INDEPENDENT AIR QUALITY REVIEW

WESTERN HARBOUR TUNNEL AND WARRINGAH FREEWAY UPGRADE

NSW Department of Planning, Industry & Environment

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Independent Air Quality Review
Western Harbour Tunnel and Warringah Freeway Upgrade

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TABLE OF CONTENTS

LIST OF APPENDICES

Appendix A – Review of Response to Submissions
Appendix B – Technical review of Adequacy of Air Assessment in regard to the Air Modelling Regulatory Requirements

LIST OF FIGURES

1 SUMMARY

Todoroski Air Sciences has completed an independent technical review of air quality matters associated with the proposed Western Harbour Tunnel and Warringah Freeway Upgrade (the Project). In general, the air quality assessment is considered adequate, and shows that the Project would mostly result in minor improvements to surface air quality along key surface roads, but minor increases in air pollutant levels would arise at some locations along these roads.

The modelling approach is adequate overall, however it is considered that in future such assessments, improvements could be made in the adopted approach which uses the dispersion model in a less than ideal manner in terms of delivering the most accurate results at the most potentially affected locations. A simpler approach could obtain results at least as accurate, with less effort and complexity. Various other approaches could also be applied to overcome the model's limitations in representing potential pollutant dispersion over a large spatial area. Detailed modelling near to roads, per the model's potential strengths could be used to obtain more accurate results at the most affected locations and should be considered in other future assessments.

The meteorological component of the model has limited spatial performance. Meteorological conditions will significantly affect air pollutant dispersion over a significant distance, but less so near the source. As the traffic pollution levels far from the assessed roads would be low, any inaccuracy arising due to poor meteorological performance will also be small. However, it is not clear why modelling tens of thousands of generally distant, little affected locations is a key feature of the assessment approach.

The representation of apartments, offices (etc.) as a single receptor point increases uncertainty in the assessment as it has potential to underestimate the affected population and the pollutant impact. This is because many receptor points were selected in the centre of an apartment block or complex, rather than at the edge nearest the main road. A weighting for receptor type was used in the construction component of the assessment (e.g. 1 receptor equalled 50 people in the high density zones), but this does not tackle potential uncertainty in the level of impact due to the central placement of receptors.

Background pollutant levels are a key determinant of the absolute predicted levels. The interpolation method used for determining background levels is not ideal as there are only a few monitoring points, with significant existing pollution sources between the monitoring sites. The interpolation used results in implausible changes in pollutant levels across the modelling domain, making the approach challenging to accept, and leading to significant potential errors in the absolute predicted levels.

The issues identified in this review appear to primarily arise due to the lack of a prescribed air quality impact assessment approach for major road projects in NSW. Developing such a guideline or adapting one from other jurisdictions may resolve many of the issues. Future studies may also benefit from application of the findings from the related GRAL model validation study.

It is important to note that regardless of such issues, the overall findings of the assessment are unlikely to change. This is because any well designed tunnel would have less impact than an equivalent surface road, and in-tunnel air quality can be managed through appropriate design of the ventilation systems and outlets. The model has been shown to perform adequately well and consequently the assessment of impacts due to the project is considered adequate to support the conclusions reached.

2 INTRODUCTION

Todoroski Air Sciences has been engaged by the New South Wales (NSW) Department of Planning & Environment (DP&E) (now the Department of Planning, Industry and Environment) to review and provide independent advice in relation to air quality matters associated with the proposed Western Harbour Tunnel and Warringah Freeway Upgrade (hereafter referred to as the Project). The Transport for NSW (TfNSW) is the Proponent of the Project.

This report provides a review of the air quality assessment (AQA) for the Project (**RMS, 2020**) and related documentation. It also identifies potential areas where improvements in the air quality assessment can be made for future such projects.

3 PROJECT OVERVIEW

The Project involves the development of a new crossing of Sydney Harbour involving twin tolled motorway tunnels connecting the M4-M5 Link at Rozelle and the existing Warringah Freeway at North Sydney (the Western Harbour Tunnel) and the upgrade and integration works along the existing Warringah Freeway, including allowance for connections to the Beaches Link and Gore Hill Freeway Connection project (the Warringah Freeway Upgrade).

As part of the Project two ventilation facilities are proposed located at Rozelle (Rozelle ventilation outlet and motorway facility) and Cammeray (Warringah Freeway ventilation outlet and motorway facility). The Rozelle ventilation outlet would be constructed as part of the M4-M5 Link but would not operate until the opening of the Western Harbour Tunnel, if approved.

Figure 3-1 presents an outline of the Project context and location.

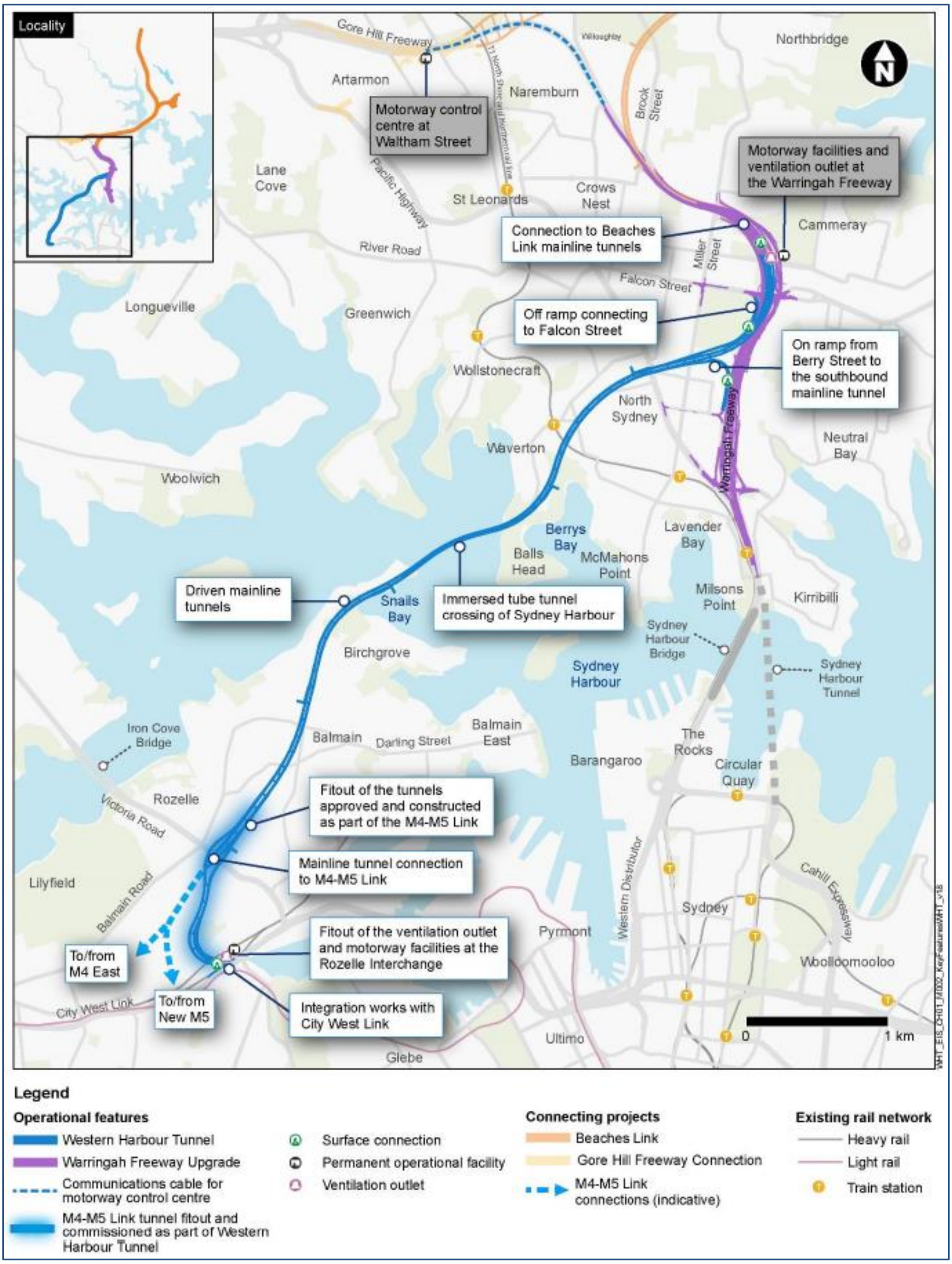

Figure 3-1: Project location and context (RMS, 2020)

4 FINDINGS OF CONSISTENCY REVIEW

The key findings of the consistency review of the Technical working paper: Air quality (Draft for Consistency) for the Western Harbour Tunnel and Warringah Freeway Upgrade (**RMS, 2019**) are outlined below. Generally, the Air Quality Technical Report was found to address the majority of the Secretary's Environmental Assessment Requirements (SEARs).

4.1.1 Avoidance of potential impacts

A general overview of potential operational control measures is given but there is no commitment or description of which measures would be used for this Project. The report states that the tunnel design would achieve the same or better outcomes as installing filtration.

4.1.2 Management or offset of residual impacts

A limited number of receptors will experience a small level of increased impact.

The ventilation design and control is assumed to be sufficient to avoid impacts, but it is not clear what specific considerations were made in the road design to minimise any specific impacts at the most affected receptors.

4.1.3 Compliance with in-stack criterion

Compliance with adopted in-stack limits is assumed in the assessment, some explanation of the process/steps/physical mechanisms that will be adopted to ensure compliance occurs in practice may be warranted.

4.1.4 Assessment of BTEX

There is no maximum hourly air toxics impacts presented for the most impacted residence (non-community receptor). Modelling results for ethylbenzene appear to be omitted for the worst-case scenario in Section 8.4.14.

4.1.5 Comparison with existing conditions

The change compared directly with the existing conditions "base year" is not shown.

4.1.6 Monitoring details

While it has been stated that monitoring will occur, specific details of monitoring including frequency and criteria, are not provided.

4.1.7 Best practice

While best practice is referred to variously, some clear and specific commentary (a comparison table etc.), on best practice design would be warranted to explicitly address this requirement. No assessment of in-tunnel air quality can be made without stating the averaging period of the predicted results.

5 PRELIMINARY REVIEW OF THE AIR QUALITY ASSESSMENT

This section outlines the key findings of the preliminary review (**TAS, 2020**) of the Technical working paper: Air quality for the Western Harbour Tunnel and Warringah Freeway Upgrade (**RMS, 2020**) and review of the Submissions Report (**Transport for NSW, 2020a**). For ease of reference, comments from the Submissions Report are immediately below the relevant issue and are shown in *grey and italicised*. Further comments by TAS are indicated in blue.

5.1 Introduction

The review of the AQA finds that overall, the assessment is adequate in that it clearly presents the expected situation; that a well-designed road tunnel, with well-designed ventilation and stack systems would mostly reduce traffic pollutant impacts by some degree at surface receptors relative to a surface road.

The AQA shows that the Project would overall result in minor improvements to surface air quality along most of the key main roads due to traffic travelling along the general route of the Project. By improving traffic flows, the quantity of traffic emissions can be reduced, and by dispersing the emissions from ventilation outlets into a larger volume of air than can occur for surface road emissions, the ambient ground level pollutant levels across the area can be improved overall.

It is noted that the AQA also identifies a limited number of receptors which will experience a small level of increased impact, beyond pre-existing impacts (above criteria) that would generally otherwise occur irrespective of the Project.

A number of areas in which any future such other assessments could be improved are outlined in the following sections.

The comments by the reviewer on the air quality impact assessment for the project overall and the improvements to surface air quality pollutant levels are acknowledged.

No further comment.

These less than ideal issues in this AQA appear to primarily arise due to a lack of specific guidance on air quality impact assessments for major roads in NSW. Developing such guidelines, or in the interim adapting the general approach in the guidelines from other jurisdictions, may help to improve future projects. For example, the US, Europe and other jurisdictions and bodies such as the World Bank have long standing guidelines and legislation requiring a range of issues to be addressed when assessing the potential development of a major road or highway.

The lack of specific guidelines is acknowledged. The key documents, guidelines and policies relevant to the assessment are discussed in Section 5.2 of Appendix H (Technical working paper: Air quality). It is noted that a similar modelling approach has been adopted on other recent major road transport projects in NSW and accepted by Department of Planning, Infrastructure and Environment.

No further comment.

5.2 Methodology review

5.2.1 Modelling approach

Similar to the air quality assessments for the WestConnex M4 East (**Pacific Environment, 2015a**), New M5 (**Pacific Environment, 2015b**), WestConnex M4-M5 Link (**Pacific Environment, 2017a**) and F6 Extension (**RMS, 2018**) the AQA used the GRAL model to predict operational impacts on ambient air quality. Modelling scenarios included the expected traffic scenarios and regulatory worst-case scenarios (an artificially exaggerated case to assess the effects that may occur if emissions were released at the permissible concentration limits for tunnel ventilation outlets at all times).

It is noted that consistent with the design of the tunnel ventilation system which would prevent portal emissions, no portal emissions have been assumed for the Project tunnels with all vehicle emissions assumed to be dispersed from tunnel ventilation outlets. It is noted that in reality some minor fugitive portal emissions may occur, and such minor emissions or portal emissions at night time/during very low traffic flows are unlikely to be a tangible issue.

Two tunnels within the modelling domain (Sydney Harbour Tunnel and the Eastern Distributor tunnel) were modelled to be releasing traffic emissions from their portals as a worst-case assumption.

One of justifications for the GRAMM/GRAL model selection was that it can characterise pollution dispersion in complex local terrain and topography, including the presence of buildings in urban areas however no building wake effects were included in the AQA as it was not considered practical to do so due to the fine grid resolution required.

A sensitivity analysis with buildings included was conducted at five community receptors and found an increase in concentrations by a maximum of 18 percent. It was however considered that the conclusions in the assessment would not change significantly with the inclusion of buildings. It is not clear if this considered that in general the selected receptor locations used in the AQA tend to represent the centre of large buildings or building complexes and there may be higher levels at the sections of the buildings closer to the roadway.

Buildings can be included in dispersion modelling to account for building wake effects in the vicinity of ventilation outlets, however, for the project assessment buildings were excluded. The rationale for this was provided in section 8.4.7 of Appendix H (Technical working paper: Air quality).

The size of the GRAL domain and the fine grid resolution meant that building data could not be practically included in the modelling. Due to the complex nature of GRAL's prognostic building calculations, the ideal model set-up to account for the effects of buildings would be a maximum domain size of around two kilometres by two kilometres, with a maximum horizontal grid resolution of five metres. To include buildings in the project set-up, and utilising GRAL's prognostic building calculation approach, would have resulted in extremely long model run times (in the order of weeks per scenario). Moreover, the post-processing of the results at a five-metre resolution across a modelling domain of the size used here would have been impractical.

In lieu of including buildings across the whole domain, the sensitivity of the inclusion of buildings to predicted concentrations was assessed. The results for the buildings tests are summarised in Table 8-35 of Appendix H (Technical working paper: Air quality) and show that when buildings were included, there was a maximum increase in concentrations associated with the ventilation outlet of 18 per cent, and a *maximum decrease of 20 per cent. Given the very small contributions made by the ventilation outlets this increase / decrease will make almost no difference to the total cumulative concentrations and not change the outcome of the assessment.*

It is also worth noting that there are only a small number of tall buildings in proximity to the proposed ventilation outlets, and therefore the effects of building downwash (refer to Annexure A of Appendix H) would probably have been limited.

It is acknowledged that the fine grid resolution adopted in the assessment makes it impractical to include building data in the model. That being said, the justification for the GRAMM/GRAL model selection (outlined in Section 8.4.2) on the basis of its ability to include the presence of buildings in urban areas is inappropriate if this feature is not being utilised.

The general selection of the centre of large buildings/ complexes is addressed under modelled receptors.

The consultant's modelling strategy/ assessment approach with the selected model appears to be too computationally large and is not set up to deliver the most accurate results where most relevant. Consequently, it appears that it was necessary to use the model in a less than ideal manner.

In the reviewer's opinion, it would have been preferable to have developed a more focussed, detailed model near to the major roadways (or at least those localities with changes in traffic volumes that are large) and to expend less effort on modelling receptors well removed from the roads. This would have made use of the model's known strengths in representing emissions near to roads and overcome its limitations in representing potential pollutant dispersion (affected by meteorological conditions) over a large spatial area.

The project covers a large area and so focussing the assessment on a small area close to roadways, as suggested, would not account for the important changes experienced in the broader surface road network as a result of the project.

Having relatively large GRAMM and GRAL domains also increases the number of meteorological and air quality monitoring stations that could be included for model evaluation purposes.

However, in terms of the more detailed analysis using the RWR receptors, this represents a very small subset of the total number of gridded receptors across the domain. The 35,000 specific residential, workplace and recreational receptors were chosen based mainly on their proximity to main surface roads that showed significant changes in traffic volumes due to the project, or near the ventilation outlets. That is, where the project was likely to have the most impact, be that positive or negative. These receptors are generally less than 1 km from these main roads and are therefore not dependent on domain size, but rather the location of the project.

The entire domain included over 2 million receptors at 10 m spacing and the contour plots across the domain provide a visual summary of predicted concentrations and changes over that area. Obviously many of these 2 million receptors do not represent locations where people may reside or work, so it was therefore appropriate to focus on a smaller number of RWR receptors closer to where the changes are occurring. These RWR receptors make up less than 2% of the total modelled receptors across the domain, *where the project impacts will be greatest. Justification for the model chosen is discussed further in Section 3.3 below.*

The response says that important changes are experienced in the context of the broader surface road network, however the most significant changes would occur near roads. Impacts from surface roads are anticipated to decrease by approximately 90% at a distance of 100m from the kerb (**Department of Planning, 2008**), and it is therefore not considered necessary to have a significant number of receptors located at distances over a few hundred metres from the key roads of interest.

Receptors (including elevated receptors) were considered within 300m of ventilation outlets. It is noted that receptors in significantly higher terrain that are further from the outlet may also need to be considered.

It is noted that the *Optimisation of the application of GRAL in the Australia context* report **Pacific Environment, (2017b)** was prepared by the same consultant. This study indicates that the model does not provide superior performance to established models and that the meteorological component is poor at representing spatial variations in meteorology.

Overall, given that;

- there is no need to assess non-permissible portal emissions;
- other models perform as accurately as the chosen model but are much less complex or computationally demanding to operate;
- other models perform considerably better at representing the prevailing meteorology; and,
- the "effort" required to conduct the chosen modelling approach would appear similar or greater than that needed to operate well established models which are able to conduct chemical transformation calculations, whereas significant additional work was necessary in this case to develop an empirical approach as the model cannot do such calculations. It would seem that other models or approaches may have been used to overcome the difficulties encountered with the model per the assessment approach which was used.

Potentially, more accurate results could have been obtained with similar effort by changing the approach, the model that was used, or how the model was applied. Also, it is considered that results which are at least as accurate and sufficiently adequate could have been obtained with less effort, using a simplified approach and/or model.

Overall, the rationale for the consultant's modelling approach and selection of the model is unclear and unconvincing. However, for the reasons previously considered, this would not change the overall outcome, and the overall approach is considered adequate for assessing impacts due to the Project.

The issues raised with the modelling approach are intimately related to the scope of the assessment and the model selection reflects the complexity of the project. The assessment needed to model surface roads (with complex changes across the road network over a large area and including more than 6,000 road links), tunnel ventilation outlets (point sources) and portal sources. In addition, large numbers of real-world receptor locations were affected, to a greater or lesser extent, by the project.

