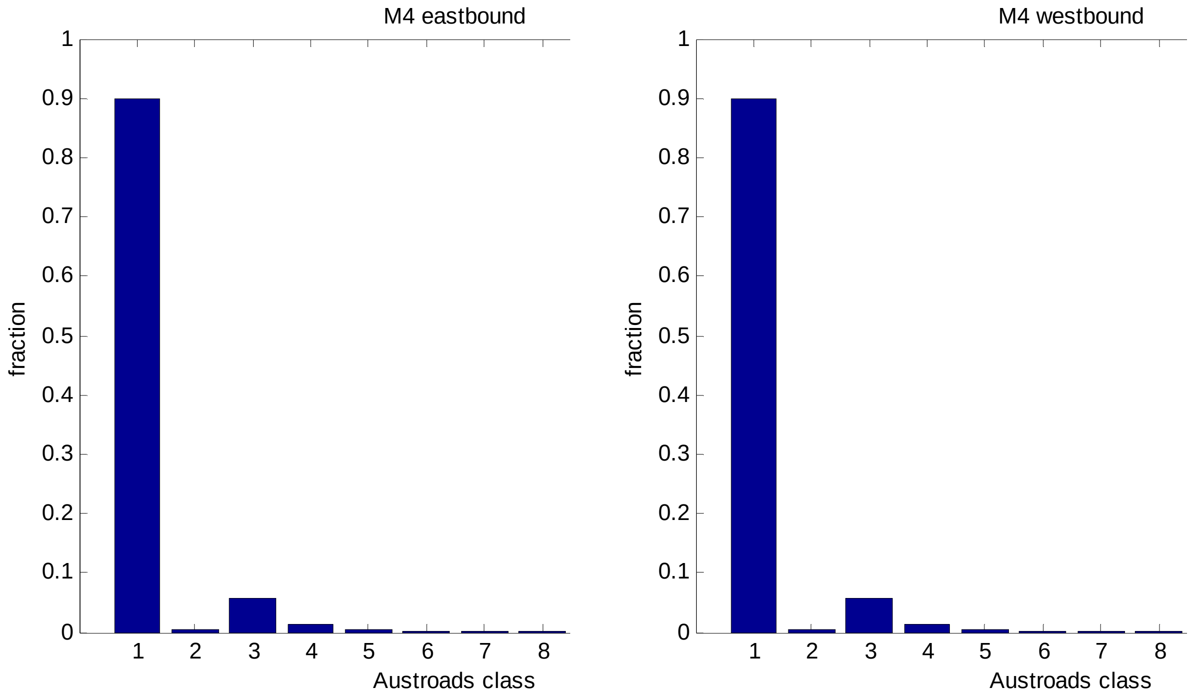
d(1): Distance between first and second axle
d(2): Distance between second and third axle

Figure 7.1. Austroads vehicle classification.

7.2.1 M4 fixed network vehicle counts

The traffic composition on the existing M4 Motorway is a guide for fleet composition expected in the New M5 tunnel. Data for the M4 Motorway given in Figure 7.2 shows that Austroads Classes 1-2 (light vehicles) comprise 90% of the fleet, with Class 3 being 5.8% and the remainder being Classes 4-12 heavy vehicles (4.2%).

The lower length limit for Class 3 vehicles (5.5 metres) is only just longer than a family station wagon, and so some of the Class 3 vehicles would be categorized by PIARC as LDVs, not HGVs. However the fraction of the vehicles in Classes 1 and 2 which should be classified as LDVs by the PIARC definition cannot be identified from the dataset in Figure 7.2.



Austroads Class	1	2	3	4	5	6	7	8	9	10	11	12
Eastbound %	90.0	0.4	5.8	1.3	0.4	0.1	0.1	0.2	1.4	0.2	0.0	0.0
Westbound %	89.9	0.4	5.8	1.3	0.4	0.1	0.1	0.2	1.5	0.2	0.0	0.0

Figure 7.2. Traffic split by Austroad vehicle class for the M4 freeway (Roads and Maritime fixed counting network).

7.2.2 M5 weigh-in-motion data

Weigh in motion (WIM) data obtained from the existing M5 East Motorway eastbound (lane 1) is shown in Figure 7.3 to Figure 7.5. Only data for Austroads Classes 3 and above are reported in this data set. Figure 7.3 shows the mass distribution taken from the WIM data, with Figure 7.4 and Figure 7.5 giving the cumulative distribution.

Using the 3.5 tonne upper limit prescribed by PIARC for LDVs; 7% of Class 3-12 could be categorized as LDVs. The HGV counts in the WRTM and associated traffic modelling need to be multiplied by 0.93 if numbers were originally assessed by including Class 3 as HGVs.

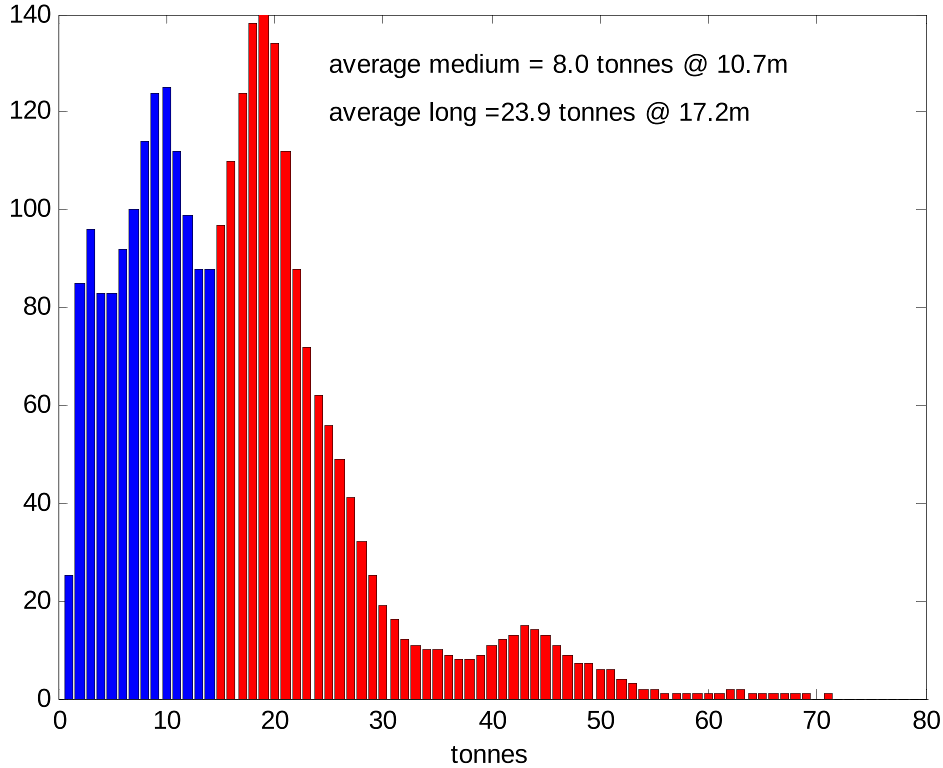


Figure 7.3. Mass distributions of medium (blue) and long (red) heavy vehicles (M5East eastbound). Only Class 3-12 are included in the data set. The vertical axis is vehicle counts in each bin.

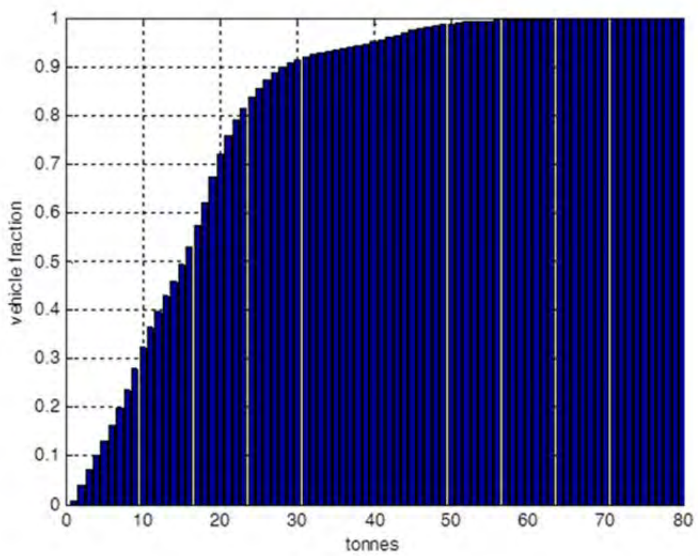


Figure 7.4. Cumulative distribution of vehicle mass on M5 eastbound. Only Class 3-12 are included in the data set.

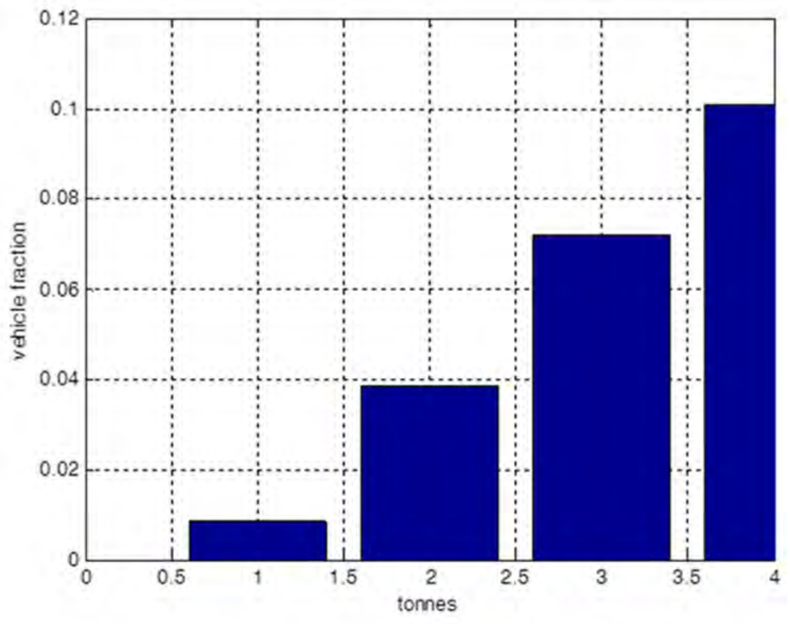


Figure 7.5. Cumulative distribution of vehicle mass on M5 eastbound in Classes 3 and up, shown up to 4 tonnes.

7.2.3 PIARC expectation

In a report section specific to Australia, PIARC[6] suggests that, for the purposes of calculation of the required ventilation capacity, the split of light (non-HGV) vehicles between PCs and LDVs is typically PC:LDV; 84%:16%. This information should be seen as a generalization which may not necessarily be applicable to the road corridors in question.

7.2.4 Air-shed studies

The NSW Greater Metropolitan Region emissions inventory adopts fleet makeups for each of several different road types. The table for commercial highways is reproduced below. When aggregated, it gives, for 2014; 74.5%PC, 18.3% LDVs, 6.8% HGVs and 0.5% motorcycles. Predictions for future years have an approximately constant LDV fraction, with a shift to diesel fuel.

Table 7.1. Adopted split within the NSW emissions inventory for a commercial highway (via Paul Boulter, Pacific Environment).

<table>
<tr><td rowspan="3">Commercial highway</td><td colspan="12">Traffic mix (%)*</td></tr>
<tr><td colspan="3">Passenger cars</td><td colspan="3">Light commercial vehicles</td><td colspan="5">Heavy goods vehicles</td><td>Motor-cycles</td></tr>
<tr><td>CP</td><td>CD</td><td>All cars</td><td>LDCP</td><td>LDCD</td><td>All LCVs</td><td>HDCP</td><td>RT</td><td>AT</td><td>BusD</td><td>All HGVs</td><td>MC</td></tr>
<tr><td>2014</td><td>67.0</td><td>7.5</td><td>74.5</td><td>11.4</td><td>6.9</td><td>18.3</td><td>0.1</td><td>4.6</td><td>1.6</td><td>0.4</td><td>6.8</td><td>0.5</td></tr>
<tr><td>2021</td><td>58.8</td><td>14.5</td><td>73.3</td><td>8.9</td><td>9.8</td><td>18.7</td><td>0.1</td><td>5.2</td><td>1.8</td><td>0.4</td><td>7.5</td><td>0.5</td></tr>
</table>

[6] Road Tunnels: Vehicles, Emissions and Air Demand For Ventilation. Document 2012R05EN, PIARC Technical Committee C4 Road Tunnels Operation. December 2012. See Table 35

2031	52.2	20.6	72.9	6.4	12.3	18.7	0.1	5.5	1.9	0.4	7.9	0.5

NOTE: * CP = petrol passenger vehicles; CD = diesel passenger vehicles; LDCP = light-duty commercial petrol vehicles (<=3500 kg); LDCD = light-duty commercial diesel vehicles (<=3500 kg); HDCP = heavy-duty commercial petrol vehicles (>3500kg); RT = rigid trucks (3.5-25 tonnes, diesel only); AT = articulated trucks (> 25 tonnes, diesel only); BusD = heavy public transport buses (diesel only); MC = motorcycles.

7.2.5 Conclusion on vehicle type split

Daily fleet mixes derived from the notes above are given in Table 7.2. This table compares the WRTM vehicle fractions to the same fractions obtained when the LDVs and HGVs are re-categorised using rules consistent with PIARC definitions. A comparison is also made with air-shed data for a commercial highway.

Table 7.2. Vehicle splits approached in several ways.

	Eastbound			Westbound			
	PC	LDV	HGV	PC	LDV	HGV	Derivation notes
WRTM (New M5 2021)	52.9%	39.2%	8.0%	52.0%	40.6%	7.4%	Reduced data from tables in the WRTM.
WRTM (New M5 2031)	54.3%	31.3%	14.4%	54.0%	32.6%	13.4%	
PIARC (New M5 2021)	77.3%	15.3%	7.4%	77.8%	15.3%	6.9%	$PC=0.84*(PC+LDV)_{WRTM}$ $LDV=0.16*(PC+LDV)_{WRTM}$ $+0.07*(Class3\text{-}12)$ $HGV=0.93*(HGV)_{WRTM}$
PIARC (New M5 2031)	71.9%	14.7%	13.4%	72.7%	14.8%	12.5%	
M4 fixed network count data (2012-2014)	75.9%	15.1%	8.9%	75.9%	15.1%	9.0%	PC=0.84*(Class1+Class2) LDV=0.16*(Class1+Class 2)+0.07*(Class3-12) HGV=0.93*(Classes 3-12)
Air-shed (Commercial highway 2014)	74.8%	18.4%	6.8%	74.8%	18.4%	6.8%	

Noting the WRTM splits to be inappropriate for ventilation purposes, there are really only two independent sources of the LDV fraction in the table above; the PIARC expectation and the generic commercial highway figures derived through the work by NSW Environmental Protection Authority (EPA). While they are not so different from each other, they are still uncertain, and it seems prudent to take the most conservative of these.

This is done by looking at the cumulative fractions coming down in vehicle size, making sure that the vehicle numbers above each size cutoff are as great in the adopted numbers as in any of the candidate distributions. The result is:

Table 7.3. Adopted vehicle type split for daily total flows on the corridor 2012 to 2021, based on all data above.

PC	LDV	HGV
74.8%	16.2%	9.0%

With a daily average adopted, a method of distributing the vehicle types through the day is still required. There is little doubt about the HGV fraction, as it is well recorded by the fixed count network to support the modelling that went into the WRTM, and only a small adjustment (7%) was made, based on the M5 data above and PIARC category weights. The issue is the fraction of the lighter vehicles which fit within the PIARC understanding of an LDV.

WRTM numbers for LDVs are actually commercially registered vehicles of all light body types. It was assumed that no PIARC-defined LDVs are actually privately registered. The task is then to estimate the fraction of commercially registered vehicles that would fit the PIARC LDV understanding. This has been done by matching the proportion of non-HGVs that are LDVs (LDV/(PC+LDV)) to that proportion in the distribution in Table 7.3. The value from Table 7.3 is 17.8%. It is noted again that the figures being used are specifically relevant to the M4 corridor rather than being simply Sydney or NSW averages.

The daily LDV totals of the project WRTM traffic data were adjusted by reducing the WRTM LDV numbers by a fixed fraction and adding 7% of the WRTM HGV numbers to the LDVs. A value of 40% for the PIARC LDVs within the WRTM LDVs was found to match the daily project fleet LDV/PC split to that in Table 7.3.

All the WestConnex traffic predictions to date have been prepared in a consistent way in so far as Class 3 has been taken as the lower bound of HGV sizing and all commercially registered Class 1 and 2 vehicles have been taken as being LDVs. The above analysis suggests an approach for converting all such data into a form which may be used for pollution estimation. It is:

- Take the HGV numbers as 93% of the numbers given earlier.
- Take the remaining (7%) of the earlier HGVs to in fact be LDVs.
- Additionally, take 40% of the previous LDVs to actually be LDVs.
- Take the remainder to be PCs. (This will be the previous PCs, plus 60% of the previous LDVs).

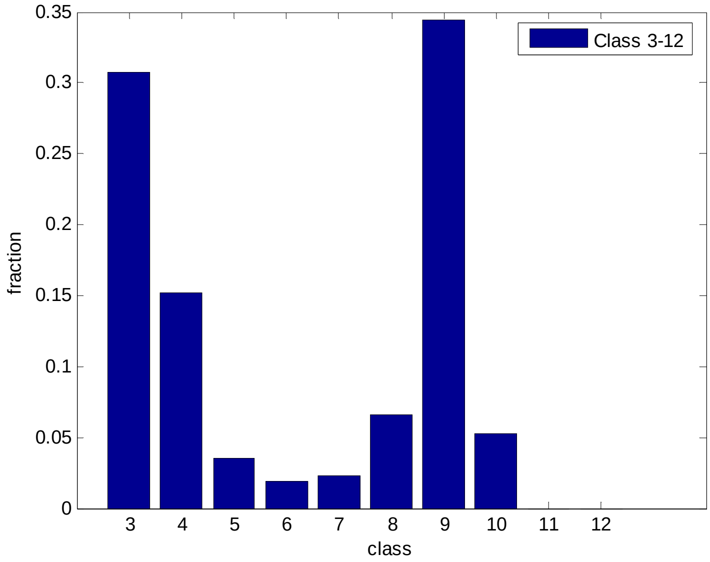
This allows the hour by hour WRTM traffic data to be transformed for ventilation purposes in a way that preserves the total hourly flows, the changing fleet mix over the 24 hours and through the years, and is also consistent with the methods proposed for pollution assessment.

7.3 Size of vehicles

Vehicle mass is important to estimating pollution generation and vehicle length affects the traffic lane density.

The mass of a large passenger car is typically 1.7 tonnes (Holden Commodore) and a small car can be less than 1.0 tonne. For this study a nominal passenger car mass of 1.5 tonnes has been adopted.

Heavy vehicle mass data obtained from lane 1 (slow lane) of M5 East tunnel is used here to categorize the heavy vehicles. Distribution of heavy vehicles by Austroads Class is shown in Figure 7.6. Classes 3-5 ("medium") comprise 49.5% of the heavy vehicle fleet and with the remainder ("long") lying in Class 6-12.



Class	3	4	5	6	7	8	9	10	11	12
%	30.7	15.2	3.6	1.9	2.3	6.6	34.5	5.3	0.0	0.0

Figure 7.6. Distribution of heavy vehicles by Austroads class (M5 East eastbound).

Weight distributions of medium (blue) and long (red) vehicles plotted in Figure 7.3 give average masses of 8.0 tonnes and 23.9 tonnes respectively. Estimates of average lengths 10.7 m and 17.2 m for medium and long vehicles are made using the assumption that lengths are in proportion to the weights and that medium vehicles range in length from 5.5 m to 14.5 m and long vehicles range from 14.5 m to 40 m. The nominal vehicle sizes are summarised in Table 7.4. The standing length includes an allowance for gaps between stopped vehicles.

Table 7.4. Adopted sizes for each vehicle category.

		PC	LDV	HGV	
				medium	long
Mass	tonne	1.5	3.0	8.0	24.0
Standing length per vehicle	m	6	10	12	20

7.4 Vehicle age

Figure 7.7 plots a typical vehicle age profile used in the estimation of emission factors.

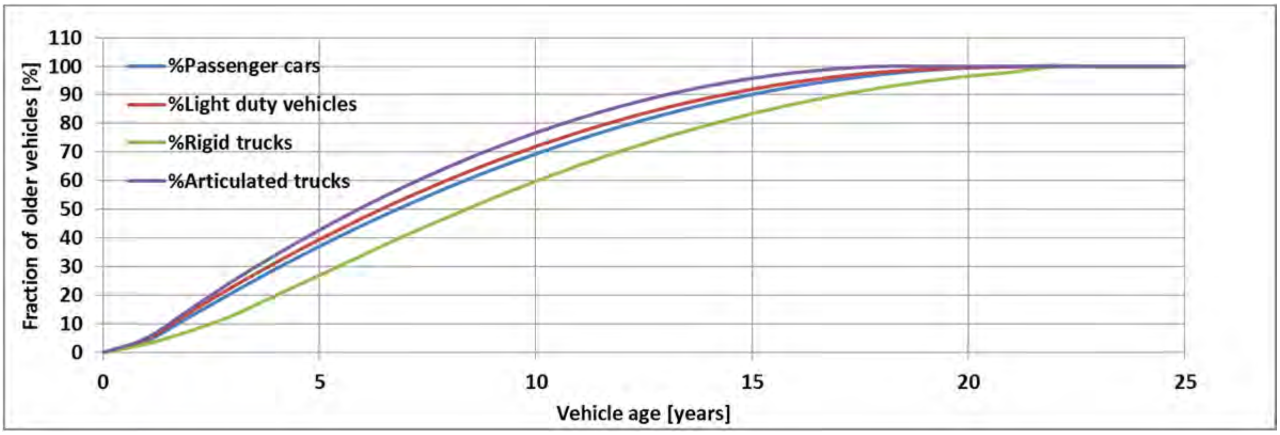


Figure 7.7. Typical age distribution plot (Australian Bureau of Statistics Motor Vehicle Census 2014).

7.5 Fuel mix

A plot of the fraction of New registrations which are fuelled with diesel is plotted for PC, LDV and HGV. The percentage of New diesel cars appears to plateau at 20% whilst New LDVs are approximately 90% diesel. New heavy vehicles are 100% diesel.

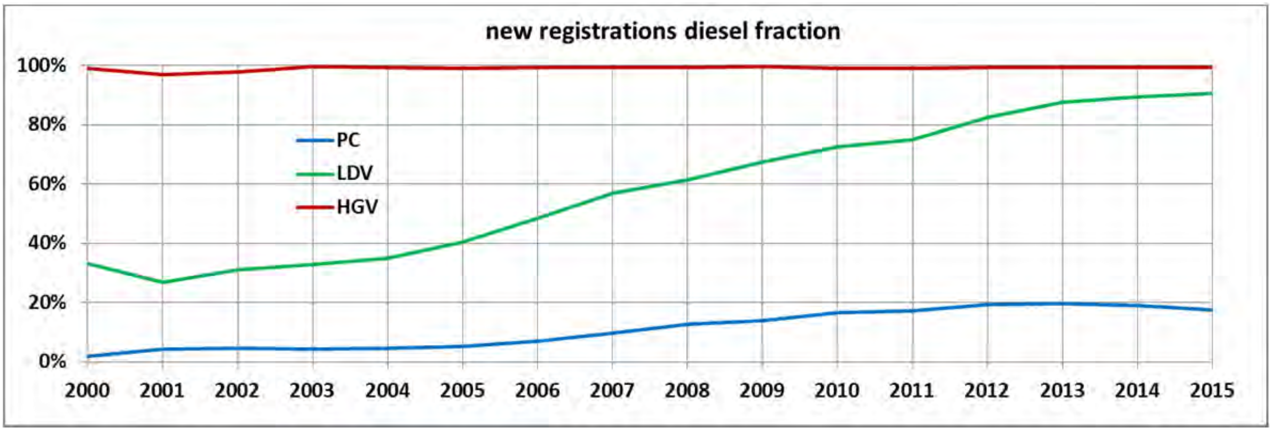


Figure 7.8. Percentage of New vehicles which are diesel-fuelled.

When the age distribution of the fleet is considered the diesel fractions adopted for the year 2020 fleet are calculated to be; PC 17.5%, LDV 91 %, HGV 100%. It should be noted that the PIARC emissions tables for Australia make the assumption that only 50% of the LDV are diesel. As there is not yet a basis on which to make an adjustment to the PIARC LDV emissions tables to account for the apparently higher LDV fraction, the existing tables have been used without modification.

7.6 Traffic flow for the New M5

Traffic flow and vehicle fractions for 2021 and 2031 are contained in Table 7.5 and Table 7.6. These figures are derived using WRTM values modified using the PIARC definitions of PC, LDV and HGV and the approach given at the end of Section 7.2.5.

Table 7.5. New M5 2021 normal traffic demand.

Hour Beginning	Eastbound				Westbound			
	Car	LDV	HGV	Total	Car	LDV	HGV	Total
0:00	41	7	8	57	177	53	33	262
1:00	25	6	8	39	45	8	11	65
2:00	23	3	8	34	35	11	11	57
3:00	24	3	8	35	50	21	11	82
4:00	37	12	8	58	58	27	21	106
5:00	100	24	13	137	161	65	33	259
6:00	375	119	53	547	247	79	54	380
7:00	786	214	90	1091	564	119	86	769
8:00	1006	267	151	1424	403	90	75	568
9:00	864	217	127	1209	578	123	129	830
10:00	775	183	126	1084	538	124	151	813
11:00	724	178	136	1038	557	154	179	891
12:00	550	159	120	829	530	136	140	806
13:00	454	138	116	708	524	138	161	823
14:00	467	135	113	715	557	139	151	847
15:00	617	137	110	864	643	149	140	931
16:00	697	137	106	940	804	213	161	1178
17:00	571	101	99	771	1078	258	148	1483
18:00	557	88	97	742	725	179	108	1012
19:00	364	75	81	520	542	144	86	772
20:00	283	72	63	418	490	131	70	691
21:00	257	67	57	380	450	118	64	632
22:00	260	73	48	381	423	109	65	597
23:00	109	22	16	146	288	85	64	437

Table 7.6. New M5 2031 normal traffic demand.

Hour Beginning	Eastbound Car	LDV	HGV	Total	Westbound Car	LDV	HGV	Total
0:00	48	9	12	69	200	59	42	301
1:00	29	7	9	45	52	9	14	75
2:00	28	4	9	41	40	12	14	66
3:00	28	4	9	41	57	23	14	94
4:00	43	14	12	69	65	30	28	123
5:00	117	28	18	163	175	68	42	284
6:00	432	139	71	641	242	89	70	401
7:00	925	248	118	1292	647	134	112	893
8:00	1161	298	213	1672	534	115	108	757
9:00	1018	252	170	1441	662	139	167	968
10:00	914	214	168	1296	616	141	195	952
11:00	818	205	180	1203	623	173	221	1017
12:00	647	185	161	993	606	154	181	941
13:00	534	161	156	851	599	156	209	964
14:00	542	158	152	851	617	158	195	970
15:00	728	160	147	1035	735	168	181	1084
16:00	825	160	142	1127	919	240	209	1368
17:00	794	134	137	1065	1321	308	218	1847
18:00	659	103	130	892	829	201	140	1169
19:00	430	88	109	627	619	162	112	893
20:00	317	84	86	486	559	147	91	797
21:00	302	78	76	456	499	132	84	715
22:00	292	84	61	437	439	112	81	632
23:00	112	25	21	159	306	81	63	450

Table 7.7. Normal traffic demand in 2031, including M4-M5 Link up to Rozelle.

Hour Beginnin	Eastbound Ca	LD	HG	Tota	Southern Extension Car	LD	HG	Tota	Westbound Car	LD	HG	Tota
0:00	32	6	15	54	114	37	3	154	216	53	38	307
1:00	20	5	7	32	61	25	3	88	42	7	13	62
2:00	18	2	7	28	33	13	3	48	19	7	13	39
3:00	18	2	7	28	33	13	3	48	19	7	13	39
4:00	29	9	7	45	96	25	5	125	47	26	13	86
5:00	79	18	11	108	191	50	10	252	184	63	38	285
6:00	29	89	45	428	799	223	20	1042	300	81	63	444
7:00	62	161	77	859	158	397	49	2026	716	121	100	937
8:00	68	165	110	963	193	512	124	2569	984	182	128	1294
9:00	68	163	108	956	160	404	103	2111	730	125	152	1007
10:00	61	138	106	860	139	353	88	1836	683	127	177	988
11:00	53	130	105	771	120	323	78	1605	629	138	197	964
12:00	43	119	102	655	111	302	73	1491	646	132	159	937
13:00	35	104	99	561	109	290	66	1448	646	134	190	971
14:00	36	102	96	567	106	277	61	1400	680	142	177	999
15:00	49	103	93	687	101	252	59	1323	771	151	165	1087
16:00	55	103	90	750	941	227	61	1229	100	216	184	1402
17:00	62	117	87	830	878	204	63	1146	120	253	206	1661

18:00	44	66	82	596	752	201	34	987	909	180	127	1215
19:00	29	57	69	416	728	200	26	954	675	147	101	923
20:00	22	54	54	332	728	199	20	947	609	133	81	823
21:00	20	50	52	306	728	199	15	942	562	120	76	758
22:00	19	51	52	300	736	198	10	945	516	105	65	686
23:00	77	17	15	108	271	99	5	374	328	68	58	454

7.7 Ramp splits M5 with M4-M5 Link

7.7.1 Eastbound

The fraction of traffic in each category departing the New M5 at SPI for 2031 traffic is given in Table 7.8. Traffic entering the eastbound M4-M5 Link tube at SPI is given in Table 7.9.

Table 7.8. Eastbound traffic split at SPI

Hour beginning	PC	LDV	HGV
0	73%	60%	42%
1	73%	60%	42%
2	61%	51%	45%
3	79%	89%	45%
4	79%	90%	72%
5	75%	77%	61%
6	74%	62%	52%
7	74%	42%	45%
8	82%	84%	61%
9	76%	73%	53%
10	78%	83%	54%
11	76%	80%	57%
12	79%	77%	58%
13	85%	75%	59%
14	76%	74%	60%
15	79%	81%	61%
16	81%	80%	59%
17	77%	72%	57%
18	83%	79%	62%
19	83%	80%	62%
20	82%	81%	74%
21	82%	78%	72%
22	83%	81%	69%
23	84%	89%	76%

Table 7.9. Eastbound traffic (vph) entering M4-M5 Link at SPI

Hour beginning	PC	LDV	HGV
0	256	27	94
1	256	27	94
2	132	17	94
3	132	17	94
4	132	17	94
5	760	47	93
6	760	47	93
7	1931	152	407
8	3086	232	534
9	2910	276	607
10	2852	278	635
11	2811	278	655
12	2825	280	647
13	2838	278	642
14	2837	278	642
15	2853	267	640
16	2883	253	632
17	2864	249	643
18	2571	270	640
19	2446	244	581
20	2131	212	465
21	2101	191	442
22	2052	182	424
23	1086	88	102

It is assumed that 50% of the M4-M5 Link exits to the Rozelle interchange and the balance is evenly split between the CWL and WHT ramps.

7.7.2 Westbound

The ramp splits for the westbound traffic are given in Table 7.10 to Table 7.12.

Table 7.10 Westbound traffic exiting at SPI.

Hour beginning	PC	LDV	HGV
0	65%	45%	83%
1	82%	78%	98%
2	91%	75%	88%
3	91%	75%	88%
4	75%	44%	84%
5	52%	24%	52%
6	63%	41%	72%
7	78%	58%	84%
8	81%	62%	86%
9	87%	65%	85%
10	82%	60%	86%
11	82%	63%	84%
12	83%	72%	89%
13	85%	71%	83%
14	83%	64%	82%
15	82%	58%	79%
16	75%	50%	74%
17	67%	45%	80%
18	68%	54%	81%
19	77%	63%	88%
20	87%	63%	94%
21	84%	65%	93%
22	85%	67%	94%
23	70%	56%	83%

Table 7.11 Westbound traffic (vph) entering at SPI.

Hour beginning	PC	LDV	HGV
0	143	32	23
1	62	16	15
2	62	16	12
3	62	16	12
4	104	32	12
5	187	61	12
6	332	95	35
7	656	128	70
8	1090	202	104
9	1165	206	128
10	1239	259	174
11	1624	380	196
12	1805	444	186
13	1948	474	174
14	2090	504	162
15	2426	532	133
16	2855	624	129
17	3265	680	227
18	2376	562	116
19	1625	318	104
20	1239	253	99
21	1008	227	81
22	938	222	72
23	246	35	46

Table 7.12 Westbound traffic exiting at SE.

Hour beginning	PC	LDV	HGV
0	32%	33%	9%
1	55%	65%	13%
2	73%	65%	13%
3	73%	65%	13%
4	68%	50%	22%
5	44%	46%	13%
6	40%	47%	11%
7	27%	47%	13%
8	36%	45%	15%
9	45%	61%	17%
10	57%	68%	21%
11	67%	72%	24%
12	67%	73%	27%
13	69%	74%	24%
14	69%	75%	26%
15	70%	76%	30%
16	69%	72%	30%
17	70%	71%	30%
18	70%	73%	34%
19	65%	62%	27%
20	53%	59%	22%
21	50%	57%	14%
22	49%	59%	17%
23	34%	29%	15%

8 VEHICLE-INDUCED AIR FLOWS

8.1 Piston effect

Vehicle induced air flows in a tunnel are determined from the vehicle flow and speed, along with vehicle drag parameters. The pollutant concentrations in the tunnel are determined by how the vehicle emissions are diluted by the tunnel air flows. Hence knowing the vehicle drag is central to estimating the in-tunnel pollutant concentrations.

8.2 Vehicle drag

Vehicle aerodynamic drag force on an isolated vehicle in open air is expressed by the equation: $F_d = \frac{1}{2}\rho C_d A_v (v - U)^2$, where;

- ρ is the density of air which is dependent on temperature [kg/m^3];
- C_d is the drag coefficient measured in open air. Typical drag coefficients for isolated vehicles in open air facing an oncoming air stream are given in Figure 8.1. The error bars in this graph indicate that drag coefficients are highly variable.

  When the airstream comes from the rear of the vehicle, as would occur with stopped traffic, the drag coefficient may be larger than when the airstream is coming from the front;
- A_v is the frontal area [m^2] of the vehicle;
- v is the vehicle speed [m/s], and;
- U is the tunnel air speed [m/s].

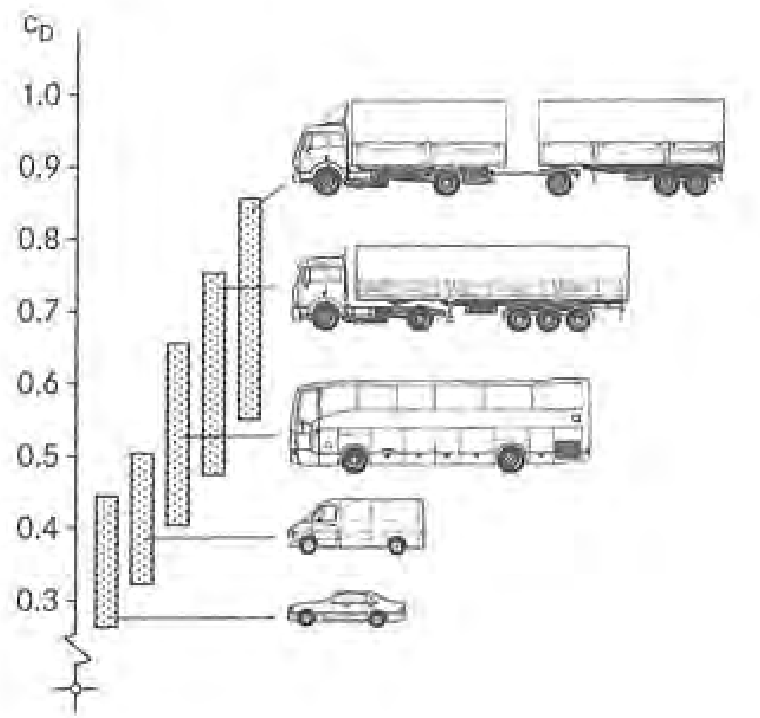


Figure 8.1. Typical drag coefficients for isolated vehicles in open air. (http://www.part20.eu/en/background/aerodynamics/)

With the tunnel walls affecting both the airspeed around the vehicle and the nature of the vehicle wake, the drag is different from that in open air. Aerodynamic drag exerted by a vehicle in a tunnel with cross sectional area A is estimated using from the modified formula:

$$F_d = \frac{1}{2}\rho C_d^{\,*} A_v (v-U)^2$$

where the effective drag factor

$$C_d^{\,*} = \frac{s_f C_d}{\left(1-\frac{A_v}{A}\right)^2}$$

is influenced by;

- the ratio of frontal area of the vehicle relative to the tunnel area. The restriction of the air between the vehicle and the walls tends to increase the effective drag coefficient by increasing the air speed local to the vehicle.
- spacing factor s_f which is used to account for the proximity of other vehicles in front and behind, and the tunnel walls. This factor has a significant effect in decreasing the effective drag coefficient with closer vehicle spacing. As the vehicle separation decreases, the spacing factor decreases due to sheltering of the vehicles by those in front. Figure 8.2 shows the effect of vehicle separation on leading and trailing vehicle drag coefficients of a typical passenger car[7]. The distance between vehicles is denoted ‘x’, with the vehicle length being ‘L’. This graph suggests that the spacing factor is in the range $0.73 \le s_f \le 0.85$, as the separation increases up to at least four car lengths, corresponding to a traffic speed of 50 km/h. Being only a fraction of the tunnel fleet, large vehicles are more likely to be widely separated from each other and would not be shielded significantly by the surrounding cars.

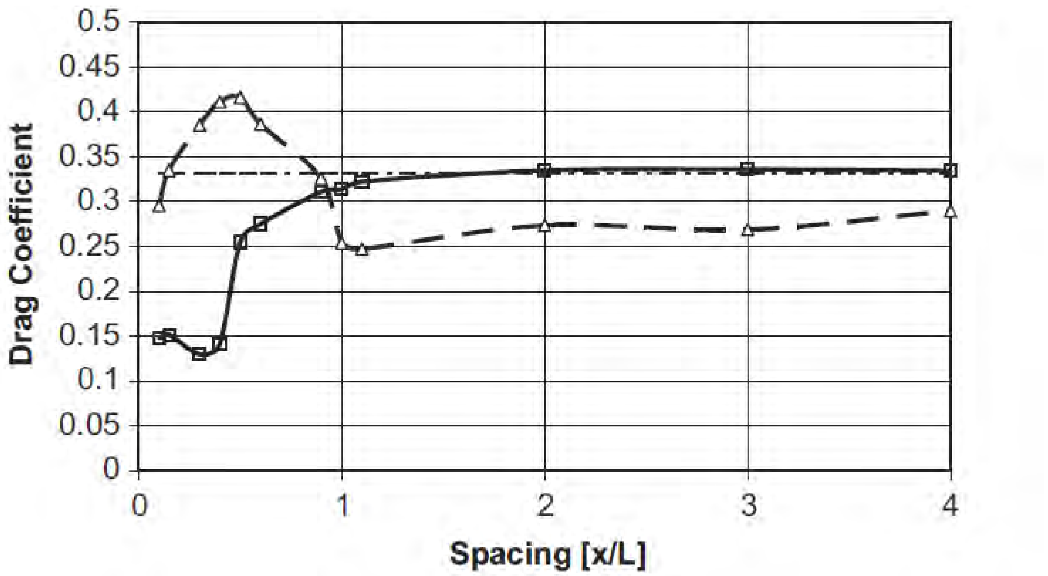


Figure 8.2. Effect of vehicle spacing (separation) on vehicle drag coefficients of the lead (square) and trailing (triangle) vehicle (Watkins & Gino 2007).

Proximity of the tunnel walls and traffic in adjacent lanes has the effect of suppressing the wake being shed from a vehicle, thus reducing its effective drag coefficient.

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[7] Watkins S., Vino G., The effect of vehicle spacing on the aerodynamics of a representative car shape. J. Wind Eng. Ind. Aerodyn. (2007), doi: 10.1016/j.jweia.2007.06.042

The shaded area in Table 8.1 summarises the results derived from in-tunnel experimentation[8] by Jang and Chen. The un-shaded area is a calculation of the spacing factors which give the Jang and Chen numbers, starting from nominal open air vehicle drag coefficients for small and large vehicles in high and low density traffic.

The spacing factor (s_f = 0.54) for high density small vehicle traffic is significantly smaller than predicted from Figure 8.2 which only applies to a single following vehicle in an open air environment. Spacing factors for low density small vehicle traffic $0.87 \leq s_f \leq 0.95$ are slightly higher than predicted from Figure 8.2. Low spacing factors $0.29 \leq s_f \leq 0.49$ for large vehicles predicted from the Jang and Chen data are associated with the proximity of the tunnel walls and the resulting suppression of the vehicle wake.

Effective drag coefficients estimated for a 100 m^2 tunnel are summarised in Table 8.2 on the basis of the nominal drag coefficients and shading factors given in Table 8.1. Figures for 60-80 km/h traffic have been adopted for general use in simulations undertaken for this report.

Table 8.1. Estimation of spacing factor from tunnel data.

C_d* (Jang & Chen)						Cd (nominal)	$\left(1-\frac{A_v}{A}\right)^2$	spacing factor (high density)	spacing factor (low density)	
Vehicle	A_T	A_V	High density 8-23 veh./lane-km	Low density < 8 veh./lane-km						
	m^2	m^2	average	min	max				min	max
small	94	2.5	0.20	0.32	0.35	0.35	0.95	0.54	0.87	0.95
large	94	7.1	0.24	0.36	0.40	0.70	0.85	0.29	0.44	0.49

Table 8.2. Vehicle drag coefficients.

	Tunnel	PC				LDV				HGV			
	A	A_v	C_d	s_f	C_d*	A_v	C_d	s_f	C_d*	A_v	C_d	s_f	C_d*
km/h	m^2	m^2				m^2				m^2			
0-10	100	2.5	0.32	0.54	0.18	4.8	0.5	0.54	0.30	7.1	0.8	0.29	0.27
20-40	100	2.5	0.32	0.87	0.29	4.8	0.5	0.87	0.48	7.1	0.8	0.44	0.41
60-80	100	2.5	0.32	0.95	0.32	4.8	0.5	0.95	0.52	7.1	0.8	0.49	0.45
reverse flow	100	2.5	0.60	0.54	0.34	2.5	0.8	0.54	0.46	2.5	1	0.29	0.31

These effective in-tunnel drag coefficients are lower than those often used in Australian design practice. Over-estimating the drag coefficient results in predictions of tunnel air flows which may be higher than those which actually occur. Over-prediction of tunnel air flow results in both an under-prediction of the in-tunnel pollutant concentrations, and oversizing of vent station capacity for portal emissions control.

[8] Jang H., Chen F., On the determination of aerodynamic coefficients of highway tunnels. Journal of Wind Engineering and Industrial Aerodynamics 90 (2002) pp 869 – 896.

9 EMISSION FACTORS

9.1 Variation of emission factors with time.

Average emission factors for the Australian vehicle fleet are continually decreasing as new emissions control technologies are supplied on new vehicles, and old vehicles pass out of service. However PIARC[9] emissions tables do not provide extrapolation factors beyond 2020. This report uses the PIARC 2010 emissions factors specific to the Australian fleet, and also uses the PIARC extrapolation to year 2020, for all simulations, including those designated as 2031 traffic. Hence the predictions made of pollution concentrations will be increasingly conservative for tunnel opening years past 2020.

A project to assess the applicability of PIARC emission factors in 2015 is nearing completion. Initial results suggest that the PIARC Australian tables as used here are a reasonably close representation of the current Sydney fleet. The PIARC tables appear to over-predict 2015 CO production and may slightly under-predict 2015 NO_2 production, when the NO_2:NO_X ratio is taken from the work of Carslaw and Rhys-Tylor[10]. Any adjustments required are unlikely to be large enough to affect conclusions.

9.2 CO emissions

Carbon monoxide emissions factors used in this report are contained in Table 9.1.

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[9] PIARC Technical Committee C4 Road Tunnels Operation. Road Tunnels: Vehicle Emissions and Air Demand for Ventilation, World Road Association, document 2012R05EN, revised December 2012.

[10] Carslaw D., Rhys-Tylor G. New insights from comprehensive on-road measurements of NO_x, NO_2 and NH_3 from vehicle emission remote sensing. Atmospheric Environment 81 (2013) pp339-347.

