Great Western Highway Upgrade Project - Blackheath to Little Hartley

Development of air quality impact descriptors - report for ACTAQ

Prepared for Transport for NSW

August 2022

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Version	Date	Prepared by	Approved by	Comments
2	8 August 2022	Francine Manansala	Paul Boulter	

Approved by

Paul Boulter
Associate Director – Air Quality
8 August 2022

Ground floor 20 Chandos Street
St Leonards NSW 2065
PO Box 21
St Leonards NSW 1590

Executive Summary

ES1 Background

Transport for NSW (TfNSW) is considering tunnel options for the Blackheath to Little Hartley section of the Great Western Highway Upgrade Project (referred to hereafter as 'the project'). For the project, TfNSW is considering options without tunnel exhaust stacks, and hence with tunnel portal emissions. As a result, the Secretary's Environmental Assessment Requirements (SEARs) for the project require that, should portal emissions be proposed, the project is assessed in accordance with air quality impact descriptors (AQIDs) that are endorsed by the NSW Advisory Committee on Tunnel Air Quality (ACTAQ). The AQIDs are different from 'air quality impact assessment criteria', which are the pollutant concentrations defined in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (the Approved Methods) (NSW EPA 2017).

With respect to the development of appropriate AQIDs for the project, ACTAQ has recommended a review of relevant approaches, noting in particular the potential for adapting an existing approach from the UK, as contained in the *Guidance on land-use planning and development control: Planning for air quality* (IAQM 2017).

The main objective of the study was to develop new AQIDs which could be used to describe the results of the air quality impact assessment (AQIA) for the project. The AQIDs will ultimately help the proponent, the regulator, and other stakeholders to understand the significance of the project's impacts on air quality, to refine the project design, and to mitigation where needed.

This report considers the context of the project, reviews the UK's Institute of Air Quality Management's (IAQM) guidance as well as some other existing approaches, and describes the development and application of the AQIDs for the project.

NB: the report does not provide any guidance on the methodology to be applied in the actual AQIA itself, such as the selection of models for calculating pollutant emissions and atmospheric concentrations. Such guidance is provided in the Approved Methods and other documents.

ES2 Considerations for the development of AQIDs

The report considers a number of factors that influence the development of AQIDs.

Firstly, the report summarises the general approach to, and limitations of, AQIAs. It then provides a brief overview of the health effects of road traffic pollutants, and notes that the quantification of health effects of air pollutants has evolved to a point where there is reasonable confidence in the estimates at the population level (IAQM 2017). However, the understanding of health impacts in specific sub-groups of the population, at particular locations, and for a wide range of health endpoints and pollutant metrics, is less well advanced.

The report then provides a summary of studies which have evaluated $PM_{2.5}$ concentrations around tunnel portals. The predicted annual mean concentration has generally been up to around 0.5 µg/m^3. These studies have either compared results against preliminary portal impact assessment criteria (based on health outcomes) or established cumulative air quality impact assessment criteria. To date, there has not been a consistent approach to interpreting predicted concentrations from portal emissions.

A summary of the existing environment in the vicinity of the project has also been provided with the aim of understanding the implications of using the proposed AQIDs.

A number of general considerations, such as appropriate pollutants and averaging periods, are also documented.

ES3 Review of existing approaches

The study includes a brief review of some approaches that have been devised to support AQIAs by informing the description and interpretation of the predicted impacts.

The review covers the approaches that are currently used in Australia, or have been used previously, as well as methods from overseas. The advantages and disadvantages of the different approaches were summarised and an evaluation of the applicability of each approach based on various evaluation criteria was presented.

ES4 Recommended method

ES4.1 Selection of method

Based on the comparison of approaches, a method based on that presented by IAQM (2017) is recommended for assessing the AQIDs of the project.

To describe project impacts, the IAQM method uses the magnitude of the modelled incremental change as a proportion of the corresponding air quality impact assessment criterion, and then examines this change (increase or decrease) in the context of the new total concentration (model plus background) and its relationship with the criterion.

The advantages of this approach are:

- its applicability to all pollutants and sources;
- its consideration of total concentrations as well as project-related changes;
- its consideration of improvements in air quality, which can be useful when weighing up the distribution of results and assessing overall significance;
- its level of stringency in terms of protecting community health (given that it considers cumulative concentrations); and
- the extensive experience in its application in the UK, including for many road projects.