The reasons for the model selection and the advantages of using GRAL are discussed in Section 8.2.4 of Appendix H (Technical working paper: Air quality). The GRAL model is able to incorporate all three different *types of sources associated with road projects, such as surface roads, stacks and portals. It is also able to incorporate a much larger number of road links than other more widely used models such as CALINE. Annexure H of Appendix H (Technical working paper: Air quality) provides a detailed model evaluation against monitoring data and shows reasonable, albeit conservative, results.*

In a number of previous assessments, separate models have been used for different types of source (e.g. CALINE for roadways and CALPUFF for ventilation outlets). This approach makes the interpretation of results more difficult, as each model involves different treatments, inputs and assumptions (ego meteorology, terrain, buildings). In addition, Gaussian models for roadways, such as CALINE, do not allow the effects of terrain to be taken into account. An alternative approach is to use a single model which includes different types of source. Examples of such models include ADMS in the UK and GRAL from Austria as discussed above

All modelling is an approximation, and each available model has strengths and weaknesses given the specifics that are being modelled. It is therefore important to recognise those strengths and weaknesses and adjust the approach accordingly, to ensure that results are realistic and that appropriate conclusions can be drawn regarding impacts. It is also worth noting that the reviewer acting on behalf of the Chief Scientist and Engineer found the model to be appropriate for the project.

It is acknowledged that the issue is not critical to the veracity of the assessment findings. However it is pointed out that the issue does not relate to the model (as in the generic publicly available model computer code, and indeed this is adequate), rather how the model has been applied. In this regard there is scope to simplify the largely irrelevant aspects where there are no tangible effects, and to instead conduct the assessment in greater depth in the areas with most effect. This would improve the quality of the assessment and may make it more relevant.

It is acknowledged that adopting a single model can make the interpretation of the results easier, however this justification appears to contradict the actual use of multiple modelling approaches in this case, as discussed further below.

5.2.1.1 Use of multiple modelling approaches

While the operational impacts of the Project were assessed using GRAMM/ GRAL, to model potential odour from construction the CALMET/CALPUFF models were used. It is unclear why the same modelling approach was not used for construction impacts as the operational impacts. It is unclear why GRAL was not used, given the model is claimed to be suitable for assessing odour emissions. Whilst there is no issue with the selection of CALPUFF for assessing odour, why CALPUFF was selected for the assessment of odour impacts from construction in preference to the GRAL model being used for all other parts of the project is unclear, and appears to be at odds with the rationale for the use of GRAL over other dispersion models.

GRAL is a complex Lagrangian model primarily designed for modelling roads, tunnel portals and ventilation outlets. The odour assessment for construction has been undertaken in accordance with the NSW EPA Approved Methods.

Both the GRAMM/GRAL and CALMET/CALPUFF models are fit for the purpose for which they have been used in this assessment.

We agree that both models are 'fit for purpose" however there has been no convincing justification provided as to why multiple modelling approaches were used in the assessment, noting this appears to contradict the reasons provided for the use of the GRAL model in the first instance.

With regard to the assessment of construction impacts arising from the treatment and stockpiling of dredged material, odour was measured for samples of dredged material within Sydney Harbour near Birchgrove using an isolation flux hood. Flux hood sampling is the correct method approved for use in NSW, however when sampling water-logged material the method can underestimate potential odour emission rates of the material when handled. However, due to various remediation and other such projects in recent times, there is generally good practical expertise in Sydney for properly handling this type of material, and even strongly odorous material is generally able to be readily managed. If odour from dredged material does turn out to be an issue during the construction phase then a suitable remediation plan could be followed to tackle such odour.

5.2.2 Meteorological modelling

A broad, meteorological analysis was conducted in Appendix F of the AQA.

The 2016 meteorological year was selected in the AQA to allow use of the available 2016 data from roadside monitoring stations for dispersion model evaluation. While it is stated that the data for 2016 were representative of longer-term trends and the long-term wind speed and direction analysis for the selected meteorological stations, 2016 has not been demonstrated to be a representative year. A long-term analysis of wind direction has not been provided and based on the single metric of annual average wind speed, any of the reviewed years could be selected.

The overall meteorological data analysis does not provide a technically robust justification that the 2016 data used in the modelling are representative of the typical meteorological conditions for the area. Further quantitative analysis would normally be applied for a range of meteorological parameters including wind direction to demonstrate the meteorological representativeness of the year selected. By doing this, any bias in 2016 relative to the overall trends in the weather data can be identified, quantified and considered when interpreting the assessment findings.

It is agreed that it is important to have used a year in which there are suitable air quality monitoring data, and it is therefore uncertain why the more recent 2017 and 2018 years where project specific monitoring data are available were not considered. The long-term wind speed analysis which covers the period from 2009 to 2016 is inconsistent with the long-term background data analysis which covers data from 2004 to 2018. No explanation has been provided as to why the 2017 and 2018 years have been excluded from the long-term analysis of wind speed data.

Annexure F of Appendix H (Technical Working Paper: Air Quality) describes the process of determining suitable meteorological data to be included in the modelling, in considerable detail. The selection of a meteorological year is linked to the selection of the ambient air quality monitoring (background) year, as the two years need to be the same in any assessment. In both cases the selected year should also be taken as the base year for the assessment. The base year for the air quality assessment was taken to be 2016. The main reasons for this include:

- *There is often an expectation that the most recent air quality data (for a complete year) are used in an assessment. The last complete year of validated data at the time the assessment commenced was 2016*
- *The use of 2016 data allowed for a roadside monitoring station (M4-M5:01 – City West Link) to be included in the dispersion model evaluation*
- *The air quality monitoring data for 2016 was representative of the longer-term trends*
- *The long-term wind speed and direction analysis for the selected meteorological stations showed consistency across the monitored years.*

A comparison was carried out from a summary of the annual data recovery, average wind speed and percentage calms from 2009 to 2016 for all sites used in the dispersion modelling, which showed considerable year on year consistency in recorded values.

Meteorology is not often the main driver of predicted concentrations near to roads where the peak impacts would be expected to occur. As has been shown in previous submissions reports (M4 East), for most receptors the meteorology has little effect on the predicted concentrations, even for short time periods where you would expect the most sensitivity.

In addition, this assessment process began in 2017 and one of the first tasks completed was to assemble the meteorological data to be used and compile GRAMM. As mentioned above, at that time, the most recent year was 2016.

While other factors such as ambient air quality data influence the selection of the modelling year, it is good practice that the meteorological data be demonstrated to be representative. The 2016 year is considered suitably representative in terms of the presented wind speed data, however a long-term analysis of wind direction is also typically needed to confirm the representativeness of a selected year. It is noted that windrose plots are presented under the heading "Analysis of wind directions" and while this gives a visual comparison of the various years there is no further analysis of the long-term wind direction data as was presented for the wind speed data.

The comment that the review process began in 2017 is acknowledged however it is noted that the long-term background analysis included 2017 and 2018 data thus it is not clear why these periods could not be considered in the long-term meteorological data analysis.

Nevertheless, the reviewer's opinion, the assessment has applied a suitably adequate year of meteorological data in the modelling as it permits important verifications to be made with actual measured pollutant levels. These comparisons are considered by the reviewer to be more important than the effects which may arise due to variability in meteorological data between years, especially as the meteorological data do not appear to be a critical factor (see further below) and also because the chosen model has relatively poor spatial meteorological performance.

Data from the DPIE Randwick, DPIE Rozelle, BOM Manly and BOM Fort Denison monitoring stations were chosen for use in the modelling. An interpolation of the 2016 annual average wind speed presented in Figure F-1 of the AQA is used as part of the justification for the selection of the DPIE Randwick monitoring station data as the most "representative" in GRAMM.

Interpolation of wind speed is not a good means of evaluating weather data in this case for reasons including that it uses invalid data affected by the presence of trees etc, there are not enough data points to make the interpolation plausible (given the interceding terrain and other land features which affect the wind speed), and it is a questionable approach relative to using well-established meteorological models that factor in terrain, land use etc. which can be applied to provide a more reliable representation of winds across the area (and were used for the construction assessment anyway).

It is however acknowledged in the AQA that the DPIE Rozelle monitoring station has siting issues due to nearby trees and as such has been assigned lesser weighting factors in GRAMM than the DPIE Randwick station. The lesser weighting factor diminishes the influence of the invalid data from the Rozelle monitor, but it would perhaps have been better practice to not use these affected data at all, or if necessary to remove the portions of the wind directions affected by the presence of trees etc., and only use the portions with valid data, and use a meteorological model to input the missing invalid data rather than to simply include invalid data at a lower weighting.

Similarly, some of the wind data from the RMS and Sydney Motorway Corporation (SMC) monitoring stations are likely to be compromised by nearby trees. The inclusion of these stations in the interpolation would magnify the differences between the Project location and the Sydney Airport AWS.

With regard to the interpolation of data points across a large domain, it is acknowledged that there are limitations associated with this approach. However, as many data points as are available have been included.

Figure F-1 of Appendix H (Technical Working Paper: Air quality) presents the variation of annual average wind speed interpolated across the GRAMM domain. It illustrates that four Bureau of Meteorology weather stations - Sydney Airport, Manly, Wedding Cake West and Fort Denison drive the higher average wind speeds at around 4.5 metres per second in the eastern part of the GRAMM domain. Annual average wind speeds near the Department of Planning, Industry and Environment Lindfield station in the north eastern part of the GRAL domain are substantially lower at around one metre per second. The majority of the project corridor shows wind speeds within the two metre per second to 3.5 metres per second range. The Department of Planning Industry and Environment's Randwick station, has wind speeds between 2.5 metres per second and 3.5 metres per second, and is therefore much more representative of winds speeds within the general project corridor. Wind direction was also considered, and the wind rose analysis is shown in Annexure F of Appendix H (Technical working paper: Air Quality).

Based on the analysis, the majority of meteorological stations were not considered representative and were therefore removed from further analysis. Reasons included such things as proximity to vastly different land-use, too far in-land, instrument siting issues or distance from the GRAL domain.

The remaining five sites were then further evaluated using a matrix to identify their 'weighting' within the GRAMM model. That is, the amount of influence they would have on the final GRAMM output to be used in the GRAL dispersion model. The weighting factors takes into account four main aspects; wind speed, wind direction, siting factors and representativeness of the project corridor.

An evaluation matrix was developed and each aspect scored based on user judgment and considerations described in Annexure F of Appendix H (Technical working paper: Air quality). While not within the GRAL domain, Department of Planning, Industry and Environment's Randwick station scored highly in the *evaluation process and therefore received a higher weighting in terms of influencing the data in GRAMM. Likewise, Department of Planning, Industry and Environment's Lindfield scored poorly on almost all aspects and was subsequently excluded from further GRAMM analysis. The remaining three sites scored relatively low on one or two aspects and were therefore included but given a low weighting so they had minimal influence across the domain.*

Refer to Section B1.6.2 of the Environment Protection Authority response in the submissions report for further details.

The inclusion of wind speed data from compromised stations into the interpolation would skew the interpolated wind speed over the project corridor. In addition, the interpolation itself adds bias that may not otherwise exist (e.g. interpolation ignores interceding terrain which may in reality skew data). It is therefore not good practice to have used interpolation, (especially with compromised data) as the basis for selecting Randwick as the most representative meteorological data for the GRAMM modelling.

The BOM Wedding Cake West site data were not included in GRAMM due to high wind speeds. However, these appear to be actual high wind speeds, which are normal and expected to arise over water bodies. In any case, it is not clear why Fort Denison and Manly which were similarly noted as having higher wind speeds were included when Wedding Cake West was excluded.

Refer to the discussion in Section B1.6.2 of the Environment Protection Authority response in the submissions report.

The response in Section B1.6.2 of the Environment Protection Authority response in the submissions report says that the Wedding Cake West station is "characterised as an exposed location and recorded the highest average wind speed of all sites across the domain". The wind speed interpolation plot is used as justification to exclude Wedding Cake West data, showing that "it is not representative of the Project corridor". For reasons outlined previously, it is not valid to use a simple interpolation to exclude actual data. (Refer to the above further comments regarding issues with the wind speed interpolation).

"These high wind speeds were also likely to lead to an underestimate of pollutant concentrations and so was not considered a conservative option. It would result in an over representation of coastal sites which are considered by including Bureau of Meteorology's Manly station and Bureau of Meteorology's Fort Denison station."

While it is agreed that the exclusion of these high wind speeds is a more conservative option, the rationale behind only the exclusion of one of the windy sites is unclear nor is the number of stations which constitute an "overrepresentation" of coastal sites defined.

The question therefore arises whether this exclusion was perhaps made to compensate for the relatively poor spatial performance of the model, as discussed below, rather than attempting to directly improve on the model configuration.

However, as outlined at the outset, the model performance in regard to its representation of the spatially varying meteorological conditions is relatively poor, which is primarily due to limitations inherent to the model used (GRAMM) and possibly due to the modelling approach and data quality control/ selection.

The meteorological model used is relatively unresponsive to the likely actual spatial (and temporal) variations in the meteorological conditions and tends to apply very similar meteorological conditions at all points in the modelling domain as those in the meteorological input data.

The model used classifies meteorological data into discrete categories according to wind speed etc. These weather parameter categories are generally related to atmospheric dispersion but do not incorporate all of the factors which actually affect the dispersion at any time. This limitation inherently prevents the model from considering the hour by hour atmospheric dispersion conditions which may be occurring differently in different spatially separated places in the modelling domain. This results in poor spatial and temporal meteorological performance, and by extension, poor capacity for the overall model to predict short term, place and time specific pollution levels at a distance from sources.

The model evaluation presented in Appendix H (Technical working paper: Air quality), has shown that the model is reasonably good at predicting concentrations, while remaining conservative.

When assessing the dispersion of pollutants from vehicles, wind speed and direction are among the more important meteorological parameters to consider. These parameters were therefore the first considered when identifying which meteorological stations best represented the modelling domain.

With respect to meteorological modelling, it was concluded that while average predictions can be good at some locations, it is a challenge for both CALMET and GRAMM to predict wind speeds accurately across a domain in a situation such as the one investigated, where wind speeds varied considerably from location to location. The prediction of hourly wind speeds is very challenging for models, especially for stations not included as reference meteorology. The Match to Observations (MtO) function in GRAMM provided an improved prediction of wind speeds compared with a set-up in which it is not used, and also compared with GRAMM using the Re-Order function.

No further comment.

The critical question is whether or not these inherent limitations are significant for assessing the Project impacts.

In the reviewer's opinion, the limitations are not critical in this case. The fundamental reason is that for roads, the dominant effects occur within tens of metres from the road. Pollution from the road takes seconds or a few minutes to reach the nearest receptors which may experience the most significant effects. In this situation, there is insufficient opportunity for the weather (air dispersion) conditions to have a big effect so close to the source. From a most impacted receptor's point of view, the wind is either blowing the pollution from the road towards it, or not. If it is, the level of pollution arriving is mostly affected by the (short) distance from the road and any intervening terrain or buildings and less by the prevailing dispersion conditions (over short distances).

For the ventilation outlets (stacks), the meteorological effects on the modelled dispersion pattern of emissions would be significant but are not important as the emissions from the stacks can only be released at relatively low pollutant levels, generally low enough for the safety of tunnel users breathing the air when in the tunnel. (It is noted that tunnel air pollution increases as one moves along the tunnel and hence the air vented from the stacks is at almost the worst/ highest in-tunnel pollutant concentrations, but the level of pollution ramping up within the tunnel is much less than the level of dispersion achieved with a stack once the air is released). In this regard the stacks can only have low impacts and any inaccuracy spatially due to the model limitations in already low levels would be insignificant.

Overall, whilst the relatively poor spatial performance of the model is not critical, and would not change the conclusions reached, the use of the model set up in this case is incongruous with the level of detail adopted throughout the approach, particularly as a key feature of the assessment approach is modelling potential impacts at many thousands of residential, workplace and recreational (RWR) receptors which are positioned well away from the road and which cannot be accurately represented using the model per the adopted set up.

It is noted that the meteorological data used in the modelling of the construction period are different to those used in the assessment of operations. While data from the Randwick, Rozelle, Fort Denison and Manly were used in GRAMM, the BoM stations Sydney Airport, Randwick, Fort Denison and Manly were used in the CALMET generated meteorological file used in the construction assessment. No justification for the use of different meteorological data sets is provided.

This dataset could have included the Rozelle station to be consistent. However, given the predicted concentrations are orders of magnitude below the theoretical level of detection and further below assessment criterion, the inclusion of data from the Rozelle station is unlikely to have resulted in any change to the outcomes.

A correction should be made to the original review comment, it is acknowledged that data from Sydney Airport is included for both GRAMM and CALMET (limited to cloud content for GRAMM, and cloud cover and cloud height for CALMET). It is agreed that while Rozelle data could have been included for consistency, it is unlikely to have resulted in any change to the outcomes.

Furthermore details of the CALMET meteorological modelling have not been provided such as critical CALMET parameters, windroses, wind vector plots or analysis of CALMET generated meteorological parameters and so the adequacy of the CALMET meteorological file cannot be evaluated.

Even though odour is not the main focus of this assessment, a detailed modelling study has been carried out. This has shown there is predicted to be almost no impact from odour from the project. Some basic CALMET information included within the model is provided below.

The TERRAD and RMAX1 values have been provided however not all seven critical CALMET parameters; TERRAD, RMAX1, RMAX2, R1, R2, IEXTRP and BIAS (**NSW OEH, 2011**) have been provided which is typically required in an evaluation of adequacy.

5.2.3 Modelled receptors

The CR receptors assessed in the AQA are defined as "representative of particularly sensitive locations such as schools, child care centres and hospitals within a zone up to 1.5 kilometres either side of the Western Harbour Tunnel and Beaches Link program of works corridor, and generally near significantly affected roadways". The CR receptors are considered in greater detail than the RWR receptors.

The RWR receptors assessed in the AQA are defined as "discrete points in space - where people are likely to be present for some period of the day".

The "simpler statistical approach" used in this AQA and in previous assessments to assess the RWR receptors remains unclear and unexplained despite requests in the reviews of previous assessments that further clarification be provided in future. The AQA simply says the *"…simpler statistical approach was used to combine a concentration statistic for the modelled roads, portals and ventilation outlets (e.g. maximum 24-hour mean PM_{10}) with an appropriate background statistic."* It is recommended that the approach used be clarified and adequately explained.

As outlined in Section 6 of Appendix H (Technical working paper: Air quality), the assessment incorporated all available and relevant background monitoring data. One of the key metrics of the air quality impact assessment is change in $PM_{2.5}$ concentrations due to the project; using either a simpler method or more complex analysis would not be relevant to these findings.

It is well known that the accuracy of dispersion model predictions decreases as the averaging period of the predictions decreases. In addition, the reliability of predictions based on a detailed contemporaneous approach for incorporating background should be greater than that of predictions based on a simpler statistical approach. Consequently, not all of the model predictions in this assessment should be viewed with the same level of confidence, but rather according to the following hierarchy (note this is not specific to the model used, but rather modelling in general as a prediction tool):

- *Annual mean predictions for community and RWR receptors*
- *Short-term (1h and 24h) predictions for community receptors*
- *Short-term (24h) predictions for RWR receptors*
- *Short-term (1h) predictions for RWR receptors*

The simplification only related to short-term metrics. Annual mean concentrations were equally valid for both types of receptor.

A contemporaneous method was used for the 42 community receptors to incorporate background concentrations. This was not possible for the large number of RWR receptors included in the assessment, and so simpler approaches were used for these.

Justification for the use of the statistic approach for RWR receptors is given.

Despite using essentially the same RWR receptor approach in several previous assessments, the actual technical or scientific purpose of the RWR receptors still remains unclear. It is stated that the RWR receptors are not designed for the assessment of changes in total population exposure, however this is at odds with the results presented in Section 8.4.11 for example in Figure 8-63 which presents the change in annual mean $PM_{2.5}$ concentration at RWR receptors that represent the population with potential effects from the project.

The air quality assessment predicts the change in air quality across the road network due to the introduction of the Western Harbour Tunnel. Predicted pollutant concentrations have been presented three main ways:

- *Spatially, across a 10 m by 10 m equally spaced Cartesian grid with ~2 million grid points used for the contour plots*

- *At ~35,500 individually identified discrete receptors (the 'RWR receptors'). In most assessments, this is typically a small number of around 10 to 50 discrete receptors*
- *At 42 community receptors for a full contemporaneous assessment.*

The RWR receptors are discrete points in space, classified according to the land use identified at that location. The RWR receptors do not reflect the number of residential (or other) properties at the location. The land use at an RWR receptor location may range from a single-storey dwelling to a multi-storey, multi-dwelling or office building.