Table 9.1. CO emissions factors 2020. The column headers in each table are roadway gradient.

v	PC CO [g/h] 2020						
km/h	-6%	-4%	-2%	0%	2%	4%	6%
0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
10	16.7	17.8	19.2	20.6	22.7	24.9	29.3
20	18.9	21.3	24.1	26.9	30.9	35.2	44.0
30	19.0	22.4	26.7	32.1	38.4	45.6	60.0
40	18.9	23.5	29.7	38.4	49.1	63.7	81.2
50	18.5	24.1	32.2	43.6	59.3	81.5	109.4
60	17.9	24.2	34.0	47.8	68.7	97.8	145.3
70	17.4	24.1	35.1	52.3	79.3	116.3	189.2
80	17.2	24.0	36.1	57.9	93.5	145.2	240.8
90	17.5	24.5	38.0	65.2	113.4	193.4	301.7
100	18.4	26.2	41.9	74.2	140.9	267.9	372.8
110	20.0	29.6	48.7	85.6	178.2	369.4	464.2
120	22.2	34.8	58.8	101.4	228.9	462.5	596.4
130	24.4	41.7	71.4	126.9	299.8	564.2	768.0

v	LDV diesel/gasoline CO [g/h] 2020						
km/h	-6%	-4%	-2%	0%	2%	4%	6%
0	5.5	5.5	5.5	5.5	5.5	5.5	5.5
10	17.7	17.7	19.6	37.6	51.2	63.5	64.3
20	17.7	17.7	27.2	55.3	49.4	27.5	32.2
30	17.7	17.7	36.0	59.2	26.1	40.0	74.1
40	17.7	17.7	43.8	37.1	33.8	75.8	140.0
50	17.7	17.7	47.2	27.9	54.0	121.9	224.2
60	17.7	17.7	58.7	28.8	91.5	200.5	314.6
70	17.7	17.7	61.2	52.5	152.9	289.6	424.0
80	17.7	17.7	66.3	92.5	242.1	387.0	555.7
90	17.7	39.2	71.4	155.4	325.2	504.1	710.5
100	17.7	53.6	78.2	254.3	437.9	656.2	905.4
110	17.7	61.1	153.4	356.3	580.4	842.5	1138.9
120	44.0	65.4	265.5	488.2	757.5	1068.0	1220.9
130	29.6	149.7	385.3	655.1	974.4	1119.3	1321.9

Table 9.1 cont.

v	HGV CO [g/h] 2020						
km/h	-6%	-4%	-2%	0%	2%	4%	6%
0	15.2	15.2	15.2	15.2	15.2	15.2	15.2
10	9.9	10.9	14.9	18.0	20.7	23.5	26.0
20	7.1	10.2	14.3	19.4	24.0	28.8	34.0
30	6.4	10.3	17.4	21.5	27.4	35.6	43.9
40	5.8	9.6	17.9	23.5	31.4	43.1	53.5
50	5.8	9.0	17.6	24.7	36.5	50.2	64.0
60	5.8	8.1	16.8	26.1	42.1	57.8	74.7
70	5.8	7.0	16.9	28.2	47.4	66.0	85.7
80	5.8	6.5	16.8	31.6	53.5	74.7	97.4
90	5.8	7.4	19.2	36.7	60.1	83.4	109.0
100	5.8	9.1	21.8	42.9	66.5	92.0	120.5
110	5.8	9.6	25.2	48.5	72.4	100.5	132.0
120	5.8	13.9	29.1	52.7	78.2	108.9	143.4
130	6.7	16.6	33.7	56.2	84.0	117.3	154.9

9.3 NO_2 emissions

PIARC tables give NO_X generation rates as a function of vehicle speed and road gradient. Since NO_2 is the dominant design pollutant, the mass ratio NO_2:NO_X is a key parameter in the PIARC method. It is highly desirable to have tables of NO_2 evolution rather than its proxy NO_X which bundles together the NO and NO_2.

NO_2:NO_x mass ratios for the various vehicle classes given in Table 9.2 are calculated using the fleet age profile given in Figure 7.7.

Table 9.2. Mass fraction NO_2:NO_X contained in vehicle exhaust.

Vehicle class	NO_2 (gram):NO_x (gram)
PC_{petrol} & LDV_{petrol}	0.08
PC_{diesel}	0.32
LDV_{diesel}	0.31
HGV	0.11

The input data to these estimates comes from Carslaw and Rhys-Tylor (2013)[11] who used remote sensing of travelling surface vehicle's emissions (measured at the vehicle tailpipe), to determine the ratio of vehicle pollutants NO_2, NO_X and NH_3 to CO_2 emissions.

It is considered that applying Carslaw and Rhys-Tyler's data (obtained from surface running vehicles) to a tunnel scenario is valid. NO from the exhaust is converted to NO_2 in the presence of ozone O_3 when it enters the atmosphere. However in a tunnel environment (remote from the entry portal), where the ozone has been depleted, NO_2 levels should be unaffected by the further conversion of NO to NO_2. Hence readings taken at the tailpipe of a vehicle (prior to conversion of NO to NO_2) should be a reasonable approximation for estimates of the resulting NO_2 in a tunnel.

Another issue which increases the uncertainty of the rate of NO_2 generation, is that the evolution of pollutants is a function of the vehicle operating power. Carslaw and Rhys-Tyler's paper does not attempt to quantify this relationship.

NO_2 emissions given in Table 9.4 for each of the three vehicle classes, are predicted from PIARC NO_X tables multiplied by the appropriate NO_2:NO_X mass ratio predicted from the Carslaw data. This introduces an additional uncertainty in that the accuracy of the PIARC NO_X emission rates is unknown. The PIARC data are used as a de-facto standard, however the PIARC document itself says the figures can be applied "if emission data for the project cannot be provided by a locally valid data base".

An average fleet conversion ratio can be calculated for an assumed distribution PC:LDV:HGV (75%:15%:10%) based on the NO_2 data given in Table 9.2 and PIARC emissions data for NO_X for the same fleet composition. The average NO_2:NO_X mass ratio for the WestConnex fleet is predicted to lie in the range 13.1% to 15.6% as shown Table 9.3. Note that the simulations follow the hourly varying fleet mix. The fleet average numbers here are simply to see the order of magnitude.

[11] Carslaw D., Rhys-Tyler G. New insights from comprehensive on-road measurements of NO_x, NO_2 and NH_3 from vehicle emission remote sensing. Atmospheric Environment 81 (2013) pp339-347.

Table 9.3. WestConnex fleet average NO_2:NO_x ratios for 2020.

	Tunnel gradient						
Speed (km/h)	-6%	-4%	-2%	0	2%	4%	6%
0	14.2%	14.2%	14.2%	14.2%	14.2%	14.2%	14.2%
10	14.1%	13.8%	12.8%	13.4%	13.7%	13.7%	13.5%
20	14.8%	14.1%	13.1%	13.9%	13.8%	13.3%	13.1%
30	14.9%	14.0%	13.3%	14.1%	13.3%	13.1%	13.3%
40	15.1%	14.2%	13.4%	13.7%	13.2%	13.3%	13.5%
50	15.1%	14.4%	13.5%	13.5%	13.2%	13.4%	13.6%
60	15.1%	14.7%	14.1%	13.4%	13.4%	13.6%	13.7%
70	15.1%	15.0%	14.4%	13.5%	13.4%	13.8%	13.8%
80	15.1%	14.9%	14.6%	13.8%	13.6%	13.9%	13.9%
90	15.1%	15.6%	14.2%	14.0%	14.0%	14.0%	14.1%
100	15.1%	15.0%	14.2%	14.2%	14.2%	14.2%	14.2%
110	15.1%	14.5%	14.6%	14.4%	14.4%	14.4%	14.3%
120	16.2%	14.9%	15.0%	14.7%	14.6%	14.6%	14.4%
130	15.8%	15.2%	15.3%	15.0%	14.9%	14.6%	14.4%

Table 9.4. NO_2 emissions factors 2020 (using NO_X tables from PIARC2012 and NO_2: NO_X ratios estimated from Carslaw and Rhys-Tyler). The column headers in each table are tunnel gradient.

v	PC NO_2 [g/h] 2020						
km/h	-6%	-4%	-2%	0%	2%	4%	6%
0	0.33	0.33	0.33	0.33	0.33	0.33	0.33
10	0.38	0.38	0.38	0.60	0.77	0.92	1.06
20	0.38	0.38	0.41	0.80	1.05	1.33	1.76
30	0.38	0.38	0.51	0.97	1.35	1.87	2.40
40	0.38	0.38	0.55	1.09	1.68	2.33	3.03
50	0.38	0.38	0.52	1.21	1.97	2.79	3.61
60	0.38	0.38	0.60	1.40	2.36	3.34	4.45
70	0.38	0.38	0.74	1.74	2.84	3.99	5.52
80	0.38	0.38	0.95	2.10	3.36	4.90	6.70
90	0.38	0.38	1.25	2.54	4.00	5.93	8.00
100	0.38	0.42	1.64	3.10	4.94	7.16	9.50
110	0.38	0.56	2.09	3.80	6.07	8.56	11.18
120	0.38	1.15	2.70	4.79	7.39	10.16	13.07
130	0.39	1.65	3.49	6.05	8.93	11.99	15.18

v	LDV diesel/gasoline NO_2 [g/h] 2020						
km/h	-6%	-4%	-2%	0%	2%	4%	6%
0	0.9	0.9	0.9	0.9	0.9	0.9	0.9
10	0.9	0.9	1.0	1.9	2.8	3.7	3.4
20	0.9	0.9	1.4	3.1	3.4	3.6	3.1
30	0.9	0.9	1.8	3.7	2.6	3.6	5.3
40	0.9	0.9	2.3	3.0	3.2	5.4	7.9
50	0.9	0.9	2.5	2.6	4.4	7.3	10.6
60	0.9	0.9	3.3	2.9	6.1	9.9	13.8
70	0.9	0.9	3.4	4.3	6.2	12.9	17.5
80	0.9	0.9	3.4	6.1	8.4	16.3	21.8
90	0.9	1.8	3.4	8.5	14.2	20.1	26.6
100	0.9	2.3	5.5	11.6	18.0	25.0	32.5
110	0.9	2.9	8.4	15.2	22.6	30.6	39.3
120	2.3	4.9	12.0	19.6	28.1	37.3	41.9
130	2.7	8.3	16.2	24.9	34.5	38.8	45.2

Table 9.4 cont.

v	HGV diesel 23t NO_2 [g/h] 2020						
km/h	-6%	-4%	-2%	0%	2%	4%	6%
0	3.9	3.9	3.9	3.9	3.9	3.9	3.9
10	2.3	3.0	6.1	8.7	10.9	13.5	16.3
20	1.5	2.4	6.9	9.9	14.0	19.8	25.2
30	1.3	2.5	8.0	11.7	18.0	26.9	35.2
40	1.2	2.2	8.4	13.5	22.6	34.4	45.1
50	1.2	1.9	8.1	14.8	27.8	41.7	55.5
60	1.2	1.5	7.1	16.4	33.3	49.4	66.0
70	1.2	1.2	7.1	19.0	38.8	57.7	76.7
80	1.2	1.3	7.5	22.9	45.2	66.1	87.5
90	1.2	1.4	9.1	27.8	51.7	74.3	98.2
100	1.2	1.9	11.9	33.9	57.9	82.2	108.8
110	1.2	2.8	15.4	39.8	63.6	90.1	119.3
120	1.2	4.9	19.6	44.3	69.0	97.8	129.8
130	1.5	7.4	24.4	47.7	74.3	105.5	140.2

9.4 Particulate matter

Exhaust (soot) and non-exhaust (from brakes, tyres, etc) particulate matter is considered in this analysis. The emissions factors are contained in Table 9.6 and Table 9.7 respectively. Exhaust particulates which are typically of the order of 0.2 µm in diameter, are in the size range which contributes to reduction in visibility in the tunnel (0.1 to 4 µm). In this report, the 4.7 m^2/g conversion factor recommended by PIARC is used to convert between light extinction coefficient (m^{-1}) and particulate concentration (g/m^3) for exhaust particulates. Non-exhaust particulates which are typically much larger than 1 µm do not contribute significantly to loss of visibility. The smaller non-exhaust particulates are estimated in this report following the PIARC approach for non-exhaust $PM_{2.5}$, for which the 4.7 m^2/g conversion factor could apparently also be applied, however that approach may not be appropriate, for the reasons set out below. Emission rates for particulates above 2.5 µm are not estimated here.

In looking at particulate emissions in vehicle tunnels, the primary focus has always been on those emitted directly from the tailpipe. Airborne particulates are also generated from wear of brakes, tyres and the road surface. Historically, no one paid too much attention to this second source, as the exhaust-sourced emissions dominated. It is welcome that the changes in vehicle design rules and the consequent improving fleet cleanliness have reduced exhaust particulate emissions greatly, and continue to do so. A consequence of the reducing exhaust emissions is that the level of non-exhaust particulates may become relatively more significant.

PIARC (2012)[12] gives a method for estimating the generation rate of non-exhaust particulates and that approach has been applied within the IDA Tunnel models of the tunnel to give the pollutant concentrations and flows noted in Appendices A and B. The PIARC approach to non-exhaust particulates is seen as a somewhat arbitrary upper bound for $PM_{2.5}$ generation, established from data, perhaps as late as 2009, when tailpipe particulate emissions still had a way to fall, carbon monoxide was much higher, and it was not so critical what non-exhaust particulates were generated. Perhaps for those reasons, the PIARC approach to estimating non-exhaust particulates was very ‘broad brush’ and was arguably conservative but without consequences for being so. The PIARC document notes that:

> The emission factors given in this document serve calculation design purposes. Therefore, they tend to be conservative in terms of emissions quantities.
>
> A large uncertainty is related to the quantification of non-exhaust particulate matter (PM) emissions (re-suspension of road dust, abrasion).

The combination of large uncertainty and conservatism means that the emissions are likely to be well above actual levels. To understand how conservative the non-exhaust particulate levels in the appendices might be, notes are made below on some of the most recent testing literature.

The first point is that particulates generated by abrasion tend to have a much larger size distribution than exhaust material. This is self-evident to the extent that wear particles go up in size to grit that would not be suspended in air. The difference in size distribution is

[12] Road Tunnels: Vehicles, Emissions and Air Demand for Ventilation. Document 2012R05EN, Permanent International Association of Road Congresses (PIARC) Technical Committee C4 Road Tunnels Operation. December 2012.

recognised as aiding the understanding of particulate generation by Henn et.al. (2009)[13]: *"Based on the fact that internal combustion in the motor produces particles with a diameter smaller than 2.5 µm, the difference between measured PM_{10} and $PM_{2.5}$ concentrations is an indicator for abrasion and resuspension"*. That is; material in the size range 2.5 µm to 10 µm is almost certainly non-exhaust in its origin.

The issue of re-suspension of road dust is an interesting one. It gets mentioned in many sources, including in PIARC (2012) and Henn et.al. (2009), as above, and Hinterhofer (2014)[14]. The term is sometimes used to include also ambient suspended material drawn into the tunnel by the vehicle-induced air flow. This is generally small and becomes insignificant in a long tunnel. Considering just the narrower, literal meaning of re-suspension, it is not clear how re-suspension in a tunnel can have any net positive contribution to airborne dust. Any material on the roadway available for re-suspension, by the narrow definition of re-suspension, must have been suspended earlier and been deposited. If the re-suspension is to be considered as a source of material, so the deposition must be accounted for as a loss. In the long term, the rate of resuspension cannot be greater than the rate of deposition and so considering neither makes the airborne pollution estimate conservative. The only possible effect of deposition and resuspension might be to shift the pollution in time relative to the generating vehicle flow. It is not proposed to consider either resuspension or deposition further.

The understanding of the 2.5 to 10 µm size range as a marker for non-exhaust contribution was extended by Hinterhofer (2014)[15] and Hinterhofer et. al. (2014)[16], in conjunction with other facts below, to make some important conclusions.

The exhaust emission rates of vehicles in Austria are well predicted by a model called NEMO (Rexeis, Hausberger (2005)). Hinterhofer, like Henn et. al. earlier, found that the $PM_{2.5}$ emissions predicted by NEMO were sufficient on their own to account for all the $PM_{2.5}$ measured in the tunnel, meaning that the quantity of non-exhaust material below 2.5 µm in size was insignificant. This is a really important conclusion. It is saying that essentially all of the material suspended following wear and abrasion is too large to affect visibility strongly.

The conclusion that there is very little non-exhaust $PM_{2.5}$ material is at odds with PIARC (2012). Being focussed on visibility, PIARC provides estimates only for the $PM_{2.5}$ fraction of non-exhaust material, which, for the year 2020, are very significant relative to the exhaust material. The fraction of the PM_{10} material that is also $PM_{2.5}$ is generally quite high, noted at many Austrian roadside locations and in the Plabutschtunnel as being around 0.7 (Hinterhofer (2014)). PIARC references Henn et al (2009). In the context of Henn et al, the numbers given by PIARC are consistent with total $PM_{2.5}$, being around 70% of the total PM_{10}

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[13] Henn M, Rodler J, Sturm PJ (2009) PM10 non-exhaust particle emissions – determination and quantification, in: ETTAP 2009 Transport and air pollution symposium, environment and transport symposium, Toulouse, France, 2009.

[14] M Hinterhofer, Anteil der verkehrsbedingten PM_{10} und $PM_{2.5}$ Emissionen aus Abrieb und Wiederaufwirbelung an der Feinstaubbelastung in Österreich. (Emissions from abrasion and resuspension of particulate pollution in Austria) doctoral dissertation, Technical University of Graz, June 2014.

[15] M Hinterhofer, Anteil der verkehrsbedingten PM_{10} und $PM_{2.5}$ Emissionen aus Abrieb und Wiederaufwirbelung an der Feinstaubbelastung in Österreich. (Emissions from abrasion and resuspension of particulate pollution in Austria) doctoral dissertation, Technical University of Graz, June 2014.

[16] M Hinterhofer, PJ Sturm, T Nöst, K Niederl, Evaluation of emissions factors based on tunnel measurements with key aspects on Heavy Metals and PM10 non-exhaust, 20th International Symposium on Transport and Air Pollution, Technical University of Graz, September 2014.

reported in Henn et al. They must then be too high for non-exhaust $PM_{2.5}$ which is clearly less than total $PM_{2.5}$ and possibly so low as to be neglected, as above.

Accepting the conclusion based on NEMO that there is very little non-exhaust material below 2.5 µm, and based on knowledge that essentially all exhaust material is below 2.5 µm, the observation by Hinterhofer and others that 70% of the PM_{10} is $PM_{2.5}$ leads to the first approximation that the non-exhaust size fractions between 2.5 µm and 10 µm are, by mass, of the order of 43% of the exhaust particulates. The PIARC-based predictions in Appendices A and B suggest that the non-exhaust mass flux is 2 or 3 times that of the exhaust particulates. With the above information, that does not seem credible. With the qualification offered in the PIARC document itself (quoted above), the non-exhaust particulate predictions in Appendices A and B can be seen as extreme upper bound figures. They serve the purpose of demonstrating compliance with pollutant criteria, albeit with a conservatism in total $PM_{2.5}$ which may be a factor of 3 or 4.

Results from the pilot filtration trial conducted in the M5 East Tunnel in 2011[17] showed that around 83% of the PM_{10} in the tunnel air was $PM_{2.5}$. This is not far from the 70% reported from European data noted above. The difference could be due to a greater rate of emission of exhaust particulates in the 2011 M5 East compared to the 2013 Austrian fleet. The small fraction in the size range 2.5 to 10 µm again points to the rate of generation of non-exhaust particulates being much lower than the rate of exhaust particulate generation.

The conclusion is that the PIARC (2012) approach to calculating non-exhaust particulate generation is certainly conservative, as the report itself notes, and probably too conservative to offer reliable guidance as to what to expect from a new tunnel. The relative uncertainty and conservatism in the non-exhaust particulate predictions is the reason why they have been noted separately in Appendices A and B, rather than being combined into a single total $PM_{2.5}$ number, and why the noted visibility figures are assessed on exhaust particulates alone.

9.5 Heat emissions and tunnel air temperature.

The temperature of the ventilation outlet streams is relevant in the dispersion assessments and the in-tunnel temperatures are also of interest. The vehicle heat generation is central to estimating air temperatures. Vehicle parameters given in Table 9.5 are used to calculate the vehicle heat emissions, on the basis of the vehicle speed and road gradient, as shown in Table 9.8. The HGV mass is the weighted average of that for the the medium and long HGV subclasses.

Table 9.5. Nominal vehicle parameters for heat generation.

	units	PC	LDV	HGV
gross mass	tonnes	1.5	3.0	15.5
engine efficiency	%	30	30	30
Idle power	kW	11	19	38
drag coefficient		0.35	0.53	0.40
frontal area	m^2	2.5	4.8	7.1

Tunnel air temperatures are determined by the heat load from vehicles and the ability of the surrounding ground to absorb heat through the tunnel walls. In the simulations it has been assumed that the ground temperatures, 10 m from the tunnel wall, in summer and winter are

[17] M5 East tunnel filtration trial evaluation program – review of operational performance. AMOG Consulting, Feb 2012 http://www.rms.nsw.gov.au/documents/projects/sydney-west/m5-east-tunnel/m5e_tunnel_air_filtration_trial_evaluation_amog_report_february_2012.pdf

20°C and 16°C respectively. These are values taken from measurements in the Sydney environs for other projects.

9.6 Climate assumptions

It is the temperature difference between the outlet air and ambient air that is most important to the dispersion and plume rise results. The ambient temperature has some effect on that difference and so simulations were done for both summer and winter conditions.

Climate data used in the ventilation simulations are from the ASHRAE IWEC database developed through Research Project RP-1477. See Yu, Huang, Donghyun and Krarti (2014)[18]. International Weather for Energy Calculations (IWEC) contains “typical” weather files, suitable for use with simulation programs, for 3,012 locations outside the USA and Canada.

In running the ventilation model to predict tunnel air temperatures, a long-term model was first run in order to bring the ground temperature to an equilibrium state using a far field ground temperature of 20°C in summer and 16°C in winter. January was the target month for summer simulations as this coincides with the highest tunnel wall temperatures along with high ambient temperature and humidity. July was chosen as the winter month.

The hottest January summer day in the climate file was chosen as the input for simulation of daily temperature variations in the tunnel. Care was taken to start the simulation 24 hours prior to the commencement of the hottest day so that an appropriate thermal initial condition could be achieved prior to the commencement of the test period.

[18] Yu J; Huang F; Donghyun S; Krarti, M; 2014, Development of 3012 IWEC2 Weather Files for International Locations (RP-1477). ASHRAE Transactions, 2014, Vol. 120 Issue 1, p340-355.

Table 9.6. Opacity emissions factors for exhaust particulates in 2020. The column headers in each table are tunnel gradient.

v	PC opacity [m²/h] 2020						
km/h	-6%	-4%	-2%	0%	2%	4%	6%
0	0.16	0.16	0.16	0.16	0.16	0.16	0.16
10	0.13	0.13	0.13	0.29	0.44	0.59	0.75
20	0.13	0.13	0.16	0.47	0.73	0.97	1.25
30	0.13	0.13	0.23	0.64	0.98	1.32	1.70
40	0.13	0.13	0.25	0.77	1.19	1.66	2.14
50	0.13	0.13	0.26	0.85	1.39	1.96	2.52
60	0.13	0.13	0.27	0.98	1.66	2.34	2.98
70	0.13	0.13	0.39	1.19	1.99	2.74	3.50
80	0.13	0.13	0.58	1.46	2.34	3.19	4.03
90	0.13	0.13	0.80	1.77	2.71	3.67	4.59
100	0.13	0.13	1.08	2.14	3.17	4.21	5.21
110	0.13	0.18	1.41	2.56	3.69	4.80	5.86
120	0.13	0.61	1.84	3.06	4.27	5.44	6.57
130	0.13	1.04	2.34	3.64	4.91	6.14	7.34

v	LDV diesel/gasoline opacity [m²/h] 2020						
km/h	-6%	-4%	-2%	0%	2%	4%	6%
0	2.4	2.4	2.4	2.4	2.4	2.4	2.4
10	0.5	0.5	0.6	1.4	2.1	2.7	3.4
20	0.5	0.5	0.9	2.3	3.4	4.6	5.8
30	0.5	0.5	1.3	3.2	4.7	6.4	8.1
40	0.5	0.5	1.7	3.9	5.9	8.1	10.3
50	0.5	0.5	1.9	4.6	7.1	9.8	12.3
60	0.5	0.5	2.5	5.6	8.7	11.8	15.0
70	0.5	0.5	3.4	7.1	10.6	14.2	17.8
80	0.5	0.5	4.7	8.8	12.8	16.9	20.8
90	0.5	1.5	6.2	10.7	15.3	19.7	24.0
100	0.5	3.3	8.2	13.2	18.1	23.0	27.7
110	0.5	5.3	10.6	16.1	21.4	26.5	31.6
120	1.7	7.7	13.5	19.3	25.0	30.5	33.4
130	4.4	10.5	16.9	22.9	28.9	31.3	35.8

Table 9.6 cont.

v	HGV opacity [m²/h] 2020						
km/h	-6%	-4%	-2%	0%	2%	4%	6%
0	15.2	15.2	15.2	15.2	15.2	15.2	15.2
10	9.9	10.9	14.9	18.0	20.7	23.5	26.0
20	7.1	10.2	14.3	19.4	24.0	28.8	34.0
30	6.4	10.3	17.4	21.5	27.4	35.6	43.9
40	5.8	9.6	17.9	23.5	31.4	43.1	53.5
50	5.8	9.0	17.6	24.7	36.5	50.2	64.0
60	5.8	8.1	16.8	26.1	42.1	57.8	74.7
70	5.8	7.0	16.9	28.2	47.4	66.0	85.7
80	5.8	6.5	16.8	31.6	53.5	74.7	97.4
90	5.8	7.4	19.2	36.7	60.1	83.4	109.0
100	5.8	9.1	21.8	42.9	66.5	92.0	120.5
110	5.8	9.6	25.2	48.5	72.4	100.5	132.0
120	5.8	13.9	29.1	52.7	78.2	108.9	143.4
130	6.7	16.6	33.7	56.2	84.0	117.3	154.9

Table 9.7. Non exhaust particulates (PM2.5) factors 2020. The column headers in each table are tunnel gradient.

v				PC non-exhaust PM [g/h]			
km/h	-6%	-4%	-2%	0%	2%	4%	6%
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.28	0.28	0.28	0.28	0.28	0.28	0.28
20	0.56	0.56	0.56	0.56	0.56	0.56	0.56
30	0.84	0.84	0.84	0.84	0.84	0.84	0.84
40	1.12	1.12	1.12	1.12	1.12	1.12	1.12
50	1.40	1.40	1.40	1.40	1.40	1.40	1.40
60	1.68	1.68	1.68	1.68	1.68	1.68	1.68
70	1.96	1.96	1.96	1.96	1.96	1.96	1.96
80	2.24	2.24	2.24	2.24	2.24	2.24	2.24
90	2.52	2.52	2.52	2.52	2.52	2.52	2.52
100	2.80	2.80	2.80	2.80	2.80	2.80	2.80
110	3.08	3.08	3.08	3.08	3.08	3.08	3.08
120	3.36	3.36	3.36	3.36	3.36	3.36	3.36
130	3.64	3.64	3.64	3.64	3.64	3.64	3.64

v	LDV diesel/gasoline non-exhaust PM [g/h] 2020						
km/h	-6%	-4%	-2%	0%	2%	4%	6%
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.28	0.28	0.28	0.28	0.28	0.28	0.28
20	0.56	0.56	0.56	0.56	0.56	0.56	0.56
30	0.84	0.84	0.84	0.84	0.84	0.84	0.84
40	1.12	1.12	1.12	1.12	1.12	1.12	1.12
50	1.40	1.40	1.40	1.40	1.40	1.40	1.40
60	1.68	1.68	1.68	1.68	1.68	1.68	1.68
70	1.96	1.96	1.96	1.96	1.96	1.96	1.96
80	2.24	2.24	2.24	2.24	2.24	2.24	2.24
90	2.52	2.52	2.52	2.52	2.52	2.52	2.52
100	2.80	2.80	2.80	2.80	2.80	2.80	2.80
110	3.08	3.08	3.08	3.08	3.08	3.08	3.08
120	3.36	3.36	3.36	3.36	3.36	3.36	3.36
130	3.64	3.64	3.64	3.64	3.64	3.64	3.64

Table 9.7 cont.

v	HGV non-exhaust PM [g/h] 2020						
km/h	-6%	-4%	-2%	0%	2%	4%	6%
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	1.04	1.04	1.04	1.04	1.04	1.04	1.04
20	2.08	2.08	2.08	2.08	2.08	2.08	2.08
30	3.12	3.12	3.12	3.12	3.12	3.12	3.12
40	4.16	4.16	4.16	4.16	4.16	4.16	4.16
50	5.20	5.20	5.20	5.20	5.20	5.20	5.20
60	6.24	6.24	6.24	6.24	6.24	6.24	6.24
70	7.28	7.28	7.28	7.28	7.28	7.28	7.28
80	8.32	8.32	8.32	8.32	8.32	8.32	8.32
90	9.36	9.36	9.36	9.36	9.36	9.36	9.36
100	10.40	10.40	10.40	10.40	10.40	10.40	10.40
110	11.44	11.44	11.44	11.44	11.44	11.44	11.44
120	12.48	12.48	12.48	12.48	12.48	12.48	12.48
130	13.52	13.52	13.52	13.52	13.52	13.52	13.52

Table 9.8. Vehicle heat emissions. The column headers in each table are tunnel gradient.

v	PC heat [kW]						
km	-6%	-4%	-2%	0%	2%	4%	6%
0	11.	11.	11.	11.	11.	11.	11.2
10	12.	11.	12.	14.	16.	18.	20.7
20	13.	12.	13.	17.	21.	26.	30.3
30	14.	12.	15.	21.	27.	33.	40.2
40	15.	12.	17.	25.	33.	42.	50.6
50	16.	12.	19.	30.	40.	51.	61.7
60	16.	11.	23.	35.	48.	60.	73.5
70	16.	12.	27.	42.	56.	71.	86.3
80	16.	16.	33.	49.	66.	83.	100.
90	15.	20.	39.	58.	77.	96.	115.
10	13.	27.	47.	68.	89.	110	131.
11	11.	34.	57.	80.	103	126	150.
12	18.	44.	69.	94.	119	144	169.
13	28.	55.	82.	109	137	164	191.

v	LDV heat [kW]						
km	-6%	-4%	-	0%	2%	4%	6%
0	19.	19.	19.	19.	19.2	19.2	19.2
10	21.	20.	21.	25.	29.3	33.3	37.3
20	24.	20.	23.	31.	39.8	47.8	55.8
30	26.	21.	26.	39.	51.0	63.0	75.0
40	27.	20.	31.	47.	63.3	79.4	95.4
50	28.	20.	37.	57.	77.2	97.3	117.
60	28.	20.	45.	69.	93.0	117.	141.
70	27.	27.	55.	83.	111.	139.	167.
80	25.	35.	67.	99.	131.	163.	196.
90	22.	47.	83.	11	155.	191.	227.
10	22.	62.	10	14	183.	223.	263.
11	37.	81.	12	17	214.	258.	302.
12	57.	105	15	20	249.	297.	345.
13	80.	132	18	23	289.	341.	393.

v	HGV heat [kW]						
km	-6%	-4%	-2%	0%	2%	4%	6%
0	38.	38.	38.	38.	38.	38.	38.4
10	59.	51.	42.	48.	68.	88.	108.
20	80.	63.	46.	59.	98.	138	178.
30	101	75.	50.	70.	130	190	249.
40	121	87.	53.	83.	163	242	322.
50	140	97.	55.	98.	198	297	397.
60	158	107	56.	116	235	355	474.
70	175	115	55.	137	276	415	555.
80	190	122	53.	161	320	480	639.
90	203	126	50.	190	369	548	727.
10	215	129	44.	223	422	621	820.
11	224	130	42.	261	480	699	918.
12	231	128	66.	305	543	782	1021
13	235	124	96.	355	613	872	1131

10 SIMULATION SOFTWARE

For analysing the in-tunnel airflow, pollution levels and temperature, software called IDA Tunnel, developed by EQUA AB in Sweden has been used.

IDA Tunnel is comprehensive road and rail tunnel ventilation and smoke control simulation software. Specific to road tunnels, IDA Tunnel includes traffic flow simulation, so that there is realism in the traffic behaviour as roads reach capacity or as lane numbers change. A traffic model within the simulation applies traffic continuity, and realistic rules on traffic flow versus speed, to predict the traffic density and speed throughout the tunnel. This avoids the assumptions involved in 'hard-coding' the traffic movement in input files before the simulation starts. The airflows resulting from traffic movement, in combination with the vehicle emissions, determine the pollutant levels in the tunnel.

IDA Tunnel is a one-dimensional network analysis program, meaning that entire underground systems can be analysed as one, with all the traffic and air flows being resolved. Being one-dimensional, all quantities are cross section averages. Sub-models within the IDA Tunnel package deal with the traffic speed and flow, aerodynamics of vehicles, the effect of jet fans on air flow, the tunnel flow resistance and the network flow balance, the generation of pollutants and heat by vehicles, the stack effect within tunnels with non-zero gradient, the heat flow from the air to the walls and on to the ground, and the thermal inertia of the walls.

Development of IDA Tunnel began around 2000, with the ambition to encompass the best and most trusted mathematical models for environmental conditions in road and rail tunnels that are available in the literature and that can be simulated with acceptable efficiency and with a manageable amount of input data. Early versions became available around 2003. The software has been mature for some time. The package is actively supported by EQUA AB.

There are other software packages for simulation of road tunnel aero-thermodynamics. The Subway Environmental Simulation (SES) software was first written in the 1970s and was the leading tunnel ventilation program for several decades, being supported by the US Department of Transportation. With advances in computing and simulation generally, it became harder to maintain and for some years now DoT support has been unavailable, with the program still used privately by some firms who maintain their own versions of the code. Other firms have independently developed in-house software, generally to address specific behaviours such as air compressibility for high speed trains. To our knowledge, IDA Tunnel is the only openly available tunnel ventilation simulation package.

IDA Tunnel was developed from scratch using the Modelica simulation environment, an advantage over the Fortran 77 base of SES. Development was informed by SES and comparative assessments of the two programs have been done, including by London Underground.

Compared to the SES program, IDA Tunnel includes more sophisticated modelling of the wall and ground temperatures and heat flows. On the thermal response of tunnels, Stacey Agnew has used IDA Tunnel to model and calibrate against wall and air temperatures of several cable and rail tunnels, three of which were in Sydney sandstone[19]. IDA Tunnel also includes thermal buoyancy (stack effect) in non-fire simulations, which SES did not do.

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[19] Reference tunnels in Sydney; Epping Chatswood Rail Link, City West Cable Tunnel, City South Cable Tunnel, and in Auckland; Vector Cable Tunnel.

11 SIMULATION RESULTS

11.1 Free flowing traffic

11.1.1 New M5 alone with 2021 and 2031 normal daily traffic

A comprehensive set of ventilation simulation results for normal free-flowing traffic in the New M5 tunnel alone (prior to the M4-M5 Link) are tabulated in Appendix A (for 2021 traffic, Table 7.5) and Appendix B (for 2031 traffic, Table 7.6). The normal free flowing traffic for the eastbound and westbound tubes was given at hourly increments over 24 hours. Simulations were done for both a summer day and a winter day.

11.1.2 New M5 and M4-M5 Link with 2031 traffic

Ventilation outputs for the New M5 combined with the M4-M5 Link tunnel with normal 2031 traffic (Table 7.7) are tabulated in Appendix C and also plotted in Figure 11.1 to Figure 11.5.

Air flows and pollution levels are not substantially different between summer and winter condition, however there are substantial differences in tunnel and outlet air temperatures.

Tunnel air temperature predictions are made on the basis of hourly varying ambient temperature and seasonally varying ground temperature inputs, in combination with the hourly varying vehicle heat load resulting from the traffic. Changes in tunnel air temperature remote from the portals are not strongly influenced by ambient conditions. Rather; air temperature is set by a balance between the vehicle heat and the seasonally varying wall temperature, which varies along the length of the tunnel according to average traffic and air flow conditions.

Hence outlet air temperature is not subject to rapid variation due to changes in ambient air temperature. However the temperature difference between outlet and ambient air may vary quite widely and rapidly as ambient conditions change.

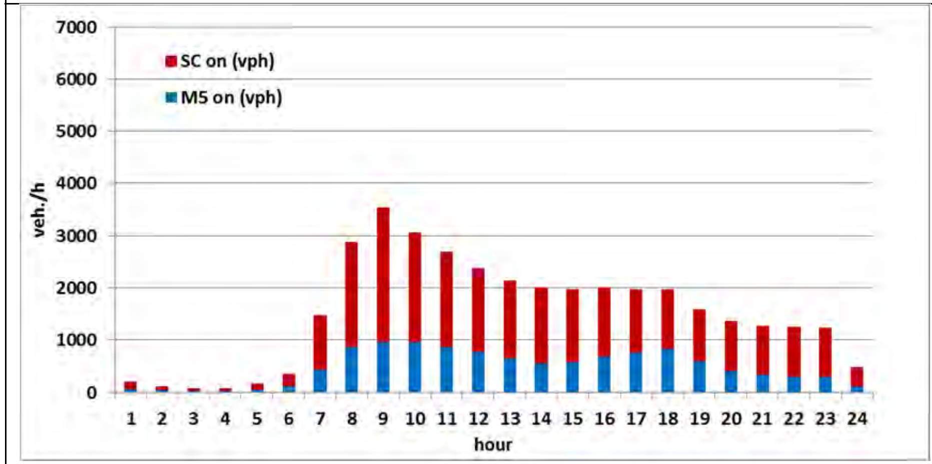
The important conclusion derived from these results is that the New M5 and M4-M5 Link tunnels are self-ventilating for the predicted traffic. Piston effect of vehicles (without the aid of jet fans) drives sufficient air along the tunnel to maintain pollutant levels below the design limits specified in Table 6.2.

11.2 Regulatory traffic

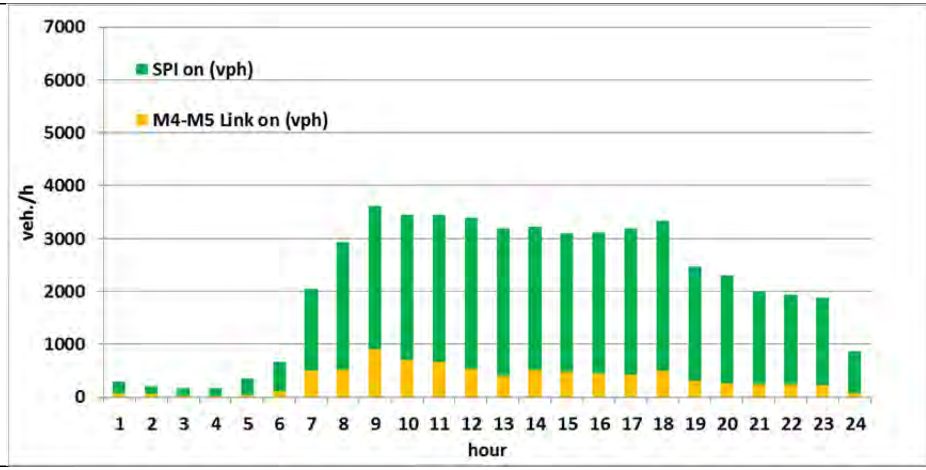
Ventilation outputs for the regulatory traffic flows in the New M5 combined with the M4-M5 Link tunnel, based on scaling 2031 traffic (Table 7.7) are also tabulated in Appendix C. The regulatory outputs are plotted in Figure 11.6 to Figure 11.10.

Figure 11.1. Modelled 2031 daily normal traffic demand for New M5 and M4-M5 Link west of Rozelle. "SC" means Southern Extension.

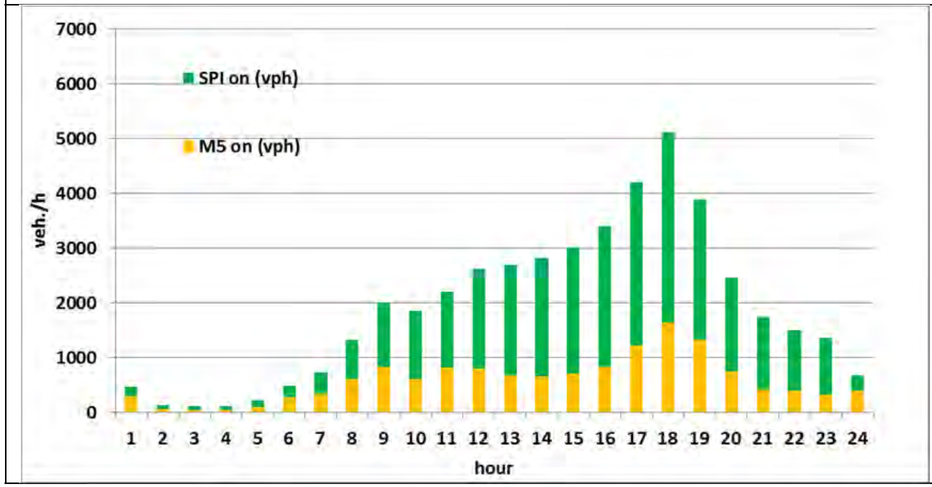
M5 Eastbound traffic



M4-M5 Link Eastbound traffic



M5 Westbound traffic



M4-M5 Link Westbound traffic

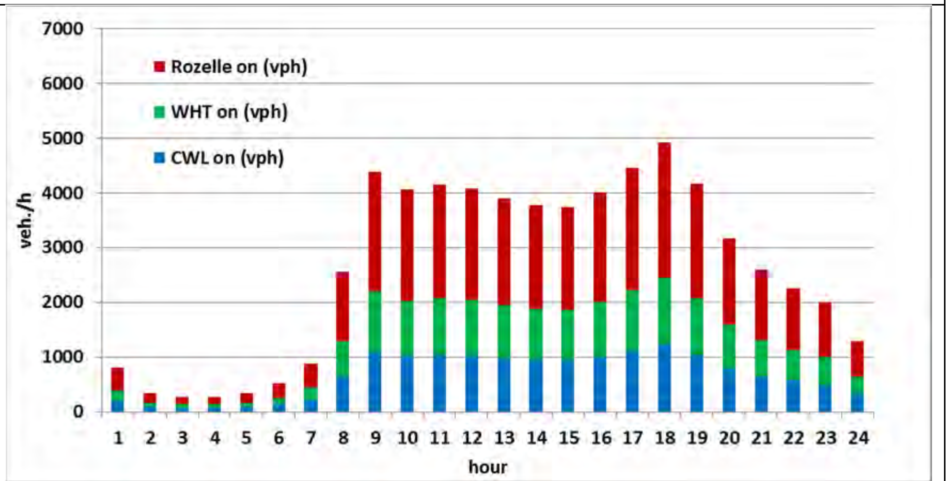
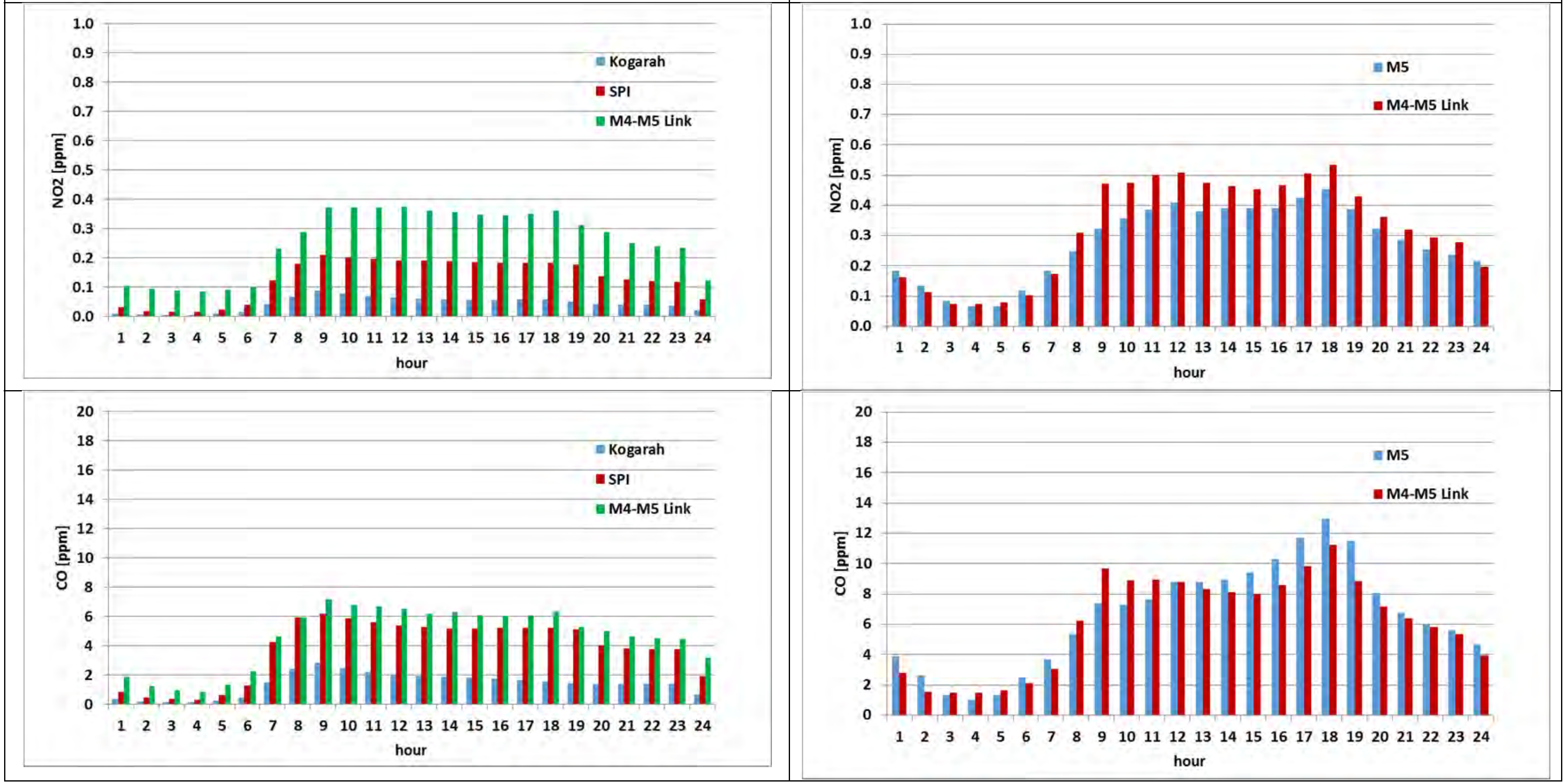
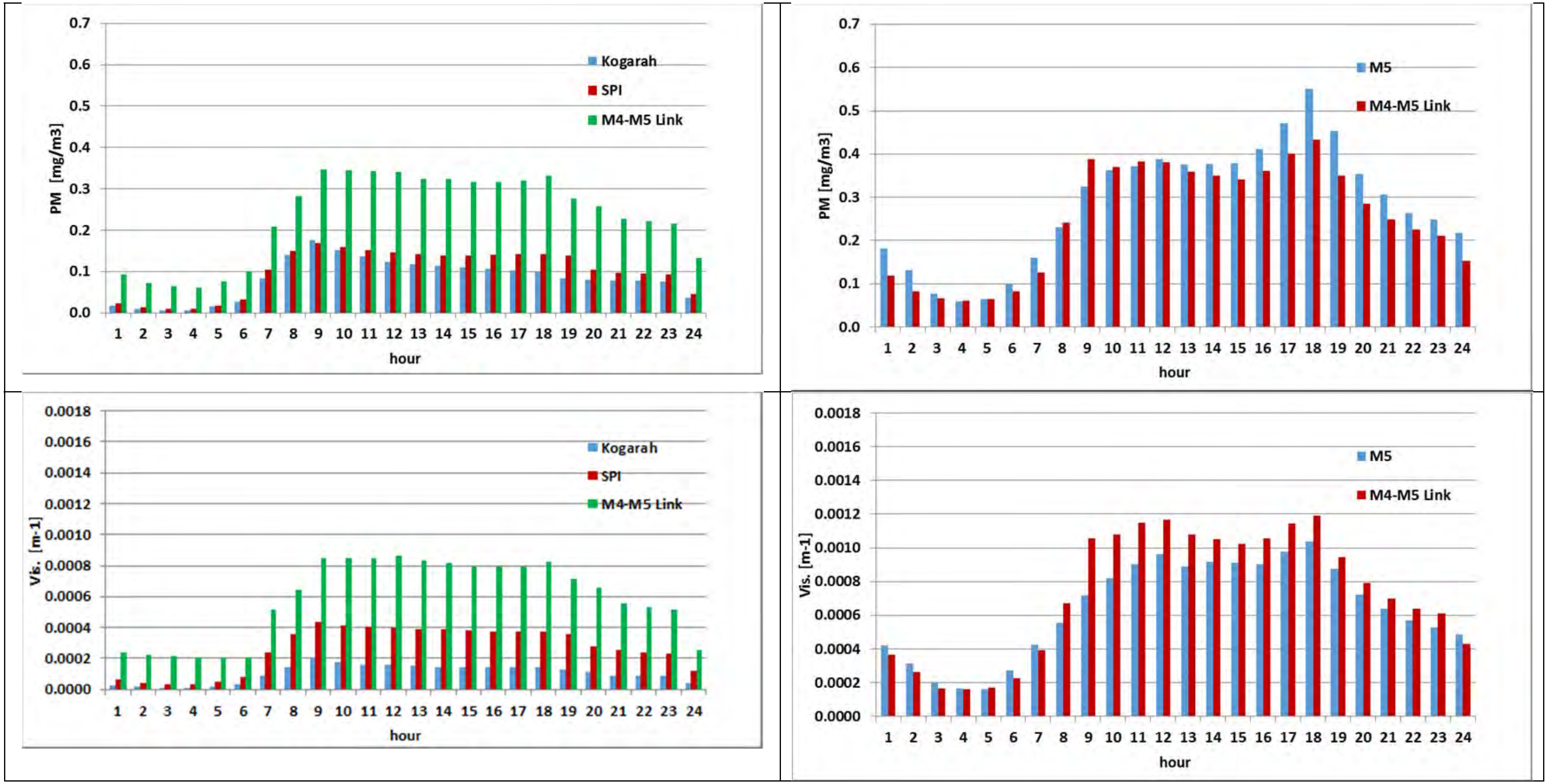


Figure 11.2. Maximum hourly in-tunnel pollution levels for normal traffic in 2031.