In addition, the method provides assistance with interpreting the overall significance of a project through the use of standardised terminology. It is noted that predicted project concentrations will still be assessed against the air quality impact assessment criteria in the Approved Methods.

The IAQM approach has therefore been adapted for the purposes of developing the AQIDs for the project. The method is applied to annual average $PM_{2.5}$ and NO_2 concentrations, and for individual receptors (ie the method must be repeated for each assessed receptor). The reasons for excluding short-term impacts are presented in the report.

ES4.2 Description of the method

The table below sets out the assessment method for annual $PM_{2.5}$ assessed against an air quality impact assessment criterion of 8 µg/m^3. The coloured cells are the AQIDs. Corresponding tables for NO_2, PM_{10}, as well as alternative air quality impact assessment criteria, are also provided in the report.

Table ES1 Project AQIDs individual receptors – annual PM2.5 (AQC of 8 µg/m3)

Total annual average concentration at receptor Use the higher of the 'without project' or 'with project' concentration	**Absolute[(a)] change in concentration relative to air quality impact assessment criterion (AQC)**				
	<0.5% (<0.04 µg/m^3)	**≥0.5% to <1.5%** (≥0.04 to <0.12 µg/m^3)	**≥1.5% to <5.5%** (≥0.12 to <0.44 µg/m^3)	**≥5.5% to <10.5%** (≥0.44 to <0.84 µg/m^3)	**≥10.5%** (≥0.84 µg/m^3)
≤75% of AQC (≤6.0 µg/m^3)	Negligible	Negligible	Negligible	Slight	Moderate
>75% to ≤95% of AQC (>6 to ≤7.6 µg/m^3)	Negligible	Negligible	Slight	Moderate	Moderate
>95% to ≤103% of AQC (<7.6 to ≤8.2 µg/m^3)	Negligible	Slight	Moderate	Moderate	Substantial
>103% to ≤110% of AQC (>8.2 to ≤8.8 µg/m^3)	Negligible	Moderate	Moderate	Substantial	Substantial
≥110% of AQC (≥8.8 µg/m^3)	Negligible	Moderate	Substantial	Substantial	Substantial

1. The change can be either an increase or a decrease. The absolute magnitude of the change is used here.

The steps of the method are summarised below:

- Step 1 – determine the total concentration at the receptor with and without the project.
- Step 2 – determine the change in concentration at the receptor with the project.
- Step 3 – determine the total concentration and change in concentration as a percentage of the air quality impact assessment criterion.
- Step 4 – identify the impact descriptor ('negligible', 'slight', 'moderate' or 'substantial').

When calculating the total concentration as a percentage of the air quality impact assessment criterion, use the higher of the 'without project' and 'with project' concentrations. That is:

- where the total concentration decreases with the project, use the 'without project' concentration; and
- where the total concentration increases with the project, use the 'with project' concentration.

In developing the method, the following modifications were made to the IAQM approach:

- The actual concentration ranges corresponding to each cell of the table have been added for clarity.

- The intervals of the values have been defined explicitly to avoid any ambiguity. In the IAQM approach, the changes in concentration are rounded to the nearest whole percent. Here, the range values for the columns have been made explicit (e.g. 2 to 5% becomes ≥1.5% to <5.5%).
- An additional column for changes in concentration of less than 0.5% of the air quality impact assessment criterion – for which the AQID is always 'negligible' – has been included based on the advice from IAQM 2017 author Stephen Moorcroft.

The report provides two worked examples for $PM_{2.5}$ and NO_2 for hypothetical receptor locations, drawing on existing data collected or modelled for the project and using some assumptions.

The report also lists some factors that could be considered in a determination of significance, such as analysing the distribution of concentration increases and decreases with the project, and determining the number of receptors experiencing a particular AQID over another (eg slight vs moderate).