As the reviewer notes, the RWR receptors are not designed to assess changes in total population exposure. Population exposure due to potential changes in air quality, is considered in the context of human health risk in Appendix I (Technical working paper: Health impact assessment).

The impacts of the project are best considered by a combination of metrics, one of these being the change due to the project as presented in Figure 8-63 (noted by the reviewer). The distributions of changes in concentration at RWR receptors are designed to given an overall indication of the impact of the project. The overall impact of the project should be determined by a combined consideration of all the presented metrics in the air quality and human health assessments.

The total impact at all three groups of receptors are also considered. That is, for the gridded, RWR and Community receptors, the impacts of the project are combined with background concentrations to determine the total impact and for comparison with the assessment criteria in the Approved Methods.

No further comment.

The representation of high density dwellings such as apartments as a single, central receptor in the modelling can underestimate the exposure of the affected population. A population weighting for receptor type was used in the construction component of the assessment, but the AQA does not apply a weighting to assess operational impacts. However, the Technical working paper: health impact assessment section of the EIS combines the air quality information with the highest resolution population data from the Australian Bureau of Statistics to calculate key health indicators which reflect varying population density across the study area. A detailed analysis of the health impact assessment is beyond the scope of this review.

Receptors in air quality modelling assessments are defined as single points in space, not the number of people that may inhabit or use that location. Predictions are presented for these locations, using a number of metrics and approaches, as discussed above.

The construction assessment was not conducted using modelling (except for odour which was dealt with separately) and so different aspects were considered. This particular methodology required the assessment of risk based on the numbers of people and their proximity to high dust generating activities, rather than the calculation of a concentration of a pollutant at a particular location.

No further comment.

The scientific validity of the relative RWR assessment approach is questionable without firstly and independently of the air assessment, justifying the spatial and/ or impacting extent to be considered as the RWR bounds and giving a population weighting to RWR receptors. This is because the outcomes can be altered by the spatial extent of RWR receptors selected alone, (as this choice governs the fraction that are negatively or positively impacted) and can be biased without considering population density within the RWR bounds.

Where results are presented as the change in concentration at RWR receptors, (without the application of population weighting), this increases the uncertainty of the findings when assessing any net benefit or detriment. The outcome of these relative analyses is thus significantly influenced by the spatial extent of the receptors selected, with a more favourable balance being obtained when selecting greater numbers of more distant (less affected) RWR receptors and a less favourable result where fewer RWR receptors nearer to the surface roads are considered. This is not to say there is any issue with the spatial extent of the RWR receptors chosen in this case, however it highlights the need for a pre-defined guideline to be established. Indeed it is noted that this issue is one of only four key air quality issues raised by **The World Bank (1997)** for consideration when assessing road projects in its Roads and the Environment Handbook.

It is suggested that a more demonstrably objective means of assessing the net relative project impact would be to consider all of the receptors where the effect of the project is above a pre-defined, tangible value (e.g. > ±0.5μg/m^3). This would obviate the present bias that arises from selecting a (too large or too small) spatial extent for the RWR receptors, and would make the evaluation of Project benefits more objective when answering the question of whether the overall impacts due to the project are positive or negative.

This project covers a large domain and includes many changes to the surface road network. By selecting RWR receptors within a few hundred metres of the main program of works and main arterial roads (as shown in Figure 8-10 of Appendix H (Technical working paper: Air quality)), the impacts and relative changes to air quality at the most impacted receptors can be assessed. The number of RWR receptors chosen (~35,500) was neither too small or too large, but demonstrative of the areas most likely to result in a change from the project and therefore important to assess.

To only assess receptors within the immediate vicinity of the main roads would not account for the changes experienced in the broader surface road network as a result of the project.

The response says that important changes are experienced in the context of the broader surface road network, however the most significant changes would occur near roads. Impacts from surface roads are anticipated to decrease by approximately 90% at a distance of 100m from the kerb (**Department of Planning, 2008**), and it is therefore not considered necessary to have a significant number of receptors located at distances over a few hundred metres from the key roads of interest.

The geographical midpoint chosen to represent high density dwellings, particularly those along main roads, may also underestimate exposure for residents closest to the road and overestimate the exposure of those residents in the apartment complex with greater setback from the road. The pollutant level with distance away from a road does not reduce linearly, hence for a residential apartment/ complex with an even spread of people, the exposure experienced by the more impacted people (between the receptor point and road) will not be balanced out by the number of less impacts people further away from the receptor point and road, hence the net effect of using a central point to represent the effects at a large apartment/ complex is a potential underestimation of both the pollution exposure and the number of people who may be more affected at that location.

Representing the number of people, and hence pollution exposure, is not the purpose of an air quality assessment. An air quality assessment does not deal with population exposure per se. Air quality is a proxy for exposure, not exposure itself.

Given that the resolution of the gridded receptors is extremely fine, at 10 metres, the spatial representation across larger buildings will be taken care of in the contour plots. In other words, while a single point may be used to represent a building, the other gridded receptors (spaced at 10 metres) will represent many other points immediately around that single point, including closer to the road.

The specialist that carried out the assessment does not believe that either the prediction of maximum impacts or the accuracy of the findings have been compromised by the choice of receptor locations. The results provide a good indication of the likely changes in air quality at a large number of locations were people could be exposed.

It is acknowledged that the Technical working paper: health impact assessment section of the EIS combines the air quality information with the highest resolution population data from the Australian Bureau of Statistics to calculate key health indicators which reflect varying population density across the study area. A detailed analysis of the health impact assessment is beyond the scope of this review.

While it is considered that the gridded receptors would adequately cover the points around buildings with regard to generating contour plots, the concern is whether the likely maximum impacts and potential for exceedances of the relevant air quality criteria at the most affected receptors (including residences in building complexes with frontages along the road) are appropriately assessed.

The population weighting adopted in the construction assessment may not adequately reflect the number of receptors for sensitive land uses. For example, the assumed number of receptors for educational facilities is 100 however this may underestimate the number of potential exposed people at certain locations such as Cammeray Public School which has approximately 900 students. It is the Reviewers understanding that educational facilities in the vicinity of the Project generally have a significantly higher number of attendees than the 100 assumed. The construction risk assessment should be revised to reflect the likely number of receptors per location type.

The construction dust assessment is based on Guidance on the assessment of dust from general construction activities (IAQM, 2014). It is a risk based assessment, which does not require an exact number of human receivers and recommended judgement is used to determine the approximate number of sensitive receivers within varying distances. While schools in the study area may have an enrolment size greater than 100, this would not alter the classification of sensitivity for the areas within the study area, noting all areas except for the area surrounding the Sydney Harbour crossing, are classified as having high sensitivity.

The exact number of 'human receptors' is not required by the IAQM guidance. Instead, it is recommended that judgement is used to determine the approximate number of receptors within varying distances.

The response indicates that schools are already given the highest sensitivity rating "high" and that a number of receptors at a school location greater than 100 would not alter that classification. This adequately addresses the comment.

5.2.4 Tall buildings near ventilation outlets

The depiction of tall buildings near ventilation outlets, the potential wake effects associated with buildings and impacts on receptors within the building is considered below.

As outlined in Section 8.4.7 of the air quality assessment, building data were not included in the modelling due to issues associated with impractically long model run times. (As noted previously, there are alternative ways to accommodate this, but the options do not appear to have been considered).

The air quality assessment comments "*there are only a small number of tall buildings in proximity to the proposed ventilation outlets, and therefore the effects of building downwash (refer to **Annexure A**) would probably have been limited*".

Annexure A acknowledges the effect of building induced turbulence and its effects on pollutant dispersion and how this is an important consideration for the design of tunnel ventilation outlets. However, the assessment focuses on vehicle-induced turbulence as this is likely to be more significant than that caused by buildings.

The sensitivity test including buildings indicated that the maximum increase in concentrations associated with the ventilation outlet was 18 percent. As the predicted impacts are low, it was determined that buildings effects are unlikely to represent a large source of uncertainty in the overall predictions.

Modelled concentrations for the Project effects on surface roads were predicted at four elevated receptor heights (10 metres (m) 20m, 30m and 45m) for annual and 24-hour average $PM_{2.5}$. The results indicate that there are no adverse impacts at existing buildings however there is potential for adverse impacts for future buildings above 20m high within 300m of the ventilation outlets. The assessment states that land use considerations would be required to manage any interaction between the Project and future development for buildings above 20 metres and within 300 metres of the ventilation outlets.

The assessment notes that current planning controls for permissible habitable structures restrict buildings to below 20m within 300m of the Warringah Freeway outlet. It is noted that there is an existing fifteen storey (approx. 45m high) residential apartment block at 20 Moodie Street, Cammeray, located approximately 160m from the proposed outlet. It is important to confirm that there are no impacts predicted at this existing tall buildings, and also to ensure that local and state government do not permit additional tall buildings to be constructed within 300m of the ventilation outlet as these buildings may alter the prevailing wind flows and cause impacts to occur, at least in the interim until the final ventilation outlet design if confirmed and more detailed modelling is completed.

Impacts at elevated receptors are assessed Section 8.4.13 of Appendix H (Technical working paper: Air quality). A more detailed analysis is presented in the responses to the Environment Protection Authority submission in Section B1.6.4.

As noted by the reviewer, the proposed outlet should be considered when determining the locations and heights of any new developments in the immediate vicinity.

An analysis of impacts at height has been provided as Section B1.6.4 of the response to Key Stakeholder Submission for the expected traffic scenario and regulatory worst case scenario for the 2037 project year. The assessment indicates potential exceedances of 1-hour NO_2 criterion for the expected traffic scenario and 1-hour NO_2, 24-hour PM_{10}, 24-hour $PM_{2.5}$, annual average $PM_{2.5}$ and 1-hour formaldehyde criteria for the regulatory worst case scenario.

It is agreed that the proposed outlets should be considered when determining the locations and heights of any new developments in the immediate vicinity.

The development and finalisation of suitable planning controls near the ventilation outlets would need to be supported by detailed modelling addressing all relevant pollutants and averaging periods. In this regard, the model used in this Project (and indeed most commercial air dispersion models) is not suitable for detailed design evaluation of the interaction of ventilation stack plumes and any new, tall buildings and thus significantly more advanced approaches may be needed.

5.2.5 Background data

Background concentrations applied in the assessment are developed from selected DPIE and RMS monitoring sites. It is understood that the three project specific monitoring stations WHTBL:01, WHTBL:02 and WHTBL:03 were established in late 2017, but not used in the assessment as the "time period covered was too short for these to be included in the development of background concentrations and model evaluation". However, based on Table D-1 there is approximately 15 months of data available for this review and it is therefore requested that these data be provided in an hourly format, along with all other monitoring data (air quality and meteorological).

One of the first tasks completed when this assessment process began in 2017 was to assemble the meteorological data to be used and compile GRAMM. At that time, the most recent year was 2016. Additional monitoring data have been added to the analysis in terms of long-term trends and conversion of NO_x to NO_2, to ensure assumptions made for 2016 remain consistent.

While there is no project specific monitoring data available for the selected 2016 modelling year, it could be useful to include the available background data for all measured pollutants into the long-term ambient air quality analysis.

For short-term background pollutant concentrations at RWR receptors, a synthetic background file was developed for the contemporaneous assessment of community receptors. Short-term background levels for RWR receptors are based on the maximum level for 1-hr CO and NO_x, and the 98^{Th} percentile for 24-hr PM_{10} and $PM_{2.5}$ for RWR receptors of the selected monitoring stations for each time period. It is noted that the background levels used for PM_{10} are approximately double those used for the F6 assessment, and this appears to arise from the use of data from the M4E-05 monitor (not used for the F6). This monitor recorded a large spike in PM_{10} levels in April 2016, (which may perhaps be the reason for the high level used) and it is not clear whether adequate data quality checks have been made for the SMC monitor data. Also, there may be a typo or possible error in Table D-20 at D.8.5, which indicates that there are different background levels used for the community and RWR receptors. Overall, although a more transparent description of what was done would be appropriate, as it is currently understood, the approach used is considered likely to overestimate background levels for CO and NO_x, and to mostly overestimate 24-hour particulate levels.

The decision was taken in consultation with regulatory agencies to alter the approach and to include the elevated PM measurements due to bushfires and other events in the background analysis. This differed from the assessment of the M6 Motorway (formerly the F6 Extension) which did not include these events.

The synthetic profile adopted for the contemporaneous assessment is a different methodology to that used for the RWR receptors.

The response sufficiently explains why there is a significant difference between the PM_{10} background levels used in the WHT assessment compared with previous road projects. Generally it would be considered useful to include details within the technical working paper of the consultation with regulatory agencies in regard to methodology changes from past similar projects.

The text in sub-section D.8.4.2, which is assumed to relate to RWR receptors as Section D.8.4. is labelled "Background concentrations for short-term metrics at RWR receptors", states that "For PM_{10} and $PM_{2.5}$ the maximum 24-hour concentration from GRAL was added to the 98th percentile 24-hour concentration from the synthetic background profile (48.04 µg/m^3 for PM_{10} and 22.06 µg/m^3 for $PM_{2.5}$)." This is at odds with the 98th percentile 24-hour concentrations of 43.6µg/m^3 and 22.8µg/m^3 for PM_{10} and $PM_{2.5}$ respectively presented in Table D-50 for RWR receptors. It is noted that the 98th percentile 24-hour concentrations values presented in Table D-50 for community receptors are 48.02µg/m^3 and 22.06µg/m^3 for PM_{10} and $PM_{2.5}$ respectively. The difference between the values stated in the text and table may perhaps be due to a transcription error, however this should be clarified.

The annual average pollutant levels measured in 2016 at the DPIE and SMC monitors were interpolated in order to map the background concentration over the GRAL domain. Overall, the spatial interpolation of a few data points, some which are closely spaced and others well apart and the subsequent extrapolation of these data across an area with large expected variations in pollutant levels is challenging to accept as being valid or realistic, especially as represented in Figure D-24 and Figure D-25. The figures show a diagonal southwest to northeast graduation in NO_X levels and a southeast to northwest graduation in PM_{10} levels across the GRAL modelling domain, neither of which is likely to actually occur in reality when considering the factors affecting background pollution across the mapped area or the modelled area.

This limitation is acknowledged in Appendix H (Technical working paper: Air quality). However, it is clear from measurements at the different locations that the background levels are likely to vary across the large domain, due to such things as existing industry and density of the road network. This method attempted to account for at least some of that.

The background maps were created using a geostatistical Kriging method, whereby gridded values are interpolated based on the statistical relationship of the surrounding measured values. Clearly, the absence of monitoring data for much of the GRAL domain meant that there was uncertainty in the extrapolation. For the creation of the background maps, the data from all background stations in Sydney with relevant measurements were used.

To determine background pollutant concentrations for any discrete receptor location within the GRAL domain, the 'grid residual' function in Surfer was used. This function calculates the difference between the grid value and a specified data value at any x-y location. By setting the data value for a given x-y point to zero, it can be used to identify the estimated concentration for the point. Although this approach did not allow for localised influences on background concentrations, it was considered to be better than the alternatives (e.g. using a single annual mean value for the whole domain).

The interpolation method applied cannot produce realistic patterns of background concentrations across the modelling domain. While background levels would vary across the large modelling domain it is not considered useful to assume such a high degree of precision from the interpolation in order to try to account for this variation. The use of unrealistic data this produces could lead to over or under predictions where the background levels are close to the criteria limit.

Data interpolation is not appropriate in situations with limited information, as in this case where there is only one NO_X and one PM_{10} monitor in the modelled area, hence the potential errors in the interpolated background levels used in this case are very likely to be high. These errors are significant in regard to the absolute accuracy of the assessment predictions but only matter if there are criteria applicable for compliance or assessment purposes (which there are not).

The limitations with this method are acknowledged and addressed in the previous response above. The aim was to provide an indication of the trends across the domain which is why there were stations outside the GRAL modelling domain that were relevant. These provide an indication of how this trend progresses. Given the very large size of the domain this approach is likely to be more accurate than selecting a single value to represent all receptors. It is also noted that the concentration gradients are not large. For example, along the length of the project the background NO_x concentration ranges from around 18 µg/m^3 to 38 µg/m^3, which equates to a small variation in NO_2, PM_{10} concentrations range from around 16 µg/m^3 to 18 µg/m^3 and $PM_{2.5}$ remains relatively consistent at around 7.5 µg/m^3 to 8 µg/m^3 across the domain.

The background maps should be viewed as 'best estimates' based on the available data, and they have a low spatial resolution.

Refer to further comments above regarding the background data interpolation.

Also, the review was unable to find what data were used in the interpolation, for example actual annual average values used for the M4E-5, NewM5-1, NewM5-4, NewM5-6 RMS stations do not appear to be presented in the AQA. Furthermore, the interpolated map appears to contain more data, or utilise off-map data, or to have been be interpolated or created differently to those stated in the AQA. It is therefore requested that all of the data and information used to create the interpolation maps be provided and described to enable a complete review to be made.

The data are described in detail in Annexure D of Appendix H (Technical working paper: Air quality). The actual data from each site are not provided but description of how used in model provided at a high level. The individual maps show the sites used for the interpolations, in this case 14 available sites for NO_x, 15 sites for PM_{10} and eight for $PM_{2.5}$. All data are from 2016, the chose base year for modelling and in the case of PM, include elevated levels due to events such as bushfires.

Actual data used in the interpolation plots should be provided.

The approach of using background levels which exceed criteria in some cases does not allow scope to evaluate the possible issue of the Project leading to cumulative levels above a criterion or standard in some specific locations. This is however not directly relevant at present as the existing EPA criteria and NEPM standards (**NEPC, 2016**) do not apply to road projects. The issue may be relevant should any future road project assessment guideline set out an applicable cumulative criterion.

In the reviewer's opinion, the approach used may overestimate the absolute cumulative impacts for $PM_{2.5}$, one of the key pollutants associated with motorway operations.

5.3 Assessment and mitigation measures

5.3.1 Assessment of impacts

As the selected model cannot conduct chemical transformation calculations, an empirical method was used to evaluate NO_x effects based on an analysis of selected ambient monitoring data. The approach appears to be conservative (unlikely to underestimate results).

It is also noted that an evaluation of model performance can only be conducted at locations with known (measured) levels of pollutants and these known pollutant levels (background data) are used as an input to the assessed (predicted) cumulative total pollutant levels (variously). However, there is inherent uncertainty in the background levels that may occur between locations with known pollutant levels, for example due to the interpolation approach applied (or other such approaches which could potentially be used). The broad, generic discussion of uncertainty provided in the AQA does not adequately address or attempt to quantify the scale of the potential uncertainty, and importantly whether this may or may not affect the conclusions. Thus, a more rigorous evaluation may be reasonable.

In the case of particulate matter, it is well documented that the measurements are sensitive to the technique used. The data used in this analysis were collected using different instruments (both used to measure airborne particulate matter), and this clearly introduces some uncertainty in the results. For example, Tapered element oscillating microbalance devices (TEOMs) were used at the Roads and Maritime M5 East stations, whereas Beta Attenuation Monitors (BAMs) were used at the WestConnex and Western Harbour Tunnel and Beaches Link project stations. For the measurement of $PM_{2.5}$ at the Department of Planning, Industry and Environment (formerly OEH) stations, TEOMs were used until early 2012. A combination of TEOMs and BAMs were used during 2012, when a decision was made to replace the continuous TEOM $PM_{2.5}$ monitors with the USEPA equivalent method BAM. However, for traceability, in this assessment all data were used as received. As noted above in previous responses, the gradients across the domain are not large, presenting a good degree of confidence in the approach.