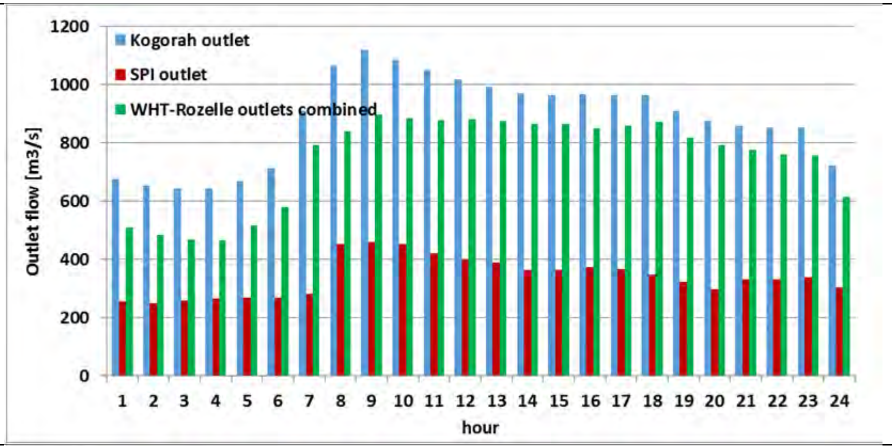
Eastbound	Westbound

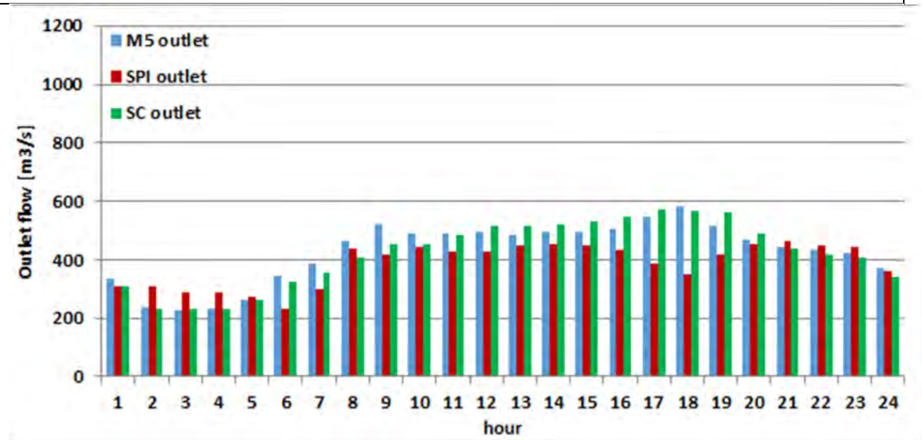


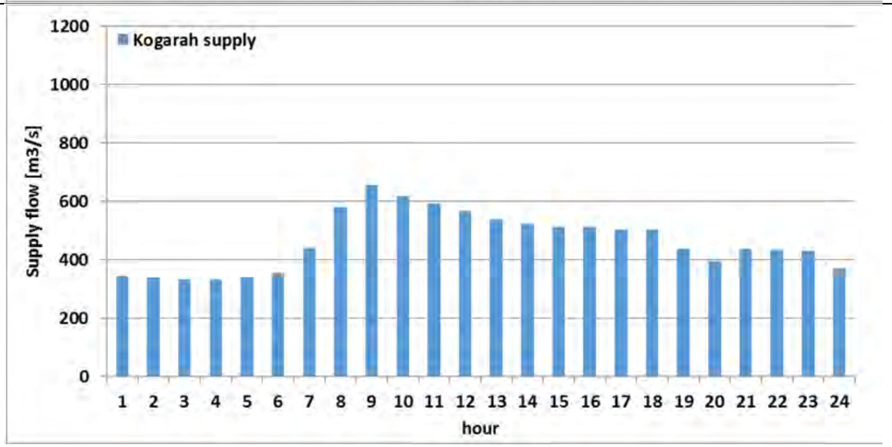


PM [mg/m3]
Kogarah
SPI
M4-M5 Link
hour
PM [mg/m3]
M5
M4-M5 Link
hour
Vis. [m-1]
Kogarah
SPI
M4-M5 Link
hour
Vis. [m-1]
M5
M4-M5 Link
hour

Figure 11.3. Outlet flows for normal traffic in 2031. "SC" means Southern Extension.

<table>
<tr><th></th><th>Eastbound</th><th>Westbound</th></tr>
<tr><td>Extraction</td><td>


</td><td>


</td></tr>
<tr><td>Supply</td><td>


</td><td></td></tr>
</table>

Figure 11.4. Outlet temperature (summer and winter) for normal traffic in 2031. "SC" means Southern Extension.

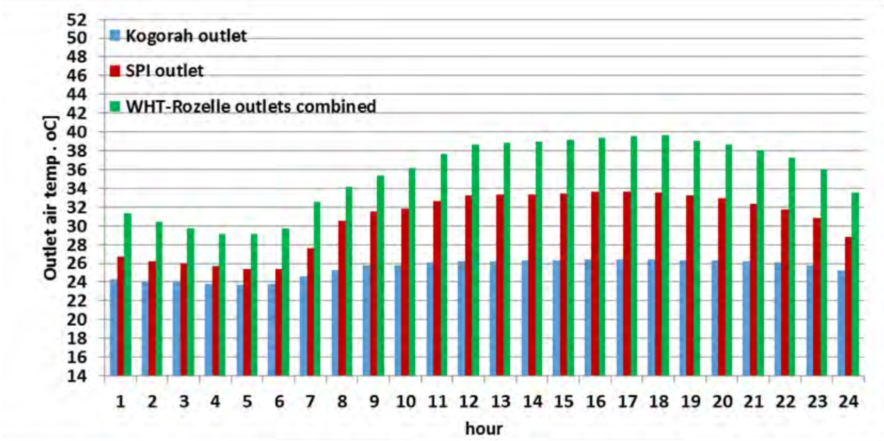
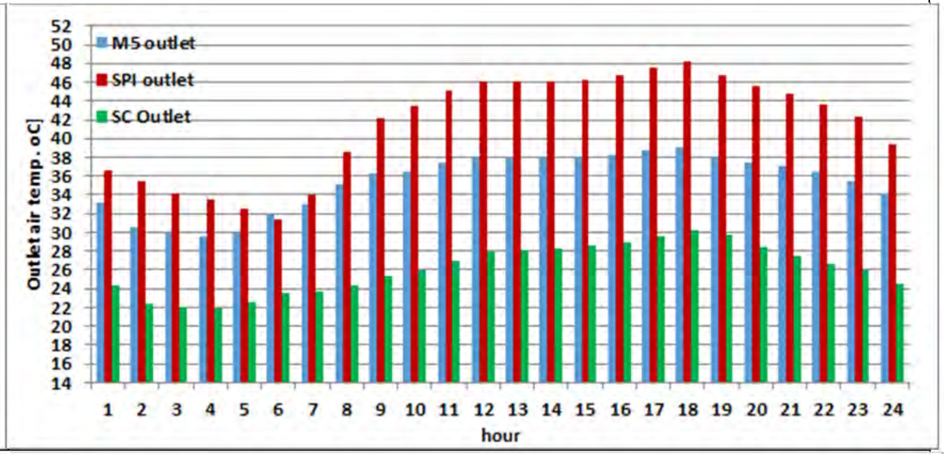
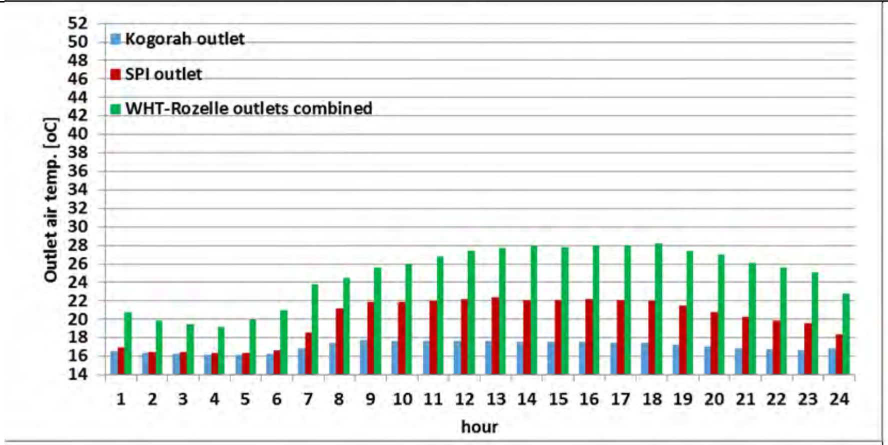
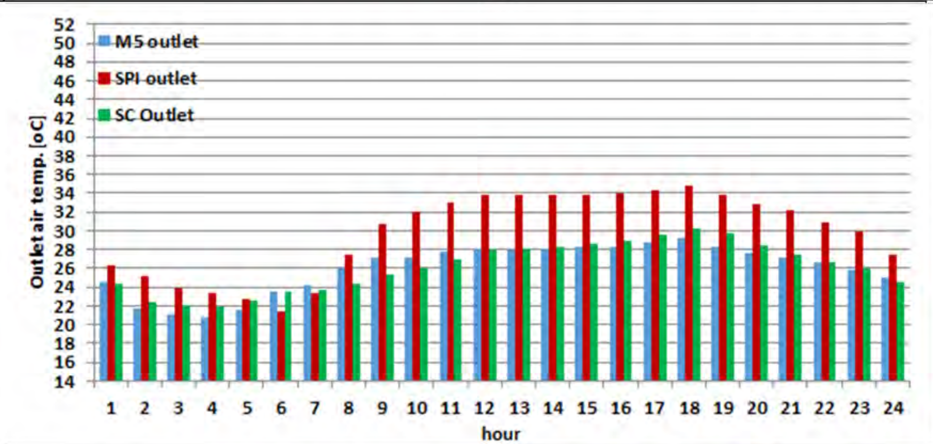
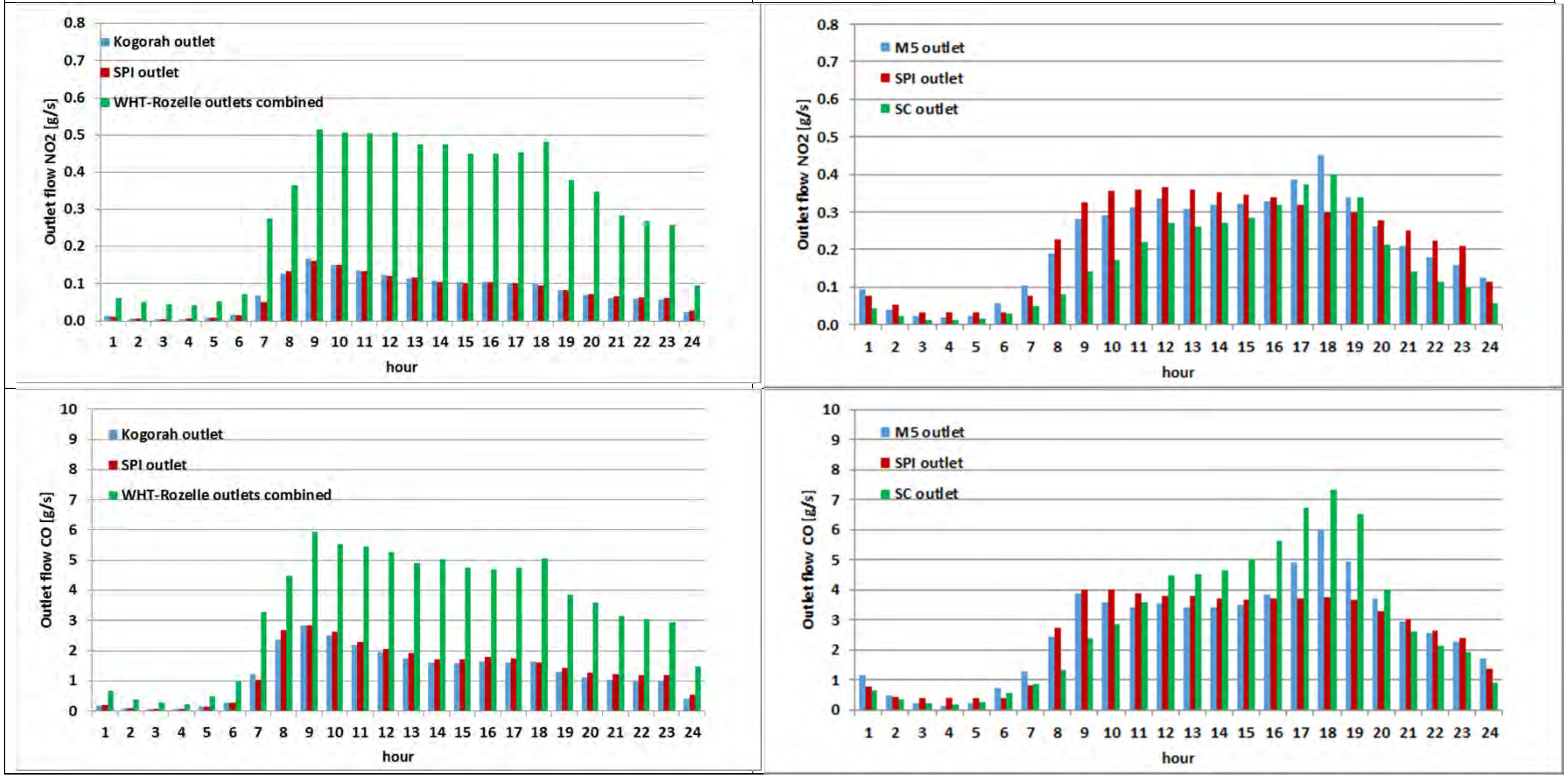
	Eastbound	Westbound
Summer		
Winter		

Figure 11.5. Outlet discharge for normal traffic in 2031. “SC” means Southern Extension.

Eastbound	Westbound



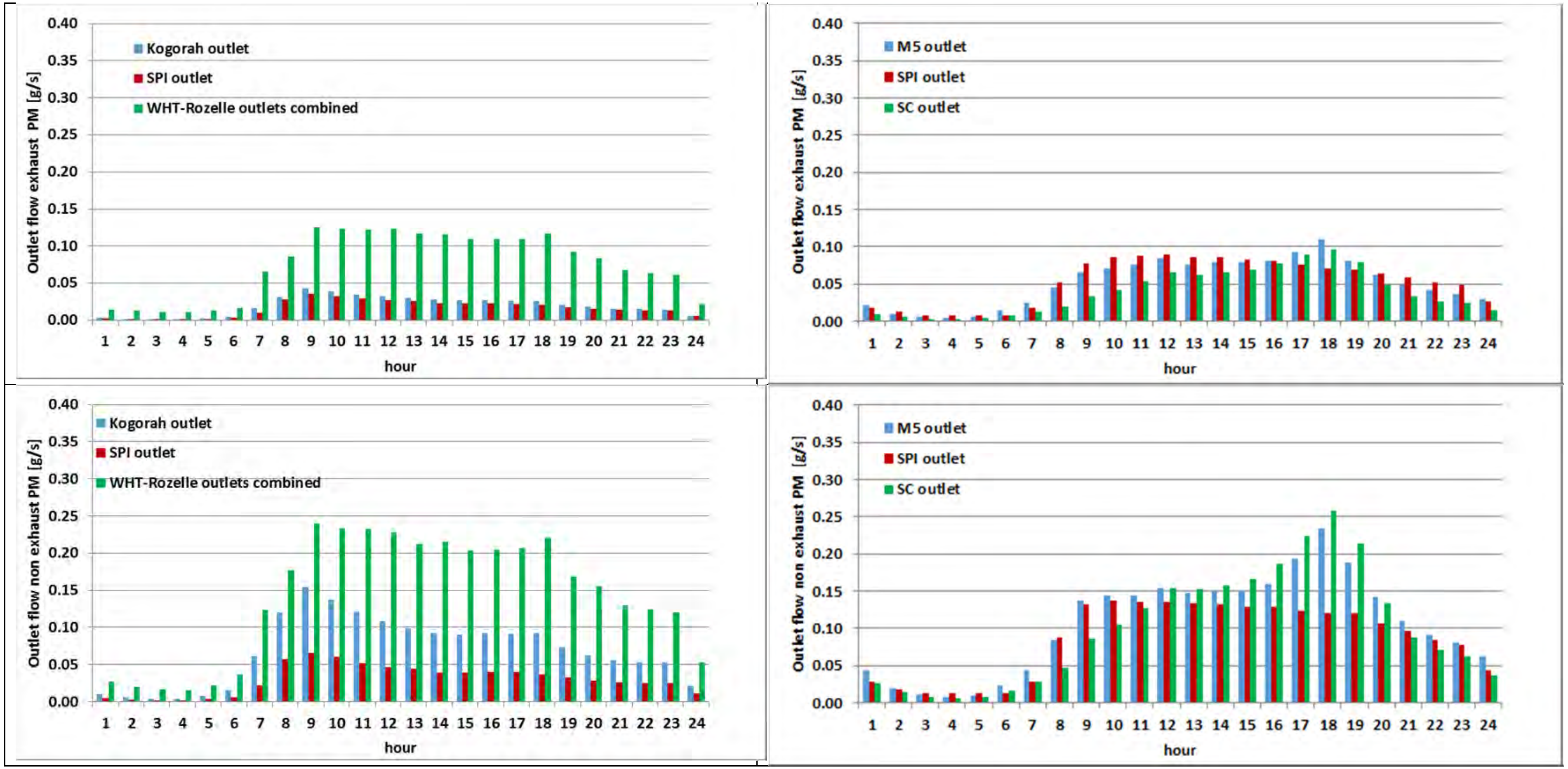

Kogorah outlet
SPI outlet
WHT-Rozelle outlets combined
Outlet flow exhaust PM [g/s]
hour
M5 outlet
SPI outlet
SC outlet
Outlet flow exhaust PM [g/s]
hour
Kogorah outlet
SPI outlet
WHT-Rozelle outlets combined
Outlet flow non exhaust PM [g/s]
hour
M5 outlet
SPI outlet
SC outlet
Outlet flow non exhaust PM [g/s]
hour

Figure 11.6. Modelled 2031 daily regulatory traffic demand for New M5 and M4-M5 Link west of Rozelle. "SC" means Southern Extension.

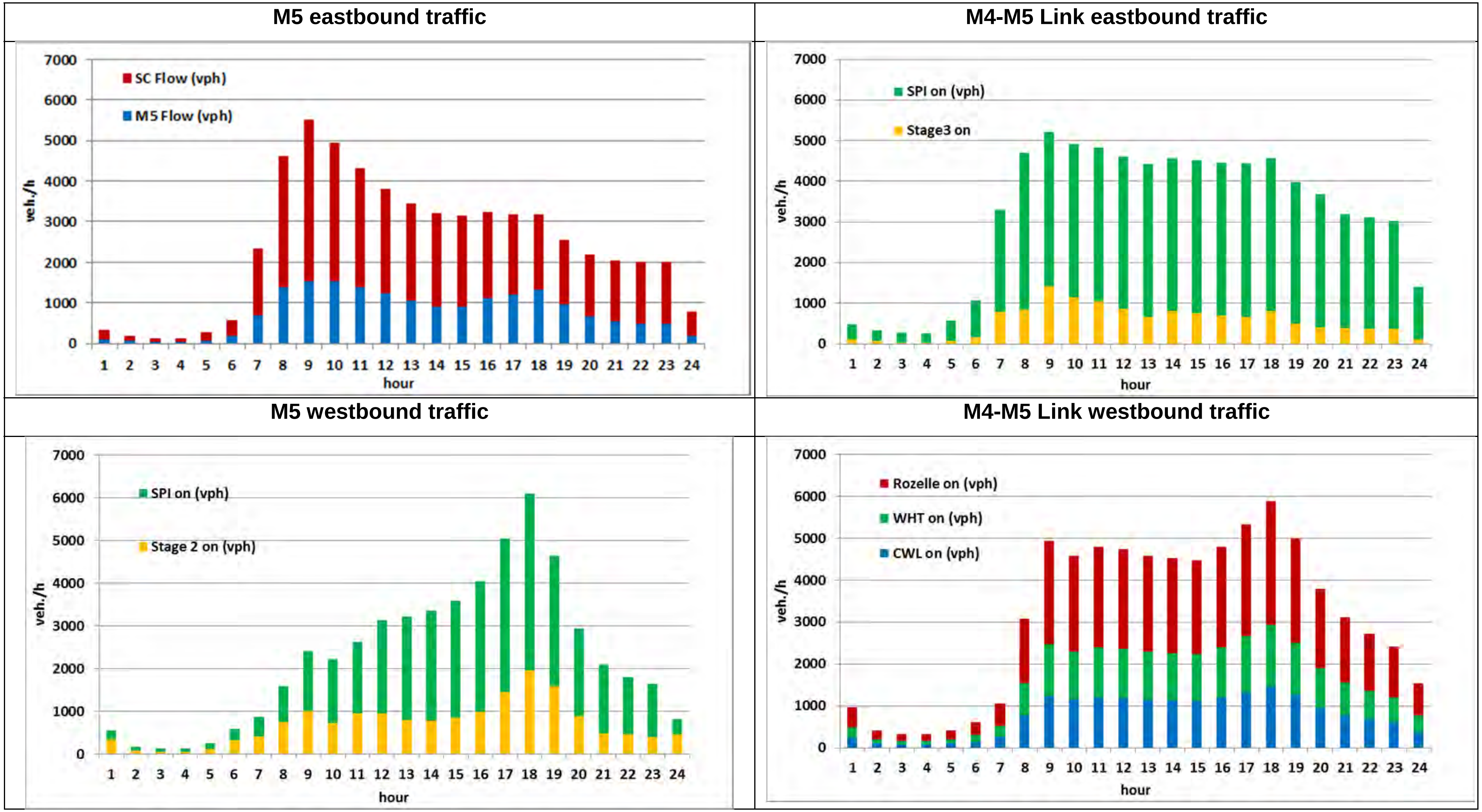
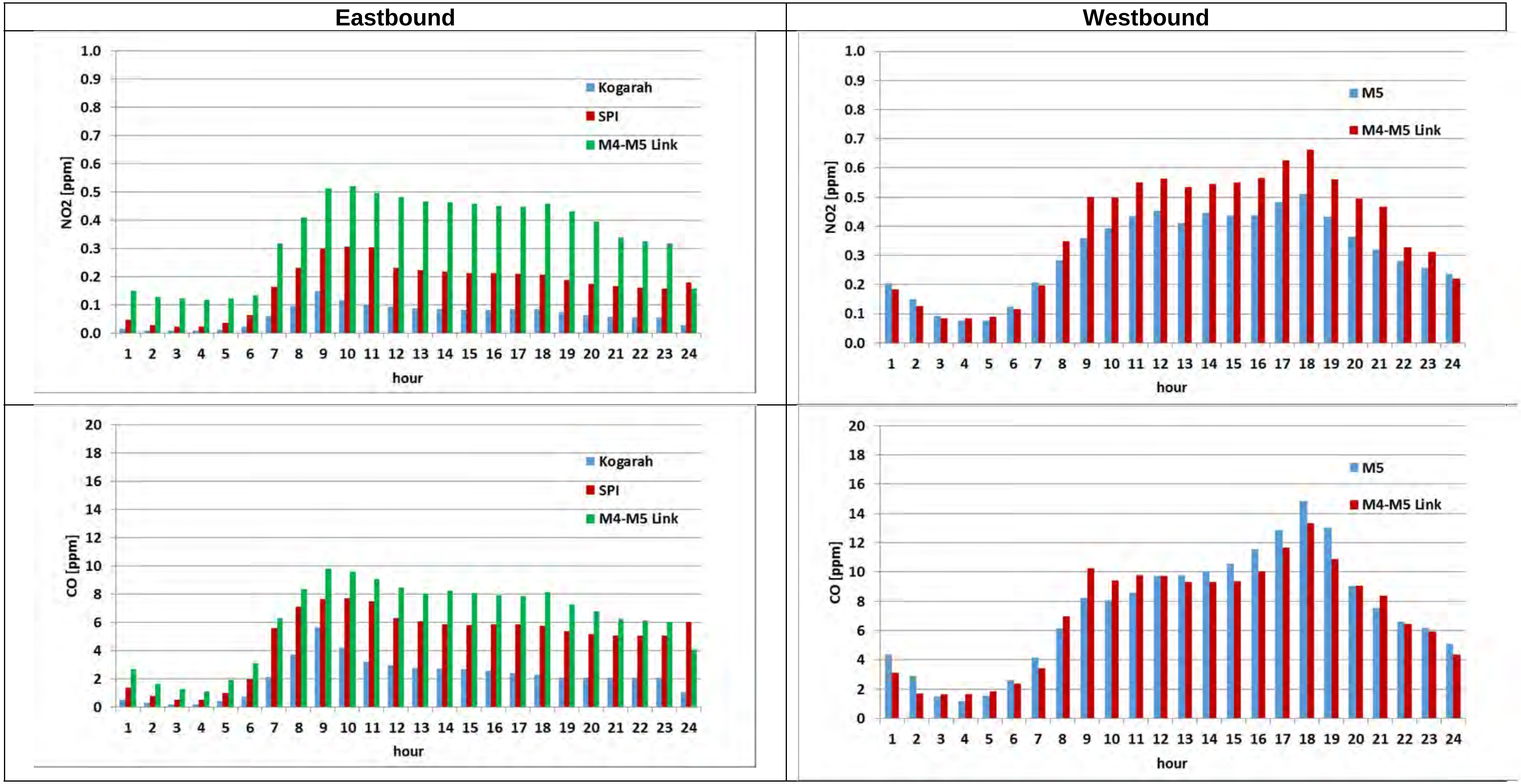


Figure 11.7. Maximum hourly in-tunnel pollution levels for regulatory traffic in 2031.



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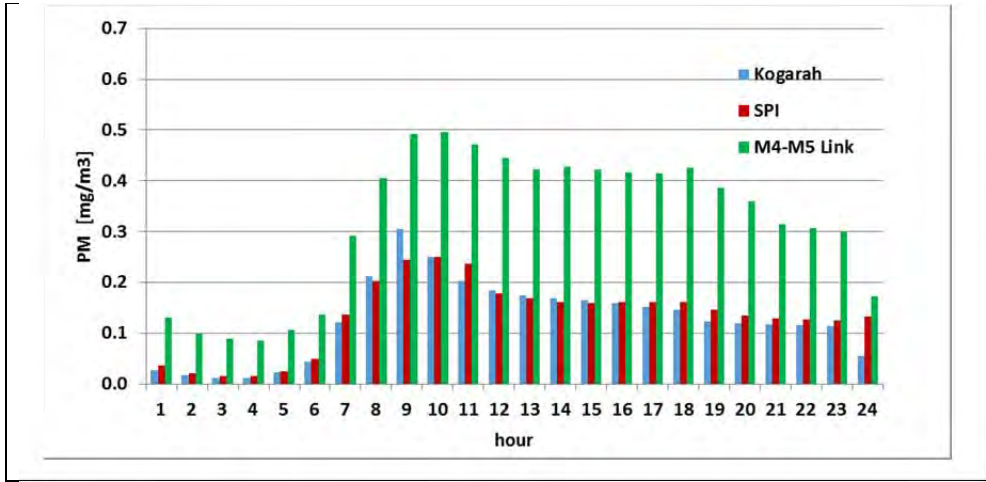
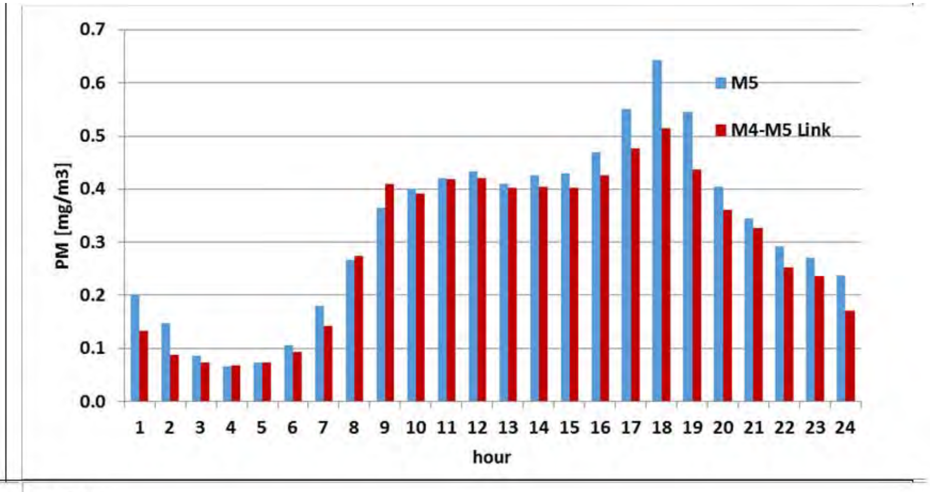
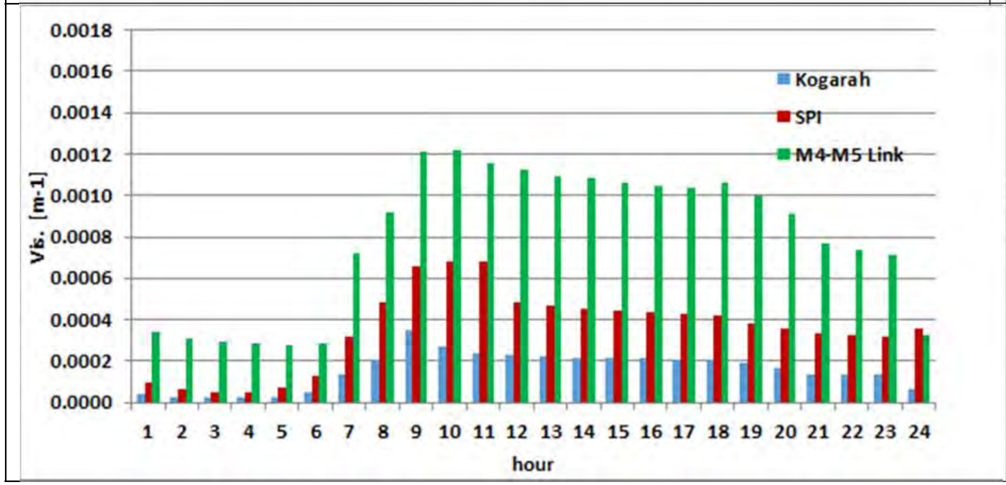

PM [mg/m3]
Kogarah
SPI
M4-M5 Link
hour


PM [mg/m3]
M5
M4-M5 Link
hour


Vis. [m-1]
Kogarah
SPI
M4-M5 Link
hour

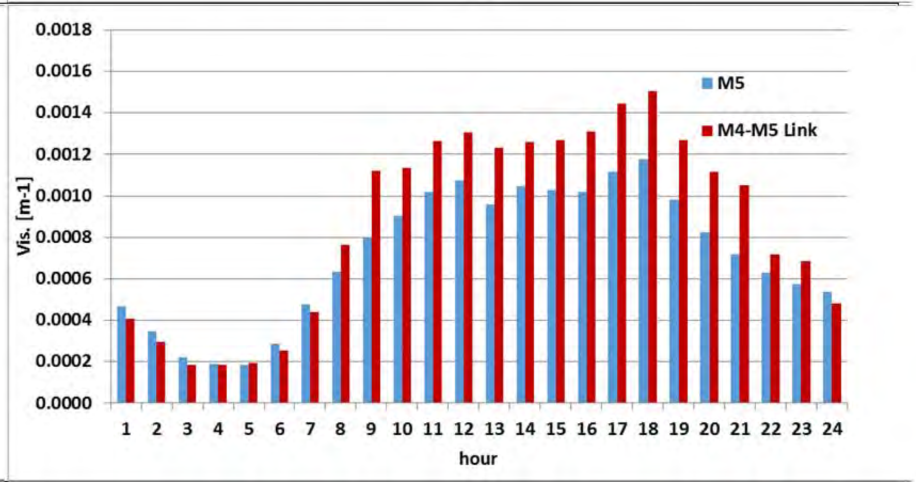
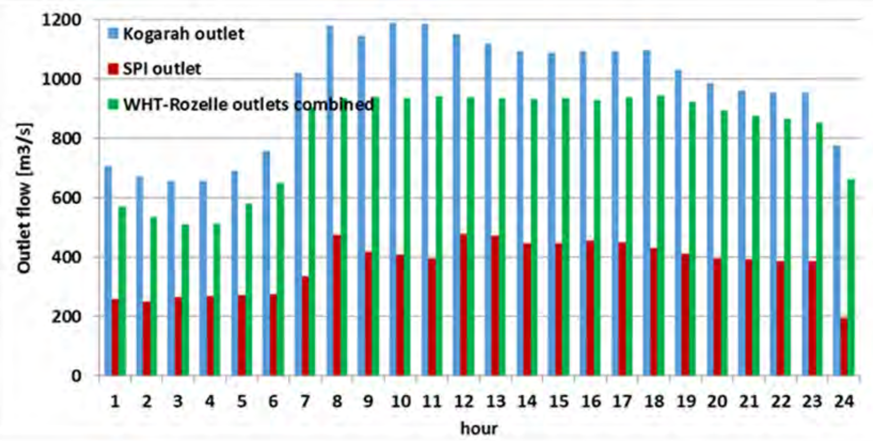
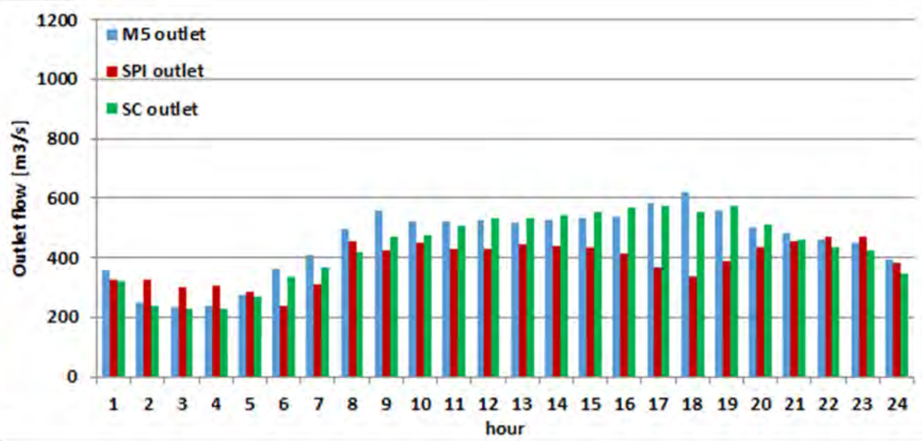

Vis. [m-1]
M5
M4-M5 Link
hour

Figure 11.8. Extraction and supply station flows for regulatory traffic in 2031. “SC” means Southern Extension.

Eastbound | **Westbound**

Extraction





Supply

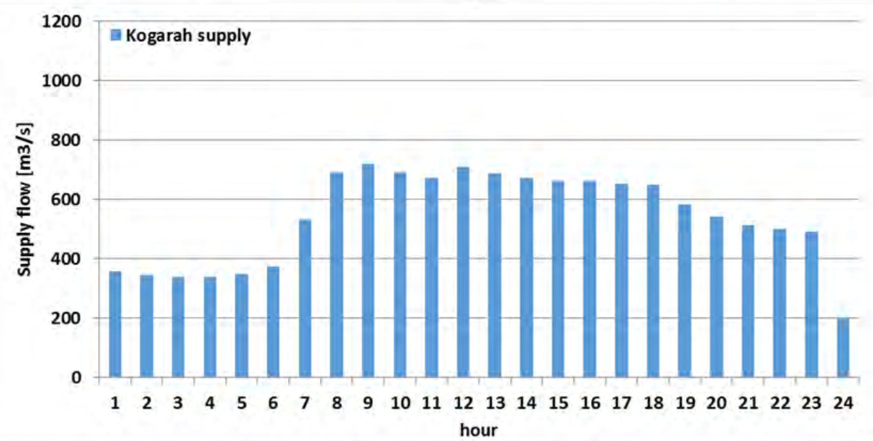


Figure 11.9. Outlet temperature (summer and winter) for regulatory traffic in 2031. “SC” means Southern Extension.

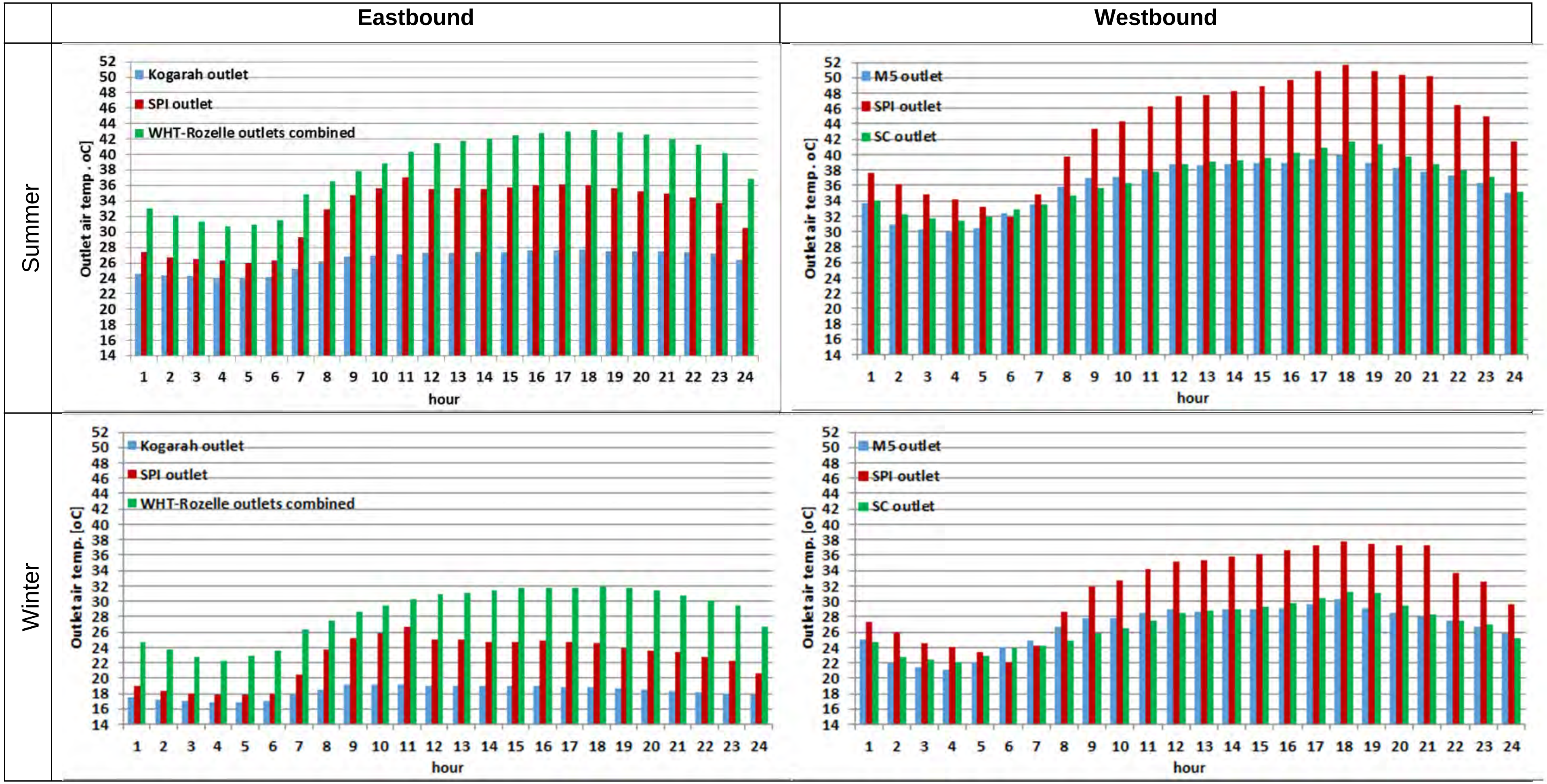
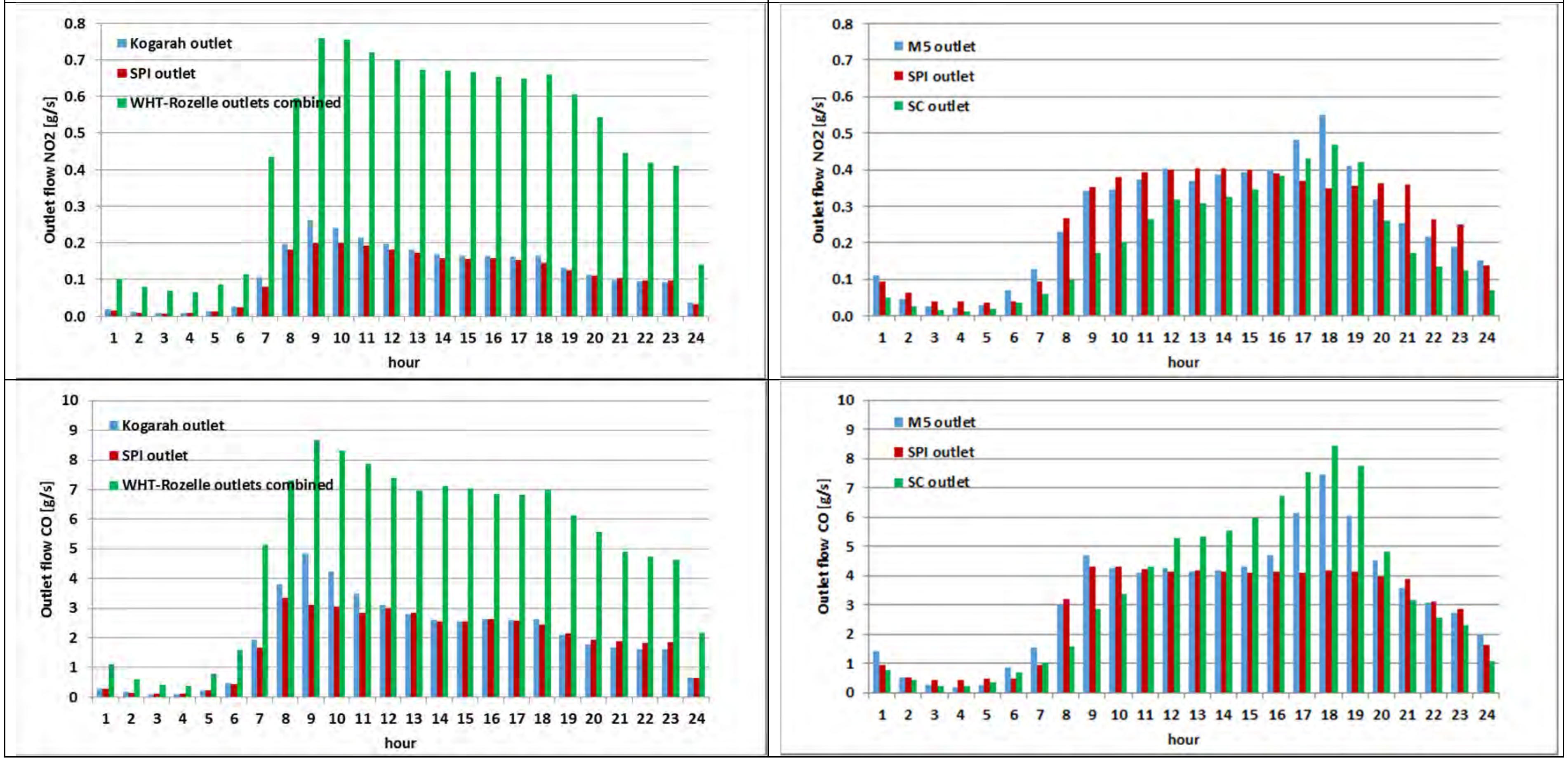
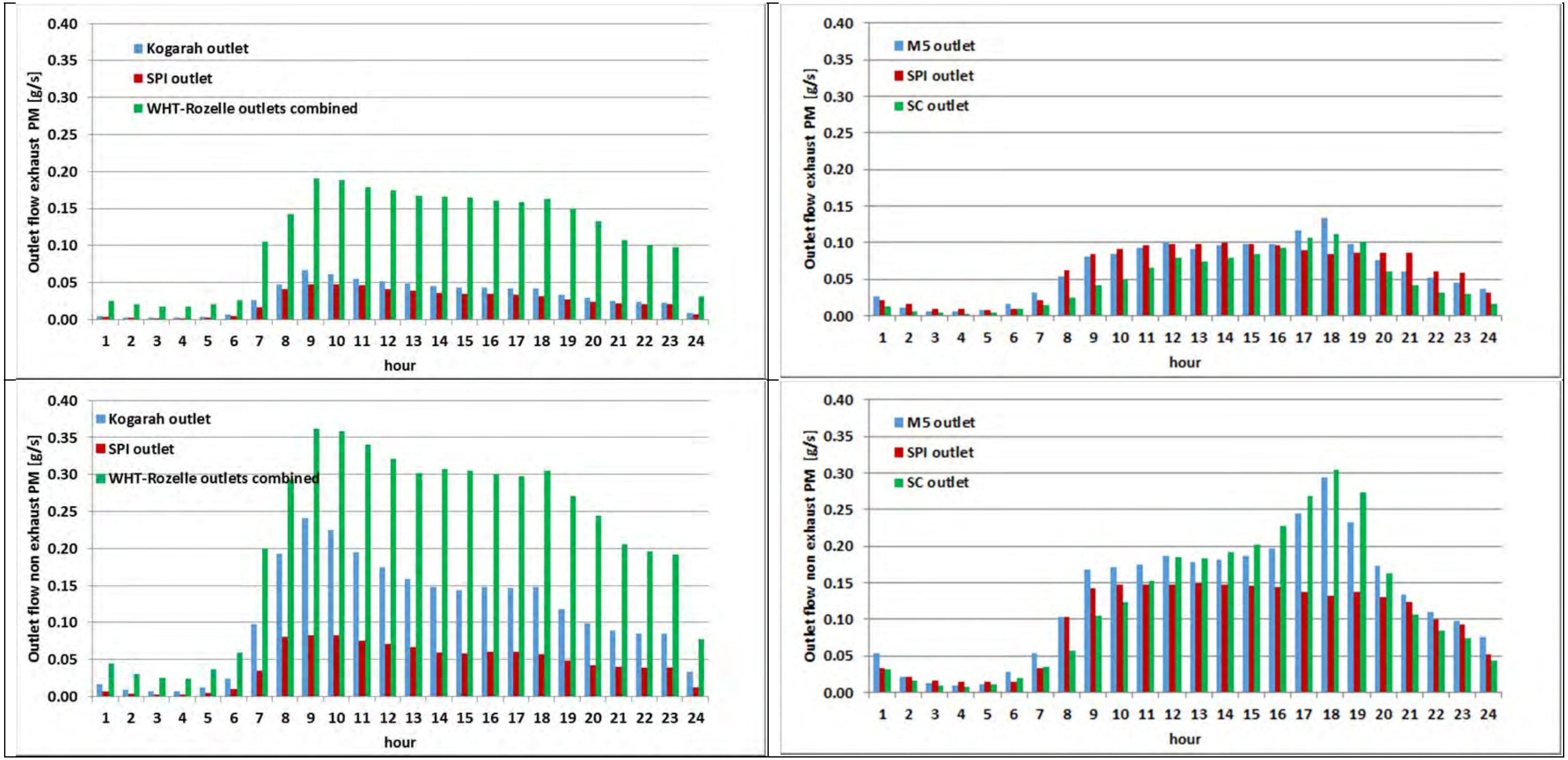


Figure 11.10. Outlet discharge for regulatory traffic in 2031. "SC" means Southern Extension.