The background maps were created using a geostatistical Kriging method, whereby gridded values are interpolated based on the statistical relationship of the surrounding measured values. Clearly, the absence of monitoring data for much of the GRAL domain meant that there was some uncertainty in the extrapolation. For the creation of the background maps the data from all background stations in Sydney with relevant measurements were used.

It is acknowledged that there is likely to be some variation in measured levels due to the various different monitoring methods. Refer to further comments above regarding the background data interpolation.

It is noted that the background data dominate the total level predicted in the assessment and it is thus relevant to consider the background data in detail when considering total cumulative pollutant levels at any location. However, as the background data are assessed to be the key determinant of the total cumulative pollutant levels, the assessment results are not governed by modelling the impacts from the roads, but by a simple interpolation map of a limited data set.

As outlined previously, the simple interpolation used in the AQA to determine the background levels is not considered to be realistic.

Due to the importance of these data to the assessment, Annexure D of Appendix H (Technical working paper: Air quality) presents a full analysis of measured background data. This shows longterm trends, justification that 2016 is representative as well as presenting methodologies around how these data are used to represent the background concentrations for different pollutants and different averaging periods.

Refer to further comments above regarding the background data interpolation.

Contrary to the claim in the AQA, a level 2 contemporaneous assessment method for short-term impacts at community receptors has not been conducted per the NSW EPA Approved Methods (**NSW EPA, 2017**) as only the maximum impact is presented. The Approved Methods require the frequency at which the short-term impact assessment criteria are exceeded to be determined, with and without the subject source. The frequency of occurrence of any potential exceedances are not shown, hence it is not possible to tell how many additional short-term exceedances may occur due to the Project. (It is important to note that a level 2 contemporaneous assessment can only be reasonably conducted at a small number of receptors). The approach adopted only shows maximum levels (governed by background data) and does not make it possible to make any reasonable evaluation of this issue. Again, it is important to note that although applied in general in the AQA, the EPA criteria are not directly applicable.

A contemporaneous approach is used for community receptors in the project assessment. This was broadly consistent with the 'Level 2' method described in the NSW Approved methods. As noted by the reviewer it is not reasonable to consider this for a large number of receptors, as is the case for this assessment.

The contemporaneous analysis presented for the 42 community receptors is detailed in both model outputs and the determination of the varying background (hourly and daily). For a large urban area such as Sydney, the background levels will form a large part of the total cumulative concentration (modelled sources + background). This is why metrics such as the change due to the project were considered, in addition to those metrics noted in the Approved Methods. This removes the influence of the dominant background and is able to look at the project in the context of the changes that result from it. This is above and beyond what is required in the Approved Methods.

As noted by the reviewer, the approach used to determine the background concentrations may result in an overestimation of the absolute cumulative impacts for $PM_{2.5}$. The difficulties with regard to determining background PM concentrations are discussed in detail in air quality impact assessment, and conservative estimates are made to ensure impacts are not underestimated. In the case of $PM_{2.5}$, being one of the main health indicators, the assessment also specifically looked at the change in annual mean $PM_{2.5}$. This is a critical metric for the health risk assessment and also removes the influence of the background concentration estimates.

While annual average $PM_{2.5}$ is the main health indicator, that does not mean that potential short-term particulate impacts should be dismissed. A contemporaneous assessment should include some representative results so that the frequency of occurrence of any potential short-term exceedances can be evaluated.

Regardless of the above, the key analysis that should be, and is generally well set out in the assessment, is the relative change which may result in road traffic (and ventilation outlet) emissions. The results for this analysis are governed by the modelling predictions generally near the roads. The model has been shown to perform adequately in such locations and consequently the assessment of impacts due to the Project is considered to be adequate.

The assessment states that *"There is also the potential for crystalline silica emissions to occur during tunnel excavation due to the high temperature caused at the excavation face. This risk would be managed to ensure safe working conditions for workers and in accordance with relevant NSW and Australian guidelines. This would effectively manage any potential impact to ambient air quality. Crystalline silica is not considered further in this assessment."*

The Reviewer agrees that any risk to worker health could be managed to ensure compliance with the relevant work health and safety guidelines. It is understood that the mechanisms generating potentially respirable silica dust are the physical high-speed grinding and cutting activities (which may or may not generate high temperatures), but lead to potential risks of adverse exposure to workers near the source of the dust, and not the public.

Wherever reasonable worker controls are applied, it is anticipated that there would not be any broader silica dust impacts in the community. This is reflected by the absence of crystalline silica impact assessment criteria for sensitive receptors in NSW. Developing such criteria for NSW was considered by the EPA, but was determined to be unnecessary, given that existing particulate criteria provide sufficient protection.

5.3.2 Mitigation measures

With regard to the assessment of construction dust impacts, the assessment concludes that any effects would be temporary and relatively short-lived, and would only arise during dry weather with the wind blowing towards a receptor, at a time when dust is being generated and mitigation measures cannot be fully effective but that construction dust is unlikely to represent a serious ongoing problem.

Other than to offer an opinion, (potentially at odds with the experience of some in the community), the conclusions in regard to construction impacts do not well acknowledge or discuss how the proposed mitigation measures would transform the "Step 2C" unmitigated "high risk" of dust impact to human health for receptors in the Zone 5 area identified in Table 7-12 of the AQA to a low level of risk that would be consistent with the conclusion. The report appears to jump a step between "Step 3" and "Step 4" of the risk assessment. For example, what options are available to mitigate the risks if the proposed controls or how they are applied turn out to be inadequate?

To clarify, the qualitative Institute of Air Quality Management (IAQM) approach adopted here does not assess the impacts of dust, but rather the risk of impact if dust generating activities remain unmitigated. It is a qualitative methodology which rates the risk based on a number of factors, including the number of receptors and their proximity to the construction activities. The outcomes are then used to inform the recommendations for mitigation which, when carried out, should reduce this risk considerably.

Construction environmental management documentation would contain details of the site-specific mitigation measures to be applied. Additional guidance on the control of dust at construction sites in NSW is provided as part of the NSW Environment Protection Authority Local Government Air Quality Toolkit. Detailed guidance is also available from the UK (GLA, 2006) and the United States (Countess Environmental, 2006). For precise requirements, reference should be made to the Baseline Conditions of Approval for the project.

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The purpose of the construction assessment is to identify areas which would benefit from specific mitigation and management.

The effects of airborne dust during construction would be temporary and of relatively short duration, as discussed in Section C12.2.3 of the submissions report. As such, mitigation is considered straightforward because dust suppression measures are routinely employed as 'good practice' at most construction sites where there is surface disturbance. Environmental management measures to mitigate construction dust are provided in Section D1 (refer to Table D2-1 of the submissions report).

Dust and air quality complaints would be managed in accordance with the overarching complaints handling process for the project.

The response indicates that the construction environment management plan will contain details of the site-specific air quality mitigation measures to be applied. No further comment.

While the Project presents a general overview of potential operational control measures the Reviewer was unable to identify any commitment or description of which measures would be used for this Project. The ventilation design and control is assumed to be sufficient to avoid impacts, but it is not clear what specific considerations were made in the road design to minimise any specific impacts at the most affected receptors. Some explanation of the process/steps/physical mechanisms that will be adopted to ensure compliance occurs in practice may be warranted.

The scope of the assessment is to model the likely and worst-case emissions from the tunnel ventilation outlets, which has been done.

The ventilation system would be designed and operated to maintain in-tunnel air quality under all traffic scenarios, including breakdown and congested scenarios. The project has been designed such that the generation of pollutant emissions by traffic would be minimised. This is demonstrated by the modelling and assessment presented in Appendix H (Technical working paper: Air quality).

The assessment has also included an analysis of the Regulatory Worst Case which assesses a scenario which is theoretically impossible. That is, that the maximum in-tunnel concentrations occur for every hour of the year.

The project design provisions to reduce pollutant emissions and concentrations within the tunnel would include:

- *Minimal gradients as far as reasonably practicable*
- *Large tunnel cross-sectional area to reduce the pollutant concentration for a given emission into the tunnel volume, and to permit greater volumetric air throughout. The tunnels would have a width varying between nine to 12.5 metres and a vertical clearance of about 5.3 metres, which would be higher than most previous tunnels*
- *Increased height to reduce the risk of incidents involving high vehicles blocking the tunnel and disrupting traffic. This would reduce the risk of higher pollutant concentrations associated with flow breakdown.*

Considerations for road design in terms of air quality impacts are provided in the response. No further comment.

It is noted that this Project has been designed with the Cammeray and Rozelle ventilation outlets spaced approximately 6km apart. It is also proposed that the Western harbour Tunnel northbound and potential future Beaches Link southbound outlets would be located within close proximity to each other. This approach of co-locating ventilation outlets was similarly adopted in the recent F6 extension Project, where outlets for the F6 and New M5 tunnel projects were located within the Arncliffe Ventilation Facility. The co-location of the Western harbour Tunnel northbound and potential future Beaches Link southbound outlets is not considered to be an issue provided that the cumulative impacts are considered in the final design of the outlets. This co-location may lead to enhanced buoyancy and therefore greater dispersion.

5.4 Gap analysis

As discussed in the methodology review data from the three project specific monitoring stations WHTBL:01, WHTBL:02 and WHTBL:03 were not used in the assessment. However, based on Table D-1 there are approximately 15 months of data available for this review and it is therefore requested that these data be summarised and presented in graphical or tabular form in the response to submissions.

The reviewer was unable to identify any commitment or description of control measures that would be used for this Project. As such, clear and specific operational control measures and commitments for the Project are requested. Without any further information the reviewer is unable to assess the appropriateness and effectiveness of management and mitigation measures for the Project.

5.5 Recommendations

Whilst in the opinion of the reviewer the technical approach taken in the air quality assessment could be significantly improved and simplified, it is however considered adequate to assess the Project impacts, and indicates that no major air quality issues would arise if the Project is approved. The primary recommendation therefore is that the typical approval conditions applied to recent such projects to mitigate potential impacts be applied if the Project proceeds.

It is also suggested that any future assessment consider using an alternative modelling approach to address the issues identified in this review, or if the GRAL model is used, to consider the following:

- Apply the building features of the model and use a finer scale resolution near to the roadways (to improve modelling precision where it is most relevant);
- Focus more on modelling near the roadways and localities along the roadways where there is a tangible change in effects, for example a change in annual average $PM_{2.5}$ greater than say ± 0.5µg/m^3 would allow a more accurate and more clearly objective analysis of the net benefits or disbenefits to be made;
- Improve meteorological inputs if a large modelling domain is used, for example by:
    - Pairing the model with a more reliable meteorological model than GRAMM.
    - Use more meteorological categories.
    - Use more metrological station inputs with a correspondingly greater number of smaller modelling domain(s).
- Apply the findings of the GRAL validation study.

Irrespective of the modelling approach taken, it is also recommended to:

- Ensure all key vehicle types are accounted for in the emissions inventory and that the trends in future emissions are sensible.

It is noted that in February 2018, the EPA obtained regulatory oversight for the environmental aspects of motorway tunnel and ventilation outlet operations. Prior to this the EPA regulated only the construction aspects and only assisted with the management of any operational issues. The EPA now has the power to directly regulate those aspects of motorway construction and tunnel operation that can be affected by the actions of an operator. In light of this, consideration by state authorities should be given to developing a Major Road Infrastructure Air Assessment guideline, or in the interim, adapting a suitable guideline from another jurisdiction for application to future other projects.

5.6 Conclusions

The air quality assessment shows that the Project overall would result in minor improvements in surface air quality along most of the key main roads. This occurs as it is expected that through traffic would travel along the Project tunnel roads, where vehicle emissions can be captured and dispersed up into the atmosphere from the ventilation outlets. By improving traffic flows, the quantity of emissions can be reduced, and by dispersing the emissions from ventilation outlets into a larger volume of air than can occur for surface road emissions, the ambient ground level pollutant levels across the area can be improved overall.

It is noted that the assessment also identifies that minor increases in traffic pollution can be expected alongside some sections of surface roads affected by the Project.

Overall, the assessment is adequate and clearly presents the expected situation; that a well-designed road tunnel, with well-designed ventilation and stack systems would improve net traffic movements and result in an overall reduction in traffic pollutant impacts at surface receptors.

As outlined above there are however several less significant issues with the assessment which may potentially affect the calculated results, leading to somewhat higher or lower results. These issues primarily result due to some of the assumptions used and the lack of a specific NSW guideline for assessing air quality for major road projects. Developing such a guideline, or in the interim adapting a guideline from another jurisdiction would ensure that all key issues are considered reasonably and consistently, which is likely to improve future assessments of other such projects.

However, it is important to observe that regardless of these issues, the key conclusions of the assessment are unlikely to change. This is because any well-designed tunnel would have less impact than a surface road and in-tunnel air quality can be managed through appropriate design of the ventilation systems and outlets.

Overall, it is concluded that the assessment is adequate, however suggestions to potentially improve any future such assessments have been made for consideration.

6 POST EXHIBITION DOCUMENT REVIEW

6.1 Review of response to agency and public submissions

The response to key stakeholder and in community submissions are provided in the Submissions Report (**Transport for NSW, 2020b**). The review of the responses to issues raised by key stakeholder and in community submissions is summarised in **Table A-1** in **Appendix A**.

Key stakeholders who raised issues regarding air quality include NSW EPA, NSW Health, Office of the Chief Scientist and Engineer, Port Authority of NSW and relevant local councils.

There were over sixty air quality issues raised and responded to in the submissions report however as evident in **Table A-1** in **Appendix A**, there is much overlap of issues raised in the various submissions.

6.1.1 Additional advice

The NSW EPA provided additional comment/recommendations regarding the Submissions Report on 1 October 2020 (**NSW EPA, 2020**). Issues identified as not being resolved in the Response to Submissions are related to the ventilation flowrates used in the Regulatory Worst Case scenario and the evaluation of impacts at elevated receptors.

The NSW EPA recommends the proponent provide robust justification to demonstrate that the ventilation outlet emissions at the proposed emission limits will not cause adverse air quality impacts. Analysis should include, at a minimum:

- A focus on
  - PM exceedances at 30 m near the Cammeray stack;
  - 1-hour average NO_2 exceedances at 10 m near the Rozelle stack; and
  - Predicted exceedances of PM, NO_2 and formaldehyde at non-existing receptors.
- Frequency, likelihood and severity of exceedances;
- Operational management and mitigation measures, including but not limited to augmentation of the ventilation outlets;
- Review of the appropriateness of proposed emission limits for the ventilation outlets.

It is also recommended by the NSW EPA that if the Project is approved, the Inner West Council should implement building height restrictions within 300m of the Rozelle stack as otherwise there could be significant exceedances in 24-hour average and annual average PM, 1-hour average NO_2 and formaldehyde at future buildings at height.

TAS largely agrees with the NSW EPA recommendations.

6.2 Response to gap analysis

The project specific monitoring data requested in the preliminary review was not provided.

Management and mitigation measures have been clarified in the response to submissions and are discussed in **Section 7.3**.

7 FURTHER REVIEW OF THE AIR QUALITY ASSESSMENT

7.1 Technical adequacy

The key technical issues related to the assessment are discussed in the body of the report, and a complete list of technical issues examined in the review is summarised in **Table B-1** in **Appendix B**

These matters are largely technical or administrative in nature, and mostly stem from the lack of a specific AQTR assessment methodology for road projects in NSW. These issues are not of great significance to the assessment as the current NSW methodology is not technically applicable to road projects. For this reason, it is suggested that DPIE, RMS and EPA consider developing an agreed, methodology for modelling and assessing future major road and road tunnel projects.

Based on the review of the assessment approach applied in this Project, there is clearly ample scope to develop a better approach that is more robust and efficient. This would reduce the complexity, cost and time needed for such assessments, and provide the community, government and proponent with more confidence in the likely outcomes.

7.2 Compliance with applicable legislation and guidelines

In general, the Air Quality Technical Report was prepared in compliance with the applicable guidelines.

The findings of the consistency review outline the assessment's compliance with the SEARs. Generally the Air Quality Technical Report was found to address the majority of the SEARs.

Ventilation outlets of motorway tunnels in NSW are regulated by the EPA. The Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (**NSW EPA, 2017**) does not contain specific information on the assessment of major road projects. While GRAL/GRAMM is not listed as an approved dispersion model in this document, the assessment indicates that the NSW EPA have approved the use of this model for the Project. It is also noted that this model has similarly been used for other recent major road projects in Sydney.

Air quality impacts have been assessed against the relevant NSW EPA criteria. In general, the AQA shows compliance with the relevant air quality criteria and that the Project would overall result in minor improvements to surface air quality along most of the key main roads however there is a limited number of receptors that would experience additional exceedances from the operation of the Project.

The POEO and Clean Air Act in-stack concentration limits are addressed in the assessment however these limits are not strictly applicable to road projects.

7.3 Management and mitigation measures

7.3.1 Construction

It is understood that specific mitigation measures will be detailed in the construction air quality management plan and thus the appropriateness and effectiveness is not able to be evaluated in this review. However as stated, construction dust is unlikely to represent a significant impact, following the implementation of standard mitigation measures.

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7.3.2 Operation

The ventilation design and control is assumed to be sufficient to avoid impacts. As referenced from the NSW Chief Scientist and Engineer, there is little to no health benefit for surrounding communities in installing filtration and air-treatment systems in well-designed road tunnels and as such it is the opinion of the Reviewer that it is not considered necessary to apply filtration to the project ventilation outlets.

The air quality assessment and response to submissions provide considerations for road design in terms of air quality impacts. The road design is considered appropriate for mitigating air quality impacts.

7.4 Conditions of approval

The Department provided the draft conditions of approval for review. The conditions of approval are generally in line with that of other recently approved road projects.

8 CONCLUSIONS

The assessment applies an unconventional modelling approach for the assessment of major road projects. A key benefit of the approach is its ability to consider a large number of receptors.

Like any air dispersion model, the model used is powerful at making relative comparisons, and this aspect of the assessment is done well.

The assessment convincingly shows that the proposed Project would result in reduced air quality impacts at most nearby receptors, but some increased impacts would arise at a minority of receptors, generally on side roads related to the Project.

Due to a number of shortcomings inherent to the selected model and the modelling approach and assumptions applied, the assessment is less convincing in its estimation of the potential concentration of pollutants in the air. However, this is not seen as a major issue in light of the clear evidence that the Project would only change existing pollutant levels by a small degree, and that for the majority of receptors this would result in lower pollutant levels.

On this basis, the Project can be expected to reduce the levels of air pollution experienced by the majority of the residents living in the vicinity of the Project.

Due to some shortcomings in the assessment approach, it is suggested that TfNSW, DP&E and EPA consider developing an agreed, standardised methodology for the assessment of air emissions arising from future major road and road tunnel projects.

The outcomes of the assessment are largely dependent on the predicted traffic emissions and hence the predicted traffic numbers. To ensure that the Project is able to achieve the claimed air quality outcomes for the operation of the tunnel, in-tunnel air quality limits, including ventilation stack limits have been developed to be applied in the conditions of approval for the Project. These conditions also set out monitoring and reporting requirements which will demonstrate that the required limits are being met.

Please feel free to contact me if you would like to discuss or clarify any aspect above.

Yours faithfully,

Todoroski Air Sciences

9 REFERENCES

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"Western Harbour Tunnel and Warringah Freeway Upgrade (SSI 8863) EPA supplementary advice on the Response to Submissions", NSW Environment Protection Authority, October 2020.

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"Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System, for Inclusion into the 'Approved Methods for the Modelling and Assessment of Air Pollutants in NSW, Australia'", NSW Office of Environment and Heritage, March 2011.

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"WestConnex New M5 Air Quality Assessment Report", prepared by Pacific Environment for WestConnex Delivery Authority, November 2015.

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"Optimisation of the Application of GRAL in the Australian context", prepared for Roads and Maritime Services by Pacific Environment, August 2017.

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"Western Harbour Tunnel and Warringah Freeway Upgrade – Technical Working Paper: Air Quality – Draft for Consistency", prepared by ERM for Roads and Maritime Services, September 2019.

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Transport for NSW (2020b)

"Western Harbour Tunnel and Warringah Freeway Upgrade Submissions Report", prepared by Transport for NSW, September 2020.

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Appendix A

Review of Response to Submissions

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The responses to submissions were considered to be too lengthy to be included in the table here and in some cases included tables and figures and thus only a summary of the response is presented in **Table A-1**. For the full response please refer to the Western Harbour Tunnel and Warringah Freeway Upgrade Submissions Report (**Transport for NSW, 2020b**).

Table A-1: Review of response to key stakeholder and community submissions

Item	Issue raised	Summary of response	Reviewer comment
	NSW Environment Protection Authority		
B1.6.1	The NSW Environment Protection Authority notes that the Appendix H (Technical working paper: Air quality) adequately addresses all requirements of the Secretary's environmental assessment requirements, and has been conducted in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW (Environment Protection Authority, 2016)	Comment acknowledged.	Refer to the finding of the consistency review in Section 4 and the technical review of adequacy in Appendix B.
B1.6.2	The NSW Environment Protection Authority requests that justification be provided regarding the choice of meteorological data and weighting used in the meteorological modelling. The NSW Environment Protection Authority recommend that the GRAZ Mesoscale Model (GRAMM) should be validated using other meteorological stations (where possible) not included in the model, e.g. Bureau of Meteorology Wedding Cake West and Department of Planning, Industry and environment Lindfield station. If the revised model validation does not demonstrate acceptable agreement, GRAMM modelling should be revised to more accurately simulate the meteorology.	A detailed response is provided including the tabulated criteria for weighting meteorological stations in GRAMM.	Refer to comments in Section 5.5.2.
B1.6.3	The NSW Environment Protection Authority requests additional supporting justification to robustly demonstrate that minimum discharge flowrate adequately simulates expected reasonable worst case impacts for the regulatory worst-case scenario. The NSW Environment Protection Authority does not consider that using the minimum discharge flowrate (velocity) necessarily constitutes regulatory worst case and therefore requires additional supporting justification. In the absence of transparent and robust justification for using minimum flowrate, for the regulatory worst-case scenario, the NSW Environment Protection Authority recommends the proponent provides additional regulatory worst-case predictions using the maximum ventilation flowrate for the expected traffic case (Table G-8 of Appendix H (Technical working paper: Air quality)), including: • Total impact (ventilation outlet, surface roads and backgrounds) at sensitive receivers for all pollutants except air toxics • Predicted impact (ventilation outlet and surface road) at sensitive receivers of speciated air toxics • Contour maps for the ventilation outlet alone for all pollutants and all averaging periods	Additional modelling results are presented for the highest flow rate for each ventilation outlet for the 2037-Do something cumulative regulatory worst case scenario. When considering the maximum ventilation outlet contribution, the results show that for all pollutants and averaging periods the results are higher for the maximum exit velocity model runs. However, for 24-hour and annual averages these increases are small and concentrations are still well below the impact assessment criterion. For the shorter 1-hour averaging periods the relative increases are much larger, at the most impacted sensitive receiver. This does not lead to any additional exceedances.	The assessment of modelling results appears only to consider the most impacted receptor for the maximum outlet contribution and maximum total impacts for each pollutant and thus it is unknown how many additional exceedances may occur as a result of the higher airflow. It is however acknowledged as stated that the regulatory worst case represents a theoretical upper bound that would never occur for periods longer than a few hours, and thus even if modelling predictions at community and RWR receptors do show additional exceedances (particularly over 24-hour and annual periods) these additional exceedances would be unlikely to actually occur.

B1.6.4	The NSW Environment Protection Authority outline that the assessment of impacts at elevated sensitive receptors has only been carried out for annual and 24 hour average $PM_{2.5}$ for the 2037-Do something cumulative scenario. Impacts were not assessed in the regulatory worst case scenario and impacts due to other pollutants were not analysed. Further, the assessment was carried out using the change in 24 hour $PM_{2.5}$ concentrations as a metric, and therefore does not consider background concentrations nor presents the actual predicted impact/pollutant exposure at these sensitive receiver locations. Table 8-23 of Appendix H (Technical working paper: Air quality) indicates that the potential for adverse impacts increases significantly for building heights greater than 30m, while Figure 8-12 of Appendix H (Technical working paper: Air quality) illustrates there is at least one building of height greater than 30m within 300m of the ventilation outlets. The NSW Environment Protection Authority requests that further assessment is provided of existing and approved elevated receivers located in proximity to proposed ventilation outlets. The NSW Environment Protection Authority requests that the assessment: • Considers the regulatory worst-case scenario, as well as expected traffic scenarios • Is conducted for existing and approved receivers at least 30 metres high and within 300 metres of the ventilation outlet • Presents incremental (ventilation outlet), background (surface road and other non-surface road contributions) and cumulative concentrations for PM (24 hour and annual), and NO_2 (1 hour and annual) • Quantifies the percentage of exceedances for the expected traffic scenario, both with and without the project • Presents incremental (ventilation outlet) concentrations for air toxics.	Additional modelling is presented for all pollutants at elevated receivers, for the expected traffic cases and the regulatory worst case scenario at heights of 10 metres, 20 metres, 30 metres and 45 metres above ground level.	The assessment indicates potential exceedances of 1-hour NO_2 criterion for the expected traffic scenario and 1-hour NO_2, 24-hour PM_{10}, 24-hour $PM_{2.5}$, annual average $PM_{2.5}$ and 1-hour formaldehyde criteria for the regulatory worst case scenario at elevated receptors.
B1.6.5	The NSW Environment Protection Authority request clarification regarding whether the project contributes to additional exceedances in the annual average $PM_{2.5}$ criterion. Should the project result in additional exceedances, the incremental contribution from the ventilation outlets of the project should be provided.	The response provided tabulated results for additional exceedances (determined by comparing the Western Harbour Tunnel Do-Something or Do-Something-Cumulative scenario results for 2027 and 2037 with the Do-Minimum scenario results for 2027 and 2037) of annual average $PM_{2.5}$. The maximum change for the any of the residential, workplace and recreational receiver with an additional exceedance is only 0.3 $\mu g/m^3$, which is negligible when compared to the criterion.	While up to 227 additional exceedances are predicted to occur, these appear to occur when the "Do minimum" scenario is at or close to $8.0 \mu g/m^3$.

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B1.6.6	The NSW Environment Protection Authority outline that validation of the in-tunnel emissions model is not presented, and insufficient data is provided to allow transparent demonstration that the stated methodology was correctly implemented. The NSW Environment Protection Authority conducted an evaluation of the 'Do Something 2027' total emission flows presented in Figure 7-1 of the environmental impact statement using the fleet profile presented in Table 6.13 of the environmental impact statement, the Permanent International Association of Road Congresses (PIARC) emission factor workbook available on-line, traffic volumes estimated from Figure 6-5 of the environmental impact statement and from Appendix F (Technical working paper: Traffic and transport), and Western Harbour Tunnel gradients estimated from Figure 6.1 of the environmental impact statement. Based on the statement in Section 6.1.3.1 of the environmental impact statement, the NSW Environment Protection Authority assumed a constant speed of 80 kilometres per hour. A comparison of the emissions estimated by the NSW Environment Protection Authority to those scaled off Figure 7-1 of the environmental impact statement are presented in Table B1-30. There is concern that for CO, the emissions estimated in the environmental impact statement were consistently significantly higher than NSW Environment Protection Authority estimates by more than 100 per cent. In order to demonstrate that the sound and otherwise well documented methodology has been correctly implemented, the NSW Environment Protection Authority request that tabulated vehicle emission model verification be provided for one scenario (ego 'Do something 2027') presenting: • Traffic volumes • Tunnel lengths and gradients • Emission factors • Resulting total emissions.	The response provides the requested parameters.	No further comment.

B1.6.7	The environmental impacts statement estimates ventilation outlet temperatures by applying the same ambient to ventilation outlet temperatures differential measured on the Lane Cove Tunnel to the Western Harbour Tunnel ventilation outlets. While the small temperature difference of the ventilation outlet due to ambient temperature is likely to have minor impact of ventilation outlet dispersion and the ventilation outlet contribution to the ambient pollution concentrations is very small, the assumption underlying this approach is inappropriate. The temperature difference will be determined by the heat rejection of the vehicles passing through the tunnel, which primarily a function of traffic volumes and the tunnel ventilation rates. The NSW Environment Protection Authority request additional justification for this methodology adopted to calculate ventilation outlet temperature, including any potential impact on assessment results presented. Furthermore, it is recommended that the IDA tunnel software modelling approach is taken in future.	Data from existing road tunnels does not demonstrate a strong correlation between traffic flow and the temperature air at ventilation outlets. While there are a number of factors that may influence the temperature of air, review of existing tunnel data demonstrates that temperature of air discharged from ventilation outlets is primarily influenced by temperature of ambient air drawn into the tunnel and the temperature of the ground.	No further comment.
B1.6.8	The environmental impact statement assumed the introduction of Euro 6 for light duty petrol and vehicles in 2019. The environmental impact statement performed a sensitivity analysis which found that NO_x and NO_2 increased by 12 to 26 per cent in 2027 if Euro 6 were not implemented. The NSW Environment Protection Authority considers that no Euro 6 is the likely scenario as no progress has been made towards the promulgation of Euro 6 as of February 2020, and that the Petrol Fuel Quality Standard to require Euro 5/6 levels of sulfur will not take effect until 2027. The NSW Environment Protection Authority therefore estimates that in-tunnel levels of NO_2 will be in the order of 20 per cent higher than estimated in the environmental impact statement having the potential to impact on ambient air quality. The NSW Environment Protection Authority therefore request additional justification for the adopted assumption of Euro 6 introduction in 2019, including any potential impact on assessment result presented.	Given the small contribution that outlets make to the total ambient concentrations at ground level, when considered in conjunction with surface roads and background concentrations, there is likely to be no difference in outcomes when applying more conservative Euro 5 assumptions for tunnel emissions. The ventilation analysis assumes that there would be a transition of the passenger car and light duty vehicle fleet towards Euro 6 vehicle emissions standards in NSW. This assumption was not applied to the wider air quality assessment.	It would be useful for transparency to explicitly state where Euro 5 and Euro 6 emission factors are assumed and explain the reason for any potential differences i.e. the assessment appears to have used Euro 5 emissions for surface roads and Euro 6 emissions for tunnels.
B1.6.9	While the NSW Environment Protection Authority model predicts a PM_{10} to $PM_{2.5}$ ratio of 1.65 versus the environmental impact statement value of 1.45, this is not likely to have a significant impact as the in-tunnel $PM_{2.5}$ is overestimated. However, the NSW Environment Protection Authority predicts a GMR fleet wide THC:NO_x ratio of about 0.2 for 2026 (excluding evaporative emission) versus the environmental impact statement figure of 0.068 for 2027. This will result in underestimation of volatile organic compound (VOC) and air toxics from the ventilation outlet emission. As a result, the NSW Environment Protection Authority requests additional justification for the adopted ratio THC:NO_x including any potential impact on assessment results presented.	The response provides the THC:NO_x ration calculations used in the assessment. The results presented in Appendix H (Technical working paper: Air quality) show that air toxics derived from the THC predictions, are all well below their air quality assessment criterion, even for the regulatory worst case scenarios. If the ratio used was three times higher at 0.2, and these predictions would also be of the order of three times higher, they would still be well below the relevant air toxics criteria.	No further comment.

B1.6.10	Tabulated particulate emission factors outlined in Table 6.16 of Appendix H (Technical working paper: Air quality), are stated to be $PM_{2.5}$ however the PIARC workbook states emission factors to be PM_{10}. This will result in an overestimation of the $PM_{2.5}$ and PM_{10} in the tunnel and ventilation outlet emissions.	Comment acknowledged.	No further comment.
NSW Health			
B2.1.1	Traffic-related air pollution, including fine particular matter, is associated with a range of health effects. Although the individual risk is low, effects have been observed at the level of air pollution experienced in Sydney. Therefore it is important that reasonable measures are taken to minimise any increase in exposure to traffic-related air pollution. This is particularly important in places where $PM_{2.5}$ levels exceed, or are predicted to exceed, the NSW Environment Protection Authority's annual average impact assessment criterion of 8µg/m^3. A sensitivity analysis of traffic flows with a "regulatory worst case scenario" and a "sensitivity analysis scenario" is presented for each of the project's ventilation outlets (refer to Section 8.4.17 of Appendix H (Technical working paper: Air quality)). The "regulatory worst case scenario" and "sensitivity analysis scenario" predict a maximum increase in annual $PM_{2.5}$ of 0.89µg/m^3 and 0.46µg/m^3 respectively at the location of the most affected residential, workplace and recreational (RWR) receivers. The "sensitivity analysis scenario" demonstrates that underestimation of expected traffic flows has the potential to underestimate future $PM_{2.5}$ levels. Given the sensitivity of $PM_{2.5}$ levels to traffic flows, it is recommended that the proponent demonstrates the ventilation system has sufficient capacity to achieve the optimal environmental outcome in the event that there is more traffic than expected. Tunnels with well-designed and operated ventilation outlets improve dispersion of traffic pollution and reduce local ground level concentrations, compared to emissions from surface roads and tunnel portals. Increasing the height of stacks above the currently proposed height should be considered to help disperse pollutants. While ventilation stacks have an important role in reducing local air pollution, parameters such as stack height, exit velocity and ventilation rates should, where practical, be maximised to benefit local air quality. These actions are especially important given that some parts of the project area, such as the Balmain Peninsula, exceed annual and 24-hourly $PM_{2.5}$ National Environmental Protection (Ambient Air Quality) Measure (Ambient Air Quality NEPM) levels at times.	The assessment demonstrates that the proposed ventilation system would meet the New South Wales in-tunnel air quality criteria even under worst case conditions. The "regulatory worst case scenario" assumes that emissions from the outlets are always at the regulatory limits, i.e. the outlets are operating at the regulatory limits for 8760 hours per year. The "sensitivity analysis scenario" takes the expected daily emission profile for the road and scales it up by between 2.9 and five times so that daily $PM_{2.5}$ emissions are at the regulatory limit. These scenarios are not based on modelled traffic scenarios. The traffic scenarios that would be required to produce these emission scenarios are unrealistic. They have been modelled purely to test the sensitivity of contributions to annual average $PM_{2.5}$ concentrations at ground level to changes in emissions from the ventilation outlets. The sensitivity analysis for ventilation outlet height showed that only very small decreases (in absolute terms) would occur if the outlet height was raised	No further comment.
B2.1.2	As the ventilation outlets are not filtered, it is recommended that the environmental impact statement and all public communications about the project clearly articulate the reasons for this.	The independent NSW Chief Scientist and Engineer has recently released a report in relation to road tunnel air quality. The report found that emissions from well-designed road tunnels cause a negligible change to surrounding air quality, and as such, there is little to no health benefit for surrounding communities in installing filtration and air-treatment systems in such tunnels.	It is agreed that the reasons for not implementing filtration should be included in the assessment. This would be useful as this issue has been raised by numerous key stakeholders and community members.

B2.1.3	Given that ventilation outlets G and H (Warringah Freeway) are in close proximity to one another, predicted emission impacts and estimates of the influence of ventilation outlet temperature should be assessed and presented for each outlet both separately and together. It is not clear whether the outlets have been assessed separately or together.	The outlets at the Warringah Freeway have been modelled both separately and together; the outlet for the Western Harbour Tunnel (Outlet G) only operating in the 'Do something' (with project) scenarios and the outlets for the Western Harbour Tunnel (Outlet G) and Beaches Link tunnel (Outlet H) both operating in the 'Do something cumulative' scenarios in 2027 and 2037. In addition, further analysis was done with varying temperatures to understand the sensitivity of ground level concentrations to temperature. This included both Outlets G and H combined, at temperatures 10ºC above and below the 25ºC used for the bulk of the modelling.	No further comment.
B2.1.4	Construction site dust is a potential source of local air pollution during construction. The project footprint is close to a number of sensitive receivers in the Inner West Sydney. While standard dust suppression measures will be applied throughout the project, considerable community concern has arisen about dust from similar projects in recent years around M4 and M5 construction sites. Regular monitoring and review of the success of dust suppression measures (and increases in such measures as required) are vital to mitigating the impacts of construction dust on the local population, particularly at child care centres, schools, aged care facilities and health facilities.	Environmental management measure AQ1 (refer to Table D2-1 of this submissions report) commits to the implementation of standard construction air quality mitigation and management measures during construction. These measures include regular monitoring and review of the success of dust suppression measures. Environmental management measure AQ2 (refer to Table D2-1 of this submissions report) also proposes that dust and air quality complaints will be managed in accordance with the overarching complaints handling process for the project. Appropriate corrective actions, if required, will be taken to address dust-related issues in a timely manner.	The commitment for regular monitoring and review of the success of dust suppression measures satisfies the issue raised.

B2.1.5	The modelled in-tunnel pollutant levels comply with the current recommendations made by the Advisory Committee on Tunnel Air Quality. These recommendations are for short-term nitrogen dioxide exposure. Figures 8.1 and 8.2 of Annexure K to Appendix H (Technical working paper: Air quality) show the predicted nitrogen dioxide levels barely comply with the recommended average level of 0.5 parts per million under a 'worst case scenario' (heavy traffic, 20-40km/hr), meaning the is no excess capacity to achieve recommended levels if the modelling has underestimated pollutant levels. Therefore, it is imperative that the tunnel; ventilation system be adequate to re-establish guideline levels should they be breached. Motorists should be advised through signage and regular reminders to close their windows and recirculate the air in their vehicles while travelling through tunnels to reduce their exposure to traffic related air pollution.	During operation, air quality within the tunnel and the tunnel ventilation system would be continuously monitored and controlled to ensure air quality limits are not exceeded. In addition, traffic management measures may also be applied in order to assist in managing traffic flow and emissions, in the unlikely event that the ventilation system alone is unable to achieve the objectives. Worst case scenarios demonstrate that the tunnel ventilation system can manage in-tunnel air quality even when traffic is at its theoretical maximum capacity in the tunnel and for any given speed. Consistent with advice from the Advisory Committee on Tunnel Air Quality, it is now considered common practice to provide signage to remind motorists to close their windows and recirculate the air in their vehicles while traveling through tunnels and would be implemented as part of the project.	No further comment.
Office of the Chief Scientist and Engineer (Advisory Committee on Tunnel Air Quality)			
B3.3.1	The ACTAQ find that the assessment methodology is sound and represents best practice. All of the models and data used are appropriate and expertly used. No significant errors nor important omissions were identified.	Comment acknowledged.	Refer to Section 5 for an independent review of the methodology which outlines aspects of the modelling where improvements could be made.

B3.3.2	The methodology used to estimate in-tunnel emissions to assess in-tunnel air quality, and further being used as input to dispersion modelling of exhaust emitted through the tunnel ventilation stacks, is thoroughly and clearly described in the environmental impact statement, as is also the modelling of the emissions on surface roads. The ACTAQ note improvements over emission modelling undertaken for the F6 Extension environmental impact statement in 2018 including the application of the new PIARC approach for calculating vehicle emissions in tunnels and the modelling of worst-case traffic operation scenarios. In general, the emission estimates for surface roads are conservative, which is particularly true for future years, since no further (stricter) emission legislation is assumed after Euro 5. This is because any Euro 6 emission legislation has not been adopted in Australia yet. Therefore, the emission levels calculated for the years 2027 and 2037 can generally be considered as "upper limits", especially in regard to nitrogen oxides (NO_x). The ACTAQ note that the in-tunnel emissions modelling in the environment impact statement has assumed Euro 6 emission legislation being adopted in Australia for light duty vehicles and passenger cars from 2021. As this adoption is not yet clear, in-tunnel emissions in 2027 and 2037 may become higher than those presented in the environmental impact statement. However, since tunnel concentrations are subject to regulatory limits, an emission increase will not affect the tunnel concentrations, since the ventilation system operation will be managed and adjusted accordingly, but the emission rate (expressed in pollutant mass per time unit) through the ventilation stack will increase. The sensitivity analysis of the in-tunnel emissions modelling assuming no Euro 6 implementation by 2027 and 2037 in the environmental impact statement is acknowledged. In section 6.2.4.5 it is stated that the new PIARC approach provides emission data as of year 2019 – this is incorrect, the correct reference should be 2018. Furthermore, it is unclear what is meant with the subsequent sentence "Therefore, no degradation for old engine technologies are required to be applied." In this context.	In accordance with the Permanent International Association of Road Congresses (PIARC) report number 2019R02EN, engine degradation factors are no longer appropriate for the emission modelling because the emissions databases are based on the year 2018, where either the degradation of old technology is already at its maximum (Euro 0 to Euro 4) or statistically valid information about engine degradation is not available (Euro 5 and Euro 6).	It would be useful for transparency to explicitly state where Euro 5 and Euro 6 emission factors are assumed and explain the reason for any potential differences i.e. the assessment appears to use Euro 5 emissions for surface roads and Euro 6 emissions for tunnels.