Eastbound	Westbound





Kogarah outlet
SPI outlet
WHT-Rozelle outlets combined
Outlet flow exhaust PM [g/s]
hour
M5 outlet
SPI outlet
SC outlet
Outlet flow exhaust PM [g/s]
hour
Kogarah outlet
SPI outlet
WHT-Rozelle outlets combined
Outlet flow non exhaust PM [g/s]
hour
M5 outlet
SPI outlet
SC outlet
Outlet flow non exhaust PM [g/s]
hour

11.3 Congested traffic

Multi-lane tunnels have an advantage in mitigating congestion in that slow vehicles can occupy the left lane, allowing the remaining lanes to accommodate faster moving traffic. As discussed in Section 6.1, the notion of uniformly slow moving traffic throughout a tunnel is unrealistic. The speed difference between lanes introduces another complexity. Since ventilation simulation software and other calculation methods do not consider this speed difference between lanes, they underestimate the vehicle piston effect and produce lower estimates of tunnel air flow and higher estimates of in-tunnel pollution; especially for congested cases where the speed difference between lanes is large.

When congestion does occur in the simulations, it is associated with high traffic demand at entry portals and occurs locally at merges, or at steep exit ramps where congestion may extend back into the mainline. Since traffic flow is compressible, especially in a long tunnel, some sections can flow freely while others are congested.

Traffic congestion is created in the simulation by placing traffic speed limits (20, 40, 60 and 80 km/h) at strategic locations within the model. For the eastbound tube, a speed limit was placed on the last 500 m of the SPI off-ramp, to simulate backup of traffic from the SPI interchange. A second speed limit zone was placed in the main tube between the SPI on-ramp merge and the diverge at the Rozelle end of the M4-M5 Link; a distance of 3775 m. For the westbound tube, speed limits were placed on the last 500 m prior to the three exit portals; SPI off-ramp, M5 exit and Southern Extension exit.

When regulatory traffic flows were applied to the model, results show that significant congestion in the main tube only occurs where the speed limits have been applied (Figure 11.11 and Figure 11.12). There is no back-up of traffic throughout the main tunnel. However the ramps (Southern Extension and SPI) become congested as the traffic backs-up in these locations (Figure 11.13 and Figure 11.14).

Pollution and temperature profiles along M5 and M4-M5 Link for the peak congestion cases are plotted in Figure 11.15 to Figure 11.19 for the eastbound route and Figure 11.20 and Figure 11.24 for the westbound route.

These results show that the eastbound tube has a higher pollutant level than the westbound tube, with the NO_2 level peaking up to 1.0 ppm at Rozelle and the peak summer air temperature reaching 47°C.

Longitudinal profiles of pollutant levels from the Southern Extension portal to the SPI portal are plotted in Figure 11.25 to Figure 11.29 for the eastbound tube and Figure 11.30 to Figure 11.34 for the westbound tube. Equivalent plots for the eastbound New M5 on its own, without M4-M5 Link, are given in Figure 11.35 to Figure 11.40. For the westbound case with New M5 alone, the combined system plots can be referenced, as M4-M5 Link simply acts as the traffic source, conservatively also contributing some pollution into New M5.

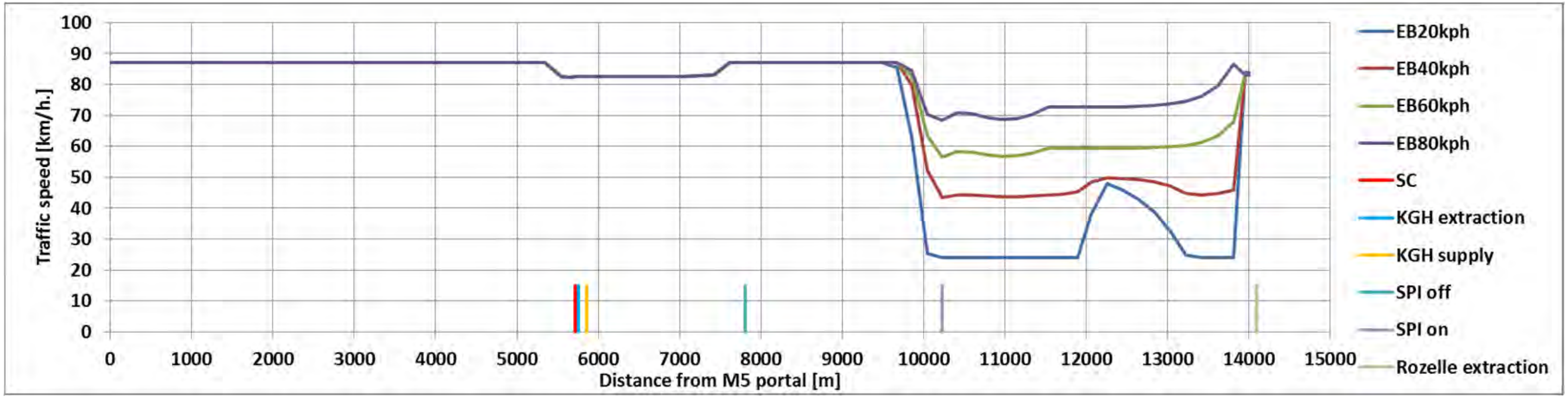


Figure 11.11. Eastbound 2031 regulatory traffic speed profile; M5 to Rozelle; 9 am peak. "SC" means Southern Extension.

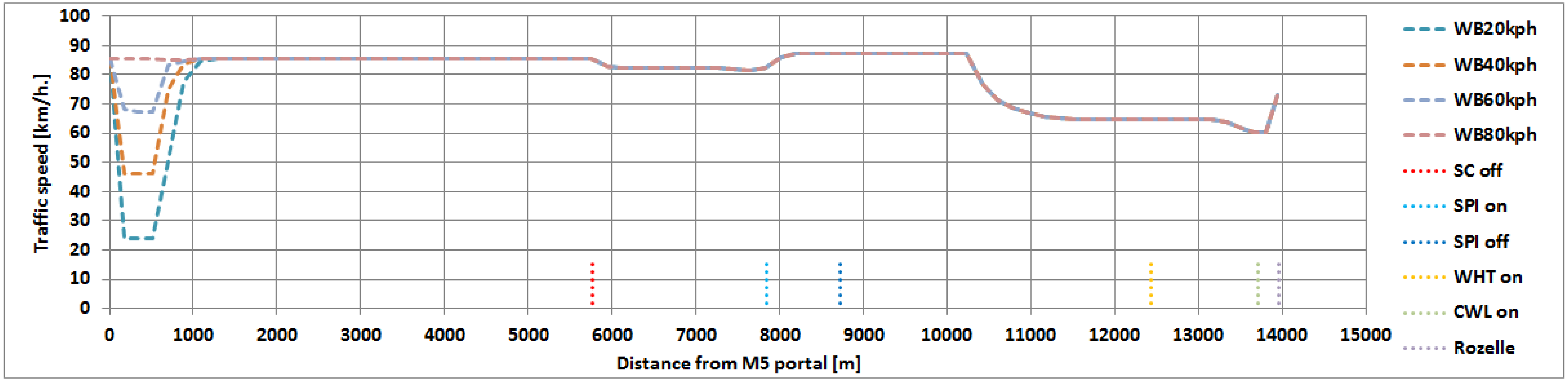


Figure 11.12. Westbound 2031 regulatory traffic speed profile; M5 to Rozelle; 6 pm peak. "SC" means Southern Extension.

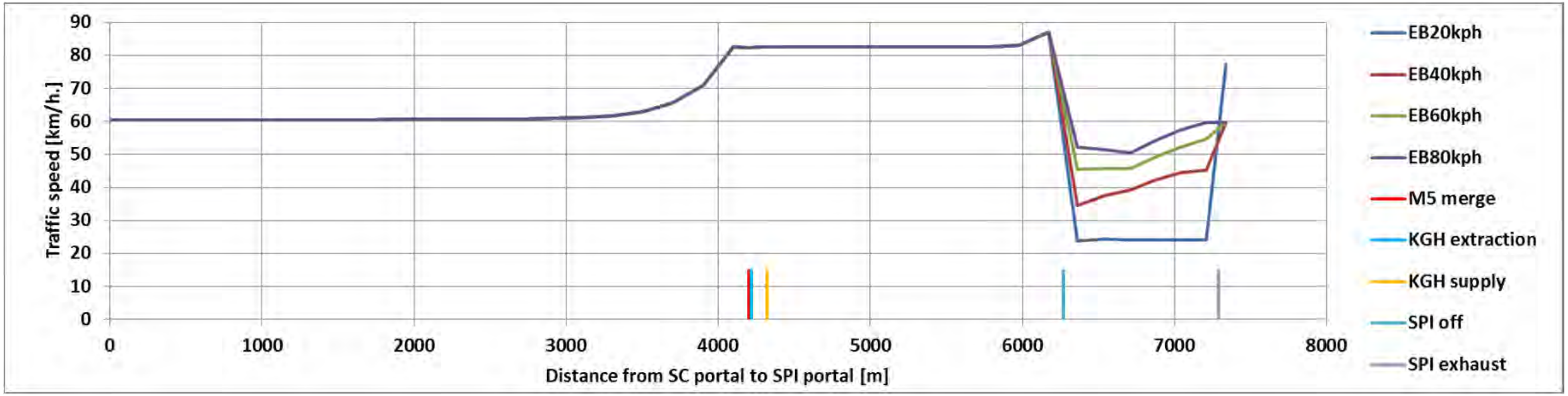


Figure 11.13. Eastbound 2031 regulatory traffic speed profile; Southern Connector (Southern Extension) to SPI; 9 am peak.

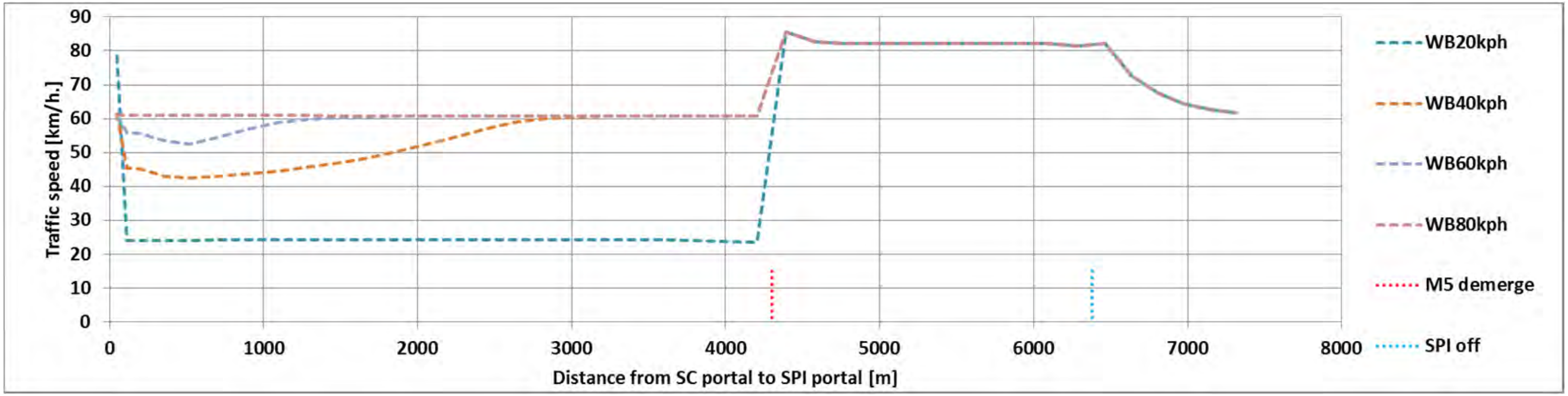


Figure 11.14. Westbound 2031 regulatory traffic speed profile; Southern Connector (Southern Extension) to SPI 6 pm peak.

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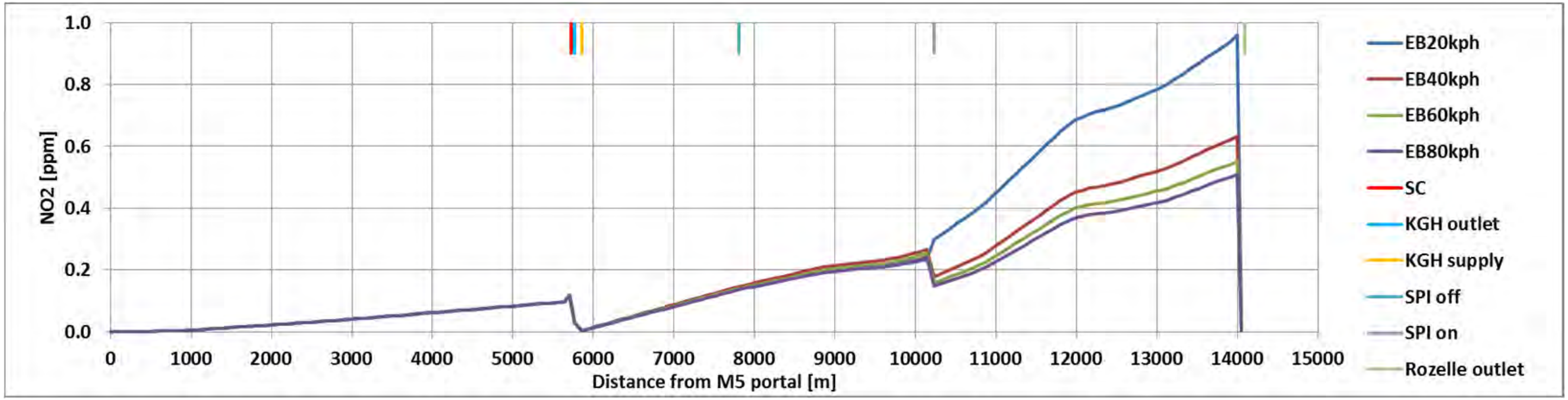

Figure 11.15. Eastbound 2031 regulatory traffic NO_2 profile; M5 to Rozelle; 9 am peak. "SC" means Southern Extension.

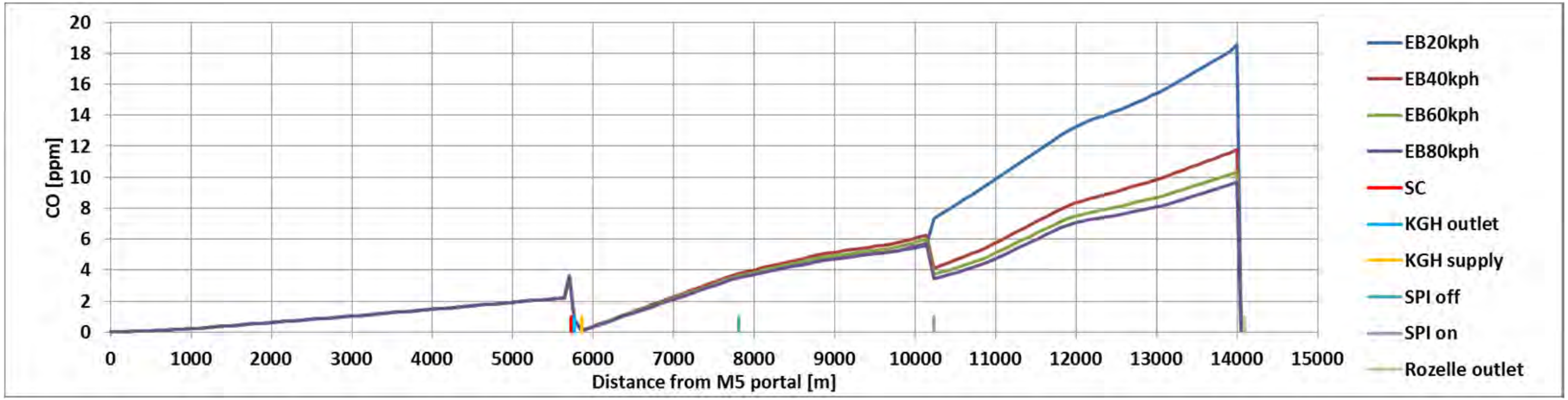

Figure 11.16. Eastbound 2031 regulatory traffic CO profile; M5 to Rozelle; 9 am peak. "SC" means Southern Extension.

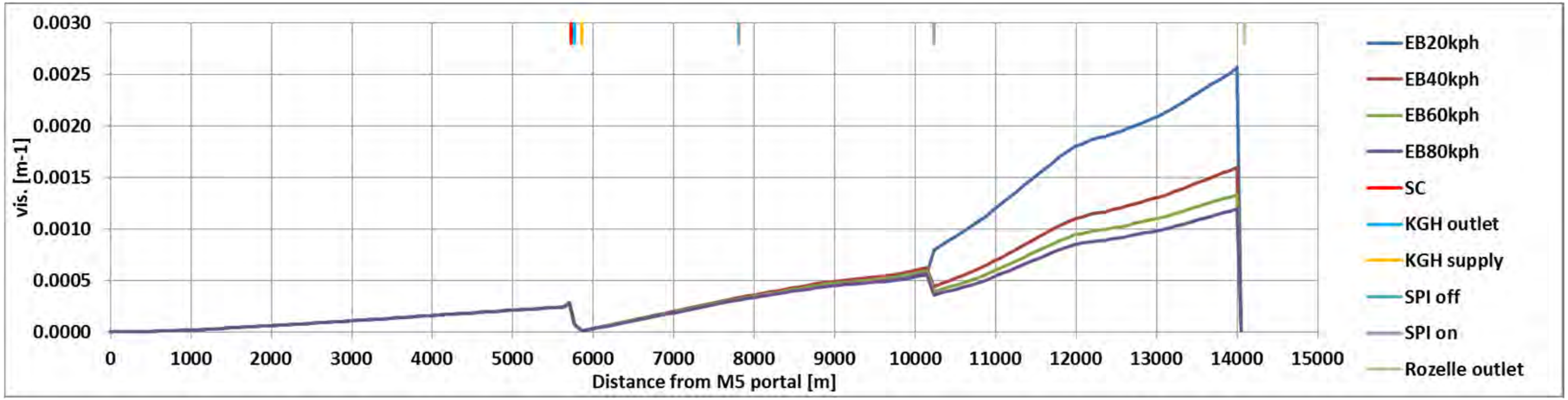

Figure 11.17. Eastbound 2031 regulatory traffic extinction coefficient profile; M5 to Rozelle; 9 am peak. "SC" means Southern Extension.

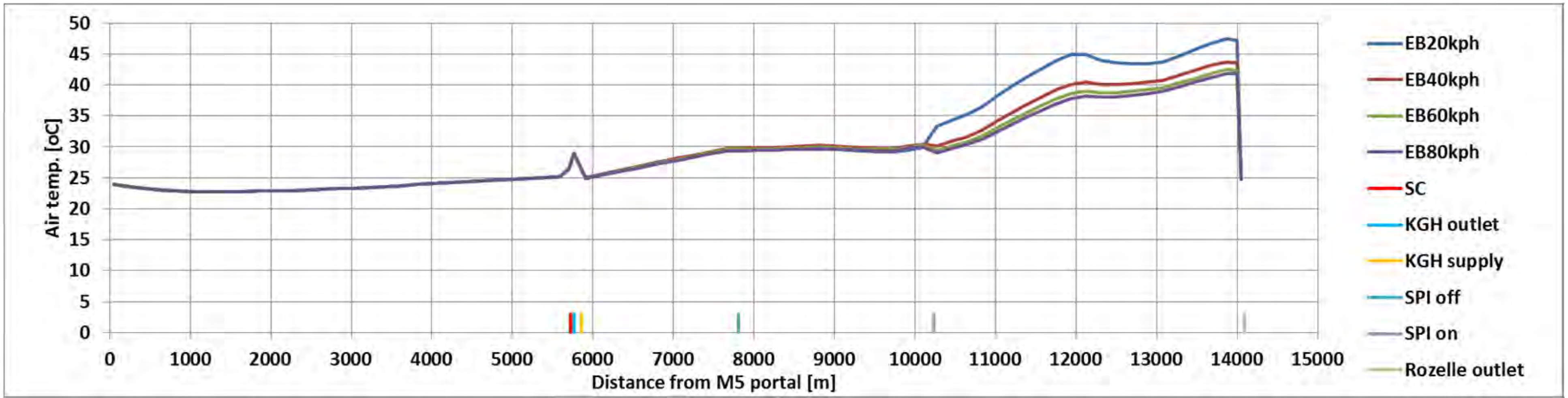

Figure 11.18 Eastbound 2031 regulatory traffic air temperature (summer) profile; M5 to Rozelle; 9 am peak. "SC" means Southern Extension.

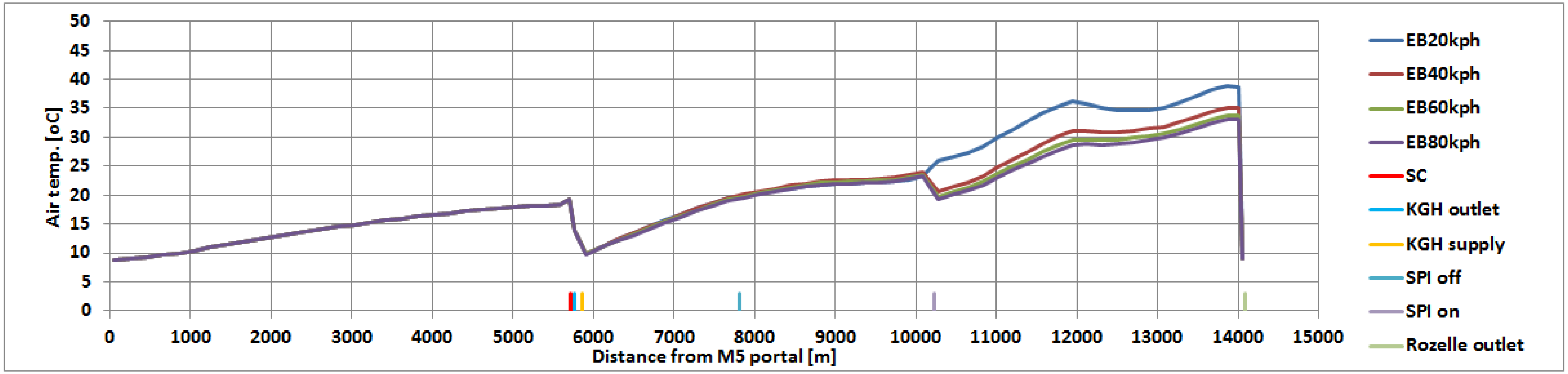

Figure 11.19. Eastbound 2031 regulatory traffic air temperature (winter) profile; M5 to Rozelle; 9 am peak. "SC" means Southern Extension.

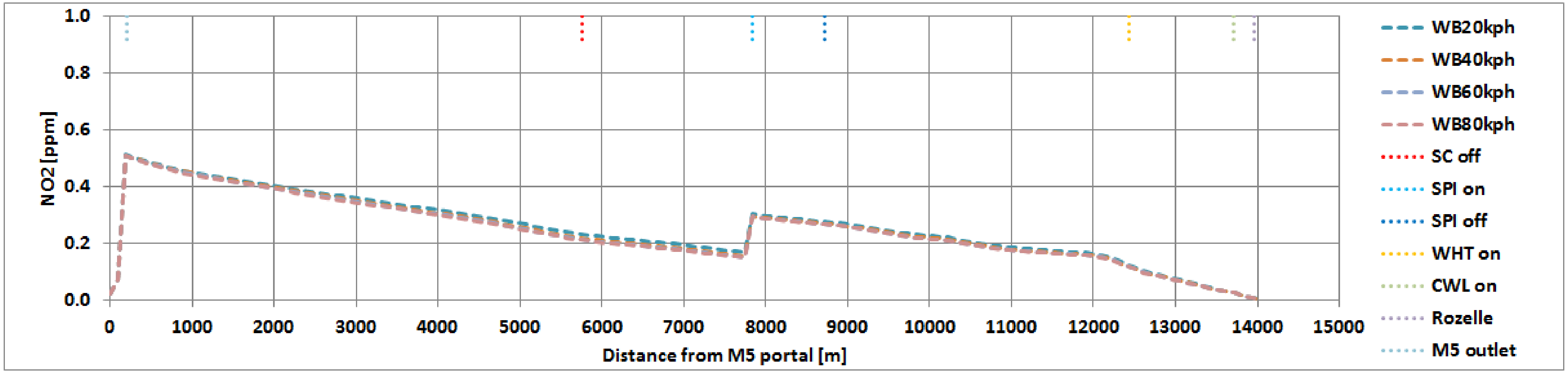

Figure 11.20. Westbound 2031 regulatory traffic NO_2 profile; M5 to Rozelle 6 pm peak. "SC" means Southern Extension.

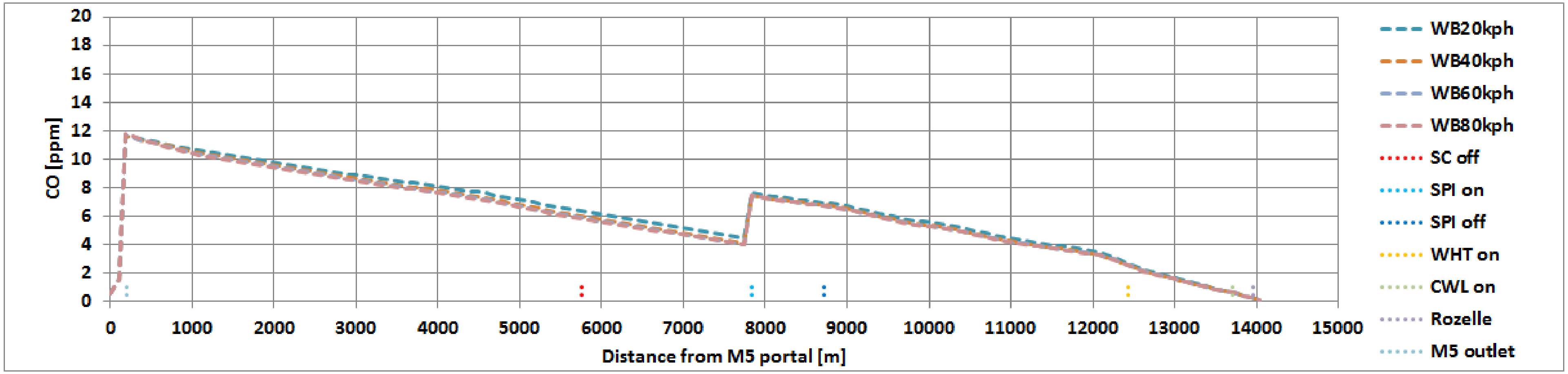

Figure 11.21. Westbound 2031 regulatory traffic CO profile; M5 to Rozelle 6 pm peak. "SC" means Southern Extension.

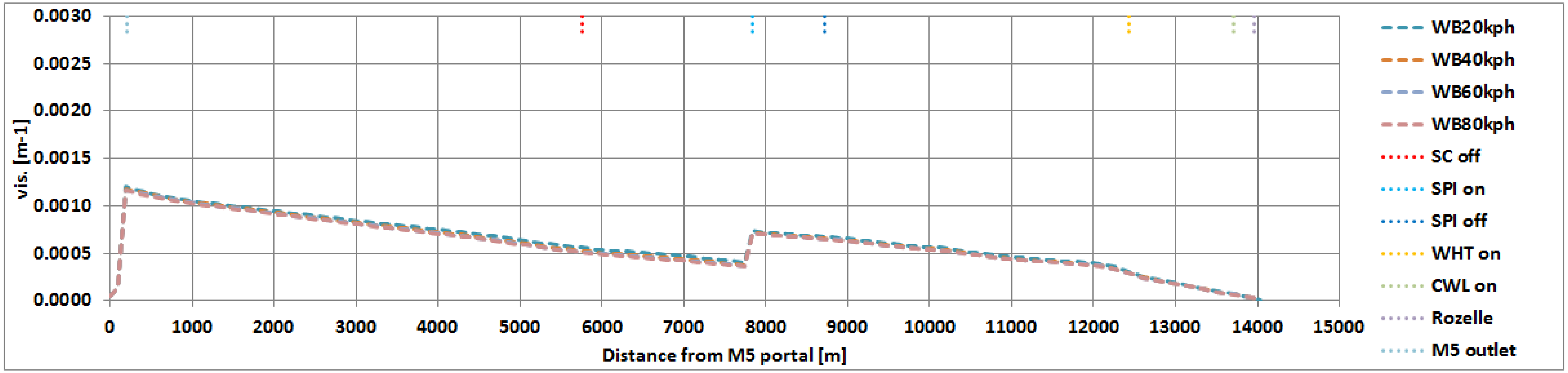

Figure 11.22. Westbound 2031 regulatory traffic extinction coefficient profile; M5 to Rozelle 6 pm peak. "SC" means Southern Extension.

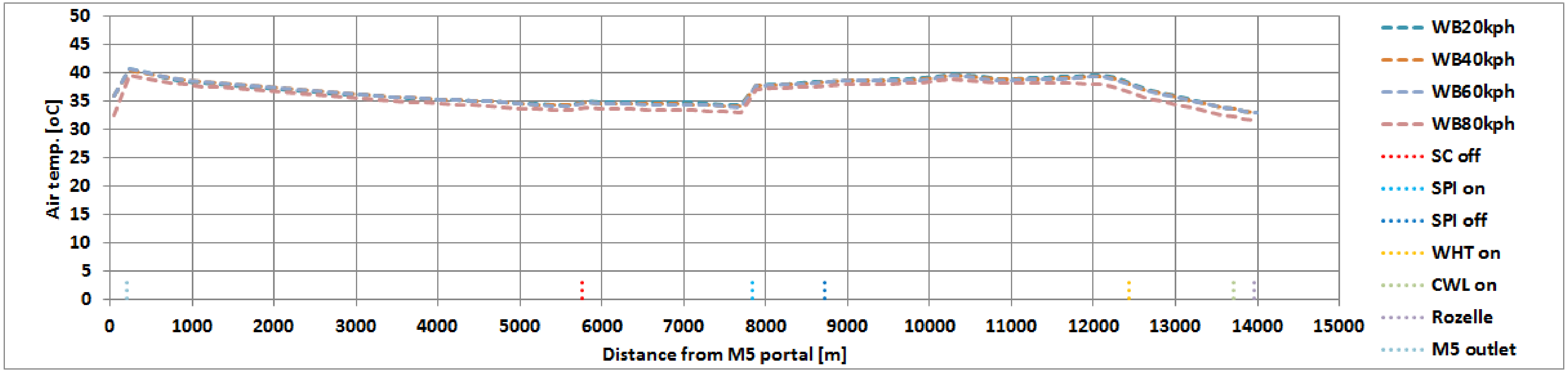

Figure 11.23. Westbound 2031 regulatory traffic air temperature (summer) profile; M5 to Rozelle 6 pm peak. "SC" means Southern Extension.

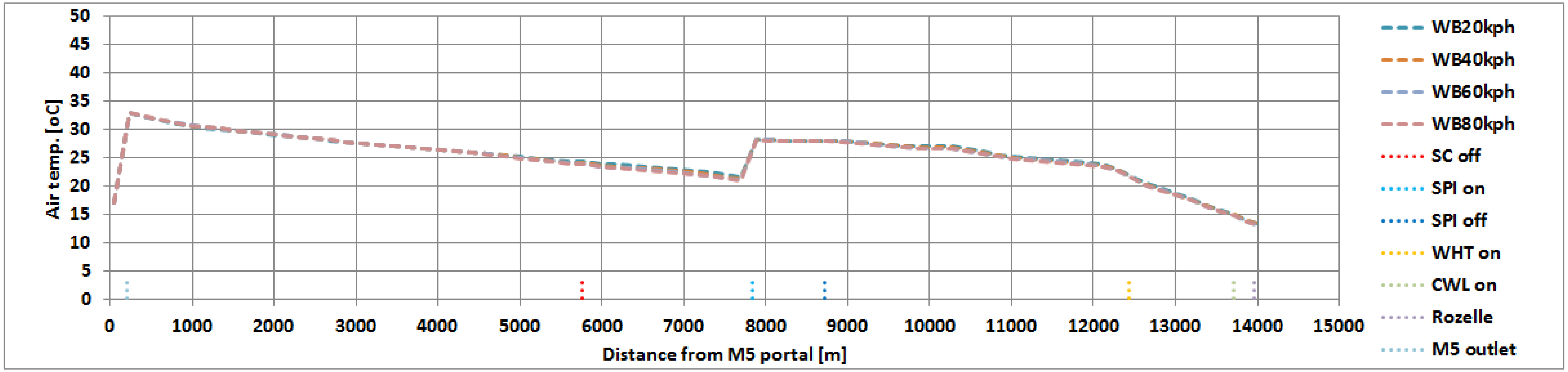

Figure 11.24. Westbound 2031 regulatory traffic air temperature (winter) profile; M5 to Rozelle 6 pm peak. "SC" means Southern Extension.

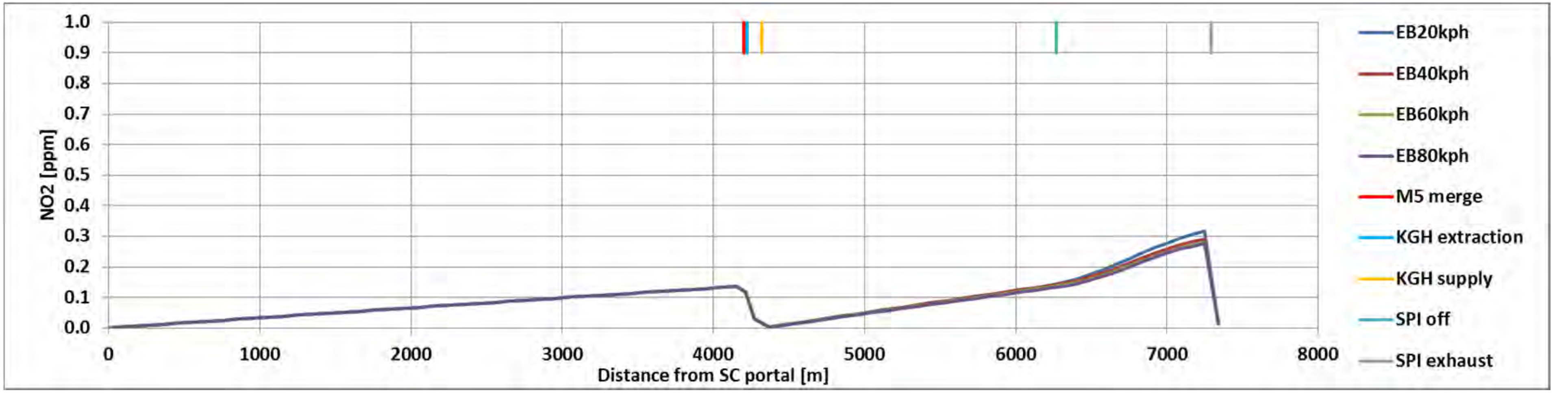

Figure 11.25. Eastbound 2031 regulatory traffic NO_2 profile; Southern Connector (Southern Extension) to SPI; 9 am peak.

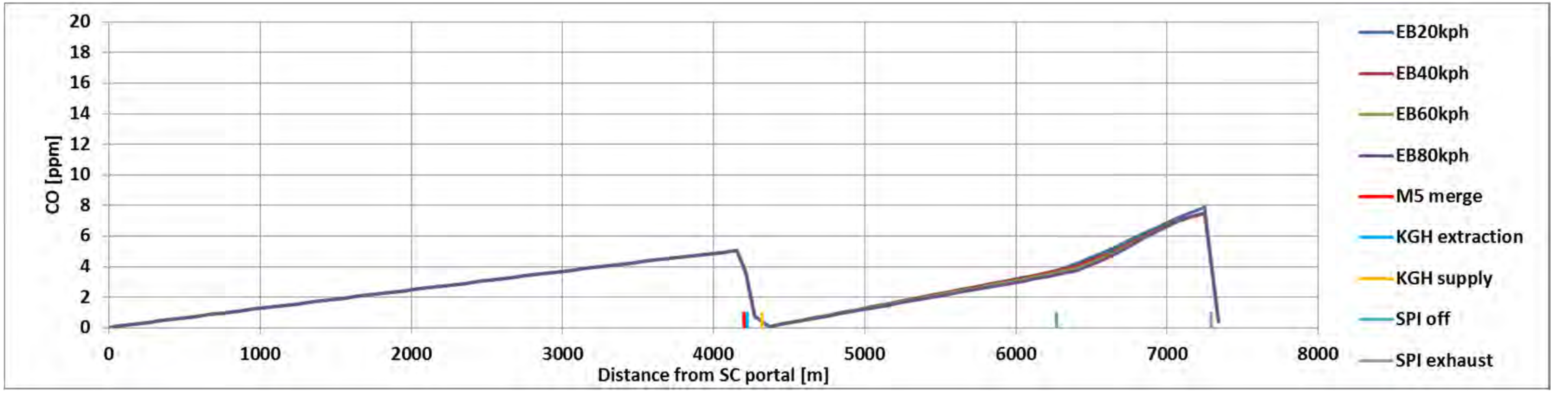

Figure 11.26. Eastbound 2031 regulatory traffic CO profile; Southern Connector (Southern Extension) to SPI; 9 am peak.

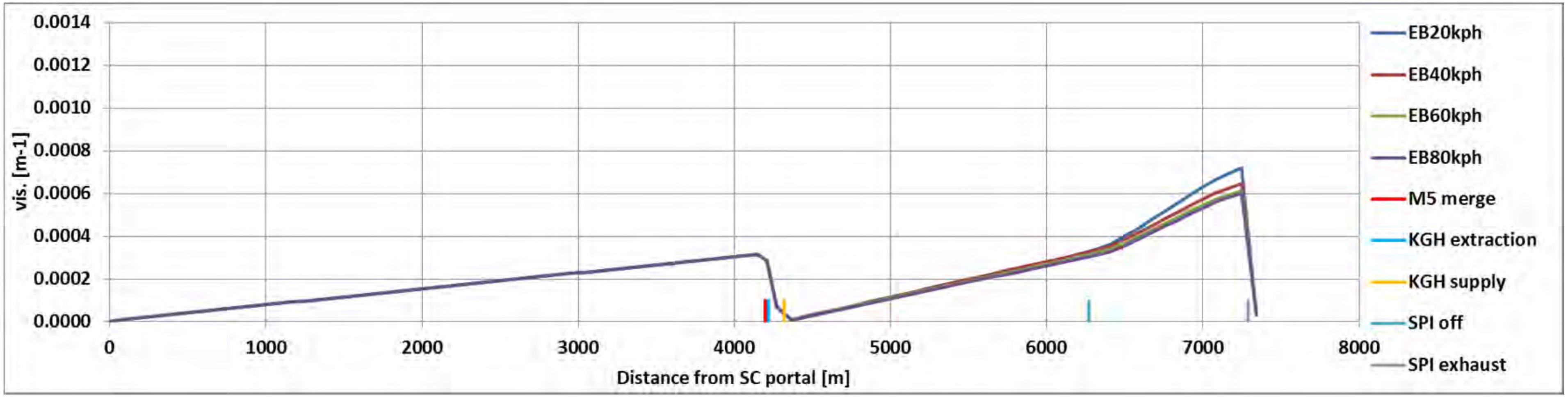

Figure 11.27. Eastbound 2031 regulatory traffic extinction coefficient profile; Southern Connector (Southern Extension) to SPI; 9 am peak.

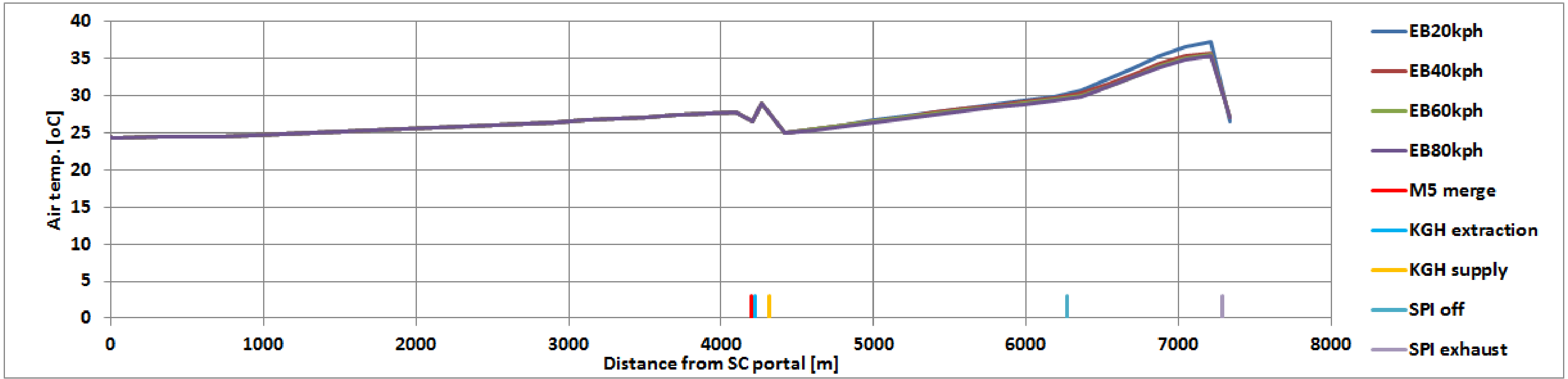

Figure 11.28. Eastbound 2031 regulatory air temperature (summer) profile; Southern Connector (Southern Extension) to SPI; 9 am peak.