B3.3.3	ACTAQ outline that the approach used to address variation in wind speed and direction due to local land-sea breezes using the 'Match-to-Observations' function in GRAMM is highly appropriate in this situation and are comfortable that this is likely to provide the most representative results whilst retaining slight conservatism. While the study area contains complex terrain (specifically, the shallow valley through which the Warringah Freeway passes) having the potential to lead to the accumulation of some air pollutants, the ACTAQ are satisfied that the way the GRAMM-GRAL modelling suite has been used is sufficient to capture these potential effects. While the ACTAQ note that they are likely to be of minimal significance for this project, to provide additional confidence ACTAQ suggest additional dispersion modelling be undertaken for 2018 and compared with measurements undertaken at the project monitoring stations (see ACTAQ commentary in B3.3.4 below regarding the modelling base year). If the modelling was failing to capture this phenomenon it would show up as a relative under-prediction of concentrations at station WHTBL:03 on calm and cold winter evenings and/or mornings. In general, the GRAMM-GRAL dispersion modelling suite has been used appropriately and appears to be giving credible results. The evaluation of the models provided in Appendix H (Technical working paper: Air quality) relates to the model's ability to capture dispersion from open roadways. The model's apparent success in doing this (albeit with some conservatism) may be used to infer that they will perform similarly well in predicting dispersion from a tunnel ventilation outlet. Additionally, ACTAQ observes that although outside of the scope of an environmental impact assessment, a considerable volume of additional data has become available from monitoring around the ventilation outlets of the M4 East tunnel, which provides an opportunity to re-evaluate the model.	The comments from ACTAQ on the GRAMM-GRAL model evaluation are noted. The evaluation of the GRAMM-GRAL system performance is described in Annexure H of Appendix H (Technical working paper: Air quality). The assessment for the project adopted a model evaluation approach based on the monitoring data and model predictions for the base case (2016). However, the monitoring data available for model evaluation were limited at the commencement of the assessment.	Refer to Section 5.2.2. for comments regarding the poor spatial performance of the chosen meteorological model.

B3.3.4	ACTAQ acknowledges the challenges associated with assessment of background air quality in an environmental impact statement such as this. In common with previous WestConnex and NorthConnex projects considerable funds have been spent on air quality monitoring, putting the Western Harbour Tunnel project in the enviable position of having a far richer observational dataset available than most, if not all, comparable projects. ACTAQ notes that while the environmental impact statement identifies that over a year's worth of data was collected from three monitoring stations specifically established for the Western Harbour Tunnel and Beaches Link projects, this data has not been directly used to establish background concentrations for the modelling. This appears to be due to the modelling base year being 2016 and the monitoring data not being available until October 2017. Acknowledging restrictions around the environmental impact statement timeframe, ACTAQ outlines that this mismatch may have been solved had 2018 been chosen as the base year, not 2016. However it is unlikely that 2018 data is substantially different to 2016 data and more effort could have been made to show how 2018 data is a reasonable surrogate for 2016 data in many cases. Notwithstanding, ACTAQ does not believe that the weakness in background air quality assessment is seriously influencing the key conclusions of the environmental impact statement, and in particular does not impact the health risk assessment. This is because the health risk assessment is based on the changes in air quality due to the project, independently of background air quality. Despite identified limitations, ACTAQ finds the current assessment of background air quality to be fit for purpose.	A comparison of the background concentrations assumed for the assessment, based on 2016 data, with data collected subsequently in 2018 found that levels in 2018 were consistent with or lower than those in 2016. Hence it is not considered that re-modelling for the base year 2018 is warranted.	It is considered that the justification for the selection of the 2016 modelling year could be improved (refer to Section 5).
B3.3.5	The method used has limitations, which the environmental impact statement appropriately acknowledges. However, the ACTAQ finds the empirical approach of estimating NO_2 concentrations using observational NO_2 and nitrogen oxides (NO) data to be sound, appropriate and the approach most suited to the purposes of the environmental impact statement.	Comment acknowledged.	The empirical approach for estimating NO_2 appears to be conservative (unlikely to underestimate results).
B3.3.6	This project contains a number of elevated receptors, i.e. taller buildings and locations where ground level is higher than at the base of the tunnel ventilation outlets. ACTAQ finds that this has been well-considered in the environmental impact statement with the explicit modelling of such receptors handled thoroughly and appropriately.	Comment acknowledged.	A further analysis of impacts at height has been provided as Section B1.6.4 of the response to Key Stakeholder Submission for the expected traffic scenario and regulatory worst case scenario for the 2037 project year.

B3.3.7	The approach applied for the assessment and management of construction impacts (demolition, earthworks, construction and track out) in the Western Harbour Tunnel and Warringah Freeway Upgrade environmental impact statement is consistent with that applied in the previous environmental impact statements since 2015 (i.e. the F6 Extension Stage 1, the M4-M5 Link, the New M5 and the M4 East). ACTAQ notes that the risk assessment has been thoroughly conducted. The construction footprint of the project, defined as the total above ground area facilitating all of the surface works associated with the project, was divided into five construction assessment zones. The risks of impacts for three impact categories were estimated by means of a semi-quantitative approach for each zone. For all zones except one, risks (if unmitigated) were estimated to be medium or low. For one zone (Zone 5) risks (if unmitigated) were estimated to be high for all three impact categories (dust soiling, human health and ecological) and for all types of construction work, due to a high receptor sensitivity, a large number of receptors and a high potential for dust emissions. Also, trucks may need to accelerate uphill in this area. A range of management measures are listed in the environmental impact statement to lower the generation of dust during construction works so as to reduce sensitive receptors' exposure and to minimise impacts. Most of these measures are routinely employed as 'good practice' on NSW construction sites. Thus, since "overall construction dust is unlikely to represent a serious ongoing problem, and any effects would be temporary and relatively short-lived and only arise during dry weather with the wind blowing towards a receptor," ACTAQ states that it is likely that with appropriate mitigation in place the effects would in summary be considered to be not significant.	Comment acknowledged.	It is understood that specific mitigation measures will be detailed in the construction air quality management plan.

B3.3.8	ACTAQ commented that overall, the project (as assessed) seems to deliver a small improvement in ambient air quality at a slight majority of receptors, and a slight worsening in air quality at a slight minority of receivers. This is broadly in response to the anticipated redistribution in surface road traffic. This conclusion is dependent on the validity of the modelled changes in traffic flows. The largest improvements in air quality appear to be associated with predicted reduction in traffic volumes along the Warringah Freeway and the Western Distributor. As these central areas are amongst the most polluted in Sydney at present, the project could be seen as making a positive contribution to tackling the city's air pollution hot-spots. However, this is only true if the predicted traffic reductions actually occur. The project adds substantial new road capacity to Sydney in an area of high demand. It is reasonable to expect a high degree of additional demand induced by the project and the additional economic growth it is likely to enable. Whereas the environmental impact statement indicates that such induced traffic growth is included in the traffic modelling, the environmental impact statement does not explicitly indicate the sensitivity of the air quality impacts of the project on that induced demand, nor the magnitude of the potential error in predictions of traffic. Although the submission authors have no expertise in traffic modelling, a predicted reduction of road traffic on the Western Distributor of 37 percent (Table 8-21 of Appendix F (Technical working paper: Traffic and transport) seems remarkably high.	The Strategic Motorway Project Model (SMPM) provided outputs on a link-by-link basis for the different scenarios and for all major roads affected by the project. The calibration and validation of the SMPM was assessed by independent peer reviewers and received agreement that the model was suitable for the purposes of the environmental impact statement. Induced demand projected by the SMPM due to the project equates to about 0.3 per cent of additional daily trips in the Sydney metropolitan area in 2037, which would result in a negligible impact to the traffic network. The traffic forecasting carried out for the environmental impact statement also indicates that demand on the Sydney Harbour Bridge and ANZAC Bridge would reduce by about 16 per cent and 10 per cent respectively, as a result of the project. The forecast reduction on the Western Distributor is higher (37 per cent) as the section analysed serves a larger proportion of long-distance, regional trips than the Sydney Harbour Bridge and ANZAC Bridge.	An assessment of the traffic modelling is beyond the scope of this review.
B3.3.9	Whereas ACTAQ currently has no reason to doubt the performance of the models used in this and previous environmental impact statements, it is possible than ongoing operational air quality monitoring might identify some errors or shortcomings. With multiple projects open or opening soon, each with specific air quality monitoring associated with both environmental impact statement preparation, construction and post-opening phases (often as a condition of approval) a very large database of near-road air quality is being amassed. Whereas this environmental impact statement, like similar ones before it for the WestConnex projects and F6 Extension, includes consideration of dispersion model evaluation and assessment of background air quality, theses new large datasets provide new opportunities for a more thorough evaluation of dispersion model performance in the sorts of settings relevant to urban road tunnel projects and roads in general in Sydney. Such a re-evaluation would inform future road tunnel projects, but also be valuable for assessment and planning of road transport emissions generally in Sydney and across Australia and beyond. To enable this, ACTAQ recommends that air quality data for all monitoring sites over central Sydney for the base year 2018 is extracted, modelled or remodelled and the data published.	As noted in Section B3.3.4, a comparison of the background concentrations assumed for the assessment, based on 2016 data, with data collected subsequently in 2018 found that levels in 2018 were consistent with or lower than those in 2016. Hence it is not considered that re-modelling for the base year 2018 is warranted.	While the background data (which dominates the predicted cumulative impacts) were found to be generally consistent for the 2016 and 2018 years, data from the roadside monitors should be used in the evaluation of modelling predictions once the Project opens.

B3.3.10	In Chapter 8 – Assessment of operation impact Appendix H – Air quality: • Second paragraph from bottom of page 81 and 4th paragraph from the top of page 82: Reference is given to the M4-M5 Link, ACTAQ suggest this should refer to the Western Harbour Tunnel? • Page 91: There seems to be some minor inconsistencies between what the bars show in Figure 8-7 and what appears in Table 8-8.	Comment acknowledged and clarified in Section A4 (clarifications) of the submissions report.	No further comment.
Port Authority of NSW			
B9.5.1	The Secretary's environmental assessment requirements required an air quality assessment for construction to be carried out in accordance with the current guidelines, including Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (NSW Environment Protection Authority, 2016). The Western Harbour Tunnel and Warringah Freeway Upgrade Technical working paper: Air Quality (appendix H) indicates that in the absence of specific guidance for road and tunnel projects in NSW, a semi-quantitative construction air quality impact assessment was prepared based on the UK institute of Air Quality Management (IAQM)'s Guidance on the Assessment of Dust from Demolition and Construction (IAQM, 2014). The air quality assessment for WHT3 construction support site does not asses $PM_{2.5}$ impacts and does not include a cumulative quantitative assessment of particles and other air pollutants from the project and other nearby infrastructure projects that have the potential to generate emissions to air. Port Authority seeks further clarification and justification for the assessment method used in the environment impact statement to assess construction air quality impacts at WHT3 and the surrounding locality.	Qualitative assessment of construction dust is common practice, there is difficulty in predicting construction dust as temporary and short durations. Dust from construction activities is generally mechanically generated and generally coarser fraction size. Cumulative impacts are outlined in Section 27.3.1 of the EIS.	The difficulty in predicting construction dust is acknowledged. TAS considers the risk assessment presented (and similarly for recent major road projects in Sydney) to be adequate however would benefit from the inclusion of $PM_{2.5}$.
B9.5.2	Port Authority also request the environmental management plan for WHT3 to include a detailed air quality management plan prepared in consultation with and to the satisfaction of Port Authority. The air quality management plan must include an air quality monitoring program and mitigation measures, which should be developed once investigations, and final construction and logistic details of WHT3 have been completed such as sediment contamination investigations, volumes of contaminated sediments and spoil to WHT3 and final WHT3 site layout.	An air quality management plan would form part of the construction environmental management documentation.	While specific mitigation measures are not provided in the air quality assessment it is understood that these will be detailed in the air quality management plan.
Inner West Council			
B12.10.1	Concerns relate to the project's air pollution impacts, including widespread dust and diesel emission impacts on sensitive uses such as schools and businesses. This is of particular concern where there will be a significant number of truck movements accessing the Victoria Road construction support site (WHT2), impacting upon the Rozelle Public School and where trucks pass through the Annandale village, reducing traffic and affecting business substantially. Although construction activities at the sites themselves would be within acoustic sheds, the sheds will not (and cannot) fully shield residents from dust particularly given their close proximity.	The proposed access routes to the construction support sites in the Rozelle area and surrounds would be on major arterial roads. Construction vehicles would therefore not use Johnston Street to access construction support sites and would therefore not impact upon the Annandale Village. Overall, construction dust is unlikely to represent a significant impact, following the implementation of standard mitigation measures which would include regular site inspections at construction support sites to monitor and record dust levels.	No further comment.

B12.10.2	Due to the presence of contaminated sediments and despite the use of acoustic sheds, construction support sites at Yurulbin Point and White Bay have a high risk of imposing odour and other health impacts on residents near these sites. It is noted that odour impacts are not expected, however experience with WestConnex Stage 2 is that odour can have a major impact such a leachate odour from the St peters Interchange site. Concern is raised about possible odour from dredged harbour sediments.	Dredged material will not be handled or stored at Yurulbin Point construction support site. The site for St Peters Interchange was a former landfill. Excavation works in any landfill are not anticipated for the project Any odour impacts from the dredged material would be low, given it would remain wet and located at some distance from any sensitive receivers. The results of odour modelling show that the predicted 99th percentile odour concentrations at all of the nearest receivers are below one OU (odour unit), the theoretical level of detection.	No further comment.
B12.10.3	Concern is raised about growing vehicle emissions from surface traffic growth resulting in air pollution impacts to sensitive uses such as schools. It is noted that operational air quality impacts would be small in comparison to WestConnex, however vehicle emissions are a concern for the community. Inner West Council would prefer public transport powered by renewable energy. Increase in traffic growth created by motorways leads to an inevitable increase in vehicle emissions at both the local and regional scale and is a particular concern of the community. The environmental impact statement states that due to technology improvements, emissions from vehicles will decline over the next 20 years, whether or not tunnels are built. Emission are slightly higher for the "with tunnels" scenarios because they are expected to increase the distance people travel in cars and trucks. The project would redistribute vehicle emissions through ventilation stacks and would change ground-level air pollutions concentrations. For example, the environmental impact statement assesses an increase of $PM_{2.5}$ by 2.2 percent at St Basils Annandale and other small increases at surface feeder roads.	The modelling of the project takes into account induced demand of the project and program of works, as well as expected emission reductions due to improvements in vehicle standards. However, it does not consider other potential improvements to vehicle emissions, such as the continued transition to alternatively fuelled low emission vehicles and battery electric vehicles.	It is considered to be a more conservative approach to not include potential improvements in vehicle emissions due to public transport powered by renewable energy. The use of reduced emission factors to account for alternative public transport may result in an underestimation of impacts.

B12.10.4	Ventilation on outlets should be filtered to be consistent world best practice and Recommendation 13 from the 2018 WestConnex Parliamentary Inquiry that the NSW Government install on all current and future motorway tunnels, filtration systems in order to reduce the level of pollutants emitted from ventilation stacks. The environmental impact statement assesses that emissions from ventilation facilities would add little to existing pollutant levels when compared to existing background levels, however the assessment does not consider this against an improved public transport scenario powered by renewables. Inner West Council has strong concerns about unfiltered emissions from ventilation facilities and notes that the three stacks within the Rozelle Rail Yards will serve both WestConnex Stage 3Ba and the project. Previous concerns have been raised about ventilation facilities at the Rozelle Rail Yards in its submission to the WestConnex Stage 3 environmental impact statement and the Western Harbour Tunnel Reference Design. The community has raised concerns about emissions affecting surrounding Lilyfield and Rozelle, including two primary schools in Rozelle. Inner West Council continues to argue that, as emissions have a negative health impact at any level, all ventilation facilities must be filtered.	The independent NSW Chief Scientist and Engineer has recently released a report in relation to road tunnel air quality. The report found that emissions from well-designed road tunnels cause a negligible change to surrounding air quality, and as such, there is little to no health benefit for surrounding communities in installing filtration and air-treatment systems in such tunnels.	No further comment.
B12.10.5	Inner West Council notes from the environmental impact statement that independent experts from ACTAQ reviewed the methodology of the air quality assessments and concludes that it is sound and represents best practice, However, the environmental impact statement does not compare increases in air pollution to an improved public transport scenario and accepts the status quo as being acceptable.	A comparison between the project and an alternative public transport solution is considered out of scope for the environmental impact assessment.	Refer to B12.10.3.
B12.10.6	Construction works at the Victoria Road construction support site will result in cumulative dust and diesel emissions impacts with the nearby WestConnex Stage 3B Victoria Road construction site and existing surface traffic emissions leading to additional impacts for the Rozelle Public School, residents and remaining businesses on or near Victoria Road from Darling Street to the Iron Cove Bridge. Cumulative air quality impacts would also occur for theses receivers during operation from the WestConnex Stage 3B ventilation outlet on Victoria Road.	Overall, construction dust is unlikely to represent a significant impact, following the implementation of standard mitigation measures. Due to the separation of activities, and the different stages of construction activity, the potential for significant cumulative dust impacts due to nearby M4-M5 Link construction activity is unlikely. The M4-M5 Link ventilation outlets, including the Iron Cove Link ventilation outlet on Victoria Road, were included in the dispersion modelling carried out for the air quality impact assessment for the project within the 'Do minimum' and both 'Do something' scenarios in 2027 and 2037.	No further comment.
City of Sydney Council			
B13.6.1	Additional traffic in the Rozelle area will result in air quality impacts for residents, many of whom work in the City's local government area.	The air quality technical assessment shows that, overall across the study area, the project would result in a better outcome for ambient air quality than conditions without the project.	The change in impact plots (2037 DSC – 2037 DM) indicate an increase in some pollutant levels in parts of Rozelle however generally there is shown to be a decrease in pollutant levels in the Sydney CBD area where it is stated that many of these people work.

North Sydney Council			
B14.11.1	The environmental impact assessment concludes that the appropriate design of ventilation outlets would achieve the same outcomes as installing air filtration systems and do not represent an unacceptable health risk to the community. Communities surrounding the proposed ventilation outlets are not likely to accept any level of risk to human health. The precautionary application of a filtration system, in line with international practices, is a more responsible approach to this issue and to satisfy the Secretary's environmental assessment requirements. The additional cost associated with this would be negligible in the context of the total project cost.	The independent NSW Chief Scientist and Engineer has recently released a report in relation to road tunnel air quality. The report found that emissions from well-designed road tunnels cause a negligible change to surrounding air quality, and as such, there is little to no health benefit for surrounding communities in installing filtration and air-treatment systems in such tunnels.	No further comment.
B14.11.2	The following issues with the air quality modelling impact assessment were raised: • It is assumed that background air quality growth will continue on its current trajectory (under a no-project scenario). Modelled emissions increases (resulting from the project) are then represented as a portion or measure above the projected air quality. However, the modelling also takes some account of projected emissions reductions likely to occur over time, assumedly to present the proposed project in a more environmentally favourable light. • A more general reassessment of the potential air quality impacts of the proposal should include: • Application of the soon to be revised NO_2 (nitrogen dioxide) standards proposed in the National Environmental Protection Measure (Ambient Air Quality) • Sensitivity tests should be performed for the surface roads which could have a much greater impact on the predicted concentrations at sensitive receptors • Consider the limitations in the assessment of odour impacts from traffic and reassess proposal • Consider the limitations in the meteorological modelling and reassess proposal • Assess and consider mitigation measures near surface roads such as barriers, setbacks, gradient, vegetative barriers, etc.	The air quality assessment does not assume emission reductions to present the project in a more favourable light, the trend is simply noted as it reflects the likely scenario. The fleet forecast for ventilation design is considered to be conservative, in that it does not account for alternatively fuelled and low (or zero) emission vehicles such as hybrid, hydrogen or electric. Future background air quality has not taken into account any future reduction in emissions. Presents long-term background NO_2 trends, indicating annual average NO_2 level well below 2025 standard and 1 hour NO_2 mostly below proposed 2025 standard. There would be some exceedance of the annual and 1-hr NO_2 standards at RWR receptors. The meteorological modelling data is described in detail in Annexure F The consideration of odour impacts satisfies the Secretary's environmental assessment requirements	Refer to comments regarding euro 6 in B15.10.2. Application of the proposed NEPM NO_2 standards would lead to an increase in the perceived number of "exceedances", however the NEPM standards do not directly apply to road projects. The modelling of individual odorous pollutants from traffic is considered sufficient. Limitations of meteorological modelling addressed in the Submissions Report (**Transport for NSW, 2020a**) Mitigation measures are not addressed here, however it is understood that understood that these will be detailed in the air quality management plan.
B14.11.3	The location of the proposed ventilation outlets is a key concern for the community as has been repeatedly articulated at various forums since the announcement of the projects.	The locations of the ventilation outlets do not have any significant effect on air quality at ground level in the vicinity. The Warringah Freeway corridor was identified as the preferred location for the ventilation outlet to the north of Sydney Harbour.	No further comment.
B14.11.4	There is a need for real time dust monitoring programs for construction sites and other high risk areas, including the provision of localised management plans.	Overall, construction dust is unlikely to represent a significant, impact following the implementation of standard mitigation measures. Construction management documentation will include site-specific mitigation measures and will include site inspections to monitor for dust issues and check that appropriate mitigation measures are implemented.	If dust issues are identified during construction, investigation of the issue including real time monitoring is recommended.

Willoughby City Council			
B15.10.1	Dust control is required, and dusty work should not be permitted during school pick up and drop off times. Cammeray Oval and St Leonards Park would also be subject to dust risks.	The management of dust is considered manageable through the implementation of standard dust mitigation measures. With the implementation of these measures, restriction of works to outside school pick up or drop off times is not considered necessary.	It is agreed that if implemented appropriately dust mitigation measures would be sufficient to control construction dust such that the restriction of operations during school pick up/drop off times is not considered necessary.
B15.10.2	Willoughby City Council is of the view that air quality impacts have been underestimated as the environmental impact statement assumes Euro 6 vehicle standards that have not been legislated yet.	Sensitivity analysis Annexure K of Appendix H shows that the ventilation system is capable if Euro 6 not be implemented. As outlet contribution small overall likely to be no difference if applying euro 5 assumptions for tunnel emissions.	It would be useful for transparency to explicitly state where Euro 5 and Euro 6 emission factors are assumed.
B15.10.3	Unfiltered ventilation stacks and operations buildings would be built to service the tunnels close to schools, homes and hospitals. Sensitive receptors may be exposed to unacceptable levels of air pollution.	NSW Chief Scientist and Engineer report has found that emissions from well-designed road tunnels cause a negligible change to surrounding air quality and as such, there is little to no health benefit for surrounding communities in installing filtration and air-treatment systems in such tunnels.	No further comment.
Mosman Council			
B16.5.1	The effect of emissions from the tunnel's ventilation stacks on the health and wellbeing of surrounding community is a concern for Mosman Council. Council is seeking confirmation that air quality will be considered to ensure that health and amenity of surrounding local neighbourhoods is maintained.	In relation to health risks, the Project would generally result in no change or a small improvement ; however for some areas located near key surface roads, small increases in pollutant concentrations may occur. The health impacts associated with localised changes in air quality have been assessed and are considered to be acceptable.	It is noted that the AQA also identifies a limited number of receptors that will experience a small level of increased impact, beyond pre-existing impacts (above criteria).
Community Submissions			

C12.1.1	Submitters expressed concern about the adequacy and accuracy of the air quality assessment. Specific concerns included: • Concern that the air quality assessment is misleading, contains incorrect information, omits critical information and underestimates the potential air quality impacts • Concerns that the environmental impact statement suggests that the higher the ventilation outlet, the more that emissions would be dispersed over a wider spread area and the statement that this would reduce the impact on sensitive receivers is not accurate • The comparisons to other ventilation systems from tunnels around the world in the environmental impact statement are incorrect and misleading. The project should be compared against overseas tunnels which are filtered, specifically the CWB Hong Kong Bypass Tunnel • Question the comparison with the E4 Stockholm Tunnel, as the Stockholm tunnel would include proper ventilation. The Stockholm tunnel would have a much greater number of air exchanges and outlets • The environmental impact statement claim that the M5 East filtration trial failed is misleading. It is widely agreed among experts that the parameters of the scheme were fundamentally flawed • One graph has results covered by the key and the $PM_{2.5}$ tables do not show the correct criteria level with criterion to be lowered by 2025	A detailed response is provided to the various issues raised regarding the adequacy of the air quality assessment, emissions dispersal, comparison to other tunnel ventilation systems and filtration, and graph correction.	Generally the response is seen to adequately address the concerns raised or the issues are addressed in greater detail in the response to key stakeholders or the independent review.

C12.1.2	Submitters expressed concern about the methodology used for the air quality assessment. Specific queries, concerns and comments include: • Concern that the air quality assessment does not assess long term impacts of emissions • Concern that emissions from existing traffic movements have not been factored into the air quality assessment • The environmental impact statement should present the worst case air quality scenario • The extensive modelling of air pollution is satisfactory and highlights that the project would reduce carbon emissions due to removing the need for cars to stop and start as often • Dispersion modelling has not factored in topography and high rise buildings • The topography of the area surrounding the project would mean that certain pollutants (including carbon monoxide oxides of nitrogen, sulphur dioxide and volatile organic compounds) would settle in lower lying areas which would magnify impacts to receivers • The air quality assessment does not consider that there is usually minimal wind in the morning that could result in adverse impacts to receivers in close proximity to ventilation outlets • Air quality impacts have been averaged across community receivers. The environmental impact statement does not present accurate air quality impacts and areas included in the study area appear unrelated to the project • Only relevant sensitive receivers should be included in the analysis and results should be weighted by the number of sensitive receivers in the study area • The air quality assessment reports on the average ventilation outlet emissions and may not be accurate • The air quality assessment did not include an assessment of the accumulation of micro/nano-particles or the impacts of ultrafine particles (particularly in conjunction with other pollutants).	A detailed response is provided to the various issues raised regarding the assessment approach (operational), study area domain, analysis of results, ventilation outlet emissions – units of measure, elevated receivers, ultrafine particles.	Generally the response is seen to adequately address the concerns raised or the issues are addressed in greater detail in the response to key stakeholders or the independent review.

C12.1.3	Submitters are concerned about the assumptions and inputs used to model emissions for the air quality assessment. specific queries, concerns and comments include: • Surface road induced traffic demand assumptions around Cammeray are incorrect • Datasets used for the assessment were not representative of real-world conditions • The air quality monitoring baseline data used for the air quality assessment is deficient to scientifically assess impacts • The air quality model should use at least 12 months of background air quality monitoring data and a comprehensive network of air monitoring stations along the traffic corridor • The Environment Protection Authority's ambient or background air quality monitoring is not relevant, and the assessment should use near-road, direct measurement air quality for the assessment • The lack of air quality data means that the assessment of this project is entirely dependent on air quality modelling results to assess air quality impacts on residents • Submitters identified air quality monitoring data gaps for Miller Street, Merlin Street, Falcon Street, Morden Street and Bells Avenue.	A detailed response is provided to the various issues raised regarding the traffic assessment and meteorological and air quality data.	Generally the response is seen to adequately address the concerns raised or the issues are addressed in greater detail in the response to key stakeholders or the independent review.
C12.1.4	Submitters made the following comments about the presentation of air quality assessment and results for specific locations. Specific queries, concerns and comments include: • Air quality impacts should be presented as the number of hours per year that air quality is above the criteria • The air quality assessment should present air quality data for residents located close to existing major traffic routes and identify specific local roads that are likely to exceed the air quality criteria. Specific areas of concern included Rozelle, Cammeray and to the north of the Spit Bridge • Air quality with and without the project is not adequately presented and specific focus should be on sensitive receivers including schools, retirement villages and early learning and childcare centres in Rozelle, Forest Lodge, Waverton, North Sydney, Neutral Bay and Cammeray • The environmental impact statement does not assess the predicted reduction of total emitted pollutants as a result of the project increasing traffic speed and reducing stops/starts and idling • The construction air quality assessment underestimates impacts at schools as the number of children at each school is assumed to be 100.	A detailed response is provided to the various issues raised regarding the presentation of exceedances of air quality criteria, presentation of operational air quality impacts, consideration of changes in traffic conditions and construction air quality assessment (dust).	Generally the response is seen to adequately address the concerns raised or the issues are addressed in greater detail in the response to key stakeholders or the independent review.

C12.1.5	Submitters queried the policies and standards referred to in the air quality assessment methodology. Specific queries, concerns and comments include: • The project should meet international air quality standards as current NSW and Australian air quality standards are outdated and too low • The AAQ NEPM standards to 'minimise the risk of adverse health impacts from exposure to air pollution for all people, wherever they may live' have not been implemented • As the AAQ NEPM goal for $PM_{2.5}$ is being reduced to 7µg/m^3 from 2025, ventilation outlet emissions are unlikely to meet the national standard on opening.	A detailed response is provided to the various issues raised regarding air quality assessment policy and international standards.	Generally the response is seen to adequately address the concerns raised or the issues are addressed in greater detail in the response to key stakeholders or the independent review.
C12.2.1	Submitters raised concerns about the generation of dust and other pollutants, and the impact to air quality and sensitive receivers, during construction. Specific queries, concerns and comments include: • Concerns about dust from excavation and tunnelling, including the excavation of access declines, and that these impacts would occur 24 hours a day at tunnelling support sites • Concerns around dust impacts on remaining vegetation during construction • Concern about nuisance dust impacts on properties, cars, rainwater harvesting systems and locally grown food, resulting from construction activities • Impacts to air quality (and amenity) at town centres, active transport infrastructure or recreational areas due to dust generated by construction. This included the perception that these impacts would mean that people are unable to safely use active transport infrastructure or recreational areas close to construction areas • Concern about dust generation by the Victoria Road (WHT2) and White Bay (WHT3) construction support sites, including impacts on Rozelle Public School • Objections were raised regarding dust impacts from construction on residents of Merlin Street, Wyagdon Street, Falcon Street, Rose Street, Alfred Street North and Bent Street • Concern that local topography difference in the vicinity of the Cammeray Golf Course construction support site (WHT10/WFU8) would increase impacts at lower lying residential areas • Blasting would result in air quality impacts • Concerns about the expose to silica dust for surrounding sensitive receivers • Concerns about emissions from construction areas due to the disturbance of potentially contaminated soils or demolition of buildings and other structure (such as the release of asbestos fibres) • Cumulative dust impacts in areas already affected by WestConnex, including Rozelle, Balmain and Birchgrove.	A detailed response is provided to the various issues raised regarding controlled blasting, contaminated dust and other hazardous particles, and silica.	Generally the response is seen to adequately address the concerns raised or the issues are addressed in greater detail in the response to key stakeholders or the independent review.

C12.2.2	Submitters expressed concerns regarding air quality impacts from construction vehicles. Specific concerns and queries raised included: • The air quality assessment does not assess vehicle emissions associated with construction vehicles and would contribute to air quality emissions in surrounding areas • Standard mitigation measures identified in the environmental impact statement would not manage air quality impacts from construction traffic • Objection was raised for the Rosalind Street east construction support site (WFU9) due to the emissions from idling trucks in proximity to school grounds • Concerns around dust from heavy vehicles using Balls Head Road via either Woolcott Street, Bay Road or Crows Nest Road each day • Concern about the generation of dust from barges transporting dredged material to White Bay and Berrys Bay.	A detailed response is provided to the various issues raised regarding construction vehicle emissions, Rosalind Street east construction site, air quality impacts from construction vehicles (dust) and dust from barges transporting dredged material at Berrys Bay and White Bay.	Generally the response is seen to adequately address the concerns raised or the issues are addressed in greater detail in the response to key stakeholders or the independent review.
C12.2.3	Submitters identified concerns about impacts from odour during construction. Specific queries, concerns and comments include: • Odour impacts on residents due to the storage, handling and treatment of dredged material at the White Bay construction support site (WHT3) has not been assessed in the environmental impact statement, the impacts have been underestimated or the assumptions were not sufficiently conservative • The environmental impact statement does not refer to any odour emission testing from excavated sediments completed as part of the assessment, or does not provide detail on which odours were modelled to predict odour emissions at the White Bay construction support site (WHT3) • The environmental impact assessment did not identify odour suppression mitigation for excavated contaminated sediments and soils. Environmental management measures should include the application of foams across the surface of the sediments, mist sprays at the boundaries of the works and covers on stockpiles, barges and heavy vehicles • A spoil handling shed should be constructed at the White Bay construction support site (WHT3) to manage odour impacts • The environmental impact statement does not address offensive odours emitted when acid sulfate soils are disturbed and exposed to air (such as sulphide gas) and impacts to nearby receivers. Sediments from the upper reaches of Sydney Harbour (and estuaries), Snails Bay and Birchgrove Oval were identified as being known to release such odours. Wetting the soils would not sufficiently mitigate odours.	A detailed response is provided to the various issues raised regarding odour modelling methodology and odour emission samples, odour management at White bay construction support sites and odour from acid sulfate soil.	Generally the response is seen to adequately address the concerns raised or the issues are addressed in greater detail in the response to key stakeholders or the independent review.

C12.2.4	Submitters raised concerns that the management measures proposed within the environmental impact assessment were not sufficient to manage construction impacts to air quality and suggested a number of additional measures. Specific concerns included: • There should be an appropriate plan to manage air quality impact during construction • The conditions of approval should include strict mitigation measures for dust. This should include independent inspection of all measures • Environmental management measures included in the environmental impact statement to mitigate air quality impacts would not sufficiently manage the impacts from contaminated dust • Additional dust suppression meaqsur4es to manage dust generated by demolition, earthworks and trac-out sold be proposed and include: – All dust generating works should be ceased during periods of strong winds – Real time dust monitors should be installed for impacted residents, schools (indoors and playground/sports fields) and businesses – Loose material should not be left uncovered on roadways or within vehicles – Water sprays should be deployed to minimise impact from dust generating works – Dust generating activities should cease at 6pm on weekdays and 1pm on weekends and when in proximity of schools, these activities should not occur during lunch breaks – Schedule of staged works should be included as a condition of approval to avoid cumulative impacts on air quality resulting from construction of various components of the project – Adequate and timely pre-advice should be provided to residents of upcoming particularly dusty activity works and a ‘dust’ hotline be established – The construction phase tunnel ventilation outlet should be filtered to remove dust – Construction sites should be fully enclosed to minimise air quality impacts • Environmental management measures to control dust would not be adhered to • Real time air quality monitoring during construction should be made publicly available, particularly if pollution reaches unsafe levels • Request for the following mitigation measures to be included to manage construction vehicles emissions: – Limit the use of diesel vehicles and use non-diesel powered trucks – Audit all vehicles for exhaust emissions within acceptable limits – Divert heavy vehicles away from Miller Street or ban all diesel vehicles from using Miller Street	A detailed response is provided to the various issues raised regarding the environmental management plan, dust management measures, air quality monitoring and compliance, construction equipment emissions and at property treatments.	Generally the response is seen to adequately address the concerns raised or the issues are addressed in greater detail in the response to key stakeholders or the independent review.

	– Ban diesel vehicles movements during school travel times • Building upgrades for properties, including façade upgrades and dust filtration, were requested for residential buildings and schools in proximity to the Warringah Freeway including Wyagdon Street, Rose Avenue, Alfred Street North, and Merlin Street to enable windows to remain closed and reduce the impact of dust and pollution • During construction, schools should be moved to healthier locations or a plan should be established for alternative sports field arrangements and air quality criteria above which children must be moved indoors • Queried the proposed mitigation to manage air quality impacts at heritage listed properties where changes cannot be made.		

C12.3.1	Many submitters expressed their concerns and disagreement with the project due to the increases in emissions that would impact air quality for the community including residents, schools, aged care facilities, sports grounds and other community receivers. Specific queries, concerns and comments include:
	• The project should seek to maintain and/or reduce air emissions
	• The needs of the local community for clean air are not recognised as project benefits
	• The project should not proceed given the contribution to air pollution from the existing road network
	• The project would result in induced demand (particularly heavy vehicles) and would increase air pollution to unacceptable levels
	• Opinion that the project would have an adverse impact on schools, retirement villages and early learning and childcare centres in Rozelle, Forest Lodge, Waverton, North Sydney, Neutral Bay and Cammeray area due to reductions in air quality
	• Concerns related to changes in air quality in the vicinity of tunnel portals:
	  – Operational traffic at tunnel portals would generate substantial air pollution in surrounding areas
	  – Air pollution from vehicles in the tunnel would be concentrated at the portals at a much higher concentration compared to the current levels distributed along the roads
	• Background air pollution levels already exceed the AAQ NEPM national goal of 8µg/m^3 for $PM_{2.5}$ at a number of areas such as North Sydney and Rozelle. The project would further exacerbate this and is therefore not justified
	• Increased air pollution would discourage pedestrians along Berry Street and the Pacific Highway
	• Users of active transport along the Warringah Freeway have not been assessed and these users of would be impacted due to reductions in air quality. Objection was raised to the current and proposed changes to cycleways adjacent to the freeway due to health risks to users
	• Tree removal would result in a loss of filtration and further exacerbate pollution impacts
	• Concerns about the cumulative impact of the project with bushfires which are becoming more frequent.
		A detailed response is provided to the various issues raised regarding impacts to air quality, changes in local air quality in the vicinity of portals, $PM_{2.5}$ emissions, impacts to active transport users, reduction in air quality due to tree removal and changes in background air quality due to bushfires	Generally the response is seen to adequately address the concerns raised or the issues are addressed in greater detail in the response to key stakeholders or the independent review.