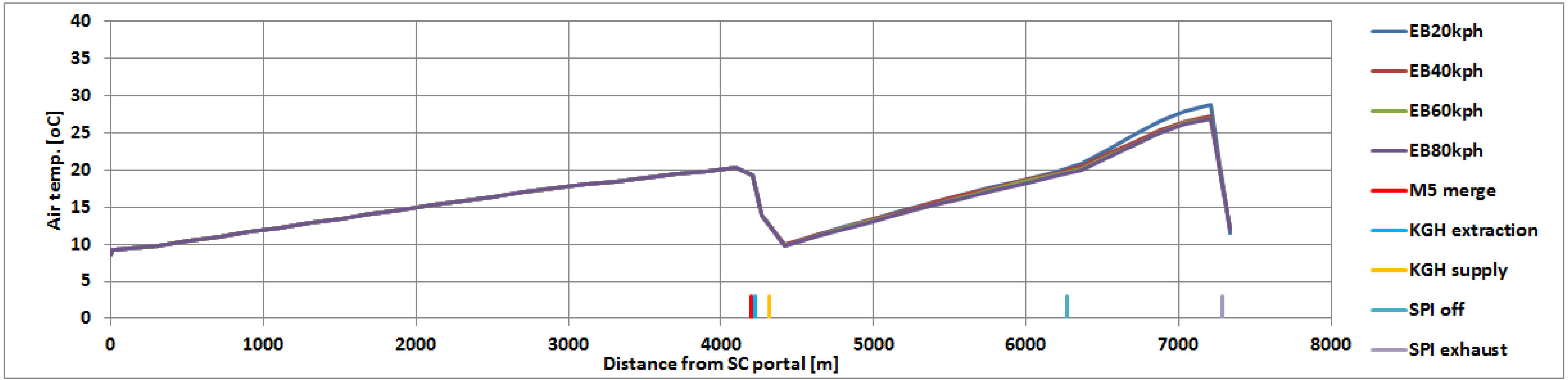

Figure 11.29. Eastbound 2031 regulatory air temperature (winter) profile; Southern Connector (Southern Extension) to SPI; 9 am peak.

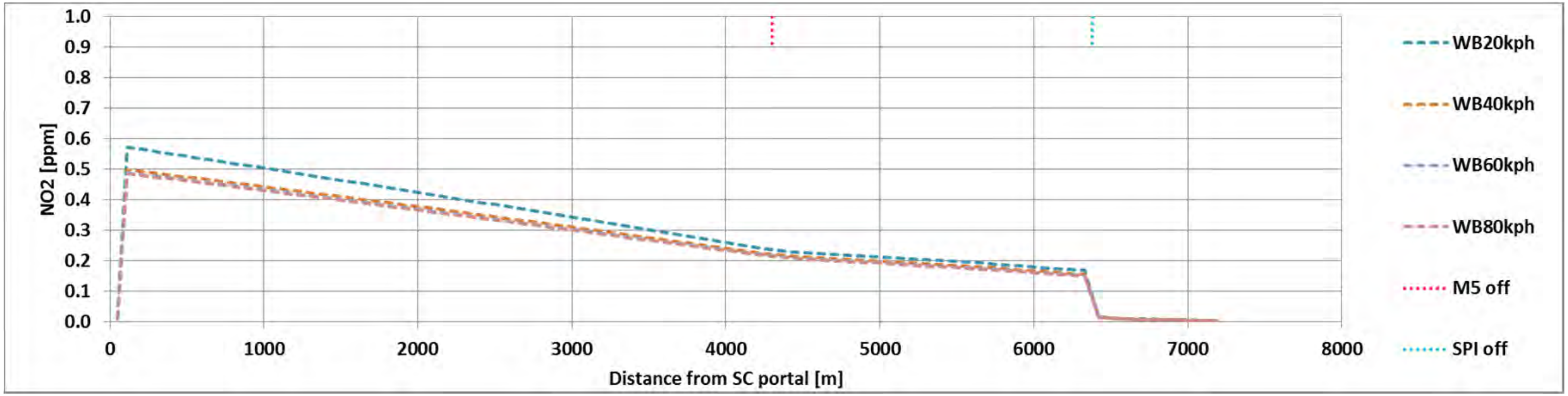

Figure 11.30. Westbound 2031 regulatory traffic NO_2 profile; Southern Connector (Southern Extension) to SPI 6 pm peak.

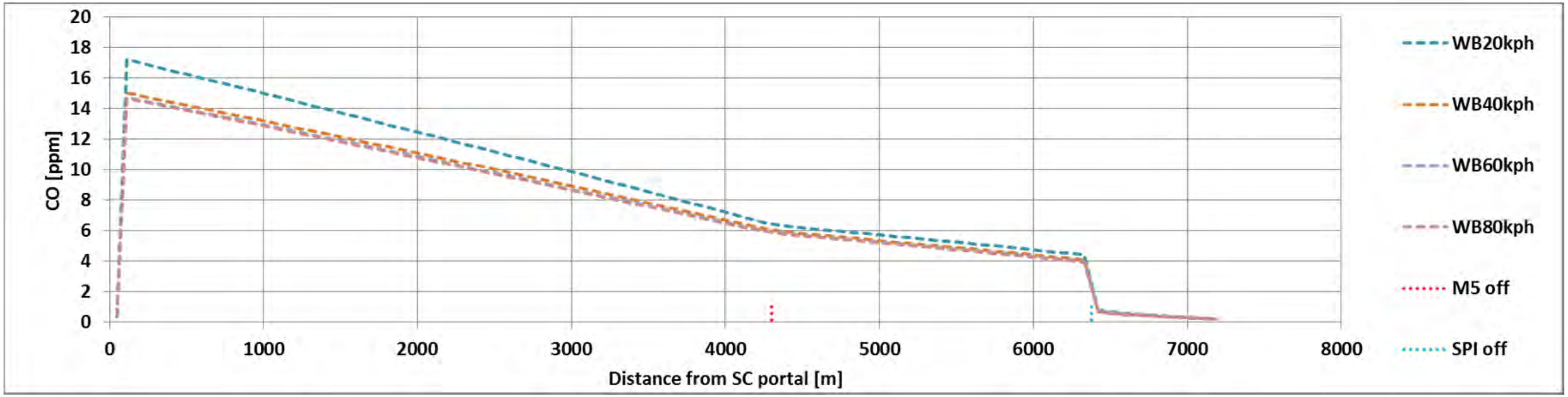

Figure 11.31. Westbound 2031 regulatory traffic CO profile; Southern Connector (Southern Extension) to SPI 6 pm peak.

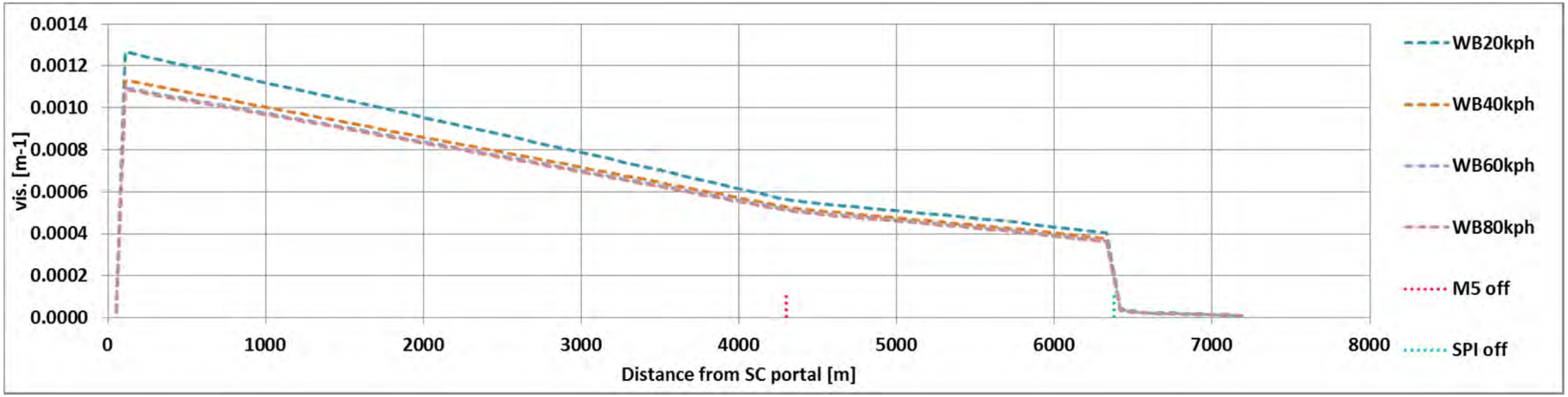

Figure 11.32. Westbound 2031 regulatory traffic extinction coefficient profile; Southern Connector (Southern Extension) to SPI 6 pm peak.

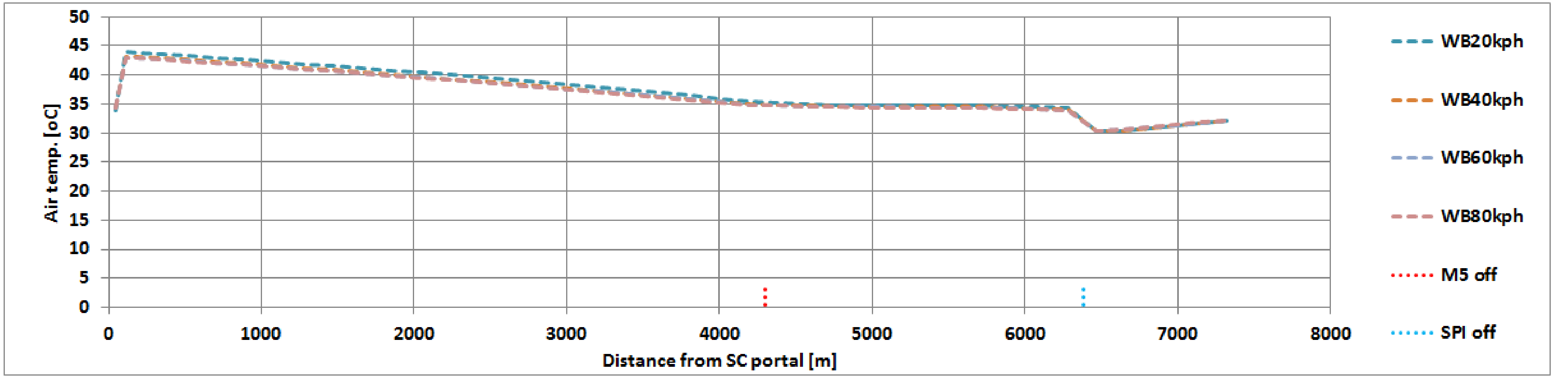

Figure 11.33. Westbound 2031 regulatory traffic air temperature (summer) profile; Southern Connector (Southern Extension) to SPI 6 pm peak.

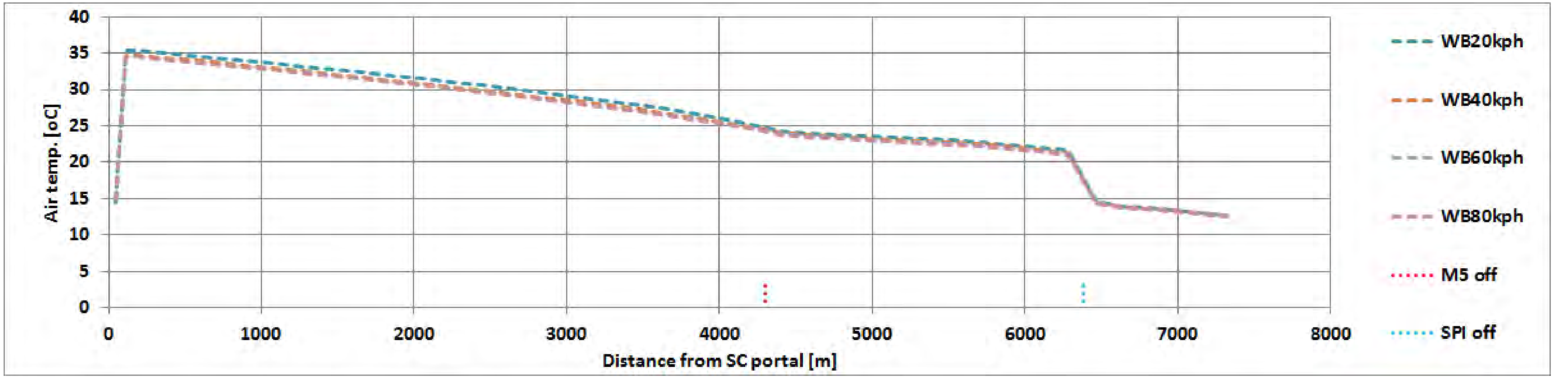

Figure 11.34. Westbound 2031 regulatory traffic air temperature (winter) profile; Southern Connector (Southern Extension) to SPI 6 pm peak.

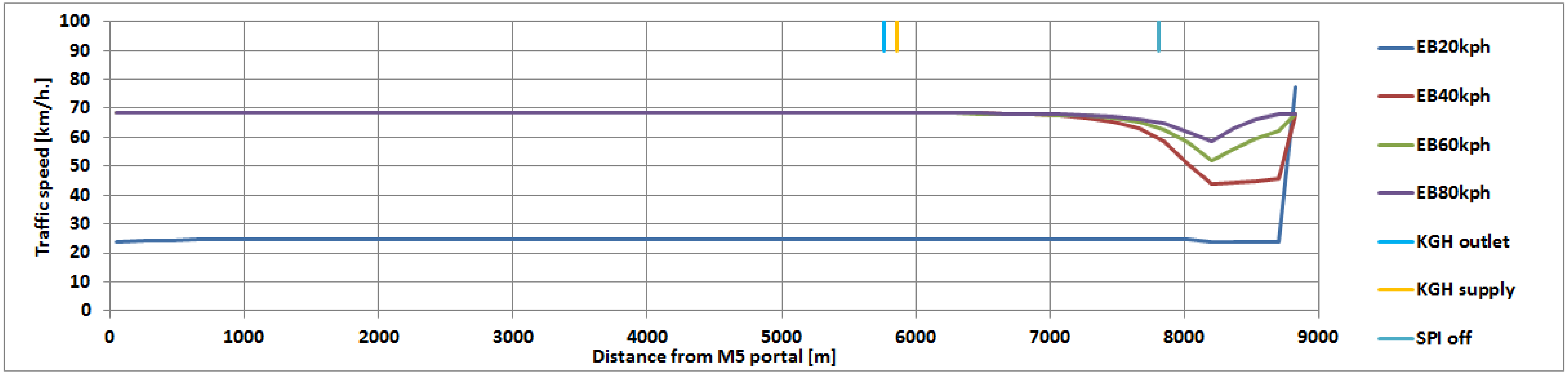

Figure 11.35. New M5 alone eastbound 2021 regulatory traffic speed profile; M5 to St Peters 9 am peak.

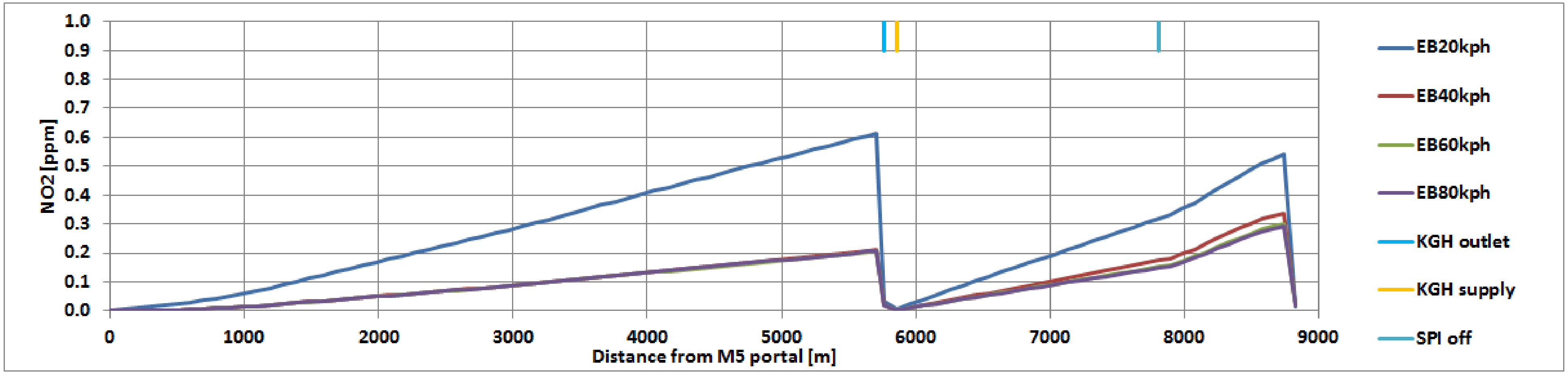

Figure 11.36. New M5 alone eastbound 2021 regulatory traffic NO_2 profile; M5 to St Peters 9 am peak.

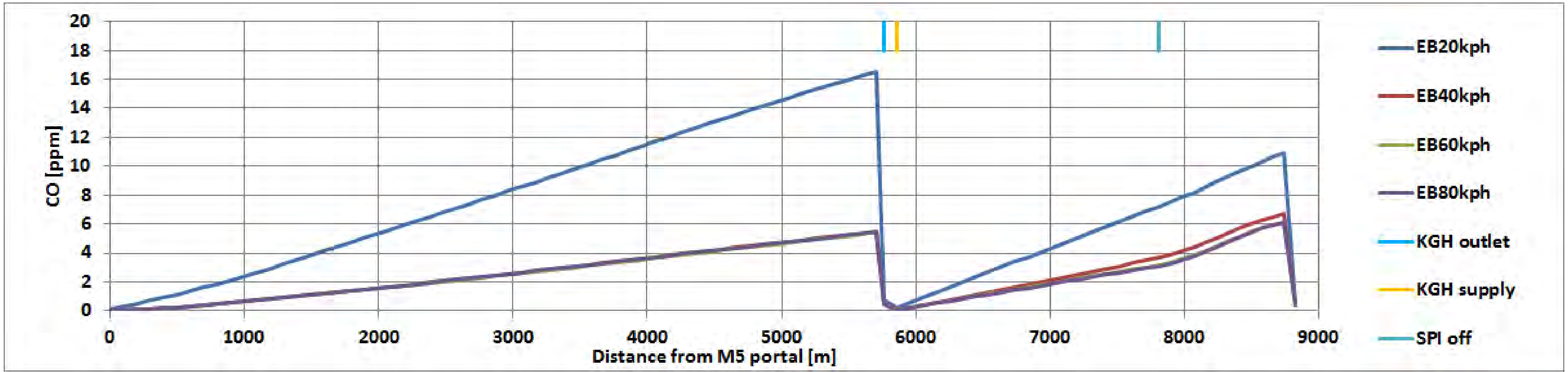

Figure 11.37. New M5 alone eastbound 2021 regulatory traffic CO profile; M5 to St Peters 9 am peak.

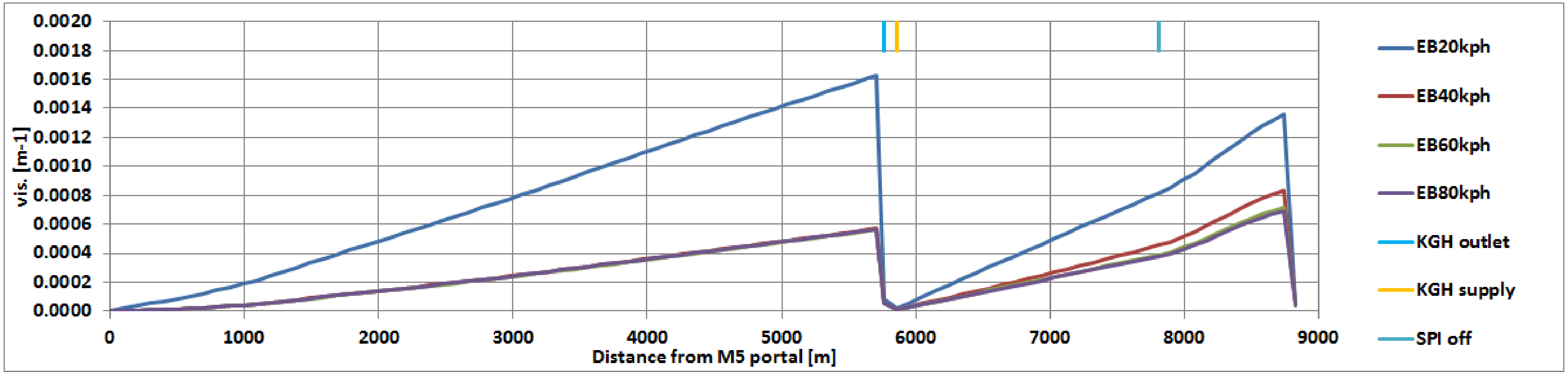

Figure 11.38. New M5 alone Eastbound 2021 regulatory traffic exhaust PM extinction coefficient profile; M5 to St Peters 9 am peak.

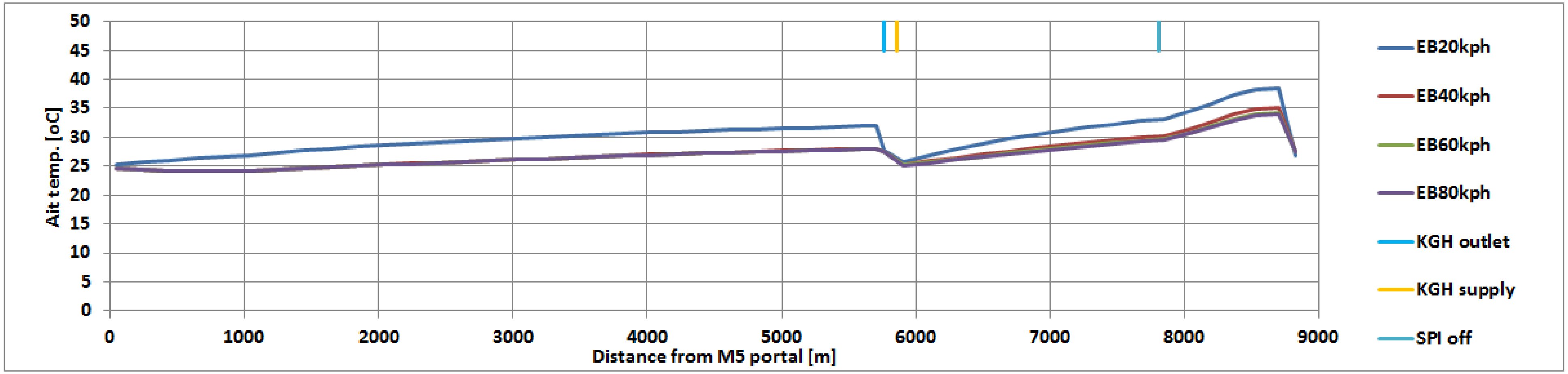

Figure 11.39. New M5 alone eastbound 2021 regulatory traffic air temperature (summer) profile; M5 to St Peters 9 am peak.

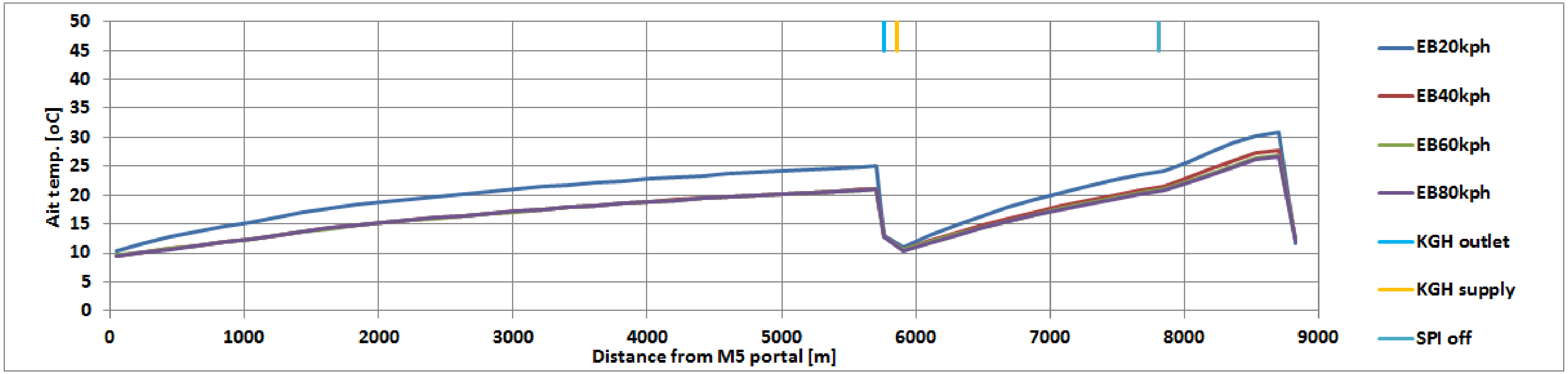

Figure 11.40. New M5 alone Eastbound 2021 regulatory traffic air temperature (winter) profile; M5 to St Peters 9 am peak.

APPENDIX A - NEW M5 ALONE 2021 SIMULATION RESULTS

Results from the simulation of New M5 alone for 2021 normal traffic.

Table A.1. New M5 normal eastbound 2021 traffic (summer). Stage 2 Eastbound 2021 24hrs Normal.xlsx

	New M5 traffic			Ambient	Peak in-tunnel levels (before Kogarah outlet)					Kogarah outlet								Peak in-tunnel levels (before SPI outlet)					SPI outlet						
Hour	M5 Flow (vph)	SPI off (vph)	Number of Jet Fans Main tube	(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	supply flow (m3/s)	exhaust flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	56	56	13.5	22.3	0.01	0.2	0.01	0.0000	24.5	112	370	0.005	0.07	0.004	0.0014	24.1	1.9	0.10	2.1	0.08	0.0002	29.1	125	0.009	0.12	0.004	0.0022	24.8	2.5
1	39	39	13.8	21.5	0.01	0.1	0.01	0.0000	24.4	109	366	0.004	0.04	0.003	0.0011	23.9	2.4	0.07	1.3	0.05	0.0001	28.6	123	0.006	0.07	0.002	0.0014	24.1	2.6
2	34	34	14.0	21.0	0.01	0.1	0.01	0.0000	24.4	108	365	0.003	0.03	0.003	0.0010	23.8	2.8	0.06	0.9	0.04	0.0001	28.5	121	0.005	0.05	0.002	0.0011	23.7	2.7
3	35	35	14.0	20.0	0.01	0.1	0.01	0.0000	24.3	108	365	0.003	0.03	0.003	0.0010	23.6	3.7	0.05	0.7	0.03	0.0001	28.4	121	0.005	0.04	0.001	0.0011	23.1	3.2
4	57	57	13.5	18.5	0.01	0.1	0.01	0.0000	24.3	111	374	0.005	0.05	0.003	0.0013	23.4	4.9	0.06	0.9	0.03	0.0001	28.5	125	0.005	0.05	0.002	0.0012	22.5	4.0
5	137	137	12.0	18.0	0.01	0.3	0.02	0.0000	24.4	122	395	0.009	0.13	0.007	0.0024	23.4	5.4	0.07	1.6	0.05	0.0002	29.1	136	0.009	0.12	0.003	0.0020	23.0	5.0
6	547	546	3.8	19.5	0.05	1.1	0.07	0.0001	24.9	177	490	0.039	0.56	0.031	0.0103	24.2	4.7	0.16	3.9	0.10	0.0003	31.0	193	0.037	0.55	0.012	0.0083	26.6	7.1
7	1,089	1,089	0.0	22.5	0.07	1.8	0.12	0.0002	25.4	297	569	0.072	1.11	0.060	0.0187	25.1	2.6	0.18	4.7	0.14	0.0004	31.0	316	0.089	1.37	0.033	0.0201	29.1	6.6
8	1,424	1,423	0.0	24.2	0.09	2.2	0.15	0.0002	25.8	374	613	0.103	1.44	0.083	0.0274	25.7	1.5	0.19	4.4	0.13	0.0004	31.3	395	0.123	1.71	0.043	0.0281	30.1	5.9
9	1,208	1,209	0.0	26.8	0.08	2.0	0.14	0.0002	25.7	334	585	0.087	1.22	0.070	0.0230	25.9	-0.9	0.19	4.3	0.13	0.0004	31.4	350	0.103	1.43	0.036	0.0235	30.4	3.6
10	1,084	1,084	0.0	31.6	0.08	1.8	0.13	0.0002	25.7	313	567	0.080	1.08	0.064	0.0215	26.3	-5.3	0.19	4.2	0.13	0.0004	31.6	326	0.096	1.26	0.033	0.0219	31.5	-0.1
11	1,038	1,038	0.0	34.3	0.08	1.7	0.13	0.0002	25.8	311	562	0.081	1.03	0.063	0.0221	26.7	-7.6	0.20	4.1	0.13	0.0004	33.6	322	0.097	1.21	0.033	0.0225	32.3	-1.9
12	829	830	0.0	34.3	0.07	1.5	0.11	0.0002	25.7	261	536	0.069	0.83	0.052	0.0192	26.6	-7.6	0.21	4.1	0.13	0.0005	33.5	272	0.081	0.96	0.026	0.0191	32.5	-1.7
13	708	708	0.0	34.1	0.07	1.3	0.10	0.0002	25.6	222	519	0.063	0.71	0.046	0.0177	26.6	-7.5	0.23	4.3	0.14	0.0005	33.2	234	0.073	0.81	0.023	0.0173	32.8	-1.2
14	715	715	0.0	34.2	0.07	1.3	0.10	0.0002	25.7	222	518	0.062	0.71	0.046	0.0174	26.6	-7.5	0.24	4.4	0.15	0.0005	33.3	233	0.076	0.83	0.024	0.0179	32.9	-1.2
15	864	864	0.0	34.2	0.07	1.5	0.11	0.0002	25.8	257	532	0.066	0.85	0.052	0.0178	26.8	-7.4	0.21	4.3	0.15	0.0005	33.5	268	0.083	1.00	0.028	0.0192	32.7	-1.5
16	940	940	0.0	33.8	0.07	1.6	0.12	0.0002	25.9	271	539	0.067	0.92	0.055	0.0178	26.8	-6.9	0.20	4.3	0.14	0.0004	33.2	283	0.082	1.07	0.029	0.0186	32.6	-1.1
17	771	771	0.0	32.9	0.06	1.4	0.11	0.0002	25.9	214	514	0.058	0.75	0.047	0.0155	26.7	-6.2	0.22	4.6	0.15	0.0005	33.0	226	0.066	0.82	0.023	0.0149	32.7	-0.1
18	742	742	0.0	31.9	0.06	1.3	0.10	0.0002	25.9	197	508	0.056	0.71	0.045	0.0149	26.6	-5.3	0.24	5.0	0.17	0.0005	33.4	210	0.066	0.80	0.023	0.0149	32.7	0.8
19	520	521	0.0	31.0	0.05	1.0	0.08	0.0001	25.7	83	476	0.043	0.51	0.034	0.0120	26.4	-4.5	0.41	8.0	0.24	0.0008	36.7	96	0.013	0.15	0.004	0.0029	31.5	0.6
20	418	418	5.2	30.1	0.04	0.9	0.07	0.0001	25.6	168	458	0.035	0.42	0.027	0.0098	26.3	-3.8	0.32	5.9	0.24	0.0007	32.4	181	0.066	0.73	0.025	0.0158	31.2	1.2
21	381	381	6.1	27.7	0.04	0.8	0.06	0.0001	25.6	163	450	0.032	0.38	0.024	0.0089	26.0	-1.7	0.20	3.8	0.13	0.0004	32.2	176	0.040	0.45	0.013	0.0093	30.1	2.4
22	381	381	6.3	23.9	0.04	0.8	0.06	0.0001	25.6	160	450	0.030	0.38	0.023	0.0082	25.4	1.5	0.19	3.8	0.13	0.0004	32.0	175	0.037	0.45	0.012	0.0087	28.5	4.6
23	147	148	11.4	21.8	0.02	0.4	0.03	0.0000	25.3	126	391	0.012	0.16	0.010	0.0031	24.7	3.0	0.15	3.1	0.11	0.0003	30.7	140	0.018	0.23	0.007	0.0043	25.8	4.1

Table A.2. New M5 normal eastbound 2021 traffic (winter). Stage 2 Eastbound 2021 24hrs Normal.xlsx

	New M5 traffic		Number	Ambient	Peak in-tunnel levels (before Kogarah outlet)					Kogarah outlet								Peak in-tunnel levels (before SPI outlet)					SPI outlet						
Hour	M5 Flow (vph)	SPI off (vph)	of Jet Fans Main tube	(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	supply flow (m3/s)	exhaust flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	56	56	15.2	10.8	0.01	0.2	0.01	0.0000	16.1	100	396	0.005	0.06	0.004	0.0013	15.2	4.5	0.13	2.8	0.10	0.0003	23.1	114	0.010	0.12	0.004	0.0022	14.6	3.9
1	39	39	15.5	10.3	0.01	0.1	0.01	0.0000	16.0	98	393	0.004	0.04	0.003	0.0011	15.1	4.8	0.10	1.9	0.07	0.0002	22.7	112	0.007	0.08	0.002	0.0015	14.0	3.8
2	34	34	15.6	9.6	0.01	0.1	0.01	0.0000	16.0	97	391	0.003	0.03	0.003	0.0010	14.9	5.4	0.08	1.4	0.05	0.0002	22.5	111	0.005	0.05	0.002	0.0012	13.5	3.9
3	35	35	15.6	9.1	0.01	0.1	0.01	0.0000	15.9	97	392	0.003	0.03	0.003	0.0010	14.8	5.8	0.07	1.1	0.05	0.0002	22.5	111	0.005	0.04	0.001	0.0011	13.1	4.1
4	57	57	15.1	8.5	0.01	0.1	0.01	0.0000	15.9	100	399	0.005	0.06	0.003	0.0013	14.8	6.3	0.07	1.2	0.04	0.0002	22.6	114	0.005	0.05	0.002	0.0013	13.1	4.6
5	137	137	13.6	7.5	0.01	0.3	0.02	0.0000	16.0	111	419	0.009	0.13	0.007	0.0024	14.7	7.2	0.09	1.9	0.06	0.0002	23.2	125	0.009	0.11	0.003	0.0020	13.7	6.2
6	547	546	5.5	6.5	0.04	1.1	0.07	0.0001	16.4	165	509	0.039	0.56	0.031	0.0103	15.3	8.8	0.17	4.2	0.11	0.0004	24.9	184	0.038	0.56	0.012	0.0085	17.4	10.9
7	1,089	1,089	0.0	6.5	0.07	1.8	0.12	0.0002	16.8	260	587	0.073	1.12	0.060	0.0187	15.8	9.3	0.21	5.4	0.16	0.0004	25.0	284	0.090	1.38	0.033	0.0203	20.2	13.7
8	1,424	1,423	0.0	7.8	0.09	2.1	0.15	0.0002	17.2	342	630	0.103	1.44	0.083	0.0274	16.3	8.5	0.21	4.8	0.15	0.0004	24.9	371	0.124	1.73	0.044	0.0284	21.5	13.7
9	1,208	1,209	0.0	10.0	0.08	1.9	0.13	0.0002	17.1	298	603	0.087	1.22	0.070	0.0230	16.4	6.5	0.21	4.8	0.14	0.0004	25.0	322	0.103	1.43	0.036	0.0235	21.5	11.6
10	1,084	1,084	0.0	12.7	0.08	1.7	0.12	0.0002	17.0	271	586	0.080	1.08	0.064	0.0215	16.6	4.0	0.22	4.8	0.15	0.0005	25.3	292	0.096	1.27	0.033	0.0219	22.0	9.4
11	1,038	1,038	0.0	13.9	0.08	1.7	0.12	0.0002	17.1	267	582	0.081	1.03	0.064	0.0221	16.8	2.9	0.23	4.8	0.15	0.0005	25.5	287	0.098	1.22	0.033	0.0227	22.4	8.5
12	829	830	0.0	13.9	0.07	1.4	0.11	0.0002	17.0	209	557	0.069	0.84	0.052	0.0192	16.7	2.8	0.26	5.2	0.17	0.0006	26.2	227	0.080	0.95	0.026	0.0186	22.0	8.1
13	708	708	0.0	14.0	0.07	1.2	0.10	0.0002	16.9	164	541	0.063	0.71	0.046	0.0178	16.6	2.6	0.33	6.2	0.20	0.0007	27.6	180	0.069	0.78	0.021	0.0163	21.7	7.7
14	715	715	0.0	14.0	0.07	1.3	0.10	0.0002	16.9	164	540	0.062	0.71	0.046	0.0174	16.6	2.6	0.37	6.7	0.23	0.0008	27.8	180	0.077	0.85	0.024	0.0183	21.8	7.8
15	864	864	0.0	13.5	0.07	1.4	0.11	0.0002	17.0	204	555	0.066	0.85	0.052	0.0179	16.7	3.2	0.30	6.0	0.21	0.0007	26.5	222	0.090	1.07	0.031	0.0211	22.0	8.5
16	940	940	0.0	13.0	0.07	1.6	0.11	0.0002	17.1	220	562	0.068	0.92	0.055	0.0178	16.7	3.7	0.26	5.6	0.18	0.0005	26.2	238	0.084	1.10	0.030	0.0193	22.0	9.0
17	771	771	0.0	12.5	0.06	1.3	0.10	0.0002	17.0	153	538	0.058	0.75	0.047	0.0156	16.5	4.0	0.32	6.7	0.21	0.0007	28.1	169	0.060	0.76	0.020	0.0134	21.0	8.5
18	742	742	2.5	12.0	0.06	1.3	0.10	0.0001	16.9	186	532	0.056	0.71	0.045	0.0149	16.4	4.4	0.28	5.7	0.20	0.0006	26.4	204	0.072	0.88	0.026	0.0166	21.0	9.0
19	520	521	5.6	12.0	0.05	1.0	0.08	0.0001	16.8	165	501	0.044	0.51	0.034	0.0121	16.2	4.2	0.26	4.9	0.18	0.0006	26.0	181	0.055	0.63	0.019	0.0127	20.0	8.0
20	418	418	7.4	11.9	0.04	0.8	0.06	0.0001	16.7	153	484	0.035	0.42	0.027	0.0098	16.1	4.2	0.24	4.5	0.16	0.0005	25.6	169	0.045	0.51	0.015	0.0106	19.3	7.5
21	381	381	8.1	9.9	0.04	0.8	0.06	0.0001	16.6	148	477	0.032	0.38	0.024	0.0089	15.8	5.9	0.23	4.3	0.15	0.0005	25.4	164	0.040	0.46	0.013	0.0095	18.2	8.3
22	381	381	8.3	8.0	0.04	0.8	0.06	0.0001	16.6	146	477	0.030	0.39	0.023	0.0082	15.5	7.5	0.22	4.4	0.14	0.0005	25.2	163	0.038	0.46	0.013	0.0089	17.2	9.2
23	147	148	13.3	8.0	0.02	0.4	0.03	0.0000	16.3	113	421	0.011	0.16	0.010	0.0030	15.0	7.0	0.18	3.8	0.13	0.0004	24.1	128	0.018	0.23	0.007	0.0043	14.4	6.4

Table A.3. New M5 normal westbound 2021 traffic (summer). Stage 2 Westbound 2021 24hr Normal.xlsx

Hour	Stage 2 traffic		No. of jet fans running	Ambient	Peak in-tunnel levels (Stage 2)					M5 stack						
	M5 off (vph)	SPI on (vph)		(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	263	263	0	22.0	0.10	2.2	0.09	0.0002	31.5	342	0.056	0.70	0.025	0.014	29.1	7.1
1	64	64	0	21.0	0.06	1.0	0.06	0.0001	30.8	253	0.019	0.21	0.009	0.005	27.2	6.2
2	57	57	0	20.9	0.05	0.8	0.04	0.0001	30.8	263	0.015	0.15	0.006	0.004	27.1	6.2
3	82	82	0	19.0	0.06	1.1	0.05	0.0001	30.8	288	0.019	0.22	0.008	0.005	26.9	7.9
4	105	106	0	18.0	0.07	1.2	0.05	0.0002	30.8	296	0.029	0.29	0.011	0.007	26.9	8.9
5	259	259	0	18.0	0.10	2.2	0.09	0.0002	31.2	366	0.057	0.73	0.024	0.014	28.0	10.0
6	380	380	0	21.0	0.14	2.7	0.12	0.0003	31.5	414	0.086	1.02	0.036	0.021	29.1	8.1
7	768	769	0	24.0	0.18	4.1	0.18	0.0004	32.1	471	0.148	1.97	0.069	0.035	30.7	6.7
8	569	568	0	24.4	0.17	3.4	0.16	0.0004	31.9	455	0.119	1.45	0.053	0.029	30.4	6.0
9	829	830	0	29.2	0.23	4.1	0.20	0.0005	32.5	492	0.188	2.07	0.081	0.046	32.0	2.8
10	813	813	0	34.0	0.26	4.2	0.22	0.0006	34.5	505	0.204	2.02	0.084	0.051	32.9	-1.1
11	888	890	0	34.5	0.26	4.2	0.22	0.0006	34.7	497	0.238	2.25	0.095	0.060	33.3	-1.2
12	808	806	0	34.0	0.24	4.1	0.21	0.0006	34.3	492	0.197	2.04	0.082	0.049	33.0	-1.0
13	823	823	0	34.1	0.25	4.2	0.21	0.0006	34.5	496	0.216	2.07	0.087	0.054	33.2	-0.9
14	847	847	0	34.2	0.25	4.4	0.22	0.0006	34.6	502	0.210	2.13	0.087	0.052	33.2	-1.0
15	931	932	0	34.2	0.26	5.0	0.23	0.0006	34.8	535	0.209	2.36	0.090	0.051	33.3	-0.9
16	1175	1177	0	33.3	0.27	5.7	0.25	0.0006	34.6	572	0.255	3.06	0.111	0.062	33.6	0.3
17	1481	1483	0	32.4	0.26	6.0	0.25	0.0006	33.9	554	0.275	3.87	0.130	0.065	33.8	1.4
18	1014	1012	0	31.4	0.22	5.0	0.21	0.0005	33.2	513	0.193	2.65	0.090	0.046	33.0	1.6
19	772	772	0	30.5	0.19	4.2	0.18	0.0004	32.8	469	0.152	2.04	0.069	0.036	32.5	2.0
20	692	691	0	29.6	0.17	4.0	0.17	0.0004	32.6	451	0.131	1.84	0.061	0.031	32.2	2.6
21	633	632	0	25.8	0.16	3.7	0.16	0.0004	32.5	444	0.120	1.68	0.056	0.028	31.4	5.6
22	598	597	0	22.0	0.16	3.4	0.15	0.0004	32.4	427	0.116	1.58	0.054	0.028	30.6	8.6
23	439	437	0	22.5	0.15	2.9	0.13	0.0003	32.0	411	0.099	1.16	0.042	0.024	30.0	7.5

Table A.4. New M5 normal westbound 2021 traffic (winter). Stage 2 Westbound 2021 24hr Normal.xlsx

Hour	New M5 traffic		No. of jet fans running	Ambient	Peak in-tunnel levels (New M5)					M5 outlet						
	M5 off (vph)	SPI on (vph)		(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	263	263	0	10.5	0.10	2.1	0.09	0.0002	23.8	344	0.056	0.71	0.025	0.014	20.4	9.9
1	64	64	0	10.0	0.05	0.9	0.05	0.0001	23.2	265	0.019	0.21	0.009	0.005	18.5	8.5
2	57	57	0	9.1	0.04	0.8	0.04	0.0001	23.1	276	0.015	0.15	0.006	0.004	18.2	9.1
3	82	82	0	9.0	0.05	1.0	0.04	0.0001	23.2	296	0.019	0.22	0.008	0.005	18.5	9.5
4	105	106	0	8.0	0.08	1.4	0.06	0.0002	23.3	345	0.029	0.29	0.011	0.007	18.6	10.6
5	258	259	0	7.0	0.10	2.2	0.09	0.0002	23.6	390	0.058	0.73	0.024	0.014	19.5	12.5
6	379	380	0	6.0	0.13	2.6	0.12	0.0003	23.8	415	0.086	1.03	0.037	0.021	19.9	13.9
7	768	769	0	7.0	0.18	3.9	0.17	0.0004	24.4	486	0.149	1.98	0.070	0.035	21.3	14.3
8	569	568	0	8.6	0.16	3.3	0.15	0.0004	24.2	469	0.120	1.46	0.054	0.029	21.1	12.5
9	829	830	0	11.3	0.22	4.0	0.20	0.0005	24.7	508	0.189	2.08	0.082	0.046	22.4	11.1
10	813	813	0	14.0	0.25	4.1	0.21	0.0006	24.9	522	0.206	2.03	0.085	0.051	23.0	9.0
11	888	890	0	13.8	0.25	4.0	0.21	0.0006	25.0	515	0.239	2.26	0.095	0.060	23.4	9.6
12	808	806	0	14.0	0.24	4.0	0.20	0.0006	24.9	510	0.198	2.05	0.082	0.049	23.1	9.1
13	823	823	0	14.0	0.24	4.0	0.21	0.0006	25.0	514	0.217	2.08	0.087	0.055	23.3	9.3
14	847	847	0	14.0	0.24	4.2	0.21	0.0006	25.1	521	0.211	2.14	0.087	0.053	23.3	9.3
15	931	932	0	13.0	0.25	4.9	0.22	0.0006	25.3	554	0.210	2.37	0.091	0.051	23.2	10.2
16	1175	1177	0	13.0	0.26	5.6	0.24	0.0006	25.6	590	0.256	3.07	0.112	0.062	23.7	10.7
17	1481	1483	0	12.0	0.25	5.8	0.25	0.0006	25.6	572	0.276	3.89	0.131	0.065	24.0	12.0
18	1014	1012	0	12.0	0.21	4.7	0.20	0.0005	25.2	522	0.194	2.66	0.090	0.046	23.2	11.2
19	773	772	0	12.0	0.18	4.1	0.17	0.0004	24.9	487	0.152	2.05	0.070	0.037	22.7	10.7
20	692	691	0	11.7	0.16	3.8	0.16	0.0004	24.7	469	0.131	1.85	0.061	0.031	22.4	10.7
21	633	632	0	8.0	0.15	3.5	0.15	0.0003	24.6	462	0.120	1.69	0.056	0.029	21.5	13.5
22	598	597	0	8.0	0.15	3.3	0.14	0.0003	24.5	441	0.117	1.58	0.054	0.028	21.4	13.4
23	438	437	0	11.0	0.15	2.8	0.13	0.0003	24.3	421	0.099	1.16	0.042	0.024	21.4	10.4

APPENDIX B - NEW M5 ALONE 2031 SIMULATION RESULTS

Results from the simulation of New M5 alone for 2031 normal traffic.

Table B.1. New M5 alone normal eastbound 2031 traffic (summer). Stage 2 Eastbound with Kogarah 2031 24hr summary.xls

Hour	New M5 traffic		Number of Jet Fans Main tube	Ambient	Peak in-tunnel levels (before Kogorah outlet)					Kogorah outlet								Peak in-tunnel levels (before SPI outlet)					SPI outlet						
	M5 Flow (vph)	SPI off (vph)		(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	supply flow (m3/s)	exhaust flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	69	69	12.9	22.3	0.01	0.2	0.02	0.0000	25.5	116	373	0.007	0.08	0.005	0.0019	24.9	2.7	0.11	2.0	0.08	0.0002	30.7	130	0.011	0.13	0.004	0.0027	25.6	3.4
1	45	45	13.4	21.5	0.01	0.1	0.01	0.0000	25.4	112	367	0.005	0.05	0.003	0.0013	24.7	3.2	0.08	1.3	0.05	0.0002	30.2	126	0.007	0.08	0.003	0.0017	24.9	3.4
2	41	41	13.6	21.0	0.01	0.1	0.01	0.0000	25.3	111	365	0.004	0.04	0.003	0.0012	24.6	3.6	0.06	0.9	0.04	0.0001	30.0	125	0.006	0.05	0.002	0.0014	24.4	3.5
3	41	41	13.6	20.0	0.01	0.1	0.01	0.0000	25.3	111	366	0.004	0.04	0.003	0.0012	24.4	4.4	0.06	0.8	0.03	0.0001	30.0	125	0.005	0.05	0.002	0.0012	23.9	3.9
4	69	69	12.9	18.5	0.01	0.2	0.01	0.0000	25.3	115	377	0.006	0.07	0.004	0.0017	24.2	5.7	0.06	1.0	0.04	0.0001	30.2	129	0.007	0.06	0.002	0.0016	23.4	4.9
5	163	163	11.1	18.0	0.02	0.4	0.03	0.0000	25.4	127	402	0.012	0.16	0.009	0.0031	24.3	6.3	0.09	1.8	0.05	0.0002	30.8	142	0.012	0.14	0.004	0.0026	24.0	6.0
6	642	641	1.8	19.5	0.05	1.2	0.08	0.0001	26.0	191	508	0.048	0.65	0.037	0.0130	25.2	5.7	0.18	4.2	0.11	0.0004	32.9	208	0.048	0.67	0.015	0.0109	28.1	8.6
7	1,290	1,289	0.0	22.5	0.08	2.1	0.14	0.0002	26.5	345	596	0.089	1.31	0.072	0.0231	26.2	3.7	0.18	4.5	0.13	0.0004	32.5	367	0.108	1.59	0.039	0.0245	30.6	8.1
8	1,672	1,671	0.0	24.2	0.11	2.4	0.18	0.0003	27.0	417	640	0.129	1.66	0.101	0.0351	26.8	2.6	0.21	4.4	0.14	0.0005	33.2	441	0.156	1.94	0.053	0.0362	31.8	7.6
9	1,440	1,441	0.0	26.8	0.10	2.2	0.16	0.0002	26.9	383	614	0.108	1.44	0.086	0.0290	27.0	0.2	0.20	4.3	0.13	0.0004	33.1	402	0.130	1.69	0.045	0.0299	31.9	5.1
10	1,296	1,296	0.0	31.6	0.09	2.0	0.15	0.0002	26.9	364	596	0.100	1.28	0.079	0.0272	27.4	-4.2	0.20	4.1	0.13	0.0004	33.3	379	0.121	1.50	0.041	0.0280	32.9	1.3
11	1,203	1,203	0.0	34.3	0.10	1.9	0.15	0.0003	27.0	357	587	0.100	1.19	0.076	0.0277	27.7	-6.5	0.21	3.9	0.13	0.0005	33.8	369	0.121	1.39	0.040	0.0284	33.6	-0.6
12	993	994	0.0	34.3	0.09	1.7	0.13	0.0002	26.9	316	562	0.087	0.99	0.065	0.0245	27.7	-6.6	0.21	3.8	0.13	0.0005	33.7	328	0.105	1.15	0.033	0.0250	33.7	-0.6
13	851	851	0.0	34.1	0.08	1.5	0.12	0.0002	26.9	282	544	0.080	0.84	0.058	0.0228	27.7	-6.4	0.22	3.7	0.13	0.0005	33.9	295	0.096	0.98	0.030	0.0231	33.8	-0.3
14	852	852	0.0	34.2	0.08	1.5	0.12	0.0002	26.9	280	542	0.078	0.84	0.057	0.0223	27.7	-6.4	0.22	3.8	0.14	0.0005	33.9	293	0.096	0.99	0.030	0.0230	33.8	-0.3
15	1,035	1,035	0.0	34.2	0.08	1.7	0.13	0.0002	27.1	312	559	0.083	1.01	0.065	0.0227	27.9	-6.3	0.20	3.9	0.13	0.0004	33.9	325	0.102	1.18	0.034	0.0238	33.9	-0.3
16	1,127	1,127	0.0	33.8	0.08	1.8	0.14	0.0002	27.2	325	566	0.085	1.10	0.068	0.0227	28.0	-5.8	0.19	4.0	0.13	0.0004	33.9	338	0.103	1.27	0.036	0.0235	33.8	0.1
17	1,065	1,065	0.0	32.9	0.08	1.7	0.13	0.0002	27.3	306	556	0.080	1.03	0.065	0.0213	27.9	-4.9	0.20	4.0	0.14	0.0004	34.1	319	0.096	1.18	0.034	0.0219	33.7	0.9
18	892	892	0.0	31.9	0.08	1.5	0.12	0.0002	27.2	260	533	0.070	0.85	0.056	0.0191	27.8	-4.1	0.21	4.0	0.14	0.0005	34.4	274	0.084	0.96	0.028	0.0192	33.6	1.7
19	627	628	0.0	31.0	0.06	1.2	0.10	0.0002	27.0	173	497	0.055	0.61	0.042	0.0155	27.5	-3.4	0.27	4.7	0.17	0.0006	35.7	187	0.059	0.62	0.018	0.0136	33.5	2.6
20	487	487	0.0	30.1	0.05	1.0	0.08	0.0001	26.9	91	474	0.044	0.48	0.033	0.0126	27.3	-2.7	0.44	7.7	0.25	0.0010	38.8	104	0.022	0.22	0.006	0.0051	31.9	1.8
21	456	456	4.2	27.7	0.05	0.9	0.07	0.0001	26.9	175	467	0.040	0.45	0.030	0.0113	27.1	-0.6	0.28	4.8	0.19	0.0006	34.3	189	0.064	0.66	0.022	0.0153	31.5	3.8
22	437	437	4.9	23.9	0.05	0.9	0.07	0.0001	26.8	170	463	0.036	0.44	0.027	0.0100	26.5	2.6	0.21	3.9	0.13	0.0005	34.0	186	0.046	0.52	0.015	0.0107	29.9	6.0
23	158	159	10.7	21.8	0.02	0.4	0.03	0.0001	26.5	130	394	0.014	0.18	0.011	0.0038	25.8	4.0	0.16	3.1	0.11	0.0004	32.5	145	0.022	0.25	0.008	0.0051	26.9	5.1

Table B.2. New M5 alone normal eastbound 2031 traffic (winter). Stage 2 Eastbound with Kogarah 2031 24hr summary.xls

	New M5 traffic			Ambient	Peak in-tunnel levels (before Kogorah outlet)					Kogorah outlet								Peak in-tunnel levels (before SPI outlet)					SPI outlet						
Hour	M5 Flow (vph)	SPI off (vph)	Number of Jet Fans Main tube	(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	supply flow (m3/s)	exhaust flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	69	69	14.7	10.8	0.01	0.2	0.02	0.0000	15.7	103	400	0.006	0.07	0.005	0.0018	14.9	4.2	0.15	2.8	0.10	0.0003	24.2	117	0.012	0.13	0.004	0.0028	15.2	4.5
1	45	45	15.2	10.3	0.01	0.1	0.01	0.0000	15.6	100	394	0.004	0.05	0.003	0.0013	14.8	4.5	0.11	1.9	0.08	0.0002	23.7	114	0.008	0.08	0.003	0.0018	14.5	4.2
2	41	41	15.4	9.6	0.01	0.1	0.01	0.0000	15.6	99	393	0.004	0.04	0.003	0.0012	14.6	5.1	0.09	1.4	0.06	0.0002	23.5	113	0.006	0.06	0.002	0.0015	13.9	4.3
3	41	41	15.4	9.1	0.01	0.1	0.01	0.0000	15.6	99	393	0.004	0.04	0.003	0.0012	14.5	5.5	0.08	1.2	0.05	0.0002	23.5	113	0.005	0.05	0.002	0.0013	13.6	4.5
4	69	69	14.6	8.5	0.01	0.2	0.01	0.0000	15.6	103	403	0.006	0.07	0.004	0.0018	14.5	6.0	0.08	1.3	0.05	0.0002	23.7	118	0.007	0.06	0.002	0.0016	13.7	5.2
5	163	163	12.9	7.5	0.02	0.4	0.03	0.0000	15.6	115	426	0.012	0.16	0.009	0.0031	14.5	7.0	0.11	2.1	0.06	0.0002	24.3	130	0.012	0.14	0.003	0.0027	14.5	7.0
6	642	641	3.5	6.5	0.05	1.2	0.08	0.0001	16.2	178	527	0.048	0.66	0.037	0.0130	15.1	8.6	0.20	4.5	0.13	0.0004	26.2	198	0.049	0.67	0.016	0.0111	18.7	12.2
7	1,290	1,289	0.0	6.5	0.08	2.0	0.13	0.0002	16.7	311	613	0.089	1.31	0.073	0.0232	15.7	9.2	0.20	5.0	0.15	0.0004	25.7	339	0.110	1.62	0.040	0.0251	21.5	15.0
8	1,672	1,671	0.0	7.8	0.11	2.4	0.17	0.0003	17.1	387	657	0.129	1.67	0.101	0.0352	16.3	8.5	0.22	4.6	0.15	0.0005	26.0	420	0.157	1.96	0.053	0.0364	22.8	15.0
9	1,440	1,441	0.0	10.0	0.10	2.1	0.15	0.0002	17.0	350	632	0.108	1.44	0.086	0.0291	16.4	6.4	0.21	4.6	0.15	0.0005	25.9	377	0.130	1.69	0.045	0.0300	22.8	12.8
10	1,296	1,296	0.0	12.7	0.09	2.0	0.14	0.0002	17.0	326	614	0.101	1.29	0.079	0.0273	16.6	4.0	0.22	4.5	0.15	0.0005	26.0	350	0.122	1.51	0.041	0.0281	23.2	10.5
11	1,203	1,203	0.0	13.9	0.09	1.8	0.14	0.0002	17.0	316	607	0.100	1.19	0.076	0.0278	16.8	2.9	0.23	4.4	0.15	0.0005	26.2	338	0.122	1.40	0.040	0.0286	23.5	9.6
12	993	994	0.0	13.9	0.08	1.6	0.13	0.0002	16.9	270	583	0.087	0.99	0.065	0.0245	16.7	2.8	0.24	4.4	0.15	0.0005	26.4	291	0.105	1.16	0.033	0.0249	23.1	9.2
13	851	851	0.0	14.0	0.08	1.4	0.12	0.0002	16.9	232	565	0.080	0.84	0.058	0.0228	16.6	2.6	0.27	4.6	0.16	0.0006	26.9	251	0.096	0.98	0.029	0.0228	22.9	8.9
14	852	852	0.0	14.0	0.08	1.4	0.11	0.0002	16.9	230	564	0.078	0.84	0.057	0.0224	16.6	2.6	0.28	4.7	0.17	0.0006	27.0	249	0.097	1.00	0.030	0.0233	23.0	9.0
15	1,035	1,035	0.0	13.5	0.08	1.6	0.13	0.0002	17.0	265	581	0.083	1.01	0.065	0.0228	16.7	3.2	0.25	4.7	0.16	0.0005	26.5	286	0.105	1.20	0.035	0.0247	23.1	9.6
16	1,127	1,127	0.0	13.0	0.08	1.8	0.13	0.0002	17.1	280	588	0.085	1.10	0.068	0.0227	16.8	3.8	0.23	4.7	0.16	0.0005	26.4	301	0.104	1.29	0.036	0.0239	23.1	10.1
17	1,065	1,065	0.0	12.5	0.08	1.7	0.13	0.0002	17.1	258	578	0.080	1.03	0.065	0.0214	16.7	4.2	0.23	4.8	0.16	0.0005	26.6	279	0.096	1.18	0.034	0.0220	22.8	10.3
18	892	892	0.0	12.0	0.07	1.4	0.12	0.0002	17.0	206	556	0.070	0.85	0.056	0.0192	16.5	4.5	0.27	5.2	0.18	0.0006	27.4	225	0.082	0.95	0.027	0.0187	22.2	10.2
19	627	628	0.0	12.0	0.06	1.1	0.09	0.0002	16.9	101	522	0.055	0.61	0.042	0.0156	16.3	4.3	0.46	8.3	0.26	0.0010	32.3	116	0.036	0.39	0.011	0.0082	18.7	6.7
20	487	487	5.6	11.9	0.05	0.9	0.08	0.0001	16.7	165	500	0.044	0.48	0.033	0.0126	16.1	4.3	0.40	6.8	0.29	0.0009	27.2	182	0.086	0.87	0.031	0.0207	20.7	8.8
21	456	456	6.5	9.9	0.05	0.9	0.07	0.0001	16.7	159	493	0.040	0.45	0.030	0.0113	15.9	6.0	0.25	4.4	0.16	0.0006	26.6	176	0.051	0.54	0.016	0.0122	19.4	9.5
22	437	437	7.0	8.0	0.04	0.9	0.06	0.0001	16.6	155	490	0.036	0.44	0.027	0.0099	15.6	7.6	0.24	4.5	0.15	0.0005	26.3	172	0.046	0.53	0.015	0.0109	18.2	10.2
23	158	159	12.8	8.0	0.02	0.4	0.03	0.0000	16.3	116	425	0.013	0.17	0.011	0.0037	15.0	7.0	0.20	3.8	0.14	0.0004	25.1	131	0.021	0.25	0.007	0.0050	15.1	7.1

Table B.3. New M5 alone normal westbound 2031 traffic (summer). Stage 2 Westbound 2031 24hr summary.xlsx

Hour	New M5 traffic		No. of jet fans running	Ambient	Peak in-tunnel levels (New M5)					M5 outlet						
	M5 off (vph)	SPI on (vph)		(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	301	301	0	22.0	0.11	2.3	0.10	0.0003	33.2	360	0.067	0.80	0.029	0.016	30.5	8.5
1	75	75	0	21.0	0.06	1.0	0.06	0.0001	32.5	267	0.022	0.23	0.011	0.006	28.5	7.5
2	66	66	0	20.9	0.05	0.9	0.04	0.0001	32.4	276	0.019	0.17	0.007	0.005	28.4	7.5
3	94	94	0	19.0	0.06	1.1	0.05	0.0002	32.5	303	0.022	0.25	0.009	0.006	28.1	9.1
4	122	123	0	18.0	0.08	1.2	0.06	0.0002	32.5	312	0.036	0.33	0.013	0.009	28.3	10.3
5	285	285	0	18.0	0.11	2.2	0.10	0.0003	32.9	381	0.067	0.79	0.028	0.017	29.4	11.4
6	401	401	0	21.0	0.16	2.9	0.13	0.0004	33.3	454	0.102	1.08	0.041	0.026	30.6	9.6
7	892	893	0	24.0	0.21	4.3	0.20	0.0005	33.9	501	0.181	2.27	0.083	0.043	32.3	8.3
8	758	757	0	24.4	0.21	4.0	0.19	0.0005	33.9	501	0.165	1.92	0.073	0.040	32.2	7.8
9	967	968	0	29.2	0.26	4.4	0.23	0.0006	34.4	525	0.232	2.39	0.098	0.057	33.6	4.4
10	952	952	0	34.0	0.29	4.4	0.24	0.0007	34.9	534	0.254	2.34	0.102	0.064	34.5	0.5
11	1016	1017	0	34.5	0.28	4.4	0.23	0.0007	35.2	527	0.285	2.55	0.111	0.072	34.9	0.4
12	943	941	0	34.0	0.28	4.4	0.23	0.0007	34.9	526	0.245	2.36	0.099	0.061	34.6	0.6
13	963	964	0	34.1	0.29	4.4	0.24	0.0007	35.1	528	0.269	2.39	0.106	0.068	34.9	0.8
14	970	970	0	34.2	0.28	4.7	0.24	0.0007	35.2	535	0.258	2.42	0.103	0.065	34.9	0.7
15	1082	1083	0	34.2	0.30	5.4	0.26	0.0007	35.5	569	0.257	2.71	0.109	0.064	35.0	0.8
16	1365	1367	0	33.3	0.31	5.9	0.27	0.0007	35.4	604	0.313	3.52	0.133	0.077	35.3	2.0
17	1846	1847	0	32.4	0.32	6.9	0.31	0.0007	35.9	614	0.363	4.67	0.168	0.088	35.8	3.4
18	1169	1170	0	31.4	0.25	5.3	0.23	0.0006	35.1	543	0.235	3.03	0.107	0.056	34.7	3.3
19	893	893	0	30.5	0.22	4.5	0.20	0.0005	34.7	501	0.185	2.34	0.083	0.045	34.1	3.6
20	797	797	0	29.6	0.19	4.2	0.18	0.0004	34.5	476	0.158	2.10	0.072	0.038	33.8	4.2
21	716	715	0	25.8	0.18	3.9	0.17	0.0004	34.3	462	0.145	1.89	0.065	0.035	33.0	7.2
22	633	632	0	22.0	0.16	3.2	0.15	0.0004	34.1	429	0.133	1.66	0.059	0.032	32.1	10.1
23	452	451	0	22.5	0.15	2.9	0.13	0.0003	33.6	416	0.099	1.18	0.043	0.024	31.3	8.8

Table B.4. New M5 alone normal westbound 2031 traffic (winter). Stage 2 Westbound 2031 24hr summary.xlsx

Hour	New M5 traffic		No. of jet fans running	Ambient	Peak in-tunnel levels (New M5)					M5 outlet						
	M5 off (vph)	SPI on (vph)		(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	301	301	0	10.5	0.11	2.2	0.10	0.0003	25.2	361	0.067	0.80	0.029	0.016	21.6	11.1
1	75	75	0	10.0	0.06	1.0	0.05	0.0001	24.5	277	0.022	0.23	0.011	0.005	19.6	9.6
2	66	66	0	9.1	0.05	0.8	0.04	0.0001	24.4	287	0.019	0.17	0.008	0.005	19.2	10.1
3	94	94	0	9.0	0.06	1.1	0.05	0.0001	24.5	310	0.022	0.25	0.009	0.006	19.5	10.5
4	122	123	0	8.0	0.09	1.5	0.07	0.0002	24.7	359	0.037	0.34	0.013	0.009	19.7	11.7
5	284	285	0	7.0	0.12	2.3	0.10	0.0003	24.9	405	0.068	0.79	0.028	0.017	20.6	13.6
6	400	401	0	6.0	0.15	2.6	0.12	0.0004	25.1	430	0.103	1.09	0.041	0.026	21.1	15.1
7	892	893	0	7.0	0.20	4.3	0.19	0.0005	25.8	519	0.182	2.28	0.083	0.044	22.7	15.7
8	758	757	0	8.6	0.20	3.8	0.18	0.0005	25.7	502	0.165	1.92	0.073	0.040	22.7	14.1
9	967	968	0	11.3	0.25	4.3	0.22	0.0006	26.2	539	0.234	2.41	0.099	0.058	23.9	12.6
10	952	952	0	14.0	0.28	4.3	0.23	0.0007	26.5	550	0.255	2.35	0.103	0.064	24.5	10.5
11	1016	1017	0	13.8	0.29	4.3	0.24	0.0007	26.5	547	0.287	2.56	0.112	0.073	24.8	11.0
12	942	941	0	14.0	0.28	4.3	0.23	0.0007	26.5	543	0.245	2.37	0.099	0.062	24.5	10.5
13	963	964	0	14.0	0.28	4.3	0.23	0.0007	26.6	545	0.270	2.41	0.106	0.068	24.7	10.7
14	970	970	0	14.0	0.27	4.4	0.23	0.0007	26.6	551	0.260	2.44	0.104	0.065	24.7	10.7
15	1083	1084	0	13.0	0.28	5.0	0.24	0.0007	26.8	583	0.259	2.73	0.109	0.064	24.7	11.7
16	1365	1367	0	13.0	0.30	5.7	0.27	0.0007	27.2	622	0.314	3.53	0.134	0.077	25.3	12.3
17	1846	1847	0	12.0	0.31	6.7	0.30	0.0007	27.6	631	0.364	4.69	0.169	0.088	25.9	13.9
18	1169	1170	0	12.0	0.24	5.1	0.23	0.0005	26.8	559	0.236	3.05	0.107	0.057	24.7	12.7
19	894	893	0	12.0	0.21	4.4	0.19	0.0005	26.4	516	0.186	2.35	0.083	0.045	24.1	12.1
20	798	797	0	11.7	0.19	4.1	0.18	0.0004	26.2	496	0.159	2.11	0.073	0.038	23.7	12.0
21	716	715	0	8.0	0.17	3.7	0.16	0.0004	26.1	481	0.145	1.90	0.066	0.035	22.9	14.9
22	633	632	0	8.0	0.16	3.2	0.15	0.0004	25.8	446	0.133	1.66	0.059	0.032	22.6	14.6
23	452	450	0	11.0	0.14	2.8	0.13	0.0003	25.6	424	0.099	1.18	0.043	0.024	22.5	11.5

APPENDIX C - NEW M5 WITH M4-M5 LINK 2031 SIMULATION RESULTS

Results from the simulation of New M5 and M4-M5 Link for 2031 normal traffic.

Table C.1. New M5 with M4-M5 Link normal eastbound 2031 traffic (summer). Stage 2 and 3 normal EB 2031.xlsx

Hour	New M5 traffic			No. of jet fans running		Ambient	Peak in-tunnel levels (before Kogarah outlet)					Kogarah outlet								Peak in-tunnel levels (before SPI outlet)					SPI outlet						
	M5 on (vph)	SC on (vph)	SPI off (vph)	SC	Main tube	(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	supply flow (m3/s)	exhaust flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	53	154	140	0.0	19.1	22.3	0.01	0.3	0.02	0.0000	25.2	345	674	0.012	0.18	0.010	0.0032	24.3	2.0	0.03	0.8	0.02	0.0001	28.7	256	0.011	0.18	0.004	0.0023	26.7	4.5
1	32	89	69	0.0	20.2	21.5	0.01	0.2	0.01	0.0000	25.1	337	653	0.007	0.10	0.006	0.0020	24.1	2.6	0.02	0.5	0.01	0.0000	28.3	248	0.006	0.10	0.002	0.0014	26.2	4.7
2	27	49	58	0.0	21.0	21.0	0.00	0.1	0.01	0.0000	25.0	332	641	0.005	0.06	0.004	0.0014	24.0	3.0	0.01	0.3	0.01	0.0000	28.1	260	0.005	0.07	0.002	0.0011	26.0	5.0
3	27	49	61	0.0	21.1	20.0	0.00	0.1	0.01	0.0000	24.9	332	642	0.005	0.06	0.004	0.0014	23.8	3.9	0.01	0.3	0.01	0.0000	28.0	264	0.005	0.07	0.002	0.0013	25.7	5.7
4	45	126	127	0.0	19.9	18.5	0.01	0.3	0.02	0.0000	24.9	339	666	0.008	0.13	0.007	0.0022	23.7	5.2	0.02	0.6	0.02	0.0000	28.1	267	0.008	0.14	0.003	0.0018	25.4	6.9
5	108	251	252	0.0	17.7	18.0	0.01	0.5	0.03	0.0000	25.0	354	710	0.017	0.29	0.015	0.0042	23.8	5.8	0.04	1.2	0.03	0.0001	28.3	267	0.015	0.28	0.006	0.0032	25.4	7.4
6	427	1,041	966	0.0	5.0	19.5	0.04	1.5	0.09	0.0001	25.6	440	907	0.067	1.21	0.061	0.0166	24.5	5.0	0.12	4.2	0.10	0.0002	30.5	279	0.050	1.03	0.021	0.0104	27.6	8.1
7	860	2,025	2,356	0.0	0.0	22.5	0.07	2.4	0.14	0.0001	26.2	580	1,063	0.127	2.36	0.120	0.0311	25.3	2.8	0.17	5.7	0.15	0.0003	31.9	453	0.132	2.63	0.056	0.0282	30.5	8.0
8	963	2,569	2,620	0.0	0.0	24.2	0.09	2.9	0.18	0.0002	26.7	654	1,117	0.168	2.83	0.154	0.0433	25.8	1.6	0.20	6.0	0.16	0.0004	32.8	458	0.159	2.80	0.064	0.0350	31.5	7.3
9	957	2,111	2,373	0.0	0.0	26.8	0.08	2.5	0.16	0.0002	26.6	617	1,085	0.151	2.49	0.137	0.0387	25.8	-1.0	0.19	5.7	0.15	0.0004	32.7	451	0.148	2.60	0.059	0.0324	31.8	5.0
10	860	1,835	2,037	0.0	0.0	31.6	0.07	2.3	0.14	0.0002	26.6	592	1,048	0.135	2.19	0.121	0.0349	26.1	-5.5	0.19	5.4	0.15	0.0004	32.8	420	0.130	2.24	0.051	0.0286	32.6	1.0
11	771	1,605	1,835	0.0	0.0	34.3	0.07	2.1	0.13	0.0002	26.6	566	1,018	0.124	1.95	0.109	0.0324	26.2	-8.0	0.18	5.2	0.14	0.0004	34.4	399	0.119	2.02	0.046	0.0263	33.2	-1.0
12	655	1,491	1,731	0.0	0.0	34.3	0.06	2.0	0.12	0.0002	26.6	538	991	0.115	1.75	0.099	0.0303	26.2	-8.0	0.18	5.0	0.13	0.0004	34.4	389	0.113	1.89	0.043	0.0250	33.3	-0.9
13	561	1,448	1,497	0.0	0.0	34.1	0.06	1.9	0.12	0.0002	26.7	521	970	0.107	1.62	0.092	0.0284	26.3	-7.8	0.18	4.9	0.13	0.0004	34.2	362	0.102	1.68	0.038	0.0226	33.3	-0.7
14	567	1,400	1,493	0.0	0.0	34.2	0.06	1.9	0.12	0.0002	26.8	513	963	0.104	1.59	0.090	0.0274	26.3	-7.8	0.17	4.8	0.13	0.0004	34.3	362	0.100	1.67	0.038	0.0222	33.4	-0.7
15	687	1,324	1,574	0.0	0.0	34.2	0.06	1.8	0.11	0.0002	26.8	512	967	0.104	1.64	0.092	0.0269	26.4	-7.8	0.17	4.9	0.13	0.0004	34.4	371	0.102	1.74	0.039	0.0223	33.6	-0.6
16	750	1,229	1,559	0.0	0.0	33.8	0.06	1.7	0.11	0.0001	26.9	504	963	0.102	1.62	0.092	0.0263	26.4	-7.3	0.17	4.9	0.13	0.0003	34.1	365	0.099	1.70	0.039	0.0215	33.7	-0.1
17	830	1,145	1,470	0.0	0.0	32.9	0.06	1.6	0.10	0.0001	26.9	502	964	0.102	1.64	0.092	0.0262	26.4	-6.4	0.17	4.8	0.13	0.0003	33.8	346	0.093	1.59	0.036	0.0201	33.6	0.7
18	595	987	1,275	0.0	0.0	31.9	0.05	1.5	0.09	0.0001	26.9	435	908	0.082	1.30	0.073	0.0210	26.3	-5.6	0.16	4.6	0.12	0.0003	33.7	323	0.080	1.39	0.031	0.0173	33.2	1.3
19	417	954	1,111	0.0	0.0	31.0	0.04	1.4	0.08	0.0001	26.9	396	875	0.070	1.12	0.062	0.0181	26.3	-4.7	0.16	4.6	0.12	0.0003	33.7	297	0.069	1.23	0.027	0.0150	32.9	2.0
20	333	947	1,037	0.0	5.6	30.1	0.04	1.4	0.08	0.0001	27.0	437	857	0.062	1.04	0.056	0.0157	26.2	-3.8	0.12	3.8	0.10	0.0003	33.0	333	0.065	1.18	0.025	0.0140	32.3	2.3
21	305	942	1,011	0.0	6.2	27.7	0.04	1.4	0.08	0.0001	27.0	433	851	0.059	1.00	0.053	0.0149	26.1	-1.6	0.12	3.7	0.09	0.0002	32.9	331	0.062	1.15	0.024	0.0132	31.7	4.0
22	300	944	1,016	0.0	6.7	23.9	0.04	1.4	0.08	0.0001	27.1	429	852	0.058	1.00	0.053	0.0146	25.8	1.9	0.11	3.7	0.09	0.0002	32.7	337	0.061	1.17	0.024	0.0130	30.9	7.0
23	109	376	411	0.0	15.3	21.8	0.02	0.7	0.04	0.0000	26.7	370	721	0.023	0.42	0.022	0.0059	25.2	3.5	0.06	1.9	0.04	0.0001	31.2	303	0.026	0.52	0.010	0.0057	28.8	7.1

Hour	M4 - M5 Link traffic					No. of jet fans running		Ambient	Peak in-tunnel levels (M4 - M5 Link)					WHT-Rozelle outlets combined						
	M4-M5 Link on (vph)	SPI on (vph)	CWL off	WHT off	Rozelle off	St Peters On	CWL	T (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
1	68	236	76	76	152	0	0	22.3	0.10	1.9	0.09	0.0002	37.6	509	0.060	0.64	0.027	0.0145	31.3	9.0
2	52	152	51	51	102	0	0	21.5	0.10	1.2	0.07	0.0002	37.2	483	0.050	0.38	0.019	0.0127	30.4	8.9
3	18	152	43	43	85	0	0	21.0	0.09	1.0	0.07	0.0002	36.8	466	0.044	0.28	0.016	0.0113	29.7	8.8
4	15	152	42	42	84	0	0	20.0	0.09	0.8	0.06	0.0002	36.5	465	0.041	0.24	0.015	0.0107	29.1	9.2
5	43	317	90	90	180	0	1	18.5	0.09	1.4	0.08	0.0002	36.4	516	0.053	0.47	0.022	0.0130	29.2	10.7
6	107	562	167	167	334	0	1	18.0	0.10	2.3	0.10	0.0002	36.3	579	0.072	0.97	0.036	0.0163	29.7	11.7
7	501	1,552	513	513	1,025	0	2	19.5	0.23	4.6	0.21	0.0005	37.5	792	0.270	3.22	0.122	0.0647	32.6	13.1
8	526	2,401	732	732	1,463	0	0	22.5	0.29	6.0	0.28	0.0006	38.3	840	0.368	4.52	0.179	0.0869	34.1	11.6
9	910	2,708	904	904	1,808	0	3	24.2	0.37	7.1	0.35	0.0008	39.3	897	0.514	5.92	0.239	0.1245	35.4	11.2
10	696	2,752	862	862	1,724	0	0	26.8	0.37	6.8	0.35	0.0009	39.7	884	0.505	5.50	0.233	0.1227	36.2	9.4
11	659	2,796	864	864	1,728	0	2	31.6	0.37	6.7	0.35	0.0009	40.3	878	0.500	5.40	0.230	0.1214	37.6	6.0
12	542	2,858	850	850	1,700	0	0	34.3	0.38	6.6	0.34	0.0009	40.8	879	0.507	5.30	0.229	0.1241	38.6	4.4
13	416	2,775	798	798	1,596	0	0	34.3	0.36	6.2	0.33	0.0008	41.1	872	0.482	4.96	0.215	0.1183	38.8	4.6
14	512	2,717	807	807	1,615	0	3	34.1	0.36	6.3	0.33	0.0008	41.4	865	0.467	4.94	0.211	0.1140	39.0	4.9
15	474	2,631	776	776	1,553	0	0	34.2	0.35	6.1	0.32	0.0008	41.7	863	0.455	4.81	0.206	0.1110	39.2	5.0
16	437	2,684	780	780	1,561	0	3	34.2	0.35	6.1	0.32	0.0008	42.0	849	0.445	4.66	0.203	0.1081	39.4	5.2
17	420	2,766	796	796	1,593	0	0	33.8	0.35	6.1	0.32	0.0008	42.3	857	0.456	4.78	0.209	0.1108	39.6	5.8
18	505	2,834	835	835	1,669	0	0	32.9	0.36	6.3	0.33	0.0008	42.6	871	0.480	5.05	0.220	0.1168	39.6	6.8
19	308	2,172	620	620	1,240	0	0	31.9	0.31	5.3	0.28	0.0007	42.2	817	0.381	3.86	0.169	0.0928	39.0	7.1
20	260	2,041	575	575	1,151	0	2	31.0	0.29	5.0	0.26	0.0007	42.1	790	0.340	3.51	0.152	0.0824	38.6	7.7
21	243	1,752	499	499	998	0	0	30.1	0.25	4.7	0.23	0.0006	41.7	775	0.287	3.20	0.131	0.0686	38.1	8.0
22	236	1,705	485	485	971	0	2	27.7	0.24	4.6	0.22	0.0005	41.5	759	0.265	3.01	0.123	0.0631	37.3	9.6
23	228	1,656	471	471	942	0	1	23.9	0.23	4.5	0.22	0.0005	41.2	756	0.258	2.94	0.120	0.0611	36.1	12.2
24	74	796	218	218	436	0	0	21.8	0.12	3.2	0.14	0.0003	39.8	614	0.099	1.53	0.054	0.0221	33.5	11.7

Table C.2. New M5 with M4-M5 Link normal eastbound 2031 traffic (winter). Stage 2 and 3 normal EB 2031.xlsx

	New M5 traffic			No. of jet fans running		Ambient	Peak in-tunnel levels (before Kogarah outlet)					Kogarah outlet								Peak in-tunnel levels (before SPI outlet)					SPI outlet						
Hour	M5 Flow (vph)	SC Flow (vph)	SPI off (vph)	SC	Main tube	(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	supply flow (m3/s)	exhaust flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	53	154	140	0.0	21.2	7.5	0.01	0.3	0.02	0.0000	17.7	330	721	0.012	0.17	0.010	0.0032	16.6	9.1	0.03	0.8	0.02	0.0001	20.8	261	0.011	0.19	0.004	0.0025	17.0	9.5
1	32	89	69	0.0	22.3	7.0	0.01	0.2	0.01	0.0000	17.5	322	701	0.007	0.10	0.006	0.0019	16.4	9.4	0.02	0.5	0.01	0.0000	20.4	254	0.006	0.10	0.002	0.0014	16.4	9.4
2	27	49	58	0.0	23.1	7.1	0.00	0.1	0.01	0.0000	17.3	317	690	0.005	0.06	0.004	0.0014	16.2	9.2	0.01	0.3	0.01	0.0000	20.1	265	0.005	0.07	0.002	0.0012	16.4	9.4
3	27	49	61	0.0	23.1	7.1	0.00	0.1	0.01	0.0000	17.2	317	691	0.005	0.06	0.004	0.0014	16.2	9.1	0.01	0.3	0.01	0.0000	20.0	268	0.006	0.07	0.002	0.0013	16.4	9.3
4	45	126	127	0.0	21.9	7.0	0.01	0.2	0.01	0.0000	17.2	325	713	0.009	0.14	0.007	0.0022	16.2	9.2	0.02	0.6	0.02	0.0000	20.0	268	0.009	0.15	0.003	0.0019	16.4	9.4
5	108	251	252	0.0	19.5	7.3	0.01	0.5	0.03	0.0000	17.2	341	754	0.017	0.29	0.015	0.0042	16.2	8.9	0.04	1.2	0.03	0.0001	20.3	266	0.015	0.29	0.006	0.0033	16.7	9.4
6	427	1,041	966	0.0	6.9	7.8	0.04	1.5	0.08	0.0001	17.7	427	943	0.067	1.21	0.061	0.0166	16.9	9.1	0.12	4.2	0.10	0.0002	22.3	279	0.051	1.04	0.022	0.0105	18.5	10.7
7	860	2,025	2,356	0.0	0.0	8.0	0.07	2.4	0.14	0.0001	18.2	547	1,098	0.127	2.36	0.120	0.0311	17.5	9.5	0.18	5.9	0.15	0.0004	23.6	446	0.134	2.67	0.057	0.0287	21.2	13.2
8	963	2,569	2,620	0.0	0.0	8.4	0.09	2.8	0.18	0.0002	18.5	621	1,152	0.169	2.83	0.154	0.0433	17.7	9.3	0.21	6.2	0.17	0.0004	24.3	452	0.161	2.83	0.065	0.0355	21.9	13.5
9	957	2,111	2,373	0.0	0.0	9.9	0.08	2.4	0.15	0.0002	18.3	580	1,122	0.151	2.49	0.137	0.0387	17.7	7.8	0.20	5.9	0.16	0.0004	24.1	444	0.150	2.64	0.060	0.0330	21.9	12.0
10	860	1,835	2,037	0.0	0.0	12.0	0.07	2.2	0.14	0.0002	18.2	549	1,088	0.135	2.19	0.121	0.0349	17.7	5.7	0.19	5.6	0.15	0.0004	24.0	412	0.133	2.28	0.052	0.0292	22.0	10.0
11	771	1,605	1,835	0.0	0.0	13.9	0.06	2.0	0.12	0.0002	18.1	520	1,060	0.124	1.95	0.109	0.0325	17.7	3.8	0.19	5.4	0.15	0.0004	24.1	390	0.122	2.06	0.047	0.0269	22.2	8.3
12	655	1,491	1,731	0.0	0.0	14.9	0.06	1.9	0.12	0.0002	18.0	493	1,033	0.115	1.75	0.099	0.0304	17.7	2.8	0.19	5.2	0.14	0.0004	24.1	378	0.116	1.93	0.044	0.0256	22.4	7.5
13	561	1,448	1,497	0.0	0.0	14.5	0.06	1.8	0.11	0.0001	18.0	474	1,014	0.107	1.62	0.092	0.0285	17.6	3.1	0.19	5.1	0.14	0.0004	24.1	349	0.104	1.71	0.039	0.0232	22.1	7.6
14	567	1,400	1,493	0.0	0.0	14.4	0.06	1.8	0.11	0.0001	18.0	465	1,008	0.104	1.59	0.090	0.0275	17.5	3.1	0.19	5.1	0.14	0.0004	24.1	349	0.103	1.71	0.039	0.0227	22.1	7.7
15	687	1,324	1,574	0.0	0.0	14.4	0.06	1.7	0.11	0.0001	17.9	464	1,012	0.104	1.64	0.092	0.0270	17.6	3.2	0.18	5.2	0.14	0.0004	24.2	358	0.105	1.78	0.040	0.0229	22.2	7.8
16	750	1,229	1,559	0.0	0.0	14.0	0.06	1.6	0.10	0.0001	17.8	455	1,008	0.102	1.62	0.092	0.0264	17.5	3.5	0.18	5.2	0.14	0.0004	24.2	351	0.102	1.74	0.040	0.0221	22.1	8.1
17	830	1,145	1,470	0.0	0.0	13.5	0.06	1.5	0.10	0.0001	17.8	453	1,010	0.103	1.64	0.092	0.0263	17.5	4.0	0.18	5.2	0.14	0.0004	24.3	332	0.095	1.62	0.037	0.0205	21.9	8.4
18	595	987	1,275	0.0	0.0	13.0	0.05	1.4	0.08	0.0001	17.7	382	955	0.082	1.30	0.073	0.0210	17.3	4.3	0.18	5.1	0.14	0.0004	24.2	304	0.082	1.42	0.032	0.0177	21.5	8.5
19	417	954	1,111	0.0	7.2	12.0	0.04	1.4	0.08	0.0001	17.6	425	924	0.070	1.12	0.062	0.0181	17.1	5.1	0.14	4.0	0.11	0.0003	23.2	335	0.072	1.27	0.028	0.0155	20.8	8.8
20	333	947	1,037	0.0	8.5	10.6	0.04	1.4	0.08	0.0001	17.6	417	907	0.062	1.03	0.055	0.0157	16.9	6.3	0.13	3.8	0.10	0.0003	22.9	338	0.067	1.21	0.026	0.0144	20.3	9.7
21	305	942	1,011	0.0	9.0	9.6	0.04	1.4	0.08	0.0001	17.5	413	901	0.059	1.00	0.053	0.0149	16.8	7.2	0.12	3.7	0.09	0.0002	22.8	335	0.063	1.18	0.025	0.0136	19.9	10.3
22	300	944	1,016	0.0	9.2	8.5	0.04	1.4	0.08	0.0001	17.5	411	901	0.058	1.00	0.053	0.0146	16.6	8.1	0.12	3.7	0.09	0.0002	22.6	339	0.062	1.19	0.025	0.0133	19.6	11.1
23	109	376	411	0.0	17.8	8.0	0.02	0.7	0.04	0.0000	18.0	353	777	0.023	0.41	0.021	0.0058	16.9	8.9	0.06	1.9	0.05	0.0001	21.7	306	0.027	0.54	0.011	0.0059	18.3	10.3

Hour	M4 - M5 Link traffic					No. of jet fans running		Ambient	Peak in-tunnel levels (M4 - M5 Link)					WHT-Rozelle outlets combined						
	M4-M5 Link on	SPI on (vph)	CWL off	WHT off	Rozelle off	St Peters On	CWL	T (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
1	68	236	76	76	152	0	0	7.5	0.10	1.9	0.09	0.0002	29.8	514	0.061	0.66	0.027	0.0148	20.8	13.3
2	52	152	51	51	102	0	0	7.0	0.09	1.2	0.07	0.0002	29.4	489	0.050	0.39	0.019	0.0128	19.9	12.9
3	18	152	43	43	85	0	0	7.1	0.09	0.9	0.06	0.0002	29.0	474	0.045	0.28	0.016	0.0115	19.5	12.4
4	15	152	42	42	84	0	0	7.1	0.08	0.8	0.06	0.0002	28.7	471	0.042	0.24	0.015	0.0108	19.2	12.2
5	43	317	90	90	180	0	0	7.0	0.09	1.3	0.08	0.0002	28.6	520	0.053	0.48	0.022	0.0131	20.0	13.0
6	107	562	167	167	334	0	0	7.3	0.10	2.2	0.10	0.0002	28.6	587	0.073	0.98	0.037	0.0165	21.0	13.7
7	501	1,552	513	513	1,025	0	0	7.8	0.23	4.6	0.21	0.0005	29.7	803	0.275	3.27	0.124	0.0658	23.8	16.0
8	526	2,401	732	732	1,463	0	1	8.0	0.29	5.9	0.28	0.0006	30.4	839	0.365	4.48	0.177	0.0862	24.5	16.5
9	910	2,708	904	904	1,808	0	2	8.4	0.37	7.1	0.35	0.0008	31.2	900	0.516	5.95	0.240	0.1251	25.6	17.2
10	696	2,752	862	862	1,724	0	2	9.9	0.37	6.7	0.34	0.0008	31.5	886	0.506	5.52	0.234	0.1230	26.0	16.2
11	659	2,796	864	864	1,728	0	1	12.0	0.37	6.7	0.34	0.0008	31.9	883	0.505	5.45	0.232	0.1227	26.8	14.8
12	542	2,858	850	850	1,700	0	2	13.9	0.37	6.5	0.34	0.0009	32.3	879	0.506	5.28	0.229	0.1238	27.5	13.6
13	416	2,775	798	798	1,596	0	3	14.9	0.36	6.2	0.32	0.0008	32.5	863	0.475	4.89	0.212	0.1168	27.8	12.9
14	512	2,717	807	807	1,615	0	0	14.5	0.35	6.3	0.32	0.0008	32.7	874	0.475	5.02	0.215	0.1162	27.9	13.4
15	474	2,631	776	776	1,553	0	3	14.4	0.35	6.1	0.32	0.0008	32.8	858	0.450	4.75	0.204	0.1097	27.8	13.4
16	437	2,684	780	780	1,561	0	1	14.4	0.34	6.0	0.32	0.0008	33.0	853	0.449	4.70	0.205	0.1093	28.0	13.6
17	420	2,766	796	796	1,593	0	2	14.0	0.35	6.1	0.32	0.0008	33.2	855	0.453	4.74	0.207	0.1100	28.0	14.0
18	505	2,834	835	835	1,669	0	1	13.5	0.36	6.3	0.33	0.0008	33.5	874	0.482	5.07	0.220	0.1173	28.2	14.7
19	308	2,172	620	620	1,240	0	0	13.0	0.31	5.2	0.28	0.0007	33.0	817	0.381	3.85	0.169	0.0927	27.5	14.5
20	260	2,041	575	575	1,151	0	0	12.0	0.29	5.0	0.26	0.0007	32.8	807	0.348	3.58	0.155	0.0842	27.0	15.0
21	243	1,752	499	499	998	0	0	10.6	0.25	4.6	0.23	0.0006	32.3	780	0.284	3.15	0.130	0.0678	26.1	15.5
22	236	1,705	485	485	971	0	0	9.6	0.24	4.5	0.22	0.0005	32.0	771	0.269	3.05	0.124	0.0640	25.6	16.0
23	228	1,656	471	471	942	0	0	8.5	0.23	4.4	0.22	0.0005	31.8	765	0.259	2.96	0.120	0.0615	25.1	16.6
24	74	796	218	218	436	0	1	8.0	0.12	3.1	0.13	0.0003	30.6	605	0.096	1.48	0.053	0.0214	22.7	14.7