C12.3.2	Submitters raised concerns relating to the design and operation of ventilation outlets for the project. Specific comments and concerns included: • Request for more stringent design specifications for the ventilation outlets to demonstrate that air pollution would be adequately dispersed by the ventilation outlets • Ventilation outlets should be constructed so that air being released into the atmosphere is released at standard of 'very good' levels as set by the Department of Planning, Industry and Environment air quality index • Air quality impacts from ventilation outlets are hard to establish and could be equivalent of being next to a freeway and would raise the air quality index to dangerous levels • Localised emissions from portals and ventilation outlets would lead to localised breaches of the National Environmental Standards for PM_{10} and NO_2, as well as exceedances of Regional Air Quality Guidelines • Concern that unfiltered ventilation facilities at Rozelle and Cammeray are located close to a number of education establishments, and requests for installation of filters in ventilation outlets or relocation of ventilation outlets away from schools • Emissions modelling suggests that there would be less air quality impacts in the local area if ventilation outlets were 40 metres in height • The increase in background air quality levels as a result of the project conceals the air quality impacts from the proposed ventilation facilities • Odour from ventilation outlets could result in unacceptable odour impacts • Query on how the extraction of smoke during and post emergency conditions would impact the surrounding area and communities.	A detailed response is provided to the various issues raised regarding ventilation outlet design, outlet performance, background air quality, filtration of ventilation outlets, air quality index, odour and emergency conditions.	Generally the response is seen to adequately address the concerns raised or the issues are addressed in greater detail in the response to key stakeholders or the independent review.
C12.3.3	Submitters raised issues around the air quality within the tunnels. Specific queries relate to the following: • The environmental impact assessment did not provide an assessment of in-tunnel air quality and the impact of exposure of tunnel users given the length of the tunnel, and extended travel in the tunnel motorway network (WestConnex) • In tunnel air quality criteria should use specific limits for $PM_{2.5}$ and PM_{10} instead of a general visibility criteria.	A detailed response is provided to the various issues raised regarding the in-tunnel air quality assessment and in-tunnel air quality criteria.	Generally the response is seen to adequately address the concerns raised or the issues are addressed in greater detail in the response to key stakeholders or the independent review.

C12.3.4	Submitters raised concerns regarding the assessment of operational traffic emissions in the environmental impact statement. Specific comments included: • The assessment has relied on the implementation of Euro 6 standards, which are currently not committed to • The air quality assessment underestimates emissions from the project as it assumes an uptake in electric vehicles and underestimates the volume of traffic that would use the project • The emissions modelling used best case emissions assumptions rather than worst case assumptions for the Sydney vehicle fleet • Recent Transport Emission/Energy Research reports stated that Australia fleet vehicle emissions have actually increased in the last few years due to longer trips and the sale of large SUVs. The Transport Emission/Energy Research stated that there is little reliable data about actual or real world Australian fleet emissions which calls into question the data used in the assessment • The assessment assumes that combustion engine technology would reduce emissions of nitrogen oxide but does not consider prevailing fuel standard. Improvements would not occur without an advance in fuel standards • The assumption that air quality impacts of this project would reduce over time as fuel efficiency standards are increased is incorrect as there is no commitment by government to implement any efficiency or fuel quality standards for vehicles.	A detailed response is provided to the various issues raised regarding operational traffic emissions.	Generally the response is seen to adequately address the concerns raised or the issues are addressed in greater detail in the response to key stakeholders or the independent review.

C12.3.5	Submitters requested increased mitigation measures and commitments for mitigating air quality during construction. Specific requests included: • Recommendations in relation to air quality monitoring: – Air quality monitoring should be established at sensitive receivers within 150 metres of pollution sources. Ongoing air quality monitoring in the tunnel and at surrounding sites should extend for longer than two years from commencement – Real time air quality monitoring should be made publicly available, particularly if pollution reaches unsafe levels • Recommendations in relation to in-tunnel traffic restrictions: – As a condition of approval, the tunnel and the Warringah Freeway should be closed on days where the air quality index reaches the danger level of 200 or more – Questioned the likelihood that the project would be closed in the event that air quality monitoring identified exceedances – Diesel vehicles should be banned from the tunnels at all times or at least when particulates reach unacceptable levels. This should be benchmarked from the Paris Duplex Tunnel and Istanbul's Eurasia Tunnel. Motorcyclists should be banned from using the tunnels to avoid exposure – The conditions of approval should include a vehicle mass limit – Air quality improvements could come from limiting the use of private vehicles in the tunnel at peak times – A response plan should be in place to manage impacts if air quality targets are not met. This should include warning systems when health-based air quality protection levels are reached, limiting or closing the tunnel to traffic, communication and controls at sensitive receivers (such as schools) and adjustments to ventilation outlets including retrospective installation of filtration – A pollution toll should be introduced • Recommendations related to project design features: – The environmental impact assessment should include measures to mitigate deteriorating air quality, particularly nitrogen oxides and particulate matter – A green overpass over the Warringah Freeway between Miller and Ernest Streets should be built as a condition of approval to mitigate the increase in surface road pollution. The air within this short overpass should be redirected to the ventilation stack for subsequent filtration and distribution through the ventilation outlet	A detailed response is provided to the various issues raised regarding air quality monitoring, in-tunnel traffic restrictions, project design features and electric bus fleet.	Generally the response is seen to adequately address the concerns raised or the issues are addressed in greater detail in the response to key stakeholders or the independent review.

Appendix B

Technical Review of Adequacy of Air Assessment in regard to the Air Modelling Regulatory Requirements

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It is noted that the Approved Methods applies to Stationary Sources, which does not include emissions from motor vehicles. Technically it would appear that the Approved Methods is not applicable to the Project, but the existing industry practice is to adopt the Approved Methods for the assessment of road tunnel stack emissions and as a means of assessing the effects of a Project on road side pollutant concentrations.

Table B-1: Technical Review of Adequacy of Air Assessment in regard to the Air Modelling Regulatory Requirements

Requirements per Approved Methods/ Contemporary Practice	Appendix G – Technical working paper: Air Quality (AQIA)	AQIA reference	Adequate? (Y/N)
2. Methodology	Broadly, a Level 2 (refined dispersion modelling technique using site-specific input data) assessment was applied. Assessment methodology is described in Section 8 of AQIA. Methodology comparison with the regulatory requirements is addressed in more detail below for specific components of the approach.	Section 5 & 8	Y
3. Emissions inventory			
3.1 Identify all sources of air pollution and potential emissions	Traffic pollutants are identified in Section 3.2.2. Section 4.6 and 5.4.3 presents the ambient air quality standards and criteria of pollutants. Section 8.2 identifies all road traffic sources in the Project domain.	Section 8.2	Y
3.2 Determine source release parameters	Source parameters of the proposed and anticipated future ventilation outlets are presented in Section 8.4.7 and Annexure G. Some of the source parameters from the surface roads emissions are not presented, although these are less important. Some of the source parameters from the surface roads emissions are presented in Section 8.2.4.	Sections 8.4.7, 8.2.4 and Annexure G	Y
3.3 Estimate emission rates	Emissions from traffic on surface roads were estimated by using an emission model developed by NSW EPA as outlined in Section 8.2.4. Estimated emission rates from the ventilation outlets are presented in Annexure G. Regulatory worst case emission rates were estimated from the NorthConnex conditions of approval and are presented in Section 8.4.8. The emission rates depend on the traffic numbers predicted to occur, and also the emissions estimation approach. It is somewhat unclear why three different approaches are used, but each approach applies acceptable methods.	Sections 8.4.4, 8.2.4 and Annexure G	Y

3.3.4 Accounting for variability in emission rates	Diurnally varying emissions were taken into account in the assessment through the use of source groups. The average estimated emission rates for each source group were determined and the 'modulation factors' (ratios relative to the average) were used to take into account the varying emissions within each time period. No seasonal variation was accounted for the proposed ventilation outlets and surface roads emissions.	Sections 8.2.2, 8.2.3 and 8.2.4 and Annexure G	Y
3.4 Calculate emission concentration for point sources i. Actual concentration of a pollutant emitted from a source (mg/Am^3) calculated using the actual gaseous volumetric flow rate (Am^3/s) and measured emission rate in Equation 3.1 ii. Concentration of a pollutant emitted from a source corrected to the reference conditions as specified in the Regulation (mg/Nm^3 @ O_2%). This is calculated using the gaseous volumetric flow rate corrected to normal conditions (dry, 273K, 101.3kPa) and the measured emission rate in Equation 3.1. The emission concentration (in mg/Nm^3) is then corrected to the appropriate oxygen reference condition. Further guidance on correcting to reference and equivalent values is provided in DEC (2005)	Emission concentrations from the ventilation outlets are presented in Annexure G. Emission concentrations for regulatory worst case are presented in Section 8.4.8. Note that an Oxygen correction is not applicable to the stack emissions in this situation as the tunnel is not a combustion source and is designed to operate with a normal level of oxygen in the air.	Section 8.4.8 and Annexure G.	Y
3.5 Assess compliance with the Protection of the Environment Operations (Clean Air) Regulation.	N/A. The stack emissions were not assessed against the Regulation limit, but in any case it is noted that emissions would be well below the Regulation limits applicable to stack emissions from industrial plant.	N/A	N/A

3.6 Presentation of emissions inventory			
i. all release parameters of stack and fugitive sources (e.g. temperature, exit velocity, stack dimensions, flow rate, moisture content, pressure, carbon dioxide and oxygen concentration) (Table 3.1)	Source parameters of the proposed and anticipated future ventilation outlets are presented in Annexure G. Source parameters of the ventilation outlets for regulatory worst case scenarios are presented in Section 8.4.8. Some of the source parameters from the surface roads emissions are not presented, although these are less important. Some of the source parameters from the surface roads emissions are presented in Section 8.2.4.	Sections 8.2.4 and 8.4.8 and Annexure G	Y
ii. Pollutant emission concentrations and a comparison against the relevant requirements of the Regulation (Table 3.2)	Emission concentrations from the ventilation outlets are presented in Annexure G. Emission concentrations for regulatory worst case are presented in Section 8.4.8. Comparison against the relevant requirements of the Regulation was not undertaken. But in any case it is evident that the emissions would be well below any regulatory requirements for the emissions from any scheduled or non-scheduled premises.	Section 8.4.8 and Annexure G.	N/A
4. Meteorological data			
4.1 Minimum data requirements	A quasi - Level 2 impact assessment was conducted. The AQIA applies data from the DPIE Randwick, DPIE Rozelle, BoM Fort Denison and BoM Manly (North Head) meteorological stations located within the chosen domain. The selection of the 2016 data for the purpose of the modelling assessment is consistent with the Approved Methods in terms of the completeness of data, however only limited parameters were examined in deriving the correlation of the 2016 data set against at least five years of data. In this latter regard the approach is scant and unconvincing. It is not clear whether the data from DPIE Randwick and DPIE Rozelle are representative of the meteorology experienced in the F6 Extension Project as there are significant variations in meteorology across the modelling domain. This is exacerbated by the GRAMM model which produces little variation in the meteorology across the modelling domain, masking any actual significant variations in the prevailing meteorology across the domain.	Sections 6.5, 8.4.5 and Annexure F	Y

	However, as previously noted, this is not a major issue overall as the largest effects occur nearest the road, and the relative change in impact at each point is the key measure for making the assessment (and neither is greatly affected by the meteorology used).		
4.2 Siting and operating meteorological monitoring equipment	The AQIA applies meteorological data from the DPIE Randwick, DPIE Rozelle, BoM Fort Denison and BoM Manly (North Head). The DPIE stations are ambient air quality monitoring sites and do not record representative meteorological data as the locations are affected by large trees, and do not conform with the requirements for meteorological monitoring sites.	N/A	N
4.3 Preparation of Level 1 meteorological data	N/A. A quasi-level 2 assessment was conducted	N/A	N/A
4.4 Preparation of Level 2 meteorological data	Stability class was calculated using the temperature at 10m and the cloud content data from the BoM Sydney Airport AMO. The Approved Methods enumerate the methods of determining stability class in order of preference as: Turner's 1964 method, solar radiation-delta temperature method and sigma theta method. The method used by the Proponent is not mentioned in the Approved Methods. As there is no justification provided for an alternative method, a method per the Approved Methods, should have been used in this assessment, given that there are available data to determine stability class using an approved method.	Section 8.4.5	N
4.5 Developing site-representative meteorological data using prognostic meteorological models	N/A. A prognostic meteorological model was not used for this assessment. It is however noted that the prognostic model CALPUFF was used to assess odour from construction activities.	-	N/A
5. Background air quality data, terrain, sensitive receptors and building wake effects			
5.1 Background air quality data	Data from DPIE, SMC and RMS monitoring sites were analysed to determine background air quality data to be used for the assessment. For annual mean background data, spatial variation of background data was determined by mapping the available annual mean background data from monitoring sites. Data from a major roadside monitoring location was included and skews the mapped results.	Annexure D and Section 8.4.11.	N

	For short-term concentrations, a synthetic time series of background concentrations was produced by the Proponent by choosing the maximum short-term concentration for each short-term period from among the selected monitoring sites as explained in Annexure D. This would increase the conservatism of the assessment. The methods for applying background concentrations are presented in Table 8-17. The use of the Statistical method for RWR receptors is not compliant with the Approved Methods.		
5.2 Terrain data and sensitive receptors	Terrain and land use of the Project area are briefly described in Section 6.2. The model does not respond adequately in regard to the terrain and land use data.	Sections 6.2 and 8.4.5	Y
5.2 Building wake effects	Building wakes were excluded from the main assessment. A sensitivity test was run for buildings in the model. The validation studies used to justify the selection of the model show poor performance for traffic assessment without considering such effects, but better performance with these effects included.	Sections 8.4.4 and 8.4.16	N
6. Dispersion modelling			
6.3 Advanced air dispersion models for specialist application	The GRAL/GRAMM model is not an Approved Methods. Section 5.3 indicates that NSW EPA was consulted regarding the methodology, but there is no direct evidence presented to confirm that the EPA approved the model for such use.	-	N
2.4.3 Processing dispersion model output data	Predicted ground level concentrations (glc's) of all pollutants are in the same units and for the same averaging period as the relevant impact assessment criteria.	Section 8.4 and subsections	Y
7. Interpretation of dispersion modelling results			
7.1.2 Application of impact assessment criteria for SO_2, NO_2, O_3, Pb, PM_{10}, TSP, deposited dust, CO and HF. The Approved Methods states that the assessment criteria must be applied as follows:	It is noted that the Approved Methods applies to Stationary Sources, which does not include emissions from motor vehicles. Technically it would appear that the Approved Methods is not applicable to the Project, but the existing industry practice is to adopt the Approved Methods for the assessment of stack emissions and as a means of assessing the effects of a Project on road side pollutant concentrations.	-	-
a. At the nearest existing or likely future off-site sensitive receptor	The maximum predicted glcs at most the sensitive receptors were reported. Section 8.4.13 presents impacts at elevated receptors.	Section 8.4 and subsections	Y

	Some receptors near roads were omitted, and some non-existent receptors away from roads were included, however it is not reasonable or expected that all receptors for such a Project be evaluated. A comprehensive cross-section of representative receptors was assessed, albeit with some bias in the number and location of receptors added / omitted. The bias would make the Project more conservative.		
b. The incremental impact (predicted impacts due to the pollutant source alone) for each pollutant must be reported in units and averaging periods consistent with the impact assessment criteria.	Incremental predicted glcs of all pollutants are in the same units and for the same averaging period as the relevant impact assessment criteria.	Section 8.4 and subsections	Y
c. Background concentrations must be included using the procedures specified in Section 5.	Refer to Requirement 5.1	Annexure D and Section 8.4.11	N
d. Total impact (incremental impact plus background) must be reported as the 100th percentile in concentration or deposition units consistent with the impact assessment criteria and compared with the relevant impact assessment criteria.	Non-statistically determined cumulative impacts were reported as 100th percentiles and have units consistent with the relevant assessment criteria and compared against the relevant criteria. The use of the Statistical method for RWR receptors is not compliant with the Approved Methods. Regulatory worst-case scenario impacts appear to present ventilation outlet contributions not total impacts for CO, PM_{10} and $PM_{2.5}$.	Section 8.4.11, Section 8.4.14 and Annexure I.	N
7.2.2 Application of impact assessment criteria for individual toxic air pollutants. The Approved Methods states that the assessment criteria must be applied as follows:			
a. At and beyond the boundary of the facility.	Modelling results are presented in Section 8.4.11 and Appendix I. The top ten maximum predicted incremental glcs at the RWR receptors which should include receptors at and beyond the boundary of the facility (in this case Project), are presented.	Section 8.4.11 and Appendix I	Y

b. The incremental impact (predicted impacts due to the pollutant source alone) for each pollutant must be reported in concentration units consistent with the criteria (mg/m^3 or ppm), for an averaging period of 1 hour and as the: i. 100th percentile of dispersion model predictions for Level 1 impact assessments, or ii. 99.9th percentile of dispersion model predictions for Level 2 impact assessments	The maximum (i.e. 100th percentile) of the predictions appear to be presented for the expected traffic scenarios.	Section 8.4.11 and Appendix I	Y
c. Polycyclic aromatic hydrocarbons (PAH) as benzo[a]pyrene (BaP) must be calculated using the potency equivalency factors for PAHs in Table 7.2c.	As stated in the notes below Table 8-18, the PAH was taken from the "PAH fraction of THC from NSW EPA (2012b) and the BaP fraction of PAH from Environment Australia (2003)". There is no explanation as to why only the BaP fraction of PAH from Environment Australia (2003) was used. There is also no statement about the calculation using the potency equivalency factors for the PAH fraction of THC from NSW EPA.	Table 8-18	N
d. Dioxins and furans as toxic equivalent must be calculated according to the requirements of clause 29 of the Regulation.	N/A	N/A	N/A
7.4 Individual odorous air pollutants	Individual odorous air pollutants were assessed and results are presented in Section 8.6	Section 8.6	Y
8. Modelling pollutant transformations			
8.1 Nitrogen dioxide assessment	None of the methods in the Approved Methods was used in the assessment. An empirical conversion method was instead developed for Sydney. Whilst non-compliant, the method is considered to be technically sound, providing significant conservatism.	Annexure E	N

9. Impact assessment report			
9.1 Site plan			
- Layout of the site clearly showing all unit operations	Figure 8-1 indicates the location of the ventilation outlets in the GRAL domain while Figures 8-2, 8-3 and 8-4 show the road link included in various scenarios	Figures 8-1, 8-2, 8-3 and 8-4	Y
- All emission sources clearly identified	All emissions sources are clearly identified.	Figures 8-1, 8-2, 8-3 and 8-4	Y
- Plant boundary	N/A	N/A	N/A
- Sensitive receptors (e.g. nearest residences)	Sensitive receptors are shown in Figure 8-10.	Figure 8-10	Y
- Topography	Topography is presented in Figure 6-1.	Figure 6-1	Y
9.2 Description of the activities carried out on the site	Chapters 1 and 2 provide an overview of the Project.	Chapters 1 and 2	Y
9.3 Emissions inventory	Emission inventories are presented in Sections 8.2 and Annexure G	Section 8.2 and Annexure G	Y
9.4 Meteorological data	Section 6.5 and Annexure F present a discussion and analysis of available meteorological data from monitoring stations in the modelling domain.	Section 6.5 and Annexure F	Y
9.5 Background air quality data	Data from DPIE and RMS monitoring sites were presented and analysed to determine background air quality data to be used for the assessment.	Annexure D	Y
9.6 Dispersion modelling			
- A detailed discussion and justification of all parameters used in the dispersion modelling and the manner in which topography, building wake effects and other site-specific peculiarities that may affect plume dispersion have been treated	Section 6.2 discusses the topography and how it would affect dispersion. Section 8.4.7 presents a discussion on the limited effects of including buildings in the assessment. This contradicts the model developer's evaluation of the model at predicting traffic emissions in an urban environment.	Sections 6.2 and 8.4.7	Y
- A detailed discussion of the methodology used to account for any atmospheric pollutant formation and chemistry	Annexure E presents the methodology used in the assessment to consider the transformation of NO_x to NO_2.	Annexure E	Y
- A detailed discussion of air quality impacts for all relevant pollutants, based on predicted ground-level	Section 8.4 and Annexures I and J present a discussion of air quality impacts for relevant pollutants.	Sections 8.4, Annexures I and J	Y

concentrations at the plant boundary and beyond, and at all sensitive receptors			
- Ground-level concentrations, hazard index and risk isopleths (contours) and tables summarising the predicted concentrations of all relevant pollutants at sensitive receptors	Ground-level concentrations isopleths and graphs are presented in Section 8.4. Further results are presented in Annexure I. Plots showing the ventilation outlet impacts are presented in Annexure J.	Sections 8.4 Annexures I and J	Y
- All input, output and meteorological files used in the dispersion modelling supplied in a *Microsoft* Windows-compatible format	N/A.	-	N/A