Table C.3. New M5 with M4-M5 Link normal westbound 2031 traffic (summer). Stage 2 and 3 normal WB 2031.xlsx

	New M5 traffic					Ambient	Peak in-tunnel levels (New M5)					M5 outlet							Southern Connector outlet						
Hour	M5 off (vph)	SC off (vph)	SPI on (vph)	M5 on (vph)	No. of jet fans running SC	(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	333	142	167	283	7	22.3	0.18	3.9	0.18	0.0004	37.8	337	0.093	1.18	0.044	0.022	33.3	11.0	305	0.04	0.65	0.03	0.010	33.6	11.4
1	71	72	79	54	2	21.5	0.13	2.6	0.13	0.0003	37.6	238	0.039	0.46	0.019	0.010	30.6	9.1	229	0.02	0.35	0.01	0.006	31.9	10.4
2	43	68	75	33	1	21.0	0.08	1.3	0.08	0.0002	37.5	229	0.024	0.23	0.011	0.006	29.9	9.0	221	0.01	0.21	0.01	0.003	31.4	10.5
3	40	66	75	31	2	20.0	0.07	1.0	0.06	0.0002	37.4	231	0.019	0.15	0.008	0.005	29.6	9.6	223	0.01	0.18	0.01	0.003	31.0	11.1
4	81	126	122	94	2	18.5	0.07	1.3	0.07	0.0002	37.4	264	0.023	0.23	0.009	0.006	30.0	11.5	258	0.02	0.27	0.01	0.004	31.4	12.9
5	280	202	216	268	6	18.0	0.12	2.5	0.10	0.0003	37.4	345	0.057	0.72	0.023	0.014	31.9	13.9	320	0.03	0.57	0.02	0.007	32.5	14.5
6	421	271	381	337	9	19.5	0.19	3.7	0.16	0.0004	37.4	384	0.105	1.27	0.044	0.026	33.0	13.5	349	0.05	0.87	0.03	0.013	33.2	13.7
7	905	382	708	608	15	22.5	0.25	5.4	0.23	0.0006	38.1	466	0.189	2.44	0.085	0.045	35.2	12.7	399	0.08	1.31	0.05	0.020	34.4	11.9
8	1282	708	1161	834	17	24.2	0.32	7.4	0.33	0.0007	38.7	523	0.281	3.87	0.137	0.066	36.4	12.2	449	0.14	2.38	0.09	0.034	35.3	11.1
9	1016	834	1249	591	13	26.8	0.36	7.3	0.36	0.0008	38.6	490	0.290	3.60	0.144	0.070	36.5	9.7	448	0.17	2.86	0.11	0.042	35.9	9.1
10	982	1206	1393	808	10	31.6	0.39	7.6	0.37	0.0009	38.7	491	0.311	3.40	0.145	0.077	37.4	5.8	476	0.22	3.60	0.13	0.054	37.3	5.7
11	960	1626	1822	795	7	34.3	0.41	8.8	0.39	0.0010	39.1	496	0.335	3.53	0.155	0.084	38.1	3.8	505	0.27	4.47	0.15	0.066	38.3	4.0
12	944	1744	2025	661	5	34.3	0.38	8.8	0.38	0.0009	39.3	485	0.309	3.43	0.148	0.077	37.9	3.7	505	0.26	4.51	0.15	0.063	38.5	4.2
13	961	1828	2157	649	6	34.1	0.39	9.0	0.38	0.0009	39.5	493	0.320	3.43	0.150	0.079	38.1	4.0	512	0.27	4.64	0.16	0.066	38.6	4.6
14	989	1977	2292	704	5	34.2	0.39	9.4	0.38	0.0009	39.9	496	0.323	3.51	0.152	0.080	38.2	4.0	522	0.29	4.98	0.17	0.070	39.0	4.8
15	1061	2259	2558	827	4	34.2	0.39	10.3	0.41	0.0009	40.3	505	0.328	3.84	0.160	0.080	38.2	4.0	538	0.32	5.63	0.19	0.077	39.4	5.2
16	1340	2758	2992	1213	6	33.8	0.42	11.7	0.47	0.0010	40.9	544	0.386	4.88	0.193	0.094	38.7	4.9	565	0.37	6.74	0.22	0.090	40.0	6.2
17	1620	3326	3471	1639	13	32.9	0.45	13.0	0.55	0.0010	41.9	581	0.451	6.00	0.235	0.109	39.1	6.2	556	0.40	7.31	0.26	0.096	40.6	7.8
18	1227	2631	2554	1321	4	31.9	0.39	11.5	0.45	0.0009	41.3	517	0.337	4.94	0.189	0.081	38.1	6.2	551	0.34	6.51	0.21	0.080	40.0	8.1
19	954	1563	1719	734	6	31.0	0.32	8.0	0.35	0.0007	40.3	469	0.261	3.71	0.142	0.062	37.5	6.5	478	0.21	4.00	0.13	0.049	38.8	7.8
20	851	937	1335	405	9	30.1	0.28	6.7	0.31	0.0006	39.6	446	0.208	2.96	0.109	0.049	37.0	7.0	429	0.14	2.61	0.09	0.034	37.8	7.8
21	774	745	1106	389	9	27.7	0.25	6.0	0.26	0.0006	39.3	434	0.180	2.55	0.092	0.043	36.4	8.7	410	0.11	2.13	0.07	0.027	37.0	9.3
22	701	675	1031	327	8	23.9	0.24	5.6	0.25	0.0005	39.2	421	0.159	2.28	0.081	0.037	35.4	11.5	400	0.10	1.92	0.06	0.024	36.2	12.3
23	494	223	285	389	10	21.8	0.21	4.7	0.22	0.0005	38.3	373	0.126	1.70	0.063	0.030	34.2	12.5	330	0.06	0.89	0.04	0.014	34.3	12.6

Hour	M4 - M5 Link Traffic				No. of jet fans running	Ambient	M4 - M5 Link Peak in-tunnel levels					SPI outlet						
	CWL on (vph)	WHT on (vph)	Rozelle on (vph)	SPI off (vph)		T (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	201	201	401	540	0	22.3	0.16	2.77	0.12	0.0004	41.8	311	0.078	0.79	0.03	0.018	36.7	14.4
1	86	86	172	299	0	21.5	0.11	1.53	0.08	0.0003	40.4	311	0.054	0.44	0.02	0.013	35.4	13.9
2	69	69	138	251	0	21.0	0.07	1.47	0.07	0.0002	39.3	289	0.032	0.38	0.01	0.008	34.1	13.2
3	69	69	138	244	0	20.0	0.07	1.48	0.06	0.0002	38.8	289	0.032	0.38	0.01	0.007	33.5	13.6
4	85	85	170	243	0	18.5	0.08	1.66	0.06	0.0002	38.6	271	0.031	0.39	0.01	0.007	32.5	14.0
5	129	129	258	246	0	18.0	0.10	2.11	0.08	0.0002	38.6	232	0.032	0.40	0.01	0.008	31.3	13.3
6	221	221	443	528	0	19.5	0.17	3.03	0.13	0.0004	39.5	296	0.078	0.81	0.03	0.019	34.0	14.5
7	641	641	1283	1919	0	22.5	0.31	6.22	0.24	0.0007	42.2	436	0.226	2.73	0.09	0.052	38.5	16.0
8	1098	1098	2195	3421	0	24.2	0.47	9.68	0.39	0.0011	46.8	418	0.325	4.01	0.13	0.077	42.2	18.0
9	1015	1015	2029	3477	0	26.8	0.47	8.90	0.37	0.0011	47.2	445	0.356	4.00	0.14	0.086	43.4	16.6
10	1038	1038	2077	3363	0	31.6	0.50	8.96	0.38	0.0011	48.3	430	0.360	3.87	0.14	0.088	45.1	13.5
11	1021	1021	2043	3305	0	34.3	0.51	8.82	0.38	0.0012	48.9	430	0.365	3.80	0.14	0.089	46.1	11.9
12	974	974	1949	3287	0	34.3	0.47	8.35	0.36	0.0011	48.7	450	0.360	3.81	0.13	0.087	46.1	11.9
13	944	944	1888	3158	0	34.1	0.46	8.10	0.35	0.0011	48.8	452	0.354	3.71	0.13	0.085	46.1	12.1
14	935	935	1869	3047	0	34.2	0.45	8.02	0.34	0.0010	49.0	451	0.345	3.66	0.13	0.083	46.2	12.1
15	1002	1002	2003	3111	0	34.2	0.47	8.58	0.36	0.0011	49.8	432	0.338	3.72	0.13	0.081	46.8	12.6
16	1114	1114	2227	3144	0	33.8	0.51	9.86	0.40	0.0011	51.4	385	0.318	3.71	0.12	0.076	47.6	13.8
17	1228	1228	2457	3214	0	32.9	0.53	11.22	0.43	0.0012	53.1	352	0.300	3.77	0.12	0.071	48.2	15.4
18	1043	1043	2085	2862	0	31.9	0.43	8.83	0.35	0.0009	50.4	417	0.300	3.68	0.12	0.070	46.8	14.9
19	793	793	1587	2472	0	31.0	0.36	7.18	0.28	0.0008	48.8	452	0.276	3.29	0.11	0.064	45.6	14.7
20	650	650	1301	2228	0	30.1	0.32	6.41	0.25	0.0007	47.9	461	0.252	3.02	0.10	0.058	44.8	14.7
21	566	566	1133	1904	0	27.7	0.29	5.81	0.23	0.0006	47.1	449	0.223	2.65	0.08	0.051	43.6	15.9
22	503	503	1006	1709	0	23.9	0.28	5.33	0.21	0.0006	46.6	445	0.210	2.40	0.08	0.049	42.4	18.5
23	322	322	643	920	0	21.8	0.20	3.92	0.15	0.0004	44.6	360	0.114	1.36	0.04	0.026	39.4	17.6

Table C.4. New M5 with M4-M5 Link normal westbound 2031 traffic (winter). Stage 2 and 3 normal WB 2031.xlsx

	New M5 traffic					Ambient	Peak in-tunnel levels (New M5)					M5 outlet							Southern Connector outlet						
Hour	M5 off (vph)	SC off (vph)	SPI on (vph)	New M5 on (vph)	No. of jet fans running SC	(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	333	142	167	283	8	10.8	0.17	3.7	0.17	0.0004	29.9	343	0.093	1.18	0.045	0.022	24.6	13.8	308	0.04	0.65	0.03	0.010	24.3	13.6
1	64	68	79	52	2	10.3	0.13	2.6	0.13	0.0003	29.1	246	0.040	0.47	0.019	0.010	21.7	11.4	234	0.02	0.35	0.01	0.006	22.5	12.2
2	39	66	75	31	2	9.6	0.08	1.2	0.07	0.0002	28.9	238	0.023	0.23	0.011	0.006	21.0	11.5	229	0.01	0.21	0.01	0.003	22.0	12.5
3	40	66	75	31	2	9.1	0.06	1.0	0.06	0.0002	28.8	239	0.019	0.15	0.008	0.005	20.8	11.8	230	0.01	0.18	0.01	0.003	21.8	12.8
4	82	127	122	94	3	8.5	0.06	1.3	0.06	0.0002	28.9	271	0.023	0.23	0.009	0.006	21.6	13.1	263	0.02	0.27	0.01	0.004	22.6	14.1
5	285	202	216	270	7	7.5	0.11	2.3	0.09	0.0003	29.4	351	0.056	0.72	0.023	0.014	23.5	16.0	324	0.03	0.56	0.02	0.007	23.5	16.0
6	442	280	384	342	9	6.5	0.17	3.5	0.15	0.0004	29.8	393	0.107	1.29	0.045	0.026	24.2	17.7	355	0.05	0.88	0.03	0.013	23.8	17.3
7	938	390	710	613	15	6.5	0.25	5.4	0.23	0.0006	30.5	476	0.191	2.47	0.085	0.045	26.0	19.5	405	0.08	1.31	0.05	0.020	24.4	17.9
8	1263	699	1161	831	18	7.8	0.32	7.3	0.32	0.0007	31.0	532	0.281	3.87	0.137	0.066	27.1	19.3	455	0.14	2.35	0.09	0.034	25.4	17.6
9	1020	834	1249	593	13	10.0	0.35	7.1	0.35	0.0008	30.9	501	0.293	3.63	0.146	0.071	27.2	17.2	455	0.17	2.86	0.11	0.042	26.0	16.0
10	986	1214	1393	809	10	12.7	0.37	7.5	0.36	0.0009	31.0	504	0.314	3.43	0.146	0.077	27.8	15.1	484	0.22	3.60	0.13	0.054	27.0	14.4
11	961	1629	1824	795	7	13.9	0.40	8.6	0.38	0.0009	31.1	509	0.338	3.56	0.156	0.084	28.2	14.3	513	0.27	4.47	0.15	0.066	27.9	14.0
12	944	1744	2025	661	6	13.9	0.37	8.6	0.37	0.0009	31.0	499	0.310	3.45	0.149	0.077	27.9	14.0	513	0.26	4.51	0.15	0.063	28.1	14.2
13	961	1828	2158	649	6	14.0	0.38	8.8	0.37	0.0009	31.2	507	0.323	3.45	0.151	0.080	28.2	14.2	520	0.27	4.64	0.16	0.065	28.3	14.3
14	989	1977	2292	704	5	14.0	0.38	9.3	0.37	0.0009	31.2	510	0.325	3.54	0.153	0.081	28.2	14.2	530	0.29	4.97	0.17	0.070	28.6	14.6
15	1061	2259	2559	827	5	13.5	0.38	10.1	0.40	0.0009	31.6	520	0.331	3.88	0.161	0.081	28.2	14.7	547	0.32	5.63	0.19	0.077	29.0	15.5
16	1340	2758	2992	1213	7	13.0	0.41	11.5	0.46	0.0010	32.2	558	0.388	4.92	0.195	0.094	28.8	15.8	574	0.37	6.74	0.22	0.090	29.6	16.6
17	1620	3325	3471	1639	13	12.5	0.44	12.8	0.54	0.0010	33.1	595	0.454	6.05	0.236	0.110	29.3	16.8	564	0.40	7.32	0.26	0.096	30.2	17.7
18	1227	2631	2554	1321	5	12.0	0.38	11.3	0.44	0.0009	32.5	531	0.339	4.97	0.190	0.081	28.2	16.2	560	0.34	6.50	0.21	0.080	29.7	17.7
19	956	1568	1719	735	7	12.0	0.32	8.0	0.36	0.0007	31.6	484	0.263	3.73	0.142	0.062	27.6	15.6	488	0.21	4.00	0.13	0.049	28.4	16.4
20	849	935	1334	405	9	11.9	0.27	6.3	0.28	0.0006	31.0	460	0.210	2.98	0.110	0.050	27.2	15.3	438	0.14	2.60	0.09	0.034	27.4	15.5
21	774	745	1106	389	10	9.9	0.25	5.8	0.26	0.0005	30.8	448	0.181	2.56	0.092	0.043	26.6	16.7	420	0.11	2.13	0.07	0.027	26.6	16.8
22	701	676	1031	327	9	8.0	0.22	5.3	0.23	0.0005	30.7	434	0.160	2.29	0.082	0.038	25.8	17.8	409	0.10	1.92	0.06	0.024	26.0	18.0
23	497	225	287	389	10	8.0	0.21	4.7	0.22	0.0005	30.4	388	0.128	1.72	0.064	0.031	25.0	17.0	342	0.06	0.90	0.04	0.014	24.5	16.5

Hour	M4 - M5 Link Traffic				No. of jet fans running	Ambient	M4 - M5 Link Peak in-tunnel levels					SPI outlet						
	CWL on (vph)	WHT on (vph)	Rozelle on (vph)	SPI off (vph)		T (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	201	201	401	540	0	10.8	0.16	2.74	0.12	0.0004	31.8	314	0.078	0.80	0.03	0.019	26.3	15.6
1	86	86	172	294	0	10.3	0.11	1.53	0.08	0.0003	30.5	313	0.054	0.44	0.02	0.013	25.1	14.9
2	69	69	138	244	0	9.6	0.07	1.46	0.06	0.0002	29.5	290	0.032	0.38	0.01	0.008	23.9	14.3
3	69	69	138	244	0	9.1	0.07	1.47	0.06	0.0002	29.1	290	0.032	0.38	0.01	0.007	23.4	14.4
4	85	85	170	244	0	8.5	0.08	1.65	0.06	0.0002	28.9	272	0.031	0.39	0.01	0.007	22.7	14.2
5	129	129	258	245	0	7.5	0.10	2.08	0.08	0.0002	28.9	235	0.032	0.40	0.01	0.008	21.4	13.9
6	222	222	444	542	0	6.5	0.17	2.98	0.12	0.0004	29.8	303	0.079	0.83	0.03	0.019	23.4	16.9
7	642	642	1284	1946	0	6.5	0.31	6.14	0.24	0.0007	32.3	444	0.229	2.76	0.09	0.053	27.5	21.0
8	1097	1097	2195	3404	0	7.8	0.46	9.49	0.38	0.0010	36.6	427	0.328	4.05	0.13	0.078	30.8	23.0
9	1015	1015	2029	3479	0	10.0	0.47	8.76	0.37	0.0011	36.9	454	0.359	4.05	0.14	0.087	32.0	22.0
10	1038	1038	2077	3348	0	12.7	0.49	8.76	0.38	0.0011	37.8	442	0.364	3.92	0.14	0.089	33.1	20.4
11	1021	1021	2043	3305	0	13.9	0.50	8.61	0.37	0.0011	38.3	443	0.371	3.86	0.14	0.091	33.8	19.9
12	974	974	1949	3287	0	13.9	0.46	8.15	0.35	0.0011	38.1	464	0.365	3.86	0.14	0.088	33.8	19.9
13	944	944	1888	3158	0	14.0	0.45	7.90	0.34	0.0010	38.0	466	0.359	3.77	0.13	0.087	33.8	19.8
14	935	935	1869	3047	0	14.0	0.44	7.82	0.34	0.0010	38.1	465	0.350	3.72	0.13	0.084	33.8	19.8
15	1002	1002	2003	3112	0	13.5	0.45	8.34	0.35	0.0010	38.7	447	0.343	3.78	0.13	0.083	34.0	20.5
16	1114	1114	2227	3144	0	13.0	0.49	9.54	0.39	0.0011	40.0	401	0.324	3.79	0.13	0.078	34.4	21.4
17	1229	1229	2457	3214	0	12.5	0.51	10.82	0.42	0.0011	41.4	368	0.306	3.86	0.12	0.073	34.8	22.3
18	1043	1043	2085	2862	0	12.0	0.42	8.57	0.34	0.0009	39.0	433	0.305	3.74	0.12	0.071	33.8	21.8
19	793	793	1587	2474	0	12.0	0.35	7.01	0.28	0.0008	37.4	465	0.280	3.34	0.11	0.065	32.9	20.9
20	650	650	1300	2226	0	11.9	0.31	6.25	0.24	0.0007	36.4	474	0.254	3.04	0.10	0.059	32.2	20.3
21	566	566	1133	1904	0	9.9	0.29	5.67	0.22	0.0006	35.6	461	0.225	2.67	0.09	0.052	31.0	21.1
22	503	503	1006	1709	0	8.0	0.27	5.21	0.21	0.0006	34.8	455	0.211	2.42	0.08	0.049	30.0	22.0
23	322	322	643	923	0	8.0	0.19	3.86	0.15	0.0004	33.1	367	0.115	1.37	0.04	0.027	27.4	19.4

APPENDIX D - REGULATORY TRAFFIC SIMULATION RESULTS

Results from the simulation of regulatory traffic in New M5, and New M5 with connected M4-M5 Link, up to Rozelle.

Table D.1. New M5 with M4-M5 Link eastbound 2031 regulatory traffic (summer). Stage 2 and 3 regulatory EB 2031.xlsx

Hour	New M5 traffic			No. of jet fans running		Ambient	Peak in-tunnel levels (before Kogarah outlet)					Kogarah outlet								Peak in-tunnel levels (before SPI outlet)					SPI outlet						
	M5 on (vph)	SC on (vph)	SPI off (vph)	SC	Main tube	(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	supply flow (m3/s)	exhaust flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	86	247	225	0.0	17.3	22.3	0.02	0.5	0.03	0.0000	25.7	357	704	0.019	0.28	0.016	0.0051	24.6	2.4	0.04	1.3	0.03	0.0001	29.7	259	0.016	0.28	0.006	0.0036	27.4	5.2
1	52	141	111	0.0	19.1	21.5	0.01	0.3	0.02	0.0000	25.5	345	672	0.011	0.16	0.009	0.0031	24.4	2.9	0.03	0.7	0.02	0.0001	29.1	248	0.009	0.15	0.004	0.0021	26.7	5.2
2	45	76	92	0.0	20.3	21.0	0.01	0.2	0.01	0.0000	25.4	337	653	0.008	0.10	0.007	0.0023	24.3	3.3	0.02	0.5	0.01	0.0000	28.9	264	0.008	0.11	0.003	0.0018	26.5	5.6
3	45	76	97	0.0	20.3	20.0	0.01	0.2	0.01	0.0000	25.3	336	654	0.008	0.10	0.006	0.0023	24.1	4.2	0.02	0.5	0.01	0.0000	28.8	269	0.009	0.11	0.003	0.0020	26.3	6.3
4	72	200	203	0.0	18.5	18.5	0.01	0.4	0.02	0.0000	25.4	348	690	0.014	0.21	0.012	0.0036	24.1	5.6	0.03	1.0	0.03	0.0001	28.9	273	0.013	0.23	0.005	0.0029	26.0	7.5
5	174	403	405	0.0	14.9	18.0	0.02	0.7	0.04	0.0001	25.5	373	756	0.027	0.46	0.024	0.0068	24.2	6.2	0.06	1.9	0.05	0.0001	29.4	275	0.024	0.45	0.010	0.0052	26.3	8.3
6	684	1,669	1,548	0.0	0.0	19.5	0.06	2.1	0.12	0.0001	26.3	530	1,021	0.108	1.94	0.098	0.0266	25.2	5.7	0.16	5.4	0.13	0.0003	31.9	334	0.083	1.70	0.035	0.0171	29.3	9.8
7	1,376	3,245	3,762	0.0	0.0	22.5	0.10	3.7	0.21	0.0002	27.3	689	1,179	0.198	3.80	0.192	0.0480	26.2	3.7	0.23	7.0	0.20	0.0005	34.6	473	0.183	3.38	0.082	0.0410	32.9	10.4
8	1,544	3,969	3,817	0.0	0.0	24.2	0.15	5.6	0.30	0.0003	28.3	717	1,143	0.262	4.86	0.241	0.0671	26.8	2.6	0.29	7.5	0.24	0.0006	36.6	416	0.202	3.13	0.084	0.0479	34.7	10.5
9	1,533	3,400	3,709	0.0	0.0	26.8	0.12	4.2	0.25	0.0003	28.0	688	1,188	0.240	4.24	0.225	0.0613	26.9	0.1	0.30	7.6	0.25	0.0007	37.3	407	0.202	3.07	0.083	0.0482	35.6	8.8
10	1,378	2,944	3,745	0.0	0.0	31.6	0.10	3.2	0.20	0.0002	27.9	670	1,185	0.215	3.50	0.195	0.0555	27.1	-4.5	0.30	7.3	0.23	0.0007	38.1	395	0.194	2.87	0.076	0.0463	37.1	5.5
11	1,237	2,573	2,943	0.0	0.0	34.3	0.09	2.9	0.18	0.0002	27.9	708	1,149	0.197	3.10	0.174	0.0515	27.3	-7.0	0.23	6.2	0.18	0.0005	35.7	477	0.184	3.01	0.072	0.0411	35.5	1.3
12	1,050	2,392	2,776	0.0	0.0	34.3	0.09	2.8	0.17	0.0002	28.0	686	1,118	0.182	2.80	0.158	0.0482	27.3	-6.9	0.22	6.0	0.17	0.0005	35.8	471	0.175	2.86	0.067	0.0391	35.6	1.4
13	899	2,322	2,401	0.0	0.0	34.1	0.08	2.7	0.17	0.0002	28.2	669	1,093	0.170	2.59	0.148	0.0451	27.4	-6.7	0.21	5.7	0.16	0.0004	35.8	445	0.159	2.57	0.060	0.0356	35.6	1.5
14	910	2,244	2,394	0.0	0.0	34.2	0.08	2.7	0.16	0.0002	28.3	661	1,086	0.165	2.54	0.144	0.0436	27.5	-6.7	0.21	5.7	0.16	0.0004	36.0	445	0.156	2.56	0.059	0.0348	35.7	1.6
15	1,103	2,122	2,524	0.0	0.0	34.2	0.08	2.5	0.16	0.0002	28.4	660	1,094	0.165	2.62	0.148	0.0429	27.6	-6.6	0.21	5.8	0.16	0.0004	36.3	454	0.158	2.65	0.061	0.0348	36.0	1.8
16	1,203	1,971	2,501	0.0	0.0	33.8	0.08	2.4	0.15	0.0002	28.4	652	1,092	0.163	2.60	0.147	0.0420	27.6	-6.1	0.20	5.7	0.16	0.0004	36.5	448	0.154	2.59	0.060	0.0337	36.1	2.4
17	1,331	1,838	2,358	0.0	0.0	32.9	0.09	2.3	0.15	0.0002	28.5	649	1,097	0.164	2.63	0.148	0.0420	27.7	-5.2	0.20	5.7	0.16	0.0004	36.7	431	0.146	2.45	0.057	0.0318	36.1	3.2
18	955	1,583	2,045	0.0	0.0	31.9	0.07	2.1	0.12	0.0002	28.5	581	1,028	0.132	2.08	0.118	0.0337	27.5	-4.4	0.18	5.3	0.14	0.0004	36.4	412	0.126	2.15	0.049	0.0273	35.6	3.7
19	667	1,531	1,782	0.0	0.0	31.0	0.06	2.0	0.12	0.0002	28.5	540	984	0.112	1.79	0.099	0.0289	27.5	-3.5	0.17	5.1	0.13	0.0003	36.2	394	0.111	1.95	0.043	0.0240	35.2	4.3
20	534	1,519	1,664	0.0	0.0	30.1	0.06	2.0	0.12	0.0001	28.6	512	960	0.099	1.66	0.089	0.0251	27.5	-2.6	0.16	4.9	0.13	0.0003	36.1	392	0.104	1.90	0.041	0.0225	34.9	4.9
21	490	1,511	1,622	0.0	0.0	27.7	0.06	2.0	0.12	0.0001	28.7	500	952	0.095	1.61	0.085	0.0240	27.4	-0.3	0.16	4.9	0.12	0.0003	36.0	384	0.099	1.85	0.039	0.0213	34.5	6.8
22	481	1,515	1,629	0.0	0.0	23.9	0.05	2.0	0.11	0.0001	28.8	490	953	0.093	1.61	0.084	0.0234	27.2	3.3	0.15	5.0	0.12	0.0003	35.9	386	0.098	1.88	0.039	0.0209	33.7	9.8
23	174	601	658	0.0	0.0	21.8	0.03	1.1	0.06	0.0001	28.2	203	776	0.037	0.66	0.034	0.0093	26.4	4.7	0.15	5.0	0.11	0.0003	35.9	196	0.037	0.73	0.014	0.0079	30.5	8.7

Hour	M4 - M5 Link traffic					No. of jet fans running		Ambient	Peak in-tunnel levels (M4 - M5 Link)					WHT-Rozelle outlets combined						
	M4-M5 Link on (vph)	SPI on (vph)	CWL off	WHT off	Rozelle off	St Peters On	CWL	T (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
1	109	378	122	122	244	0	0	22.3	0.15	2.6	0.13	0.0003	39.7	568	0.102	1.10	0.045	0.0248	33.1	10.8
2	83	243	82	82	163	0	0	21.5	0.13	1.6	0.10	0.0003	39.1	533	0.079	0.60	0.030	0.0203	32.1	10.6
3	29	243	68	68	136	0	1	21.0	0.12	1.2	0.09	0.0003	38.6	510	0.069	0.42	0.025	0.0179	31.3	10.4
4	24	243	67	67	134	0	0	20.0	0.11	1.1	0.08	0.0003	38.2	511	0.066	0.37	0.024	0.0171	30.7	10.8
5	69	510	145	145	289	0	0	18.5	0.12	1.9	0.10	0.0003	38.1	579	0.087	0.80	0.037	0.0213	30.9	12.4
6	171	900	268	268	535	0	1	18.0	0.13	3.0	0.14	0.0003	38.1	650	0.116	1.58	0.059	0.0262	31.5	13.5
7	803	2,489	822	822	1,643	0	-1	19.5	0.32	6.3	0.29	0.0007	39.9	902	0.440	5.21	0.201	0.1067	34.8	15.3
8	842	3,851	1,169	1,169	2,338	0	0	22.5	0.41	8.3	0.40	0.0009	41.3	934	0.594	7.28	0.293	0.1423	36.6	14.1
9	1,419	3,793	1,299	1,299	2,598	0	2	24.2	0.51	9.7	0.49	0.0012	42.7	938	0.748	8.54	0.357	0.1877	37.9	13.7
10	1,142	3,783	1,257	1,257	2,514	0	2	26.8	0.52	9.5	0.49	0.0012	43.3	933	0.755	8.32	0.358	0.1887	38.9	12.1
11	1,058	3,765	1,207	1,207	2,415	0	2	31.6	0.49	9.0	0.47	0.0012	44.0	940	0.724	7.89	0.341	0.1799	40.4	8.8
12	869	3,744	1,154	1,154	2,308	0	0	34.3	0.48	8.4	0.44	0.0011	44.6	938	0.704	7.39	0.322	0.1750	41.4	7.2
13	667	3,752	1,105	1,105	2,210	0	1	34.3	0.46	8.0	0.42	0.0011	45.0	934	0.676	6.98	0.304	0.1682	41.7	7.5
14	821	3,758	1,145	1,145	2,290	0	2	34.1	0.46	8.2	0.43	0.0011	45.6	931	0.672	7.14	0.308	0.1665	42.1	8.1
15	760	3,757	1,129	1,129	2,259	0	0	34.2	0.46	8.0	0.42	0.0011	46.1	934	0.666	7.03	0.304	0.1645	42.5	8.3
16	701	3,760	1,115	1,115	2,231	0	2	34.2	0.45	7.9	0.41	0.0010	46.4	927	0.648	6.81	0.297	0.1594	42.8	8.6
17	673	3,768	1,110	1,110	2,221	0	0	33.8	0.45	7.8	0.41	0.0010	46.8	938	0.654	6.88	0.301	0.1605	43.0	9.2
18	811	3,756	1,142	1,142	2,283	0	0	32.9	0.46	8.0	0.42	0.0011	47.3	944	0.674	7.13	0.311	0.1659	43.2	10.3
19	495	3,481	994	994	1,989	0	0	31.9	0.43	7.2	0.38	0.0010	47.2	921	0.615	6.21	0.275	0.1516	42.9	11.0
20	417	3,271	922	922	1,844	0	1	31.0	0.39	6.7	0.36	0.0009	47.1	894	0.545	5.58	0.245	0.1336	42.5	11.6
21	390	2,808	800	800	1,599	0	0	30.1	0.34	6.2	0.31	0.0008	46.6	872	0.448	4.93	0.207	0.1081	41.9	11.9
22	380	2,734	778	778	1,557	0	0	27.7	0.32	6.1	0.30	0.0007	46.4	864	0.428	4.83	0.200	0.1028	41.2	13.5
23	367	2,658	756	756	1,512	0	0	23.9	0.32	6.0	0.30	0.0007	46.1	852	0.413	4.67	0.193	0.0987	40.1	16.2
24	119	1,277	349	349	699	0	0	21.8	0.15	4.0	0.17	0.0003	44.3	660	0.140	2.16	0.077	0.0309	36.8	15.1

Table D.2. New M5 with M4-M5 Link eastbound 2031 regulatory traffic (winter). Stage 2 and 3 regulatory EB 2031.xlsx

Hour	New M5 traffic			No. of jet fans running		Ambient	Peak in-tunnel levels (before Kogarah outlet)					Kogarah outlet								Peak in-tunnel levels (before SPI outlet)					SPI outlet						
	M5 on (vph)	SC on (vph)	SPI off (vph)	SC	Main tube	(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	supply flow (m3/s)	exhaust flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	86	247	225	0.0	19.2	10.8	0.01	0.5	0.03	0.0000	18.5	344	745	0.019	0.28	0.016	0.0051	17.5	6.7	0.04	1.3	0.04	0.0001	22.4	261	0.017	0.29	0.007	0.0037	19.0	8.2
1	52	141	111	0.0	21.0	10.3	0.01	0.3	0.02	0.0000	18.3	332	715	0.011	0.16	0.009	0.0031	17.2	7.0	0.03	0.7	0.02	0.0001	21.8	250	0.010	0.15	0.004	0.0022	18.3	8.0
2	45	76	92	0.0	22.1	9.6	0.01	0.2	0.01	0.0000	18.1	324	698	0.008	0.10	0.007	0.0023	17.0	7.5	0.02	0.5	0.01	0.0000	21.5	266	0.008	0.12	0.003	0.0018	18.1	8.5
3	45	76	97	0.0	22.2	9.1	0.01	0.2	0.01	0.0000	18.0	323	698	0.008	0.10	0.006	0.0023	16.9	7.9	0.02	0.5	0.01	0.0000	21.3	271	0.009	0.11	0.003	0.0020	17.9	8.9
4	72	200	203	0.0	20.3	8.5	0.01	0.4	0.02	0.0000	18.0	336	732	0.014	0.22	0.012	0.0036	16.9	8.4	0.03	1.0	0.03	0.0001	21.5	272	0.014	0.23	0.005	0.0030	17.9	9.4
5	174	403	405	0.0	16.7	7.5	0.02	0.7	0.04	0.0000	18.1	360	794	0.027	0.46	0.025	0.0069	17.0	9.5	0.06	1.9	0.05	0.0001	22.0	274	0.025	0.46	0.010	0.0053	18.0	10.5
6	684	1,669	1,548	0.0	0.0	6.5	0.06	2.1	0.12	0.0001	18.8	499	1,053	0.108	1.95	0.098	0.0266	17.8	11.3	0.16	5.6	0.14	0.0003	24.5	323	0.083	1.71	0.036	0.0172	20.5	14.0
7	1,376	3,245	3,762	0.0	0.0	6.5	0.09	3.6	0.21	0.0002	19.6	657	1,212	0.198	3.80	0.193	0.0481	18.6	12.1	0.23	7.1	0.20	0.0005	26.6	470	0.186	3.42	0.083	0.0415	23.8	17.3
8	1,544	3,969	3,816	0.0	0.0	7.8	0.15	5.5	0.30	0.0003	20.5	686	1,176	0.262	4.86	0.241	0.0672	19.1	11.3	0.30	7.6	0.24	0.0007	28.5	413	0.204	3.17	0.085	0.0484	25.1	17.3
9	1,533	3,400	3,709	0.0	0.0	10.0	0.11	4.1	0.24	0.0003	20.1	656	1,222	0.239	4.23	0.225	0.0613	19.1	9.1	0.30	7.7	0.25	0.0007	29.0	403	0.204	3.11	0.084	0.0487	25.8	15.9
10	1,378	2,944	3,745	0.0	0.0	12.7	0.10	3.1	0.20	0.0002	19.9	633	1,223	0.215	3.50	0.195	0.0555	19.1	6.4	0.30	7.5	0.24	0.0007	29.7	391	0.197	2.91	0.077	0.0469	26.7	14.1
11	1,237	2,573	2,943	0.0	0.0	13.9	0.09	2.8	0.18	0.0002	19.8	667	1,189	0.197	3.10	0.174	0.0516	19.1	5.2	0.23	6.3	0.18	0.0005	27.0	474	0.186	3.06	0.073	0.0418	25.1	11.2
12	1,050	2,392	2,776	0.0	0.0	13.9	0.08	2.7	0.17	0.0002	19.7	645	1,159	0.182	2.80	0.159	0.0483	19.0	5.1	0.22	6.1	0.17	0.0005	26.9	467	0.178	2.91	0.068	0.0398	25.0	11.1
13	899	2,322	2,401	0.0	0.0	14.0	0.08	2.6	0.16	0.0002	19.7	628	1,135	0.170	2.59	0.148	0.0452	18.9	4.9	0.22	5.9	0.16	0.0005	26.8	440	0.162	2.61	0.061	0.0362	24.7	10.7
14	910	2,244	2,394	0.0	0.0	14.0	0.08	2.6	0.16	0.0002	19.7	619	1,129	0.165	2.54	0.144	0.0437	18.9	4.9	0.21	5.9	0.16	0.0004	26.8	439	0.159	2.60	0.060	0.0354	24.8	10.8
15	1,103	2,122	2,524	0.0	0.0	13.5	0.08	2.4	0.15	0.0002	19.7	617	1,138	0.166	2.62	0.148	0.0429	18.9	5.4	0.21	5.9	0.16	0.0004	26.9	449	0.161	2.70	0.063	0.0355	24.8	11.3
16	1,203	1,971	2,501	0.0	0.0	13.0	0.08	2.3	0.15	0.0002	19.6	608	1,137	0.163	2.60	0.147	0.0421	18.9	5.9	0.21	5.9	0.16	0.0004	26.9	442	0.157	2.63	0.062	0.0343	24.7	11.7
17	1,331	1,838	2,358	0.0	0.0	12.5	0.08	2.2	0.14	0.0002	19.5	606	1,142	0.164	2.63	0.148	0.0421	18.9	6.4	0.21	5.8	0.16	0.0004	26.9	425	0.148	2.49	0.059	0.0324	24.5	12.0
18	955	1,583	2,045	0.0	0.0	12.0	0.07	2.0	0.12	0.0002	19.4	536	1,074	0.132	2.08	0.118	0.0338	18.6	6.6	0.19	5.5	0.15	0.0004	26.5	403	0.128	2.19	0.050	0.0279	24.0	12.0
19	667	1,531	1,782	0.0	0.0	12.0	0.06	2.0	0.11	0.0002	19.4	495	1,032	0.112	1.79	0.099	0.0289	18.5	6.5	0.18	5.3	0.14	0.0004	26.2	382	0.113	1.99	0.044	0.0246	23.6	11.6
20	534	1,519	1,664	0.0	0.0	11.9	0.05	2.0	0.11	0.0001	19.3	467	1,008	0.099	1.66	0.089	0.0251	18.4	6.5	0.17	5.2	0.14	0.0004	26.0	378	0.106	1.94	0.042	0.0230	23.3	11.5
21	490	1,511	1,622	0.0	0.0	9.9	0.05	1.9	0.11	0.0001	19.3	454	1,000	0.095	1.61	0.085	0.0240	18.2	8.3	0.17	5.2	0.13	0.0003	25.9	370	0.102	1.89	0.040	0.0219	22.8	13.0
22	481	1,515	1,629	0.0	0.0	8.0	0.05	2.0	0.11	0.0001	19.2	448	1,000	0.093	1.61	0.084	0.0234	18.0	10.0	0.17	5.3	0.13	0.0003	25.7	371	0.100	1.92	0.041	0.0214	22.3	14.3
23	174	601	658	0.0	13.9	10.5	0.03	1.0	0.05	0.0001	18.9	380	827	0.036	0.65	0.033	0.0091	17.8	7.3	0.11	3.5	0.09	0.0002	23.6	327	0.056	1.07	0.024	0.0124	20.6	10.1

Hour	M4 - M5 Link traffic					No. of jet fans running		Ambient	Peak in-tunnel levels (M4 - M5 Link)					WHT-Rozelle outlets combined						
	M4-M5 Link on (vph)	SPI on (vph)	CWL off	WHT off	Rozelle off	St Peters On	CWL	T (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
1	109	378	122	122	244	0	0	10.8	0.14	2.5	0.12	0.0003	33.1	572	0.101	1.07	0.044	0.0246	24.8	14.0
2	83	243	82	82	163	0	0	10.3	0.12	1.6	0.09	0.0003	32.4	537	0.079	0.60	0.030	0.0203	23.7	13.5
3	29	243	68	68	136	0	1	9.6	0.12	1.2	0.09	0.0003	31.9	514	0.069	0.42	0.025	0.0179	22.8	13.2
4	24	243	67	67	134	0	0	9.1	0.11	1.1	0.08	0.0003	31.5	512	0.066	0.37	0.024	0.0171	22.3	13.3
5	69	510	145	145	289	0	1	8.5	0.12	1.8	0.10	0.0003	31.3	574	0.086	0.79	0.037	0.0210	23.0	14.5
6	171	900	268	268	535	0	0	7.5	0.13	3.0	0.13	0.0003	31.2	653	0.116	1.59	0.059	0.0264	23.5	16.0
7	803	2,489	822	822	1,643	0	2	6.5	0.31	6.2	0.29	0.0007	32.9	893	0.436	5.16	0.199	0.1058	26.4	19.9
8	842	3,851	1,169	1,169	2,338	0	0	6.5	0.40	8.3	0.40	0.0009	34.0	938	0.600	7.35	0.295	0.1436	27.5	21.0
9	1,419	3,793	1,299	1,299	2,598	0	0	7.8	0.51	9.7	0.49	0.0012	35.2	947	0.756	8.64	0.361	0.1898	28.6	20.8
10	1,142	3,783	1,257	1,257	2,514	0	1	10.0	0.51	9.5	0.49	0.0012	35.7	943	0.764	8.42	0.363	0.1909	29.4	19.5
11	1,058	3,765	1,207	1,207	2,415	0	0	12.7	0.49	8.9	0.46	0.0011	36.2	949	0.731	7.96	0.344	0.1817	30.3	17.7
12	869	3,744	1,154	1,154	2,308	0	0	13.9	0.48	8.3	0.44	0.0011	36.6	943	0.708	7.43	0.324	0.1759	30.9	17.0
13	667	3,752	1,105	1,105	2,210	0	1	13.9	0.46	7.9	0.42	0.0011	36.9	938	0.680	7.01	0.305	0.1690	31.1	17.2
14	821	3,758	1,145	1,145	2,290	0	0	14.0	0.46	8.1	0.42	0.0011	37.4	940	0.681	7.22	0.311	0.1686	31.5	17.5
15	760	3,757	1,129	1,129	2,259	0	0	14.0	0.45	8.0	0.42	0.0011	37.7	941	0.671	7.08	0.307	0.1658	31.7	17.7
16	701	3,760	1,115	1,115	2,231	0	2	13.5	0.44	7.8	0.41	0.0010	37.9	930	0.650	6.82	0.298	0.1598	31.7	18.2
17	673	3,768	1,110	1,110	2,221	0	2	13.0	0.44	7.8	0.41	0.0010	38.1	929	0.647	6.80	0.297	0.1586	31.8	18.8
18	811	3,756	1,142	1,142	2,283	0	2	12.5	0.45	8.0	0.42	0.0010	38.5	932	0.664	7.03	0.306	0.1635	31.9	19.4
19	495	3,481	994	994	1,989	0	0	12.0	0.42	7.1	0.38	0.0010	38.3	923	0.616	6.22	0.275	0.1520	31.7	19.7
20	417	3,271	922	922	1,844	0	-1	12.0	0.39	6.7	0.35	0.0009	38.1	904	0.551	5.64	0.248	0.1351	31.4	19.4
21	390	2,808	800	800	1,599	0	2	11.9	0.33	6.1	0.31	0.0008	37.6	862	0.440	4.84	0.203	0.1063	30.7	18.9
22	380	2,734	778	778	1,557	0	0	9.9	0.32	6.0	0.30	0.0007	37.3	868	0.430	4.84	0.201	0.1032	30.1	20.3
23	367	2,658	756	756	1,512	0	0	8.0	0.31	5.9	0.30	0.0007	36.9	857	0.413	4.67	0.193	0.0989	29.4	21.4
24	119	1,277	349	349	699	0	1	10.5	0.14	3.8	0.16	0.0003	34.2	683	0.138	2.13	0.076	0.0303	26.6	16.1

Table D.3. New M5 with M4-M5 Link westbound 2031 regulatory traffic (summer). Stage 2 and 3 regulatory WB 2031_v1.xlsx

	New M5 traffic					Ambient	Peak in-tunnel levels (New M5)					M5 outlet							Southern Connector outlet						
Hour	M5 off (vph)	SC off (vph)	SPI on (vph)	M5 on (vph)	No. of jet fans running	(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	394	169	200	338	8	22.3	0.20	4.3	0.20	0.0005	38.0	356	0.111	1.41	0.053	0.027	33.7	11.5	319	0.05	0.77	0.03	0.012	33.9	11.7
1	85	87	94	65	2	21.5	0.15	2.9	0.15	0.0003	37.8	246	0.046	0.54	0.022	0.011	30.9	9.4	236	0.03	0.42	0.02	0.007	32.2	10.7
2	51	82	90	39	2	21.0	0.09	1.5	0.09	0.0002	37.7	235	0.027	0.26	0.012	0.007	30.3	9.3	229	0.02	0.24	0.01	0.004	31.8	10.8
3	47	80	90	37	2	20.0	0.08	1.2	0.07	0.0002	37.6	237	0.023	0.18	0.009	0.006	29.9	9.9	230	0.01	0.21	0.01	0.003	31.4	11.4
4	95	149	146	111	2	18.5	0.08	1.6	0.07	0.0002	37.6	274	0.028	0.27	0.011	0.007	30.4	11.9	269	0.02	0.33	0.01	0.005	31.8	13.3
5	325	237	259	320	7	18.0	0.12	2.6	0.11	0.0003	37.6	362	0.069	0.87	0.028	0.017	32.3	14.3	335	0.04	0.68	0.02	0.009	32.9	14.9
6	505	325	457	404	10	19.5	0.21	4.1	0.18	0.0005	37.7	406	0.128	1.54	0.054	0.031	33.5	14.0	367	0.06	1.05	0.03	0.015	33.6	14.1
7	1097	461	851	732	17	22.5	0.28	6.1	0.27	0.0006	38.6	495	0.231	2.99	0.104	0.055	35.8	13.3	419	0.10	1.59	0.06	0.025	34.8	12.3
8	1539	850	1393	1008	19	24.2	0.36	8.2	0.36	0.0008	39.2	557	0.342	4.70	0.167	0.080	37.0	12.8	472	0.17	2.88	0.10	0.041	35.7	11.5
9	1240	1002	1496	719	14	26.8	0.39	8.1	0.40	0.0009	39.1	522	0.347	4.27	0.172	0.084	37.1	10.3	474	0.20	3.35	0.12	0.051	36.4	9.6
10	1169	1416	1667	956	11	31.6	0.43	8.6	0.42	0.0010	39.3	523	0.374	4.09	0.174	0.092	38.1	6.5	504	0.26	4.31	0.15	0.065	37.7	6.1
11	1149	1945	2184	949	8	34.3	0.45	9.7	0.43	0.0011	39.7	529	0.404	4.24	0.187	0.101	38.7	4.5	534	0.32	5.29	0.19	0.079	38.8	4.6
12	1132	2086	2424	794	6	34.3	0.41	9.8	0.41	0.0010	39.9	517	0.371	4.13	0.178	0.092	38.6	4.3	534	0.31	5.34	0.18	0.075	39.1	4.8
13	1148	2184	2584	775	7	34.1	0.44	10.0	0.43	0.0010	40.2	527	0.388	4.17	0.183	0.096	38.8	4.7	542	0.33	5.54	0.19	0.080	39.3	5.2
14	1182	2351	2739	840	6	34.2	0.44	10.6	0.43	0.0010	40.6	530	0.394	4.29	0.186	0.098	38.9	4.7	553	0.35	5.95	0.20	0.085	39.7	5.5
15	1266	2701	3062	986	5	34.2	0.44	11.6	0.47	0.0010	41.1	539	0.399	4.69	0.197	0.098	39.0	4.8	570	0.38	6.73	0.23	0.094	40.2	6.0
16	1600	3224	3581	1450	11	33.8	0.48	12.8	0.55	0.0011	41.9	585	0.480	6.14	0.245	0.118	39.5	5.7	574	0.43	7.54	0.27	0.106	40.9	7.1
17	1919	3911	4149	1948	19	32.9	0.51	14.8	0.64	0.0012	43.1	622	0.550	7.47	0.294	0.134	39.9	7.1	555	0.47	8.42	0.30	0.112	41.8	8.9
18	1467	3606	3057	1583	7	31.9	0.43	13.0	0.55	0.0010	42.5	556	0.411	6.06	0.233	0.099	39.0	7.1	575	0.42	7.75	0.27	0.101	41.4	9.5
19	1140	1871	2058	878	7	31.0	0.36	9.1	0.40	0.0008	41.3	503	0.318	4.51	0.174	0.076	38.3	7.4	509	0.26	4.84	0.16	0.060	39.7	8.8
20	1017	1118	1600	484	10	30.1	0.32	7.5	0.34	0.0007	40.5	478	0.253	3.59	0.134	0.060	37.9	7.8	457	0.17	3.15	0.11	0.041	38.7	8.7
21	924	888	1323	465	10	27.7	0.28	6.6	0.29	0.0006	40.2	461	0.217	3.06	0.110	0.051	37.3	9.6	433	0.14	2.55	0.08	0.032	37.9	10.2
22	840	809	1236	392	9	23.9	0.26	6.2	0.27	0.0006	40.1	447	0.191	2.73	0.098	0.045	36.3	12.4	423	0.12	2.31	0.08	0.029	37.1	13.2
23	595	270	343	466	11	21.8	0.24	5.1	0.24	0.0005	39.1	394	0.151	2.02	0.075	0.036	35.0	13.3	345	0.07	1.05	0.04	0.017	35.1	13.4

Hour	M4 - M5 Link Traffic				No. of jet fans running	Ambient	M4 - M5 Link Peak in-tunnel levels					SPI outlet						
	CWL on (vph)	WHT on (vph)	Rozelle on (vph)	SPI off (vph)		T (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	241	241	481	644	0	22.3	0.18	3.11	0.13	0.0004	42.8	325	0.093	0.95	0.03	0.022	37.6	15.3
1	103	103	206	359	0	21.5	0.13	1.72	0.09	0.0003	41.1	326	0.064	0.53	0.02	0.016	36.2	14.7
2	83	83	166	299	0	21.0	0.08	1.66	0.07	0.0002	40.0	302	0.039	0.46	0.02	0.009	34.9	13.9
3	83	83	166	294	0	20.0	0.08	1.66	0.07	0.0002	39.4	303	0.038	0.46	0.02	0.009	34.2	14.2
4	102	102	204	292	0	18.5	0.09	1.87	0.07	0.0002	39.2	282	0.038	0.47	0.02	0.009	33.2	14.7
5	154	154	309	293	0	18.0	0.12	2.36	0.09	0.0003	39.3	240	0.038	0.47	0.02	0.009	32.0	14.0
6	265	265	530	633	0	19.5	0.20	3.40	0.14	0.0004	40.3	310	0.093	0.97	0.03	0.022	34.8	15.3
7	769	769	1538	2314	0	22.5	0.35	6.98	0.27	0.0008	43.5	454	0.269	3.21	0.10	0.062	39.7	17.2
8	1234	1234	2468	3756	0	24.2	0.50	10.23	0.41	0.0011	48.0	422	0.352	4.32	0.14	0.084	43.3	19.1
9	1145	1145	2290	3699	0	26.8	0.50	9.40	0.39	0.0011	48.1	452	0.381	4.30	0.15	0.092	44.3	17.5
10	1197	1197	2394	3643	0	31.6	0.55	9.80	0.42	0.0013	50.0	428	0.392	4.21	0.15	0.096	46.3	14.7
11	1186	1186	2372	3612	0	34.3	0.56	9.73	0.42	0.0013	50.8	426	0.401	4.15	0.15	0.099	47.6	13.4
12	1146	1146	2292	3602	0	34.3	0.54	9.32	0.40	0.0012	51.0	446	0.403	4.20	0.15	0.098	47.8	13.6
13	1131	1131	2262	3607	0	34.1	0.55	9.31	0.40	0.0013	51.7	441	0.404	4.14	0.15	0.099	48.3	14.3
14	1121	1121	2241	3600	0	34.2	0.55	9.38	0.40	0.0013	52.4	435	0.401	4.10	0.15	0.098	48.9	14.8
15	1200	1200	2401	3621	0	34.2	0.57	10.03	0.43	0.0013	53.5	414	0.390	4.13	0.14	0.096	49.7	15.5
16	1334	1334	2669	3670	0	33.8	0.63	11.69	0.48	0.0014	55.9	364	0.368	4.11	0.14	0.090	50.8	17.1
17	1472	1472	2944	3709	0	32.9	0.66	13.32	0.51	0.0015	57.9	334	0.348	4.17	0.13	0.084	51.7	18.8
18	1250	1250	2500	3708	0	31.9	0.56	10.87	0.44	0.0013	55.9	388	0.357	4.14	0.14	0.086	50.8	18.9
19	951	951	1901	3672	0	31.0	0.50	9.05	0.36	0.0011	54.9	436	0.364	3.99	0.13	0.087	50.3	19.4
20	779	779	1558	3648	0	30.1	0.47	8.36	0.33	0.0011	54.6	454	0.360	3.86	0.12	0.086	50.2	20.1
21	679	679	1357	2275	0	27.7	0.33	6.45	0.25	0.0007	50.3	472	0.265	3.12	0.10	0.061	46.4	18.7
22	603	603	1206	2049	0	23.9	0.31	5.91	0.24	0.0007	49.5	470	0.250	2.85	0.09	0.058	45.0	21.1
23	385	385	770	1106	0	21.8	0.22	4.36	0.17	0.0005	47.2	381	0.137	1.63	0.05	0.032	41.7	20.0

Table D.4. New M5 with M4-M5 Link westbound 2031 regulatory traffic (winter). Stage 2 and 3 regulatory WB 2031_v1.xlsx

	New M5 traffic					Ambient	Peak in-tunnel levels (New M5)					M5 outlet							Southern Connector outlet						
Hour	M5 off (vph)	SC off (vph)	SPI on (vph)	New M5 on (vph)	No. of jet fans running	(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	401	171	201	341	9	10.8	0.19	4.1	0.19	0.0004	30.1	362	0.111	1.42	0.053	0.027	25.1	14.4	322	0.05	0.77	0.03	0.012	24.7	13.9
1	77	81	94	62	3	10.3	0.14	2.8	0.14	0.0003	29.3	253	0.047	0.55	0.023	0.012	22.0	11.8	242	0.03	0.42	0.02	0.007	22.8	12.5
2	50	81	90	38	2	9.6	0.08	1.3	0.08	0.0002	29.1	245	0.027	0.26	0.012	0.007	21.4	11.8	236	0.02	0.25	0.01	0.004	22.4	12.8
3	47	80	90	37	2	9.1	0.07	1.1	0.06	0.0002	29.0	246	0.023	0.18	0.009	0.006	21.2	12.1	237	0.01	0.21	0.01	0.003	22.1	13.1
4	101	156	147	114	3	8.5	0.07	1.5	0.07	0.0002	29.1	282	0.028	0.28	0.011	0.007	22.0	13.5	274	0.02	0.34	0.01	0.005	23.0	14.5
5	338	241	259	322	8	7.5	0.12	2.6	0.10	0.0003	29.7	369	0.069	0.88	0.028	0.017	24.0	16.5	338	0.04	0.68	0.02	0.009	23.9	16.4
6	533	338	461	410	10	6.5	0.20	4.0	0.17	0.0005	30.1	415	0.130	1.57	0.055	0.032	24.8	18.3	372	0.06	1.06	0.03	0.015	24.2	17.7
7	1123	467	852	735	17	6.5	0.27	5.9	0.26	0.0006	30.9	505	0.232	3.01	0.105	0.055	26.6	20.1	425	0.10	1.58	0.06	0.025	24.8	18.3
8	1538	850	1394	1009	20	7.8	0.35	8.1	0.36	0.0008	31.5	567	0.342	4.72	0.168	0.081	27.9	20.1	478	0.17	2.87	0.10	0.041	25.9	18.1
9	1241	1002	1496	720	15	10.0	0.39	7.7	0.39	0.0009	31.4	532	0.350	4.30	0.173	0.085	27.9	17.9	480	0.20	3.36	0.12	0.050	26.4	16.5
10	1168	1413	1667	955	11	12.7	0.42	8.4	0.41	0.0010	31.6	536	0.376	4.11	0.175	0.093	28.5	15.8	512	0.26	4.29	0.15	0.064	27.6	14.9
11	1150	1957	2188	948	9	13.9	0.44	9.6	0.42	0.0010	31.7	542	0.407	4.28	0.188	0.102	28.9	15.0	541	0.32	5.30	0.19	0.079	28.5	14.6
12	1132	2087	2425	793	7	13.9	0.41	9.6	0.41	0.0010	31.6	531	0.370	4.14	0.178	0.092	28.7	14.8	542	0.31	5.34	0.18	0.075	28.7	14.8
13	1148	2182	2583	776	7	14.0	0.43	9.9	0.42	0.0010	31.8	541	0.390	4.18	0.183	0.097	28.9	14.9	550	0.32	5.54	0.19	0.079	29.0	15.0
14	1183	2357	2741	841	7	14.0	0.43	10.4	0.42	0.0010	31.8	544	0.396	4.33	0.188	0.098	29.0	15.0	561	0.35	5.96	0.20	0.085	29.3	15.3
15	1267	2706	3064	988	6	13.5	0.43	11.4	0.46	0.0010	32.4	553	0.401	4.73	0.198	0.099	29.1	15.6	578	0.38	6.74	0.23	0.094	29.8	16.3
16	1606	3232	3584	1454	12	13.0	0.47	12.6	0.54	0.0011	33.1	599	0.483	6.17	0.247	0.118	29.7	16.7	582	0.43	7.54	0.27	0.106	30.5	17.5
17	1920	3913	4149	1949	19	12.5	0.50	14.6	0.63	0.0012	34.3	636	0.553	7.51	0.296	0.135	30.2	17.7	564	0.47	8.42	0.30	0.112	31.3	18.8
18	1472	3647	3057	1585	8	12.0	0.42	12.8	0.53	0.0010	33.8	572	0.416	6.14	0.236	0.100	29.2	17.2	583	0.42	7.79	0.27	0.101	31.0	19.0
19	1139	1869	2058	877	8	12.0	0.36	9.1	0.41	0.0008	32.5	518	0.319	4.51	0.174	0.076	28.5	16.5	519	0.26	4.82	0.16	0.060	29.4	17.4
20	1019	1121	1600	485	10	11.9	0.30	7.2	0.33	0.0007	31.8	492	0.254	3.61	0.134	0.060	28.1	16.2	467	0.17	3.15	0.11	0.041	28.3	16.5
21	924	888	1323	465	11	9.9	0.28	6.5	0.29	0.0006	31.6	475	0.218	3.07	0.111	0.052	27.5	17.6	443	0.14	2.56	0.08	0.032	27.5	17.7
22	840	809	1236	392	10	8.0	0.25	5.9	0.26	0.0006	31.4	460	0.191	2.74	0.098	0.045	26.7	18.7	432	0.12	2.31	0.07	0.029	27.0	19.0
23	597	270	343	467	11	8.0	0.23	5.2	0.24	0.0005	31.1	408	0.152	2.03	0.076	0.036	25.8	17.8	357	0.07	1.06	0.04	0.017	25.3	17.3

Hour	M4 - M5 Link Traffic				No. of jet fans running	Ambient	M4 - M5 Link Peak in-tunnel levels					SPI outlet						
	CWL on (vph)	WHT on (vph)	Rozelle on (vph)	SPI off (vph)		T (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	241	241	482	649	0	10.8	0.18	3.08	0.13	0.0004	32.7	328	0.093	0.95	0.03	0.022	27.2	16.5
1	103	103	206	352	0	10.3	0.13	1.70	0.09	0.0003	31.2	328	0.064	0.52	0.02	0.016	25.9	15.7
2	83	83	166	298	0	9.6	0.08	1.65	0.07	0.0002	30.1	304	0.039	0.46	0.02	0.009	24.6	15.1
3	83	83	166	294	0	9.1	0.08	1.65	0.07	0.0002	29.7	303	0.038	0.46	0.02	0.009	24.1	15.0
4	102	102	204	293	0	8.5	0.09	1.86	0.07	0.0002	29.5	282	0.037	0.47	0.01	0.009	23.3	14.8
5	154	154	309	294	0	7.5	0.11	2.34	0.09	0.0003	29.5	243	0.038	0.47	0.02	0.009	22.0	14.5
6	266	266	531	651	0	6.5	0.19	3.35	0.14	0.0004	30.5	317	0.094	0.98	0.03	0.022	24.2	17.7
7	769	769	1539	2330	0	6.5	0.34	6.88	0.27	0.0008	33.5	462	0.271	3.25	0.10	0.063	28.6	22.1
8	1234	1234	2468	3756	0	7.8	0.49	10.07	0.40	0.0011	37.7	432	0.356	4.37	0.14	0.085	31.9	24.1
9	1145	1145	2290	3699	0	10.0	0.49	9.24	0.39	0.0011	37.9	461	0.385	4.35	0.15	0.093	32.8	22.8
10	1197	1197	2394	3644	0	12.7	0.54	9.59	0.41	0.0012	39.4	441	0.398	4.27	0.15	0.097	34.2	21.6
11	1186	1186	2372	3611	0	13.9	0.55	9.50	0.41	0.0013	40.0	440	0.407	4.22	0.15	0.100	35.1	21.2
12	1146	1146	2292	3602	0	13.9	0.52	9.10	0.39	0.0012	40.1	460	0.408	4.26	0.15	0.100	35.3	21.4
13	1131	1131	2262	3607	0	14.0	0.53	9.07	0.40	0.0012	40.7	456	0.410	4.21	0.15	0.101	35.8	21.8
14	1121	1121	2241	3600	0	14.0	0.53	9.13	0.39	0.0012	41.3	450	0.407	4.17	0.15	0.100	36.2	22.2
15	1201	1201	2401	3622	0	13.5	0.55	9.73	0.42	0.0013	42.2	430	0.397	4.20	0.15	0.097	36.6	23.1
16	1335	1335	2669	3670	0	13.0	0.60	11.27	0.46	0.0014	44.1	381	0.376	4.20	0.14	0.092	37.3	24.3
17	1472	1472	2944	3709	0	12.5	0.63	12.80	0.50	0.0014	45.9	350	0.356	4.28	0.14	0.086	37.9	25.4
18	1250	1250	2500	3708	0	12.0	0.54	10.50	0.42	0.0012	44.1	404	0.364	4.23	0.14	0.087	37.4	25.4
19	951	951	1901	3672	0	12.0	0.48	8.81	0.35	0.0011	43.1	450	0.368	4.04	0.13	0.088	37.3	25.3
20	779	779	1558	3648	0	11.9	0.45	8.15	0.32	0.0010	42.8	466	0.363	3.90	0.13	0.087	37.2	25.4
21	679	679	1357	2276	0	9.9	0.32	6.32	0.25	0.0007	38.7	484	0.268	3.15	0.10	0.062	33.7	23.8
22	603	603	1206	2049	0	8.0	0.31	5.80	0.23	0.0007	37.7	480	0.252	2.87	0.09	0.059	32.5	24.5
23	385	385	770	1106	0	8.0	0.22	4.29	0.17	0.0005	35.5	388	0.138	1.64	0.05	0.032	29.6	21.6

Table D.5. New M5 eastbound 2021 regulatory traffic (summer). Stage 2 Eastbound 2021 24hrs Regulatory.xlsx

Hour	New M5		Number of Jet Fans Main tube	Ambient	Peak in-tunnel levels (before Kogarah outlet)					Kogarah outlet								Peak in-tunnel levels (before SPI outlet)					SPI outlet						
	M5 Flow (vph)	SPI off (vph)		(°C)	NO_2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	supply flow (m3/s)	exhaust flow (m3/s)	NO_2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	NO_2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO_2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	222	235	0.0	22.3	0.04	0.7	0.06	0.0001	24.6	250	317	0.023	0.23	0.017	0.0066	24.1	1.8	0.07	1.0	0.04	0.0002	28.2	266	0.028	0.25	0.008	0.0068	26.5	4.2
1	156	168	0.0	21.5	0.04	0.5	0.06	0.0001	24.5	230	285	0.019	0.14	0.013	0.0056	23.8	2.3	0.07	0.7	0.04	0.0002	28.0	246	0.024	0.16	0.007	0.0060	26.0	4.5
2	138	138	0.0	21.0	0.04	0.5	0.06	0.0001	24.5	229	280	0.019	0.13	0.012	0.0058	23.7	2.7	0.07	0.7	0.04	0.0002	27.9	245	0.024	0.14	0.006	0.0060	25.7	4.8
3	138	138	0.0	20.0	0.04	0.5	0.06	0.0001	24.4	234	278	0.019	0.12	0.012	0.0057	23.5	3.5	0.07	0.7	0.04	0.0002	27.7	251	0.024	0.15	0.006	0.0061	25.4	5.4
4	145	144	0.0	18.5	0.05	0.6	0.06	0.0001	24.5	250	291	0.021	0.16	0.014	0.0063	23.2	4.7	0.07	0.9	0.04	0.0002	27.6	268	0.026	0.19	0.007	0.0065	25.1	6.6
5	284	265	0.0	18.0	0.05	0.9	0.07	0.0001	24.6	285	342	0.027	0.28	0.019	0.0077	23.4	5.4	0.07	1.3	0.04	0.0002	27.7	304	0.033	0.35	0.010	0.0078	25.3	7.3
6	1,636	1,494	0.0	19.5	0.10	2.7	0.18	0.0003	25.7	487	614	0.114	1.77	0.096	0.0292	25.1	5.6	0.15	3.8	0.11	0.0003	29.6	515	0.130	2.02	0.049	0.0291	28.1	8.6
7	3,419	3,068	0.0	22.5	0.16	5.1	0.32	0.0004	27.1	542	671	0.192	3.53	0.184	0.0508	26.8	4.3	0.22	5.7	0.19	0.0005	32.0	571	0.214	3.36	0.093	0.0506	30.7	8.2
8	3,877	3,764	0.0	24.2	0.23	6.1	0.39	0.0006	28.1	512	627	0.251	4.06	0.217	0.0738	27.9	3.7	0.30	6.3	0.24	0.0007	34.0	541	0.285	3.56	0.112	0.0726	32.9	8.7
9	3,801	3,788	0.0	26.8	0.27	7.3	0.43	0.0008	28.7	500	587	0.285	4.58	0.223	0.0857	28.7	1.9	0.33	6.7	0.25	0.0008	34.9	525	0.297	3.63	0.115	0.0767	34.0	7.2
10	2,864	2,945	0.0	31.6	0.17	3.6	0.27	0.0004	27.6	573	723	0.220	2.81	0.178	0.0618	28.0	-3.6	0.25	4.9	0.18	0.0006	33.5	591	0.268	3.10	0.096	0.0647	33.4	1.8
11	2,691	2,737	0.0	34.3	0.16	3.3	0.26	0.0004	27.7	561	708	0.205	2.54	0.165	0.0575	28.3	-5.9	0.25	4.6	0.17	0.0005	34.9	575	0.250	2.82	0.086	0.0593	33.9	-0.4
12	2,475	2,515	0.0	34.3	0.15	3.1	0.24	0.0004	27.8	548	694	0.192	2.34	0.151	0.0539	28.4	-5.8	0.24	4.4	0.16	0.0005	34.6	563	0.234	2.64	0.079	0.0556	33.9	-0.3
13	2,330	2,345	0.0	34.1	0.15	2.9	0.23	0.0004	27.9	537	682	0.181	2.17	0.140	0.0509	28.5	-5.6	0.23	4.3	0.15	0.0005	34.5	552	0.220	2.49	0.074	0.0526	33.9	-0.1
14	2,052	2,088	0.0	34.2	0.14	2.7	0.21	0.0004	27.9	518	659	0.165	1.90	0.127	0.0465	28.5	-5.6	0.22	3.9	0.14	0.0005	34.4	532	0.203	2.19	0.067	0.0483	33.9	-0.2
15	1,878	1,897	0.0	34.2	0.13	2.6	0.21	0.0003	28.0	503	644	0.153	1.78	0.119	0.0428	28.6	-5.6	0.21	3.8	0.14	0.0005	34.3	517	0.188	2.04	0.062	0.0444	34.0	-0.2
16	1,873	1,869	0.0	33.8	0.13	2.7	0.21	0.0003	28.1	503	642	0.150	1.83	0.120	0.0412	28.7	-5.1	0.20	3.9	0.14	0.0004	34.1	518	0.183	2.07	0.063	0.0427	34.0	0.3
17	2,050	2,022	0.0	32.9	0.13	2.9	0.22	0.0003	28.3	515	654	0.155	2.03	0.129	0.0420	28.8	-4.0	0.20	4.1	0.14	0.0004	34.3	532	0.187	2.27	0.067	0.0432	34.1	1.3
18	1,886	1,949	0.0	31.9	0.11	2.6	0.18	0.0003	28.2	487	624	0.121	1.77	0.103	0.0314	28.7	-3.2	0.16	3.9	0.12	0.0003	33.8	504	0.147	2.05	0.054	0.0330	33.7	1.8
19	1,486	1,511	0.0	31.0	0.10	2.4	0.16	0.0002	28.1	459	588	0.101	1.48	0.084	0.0263	28.5	-2.4	0.15	3.6	0.11	0.0003	33.5	476	0.120	1.73	0.044	0.0270	33.1	2.2
20	1,237	1,285	0.0	30.1	0.09	2.0	0.14	0.0002	28.0	429	553	0.087	1.19	0.069	0.0235	28.3	-1.7	0.14	3.1	0.09	0.0003	33.2	446	0.105	1.42	0.036	0.0242	32.7	2.7
21	1,118	1,124	0.0	27.7	0.09	2.0	0.14	0.0002	28.0	424	540	0.084	1.12	0.066	0.0228	28.1	0.4	0.14	3.0	0.09	0.0003	33.1	443	0.102	1.33	0.035	0.0235	32.2	4.5
22	1,055	1,066	0.0	23.9	0.09	1.9	0.14	0.0002	28.1	418	526	0.081	1.05	0.063	0.0219	27.7	3.8	0.13	2.8	0.09	0.0003	32.8	443	0.097	1.24	0.033	0.0226	31.4	7.5
23	464	562	0.0	21.8	0.05	1.0	0.08	0.0001	27.5	300	374	0.033	0.39	0.025	0.0093	26.7	5.0	0.08	1.4	0.05	0.0002	31.6	320	0.043	0.47	0.014	0.0101	29.5	7.8

Table D.6. New M5 eastbound 2021 regulatory traffic (winter). Stage 2 Eastbound 2021 24hrs Regulatory.xlsx

Hour	New M5		Number of Jet Fans Main tube	Ambient	Peak in-tunnel levels (before Kogarah outlet)					Kogarah outlet								Peak in-tunnel levels (before SPI outlet)					SPI outlet						
	M5 Flow (vph)	SPI off (vph)		(°C)	NO_2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	supply flow (m3/s)	exhaust flow (m3/s)	NO_2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	NO_2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO_2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
0	217	222	0.0	10.8	0.05	0.7	0.07	0.0001	17.8	265	313	0.022	0.22	0.016	0.0065	16.5	5.7	0.07	1.0	0.04	0.0002	22.1	285	0.028	0.25	0.008	0.0068	19.0	8.3
1	141	146	0.0	10.3	0.04	0.5	0.06	0.0001	17.7	245	279	0.019	0.14	0.013	0.0056	16.1	5.8	0.06	0.7	0.03	0.0001	21.8	263	0.024	0.16	0.007	0.0060	18.5	8.2
2	138	138	0.0	9.6	0.04	0.5	0.06	0.0001	17.7	247	276	0.019	0.13	0.012	0.0058	15.9	6.4	0.06	0.6	0.03	0.0001	21.6	266	0.024	0.15	0.006	0.0061	18.2	8.6
3	138	138	0.0	9.1	0.04	0.5	0.06	0.0001	17.7	247	275	0.019	0.13	0.012	0.0058	15.8	6.7	0.06	0.6	0.03	0.0001	21.5	267	0.024	0.15	0.006	0.0061	18.0	8.9
4	172	168	0.0	8.5	0.05	0.6	0.06	0.0001	17.7	261	294	0.021	0.16	0.014	0.0064	15.8	7.3	0.06	0.8	0.03	0.0001	21.4	282	0.027	0.20	0.007	0.0066	17.9	9.4
5	290	280	0.0	7.5	0.05	0.9	0.07	0.0001	17.8	294	341	0.027	0.28	0.019	0.0078	16.0	8.5	0.07	1.2	0.04	0.0002	21.4	317	0.033	0.35	0.010	0.0078	18.1	10.6
6	1,741	1,721	0.0	6.5	0.10	2.7	0.17	0.0002	18.8	495	619	0.114	1.78	0.096	0.0293	17.7	11.2	0.14	3.7	0.11	0.0003	23.1	534	0.134	2.08	0.050	0.0299	20.9	14.4
7	3,679	3,514	0.0	6.5	0.17	5.2	0.32	0.0004	20.2	580	672	0.200	3.76	0.192	0.0533	19.2	12.7	0.22	5.6	0.18	0.0005	25.0	628	0.241	3.75	0.100	0.0558	23.0	16.5
8	3,880	3,825	0.0	7.8	0.22	5.9	0.38	0.0006	21.0	577	641	0.255	4.09	0.219	0.0748	20.0	12.2	0.28	5.7	0.21	0.0006	26.2	624	0.306	3.81	0.115	0.0747	24.2	16.4
9	3,833	3,726	0.0	10.0	0.24	6.3	0.39	0.0007	21.2	526	651	0.278	4.46	0.231	0.0829	20.5	10.5	0.32	6.2	0.23	0.0008	27.3	567	0.318	3.75	0.113	0.0807	25.2	15.3
10	2,862	3,299	0.0	12.7	0.17	3.6	0.28	0.0005	20.5	455	709	0.220	2.80	0.177	0.0618	20.0	7.3	0.44	7.7	0.24	0.0011	29.8	489	0.374	3.99	0.103	0.1030	27.5	14.9
11	2,633	2,634	0.0	13.9	0.16	3.3	0.26	0.0004	20.5	568	708	0.205	2.53	0.164	0.0573	20.1	6.2	0.24	4.5	0.16	0.0005	25.9	603	0.252	2.86	0.086	0.0592	24.6	10.7
12	2,409	2,421	0.0	13.9	0.15	3.1	0.24	0.0004	20.5	556	695	0.191	2.33	0.151	0.0538	20.1	6.2	0.23	4.3	0.15	0.0005	25.8	591	0.236	2.68	0.079	0.0556	24.4	10.5
13	2,204	2,217	0.0	14.0	0.15	2.9	0.23	0.0004	20.5	544	682	0.180	2.15	0.139	0.0506	20.1	6.1	0.22	4.1	0.14	0.0005	25.7	577	0.221	2.50	0.073	0.0523	24.3	10.3
14	1,960	1,978	0.0	14.0	0.14	2.7	0.21	0.0004	20.5	521	657	0.164	1.88	0.126	0.0463	20.0	6.0	0.21	3.7	0.14	0.0005	25.5	553	0.203	2.18	0.066	0.0481	24.0	10.0
15	1,854	1,869	0.0	13.5	0.13	2.6	0.21	0.0003	20.5	510	644	0.153	1.78	0.119	0.0427	19.9	6.4	0.20	3.6	0.13	0.0004	25.3	542	0.189	2.05	0.062	0.0444	23.8	10.3
16	1,927	1,920	0.0	13.0	0.13	2.7	0.21	0.0003	20.5	510	643	0.150	1.84	0.121	0.0411	19.9	6.9	0.19	3.7	0.13	0.0004	25.3	543	0.184	2.10	0.063	0.0427	23.7	10.7
17	2,133	2,119	0.0	12.5	0.13	2.9	0.22	0.0003	20.7	524	658	0.156	2.05	0.129	0.0421	20.1	7.6	0.19	4.0	0.14	0.0004	25.4	559	0.190	2.33	0.068	0.0436	23.8	11.3
18	1,779	1,797	0.0	12.0	0.11	2.6	0.18	0.0003	20.5	492	621	0.119	1.76	0.101	0.0307	19.8	7.8	0.16	3.7	0.12	0.0003	24.7	525	0.142	2.03	0.053	0.0317	23.0	11.0
19	1,475	1,485	0.0	12.0	0.10	2.3	0.16	0.0002	20.4	466	589	0.101	1.47	0.084	0.0263	19.6	7.6	0.14	3.4	0.10	0.0003	24.3	496	0.120	1.73	0.044	0.0271	22.5	10.5
20	1,153	1,166	0.0	11.9	0.09	2.0	0.14	0.0002	20.2	436	550	0.087	1.17	0.068	0.0234	19.3	7.5	0.13	2.9	0.09	0.0003	23.9	464	0.104	1.39	0.036	0.0241	22.0	10.2
21	1,108	1,115	0.0	9.9	0.09	2.0	0.14	0.0002	20.2	431	541	0.085	1.12	0.066	0.0229	19.1	9.3	0.13	2.8	0.09	0.0003	23.7	462	0.102	1.33	0.035	0.0236	21.5	11.7
22	1,046	1,055	0.0	8.0	0.09	1.9	0.14	0.0002	20.1	424	528	0.081	1.05	0.063	0.0219	18.8	10.8	0.13	2.7	0.08	0.0003	23.4	456	0.097	1.24	0.033	0.0226	21.0	13.0
23	361	375	0.0	8.0	0.05	1.0	0.08	0.0001	19.5	307	362	0.032	0.37	0.025	0.0090	17.6	9.6	0.08	1.4	0.05	0.0002	22.2	331	0.040	0.43	0.013	0.0094	19.0	11.0

APPENDIX E - REGULATORY CONGESTED TRAFFIC SIMULATION RESULTS

Results from the simulation of regulatory congested traffic in New M5, and New M5 with connected M4-M5 Link, up to Rozelle.

Table E.1. New M5 with M4-M5 Link eastbound 2031 regulatory traffic congested 9am (summer). Stage 2 and 3 regulatory EB 2031 congested.xlsx

Case	New M5 traffic			No. of jet fans running		Ambient	Peak in-tunnel levels (before Kogarah outlet)					Kogarah outlet								Peak in-tunnel levels (before SPI outlet)					SPI outlet						
	M5 on (vph)	SC on (vph)	SPI off (vph)	SC	Main tube	(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	supply flow (m3/s)	exhaust flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
20 km/hr	1,544	4,117	3,392	0.0	0.0	24.2	0.14	5.0	0.29	0.0003	27.7	714	1,193	0.262	4.79	0.247	0.0667	26.5	2.3	0.32	7.9	0.25	0.0007	36.9	375	0.193	2.89	0.077	0.0463	34.6	10.4
40 km/hr	1,544	4,117	4,180	0.0	0.0	24.2	0.14	5.0	0.29	0.0003	27.7	717	1,193	0.262	4.79	0.247	0.0667	26.5	2.3	0.29	7.5	0.24	0.0006	35.4	473	0.232	3.62	0.098	0.0548	34.0	9.8
60 km/hr	1,544	4,117	4,185	0.0	0.0	24.2	0.14	5.0	0.29	0.0003	27.7	742	1,193	0.262	4.79	0.247	0.0667	26.5	2.3	0.28	7.4	0.23	0.0006	35.1	481	0.228	3.67	0.097	0.0531	33.7	9.5
80 km/hr	1,544	4,117	4,188	0.0	0.0	24.2	0.14	5.0	0.29	0.0003	27.7	763	1,193	0.262	4.79	0.247	0.0667	26.5	2.3	0.28	7.5	0.23	0.0006	35.1	479	0.226	3.69	0.095	0.0519	33.7	9.5

Case	M4 - M5 Link traffic					No. of jet fans running		Ambient	Peak in-tunnel levels (M4 - M5 Link)					WHT-Rozelle outlets combined						
	M4-M5 Link on (vph)	SPI on (vph)	CWL off	WHT off	Rozelle off	St Peters On	CWL	T (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
20 km/hr	1,458	3,420	1,209	1,208	2,417	0	0	24.2	0.88	17.3	0.70	0.0023	46.7	676	0.822	9.65	0.327	0.2313	38.1	13.9
40 km/hr	1,458	3,793	1,306	1,305	2,612	0	0	24.2	0.61	11.5	0.57	0.0015	43.2	831	0.761	8.61	0.356	0.2029	37.5	13.3
60 km/hr	1,458	3,793	1,305	1,305	2,610	0	0	24.2	0.53	10.0	0.51	0.0013	42.0	903	0.741	8.39	0.356	0.1895	37.1	12.9
80 km/hr	1,458	3,793	1,306	1,306	2,612	0	0	24.2	0.49	9.4	0.47	0.0011	41.4	972	0.756	8.66	0.358	0.1867	37.0	12.8

Table E.2. New M5 with M4-M5 Link eastbound 2031 regulatory traffic congested 9am (winter). Stage 2 and 3 regulatory EB 2031 congested.xlsx

Case	New M5 traffic			No. of jet fans running		Ambient	Peak in-tunnel levels (before Kogarah outlet)					Kogarah outlet								Peak in-tunnel levels (before SPI outlet)					SPI outlet						
	M5 on (vph)	SC on (vph)	SPI off (vph)	SC	Main tube	(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	supply flow (m3/s)	exhaust flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
20 km/hr	1,544	4,117	3,392	0.0	0.0	7.8	0.13	4.9	0.28	0.0003	20.2	682	1,228	0.262	4.79	0.247	0.0667	18.9	11.1	0.32	8.0	0.25	0.0007	28.4	374	0.196	2.93	0.078	0.0470	24.7	16.9
40 km/hr	1,544	4,117	4,180	0.0	0.0	7.8	0.13	4.9	0.28	0.0003	20.2	686	1,227	0.262	4.79	0.247	0.0667	18.9	11.1	0.29	7.6	0.25	0.0006	27.0	471	0.235	3.67	0.100	0.0555	24.3	16.5
60 km/hr	1,544	4,117	4,185	0.0	0.0	7.8	0.13	4.9	0.28	0.0003	20.2	711	1,227	0.262	4.79	0.247	0.0667	18.9	11.1	0.28	7.5	0.24	0.0006	26.7	479	0.231	3.71	0.098	0.0537	24.1	16.3
80 km/hr	1,544	4,117	4,188	0.0	0.0	7.8	0.13	4.9	0.28	0.0003	20.2	732	1,227	0.262	4.79	0.247	0.0667	18.9	11.1	0.28	7.6	0.23	0.0006	26.7	477	0.228	3.73	0.096	0.0525	24.1	16.3

Case	M4 - M5 Link traffic					No. of jet fans running		Ambient	Peak in-tunnel levels (M4 - M5 Link)					WHT-Rozelle outlets combined						
	M4-M5 Link on (vph)	SPI on (vph)	CWL off	WHT off	Rozelle off	St Peters On	CWL	T (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
20 km/hr	1,458	3,420	1,209	1,208	2,417	0	0	7.8	0.88	17.2	0.70	0.0023	38.1	682	0.832	9.77	0.332	0.2342	27.3	19.5
40 km/hr	1,458	3,793	1,306	1,305	2,611	0	1	7.8	0.61	11.5	0.57	0.0015	34.6	826	0.759	8.58	0.355	0.2023	27.0	19.2
60 km/hr	1,458	3,793	1,305	1,305	2,610	0	2	7.8	0.53	10.0	0.51	0.0013	33.3	898	0.737	8.35	0.354	0.1885	26.7	18.9
80 km/hr	1,458	3,793	1,306	1,306	2,612	0	3	7.8	0.49	9.4	0.47	0.0011	32.7	966	0.752	8.62	0.356	0.1857	26.7	18.9

Table E.3. New M5 with M4-M5 Link westbound 2031 regulatory traffic congested 6pm (summer). Stage 2 and 3 regulatory WB 2031 congested.xlsx

Case	New M5 traffic				No. of jet fans running	Ambient	Peak in-tunnel levels (New M5)					M5 outlet							Southern Connector outlet						
	M5 off (vph)	SC off (vph)	SPI on (vph)	M5 on (vph)		(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
20 km/hr	1976	3399	4170	1991	29	32.9	0.55	16.2	0.64	0.0012	43.7	648	0.576	7.45	0.309	0.143	39.9	7.0	509	0.47	8.32	0.27	0.112	42.1	9.3
40 km/hr	1917	3910	4150	1946	17	32.9	0.51	14.8	0.64	0.0012	42.9	622	0.547	7.26	0.293	0.134	39.7	6.9	570	0.48	8.64	0.31	0.115	41.5	8.7
60 km/hr	1937	3969	4159	1962	16	32.9	0.51	14.7	0.63	0.0012	42.7	619	0.543	7.19	0.288	0.132	39.8	6.9	579	0.48	8.66	0.31	0.114	41.5	8.6
80 km/hr	1938	3974	4159	1962	16	32.9	0.51	14.6	0.63	0.0012	42.7	621	0.545	7.29	0.286	0.132	39.8	7.0	581	0.48	8.66	0.31	0.114	41.5	8.6

Case	M4 - M5 Link Traffic				No. of jet fans running	Ambient	M4 - M5 Link Peak in-tunnel levels					SPI outlet						
	CWL on (vph)	WHT on (vph)	Rozelle on (vph)	SPI off (vph)		T (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
20 km/hr	1473	1473	2946	3141	0	32.9	0.72	12.67	0.52	0.0017	59.5	300	0.328	3.44	0.12	0.084	52.2	19.3
40 km/hr	1472	1472	2944	3822	0	32.9	0.68	13.04	0.51	0.0015	58.5	333	0.354	4.06	0.13	0.086	52.1	19.3
60 km/hr	1473	1473	2945	3843	0	32.9	0.63	12.72	0.49	0.0014	56.7	356	0.355	4.31	0.14	0.085	51.0	18.2
80 km/hr	1473	1473	2945	3845	0	32.9	0.61	12.68	0.49	0.0014	56.2	363	0.357	4.41	0.14	0.085	50.7	17.9

Table E.4. New M5 with M4-M5 Link westbound 2031 regulatory traffic congested 6pm (winter). Stage 2 and 3 regulatory WB 2031 congested.xlsx

Hour	New M5 traffic				No. of jet fans running	Ambient	Peak in-tunnel levels (New M5)					M5 outlet							Southern Connector outlet						
	M5 off (vph)	SC off (vph)	SPI on (vph)	New M5 on (vph)		(°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
20 km/hr	1976	3399	4170	1991	29	12.5	0.54	15.9	0.63	0.0012	35.1	662	0.577	7.47	0.310	0.143	30.4	17.9	519	0.47	8.35	0.27	0.113	31.8	19.3
40 km/hr	1938	3951	4161	1966	18	12.5	0.50	14.5	0.63	0.0012	34.3	636	0.552	7.25	0.295	0.135	30.2	17.7	579	0.48	8.64	0.31	0.115	31.5	19.0
60 km/hr	1936	3967	4158	1961	16	12.5	0.49	14.3	0.62	0.0011	34.2	633	0.545	7.25	0.289	0.133	30.2	17.7	588	0.48	8.67	0.31	0.114	31.4	18.9
80 km/hr	1938	3972	4159	1962	16	12.5	0.50	14.4	0.62	0.0011	34.2	635	0.547	7.34	0.288	0.132	30.3	17.8	590	0.48	8.68	0.31	0.114	31.4	18.9

Hour	M4 - M5 Link Traffic				No. of jet fans running	Ambient	M4 - M5 Link Peak in-tunnel levels					SPI outlet						
	CWL on (vph)	WHT on (vph)	Rozelle on (vph)	SPI off (vph)		T (°C)	NO2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
20 km/hr	1473	1473	2946	3141	0	12.5	0.68	12.04	0.50	0.0016	47.8	319	0.337	3.56	0.12	0.086	38.5	26.0
40 km/hr	1473	1473	2946	3825	0	12.5	0.65	12.48	0.50	0.0015	47.0	351	0.362	4.17	0.14	0.088	38.7	26.2
60 km/hr	1473	1473	2945	3843	0	12.5	0.60	12.14	0.48	0.0013	45.1	374	0.363	4.42	0.14	0.087	37.8	25.3
80 km/hr	1473	1473	2945	3844	0	12.5	0.59	12.20	0.47	0.0013	44.7	380	0.365	4.52	0.15	0.087	37.5	25.0

Table E.5. New M5 eastbound 2021 regulatory traffic congested 9am (summer). Stage 2 regulatory EB 2021 congested.xlsx

Case	New M5		Number	Ambient	Peak in-tunnel levels (before Kogarah outlet)					Kogarah outlet								Peak in-tunnel levels (before SPI outlet)					SPI outlet						
	M5 Flow (vph)	SPI off (vph)	of Jet Fans Main tube	(°C)	NO_2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	supply flow (m3/s)	exhaust flow (m3/s)	NO_2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	NO_2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO_2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
20 km/hr	3,504	3,308	0.0	24.2	0.38	10.1	0.45	0.0010	30.3	355	467	0.283	4.53	0.173	0.0791	29.4	5.2	0.53	11.0	0.32	0.0013	38.1	380	0.325	4.08	0.099	0.0855	35.6	11.4
40 km/hr	3,892	3,761	0.0	24.2	0.21	5.5	0.37	0.0006	27.9	516	683	0.253	4.02	0.225	0.0729	27.7	3.5	0.31	6.2	0.24	0.0008	34.3	545	0.289	3.52	0.115	0.0743	33.0	8.8
60 km/hr	3,887	3,764	0.0	24.2	0.21	5.5	0.37	0.0006	27.9	544	687	0.253	4.01	0.225	0.0729	27.7	3.5	0.30	6.0	0.23	0.0007	33.9	573	0.290	3.62	0.116	0.0726	32.7	8.5
80 km/hr	3,889	3,764	0.0	24.2	0.21	5.5	0.37	0.0006	27.8	556	688	0.253	4.02	0.226	0.0730	27.7	3.5	0.29	6.0	0.23	0.0007	33.6	586	0.291	3.71	0.116	0.0725	32.6	8.4

Table E.6. New M5 eastbound 2021 regulatory traffic congested 9am (winter). Stage 2 regulatory EB 2021 congested.xlsx

Case	New M5		Number	Ambient	Peak in-tunnel levels (before Kogarah outlet)					Kogarah outlet								Peak in-tunnel levels (before SPI outlet)					SPI outlet						
	M5 Flow (vph)	SPI off (vph)	of Jet Fans Main tube	(°C)	NO_2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	supply flow (m3/s)	exhaust flow (m3/s)	NO_2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)	NO_2 (ppm)	CO (ppm)	Non-exhaust PM (mg/m3)	Exhaust PM Vis. (m-1)	Temp (°C)	flow (m3/s)	NO_2 (g/s)	CO (g/s)	Non-exhaust PM (g/s)	Exhaust PM (g/s)	T (°C)	Delta T Ambient (°C)
20 km/hr	3,503	3,308	0.0	7.8	0.38	10.0	0.45	0.0010	23.1	372	457	0.282	4.51	0.171	0.0787	21.3	13.5	0.49	10.1	0.29	0.0012	30.5	407	0.327	4.09	0.099	0.0864	26.6	18.8
40 km/hr	3,903	3,759	0.0	7.8	0.21	5.5	0.38	0.0006	21.0	512	684	0.256	4.04	0.227	0.0739	19.9	12.1	0.31	6.2	0.24	0.0008	27.4	555	0.293	3.53	0.116	0.0753	24.7	16.9
60 km/hr	3,890	3,770	0.0	7.8	0.21	5.5	0.37	0.0006	20.9	549	688	0.254	4.02	0.226	0.0732	19.9	12.1	0.28	5.8	0.22	0.0007	26.6	594	0.291	3.64	0.116	0.0731	24.3	16.5
80 km/hr	3,893	3,764	0.0	7.8	0.21	5.4	0.37	0.0006	20.8	561	689	0.254	4.03	0.226	0.0733	19.9	12.1	0.27	5.8	0.22	0.0006	26.2	607	0.293	3.73	0.116	0.0729	24.2	16.4

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