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1 Introduction

1.1 Background

Transport for NSW (TfNSW) is considering tunnel options for the Blackheath to Little Hartley section of the Great Western Highway Upgrade Project (referred to hereafter as 'the project'). For the project, TfNSW is considering options without tunnel exhaust stacks, and hence with tunnel portal emissions. As a result, the Secretary's Environmental Assessment Requirements (SEARs) for the project require that, should portal emissions be proposed, the project is assessed in accordance with air quality impact descriptors (AQIDs) that are endorsed by the NSW Advisory Committee on Tunnel Air Quality (ACTAQ). The AQIDs are different from 'air quality impact assessment criteria', which are the pollutant concentrations defined in the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (the Approved Methods) (NSW EPA 2017). These are the concentrations against which projects are typically assessed.

This report describes the development of AQIDs which could be used to describe the results of the air quality impact assessment (AQIA) for the project, including consideration of tunnel portal emissions. The report summarises the considerations for the development of impact criteria, reviews some existing approaches, and proposes an approach to be applied to the project.

NB: this report does not provide any guidance on the methodology to be applied in the actual AQIA itself, such as the selection of models for calculating pollutant emissions and atmospheric concentrations. Such guidance is provided in the Approved Methods and other documents.

1.2 Project description

The Great Western Highway runs between Sydney and Bathurst and provides the main transport link between the Central West of NSW, the Blue Mountains and the Sydney motorway network for freight, tourist and general traffic. The project will separate local and through traffic, improve freight access, network efficiency, safety and community outcomes. It will also facilitate growth in the New South Wales central west.

1.3 Secretary's Environmental Assessment Requirements

The SEARs for the project include the following condition:

> *Should portal emissions be proposed, demonstration that such a design is supported by NSW intergovernmental review and is assessed in accordance with air quality impact assessment criteria [sic] and methodology endorsed by the Advisory Committee on Tunnel Air Quality.*

With respect to the development of appropriate AQIDs for the project, the ACTAQ recommended a review of relevant approaches, with a particular focus on the potential for adapting an existing approach from the UK, as contained in the *Guidance on land-use planning and development control: Planning for air quality* (IAQM 2017).

In accordance with the SEARs, the AQIDs would nominally be applicable to tunnel portal emissions. However, it would not be advisable to assess portal emissions alone. A road tunnel does not have an effect in isolation. For the project, there would be a new portal emission source and changes to the surface road network. When all sources are considered, there could be either an increase or a decrease in the pollutant concentration at a given receptor location.

1.4 Study objectives and report structure

The main objective of the study was to develop new AQIDs which could be used to describe the results of the AQIA for the project. The AQIDs will ultimately help the proponent, the regulator and other stakeholders to understand the significance of the project's impacts on air quality, and to refine the project design and mitigation where needed.

This report considers the context of the project, reviews the UK's Institute of Air Quality Management's (IAQM) guidance as well as some other existing approaches, and describes the development and application of the new AQIDs for the project.

The remaining Sections of the report are summarised as follows:

- Section 2 provides context for the study and summarises considerations for the development of AQIDs;
- Section 3 presents a review of existing approaches, and provides an overall summary of these approaches;
- Section 4 provides the AQID method developed for the project, including worked examples;
- Section 5 gives the conclusions from the work; and
- References lists the references that have been cited.

Additional background information is provided in appendices, including contextual information regarding conventions in air quality assessments, and AQID tables for pollutants and averaging periods not provided in Section 4.

2 Considerations for the development of AQIDs

2.1 Context and limitations of AQIA

In an AQIA for a road project, operational air quality can be presented numerically in the following ways:

- the predicted *total* concentration, including the existing background and the contributions from various road sources (surface roads, portals, and ventilation stacks); and/or
- the predicted *change* in concentration relative to an existing baseline.

The total concentrations obtained from the AQIA are conventionally compared against pre-defined air quality impact assessment criteria to determine if the project complies with the criteria or causes any extra exceedances. Where the project results in (extra) exceedances of the criteria, the next steps may include changes to the project design and/or the use of mitigation measures. Although this process assists with decision-making, it does not address the predicted change in air quality, and is problematic to apply it in some situations, such as where annual mean background concentrations already exceed criteria.

The use of AQIDs within the AQIA process enables decisions to be made based on evidence. However, when developing such criteria it is important to understand the limitations of the AQIA process itself. For example, AQIAs mostly involve the use of models to represent the emission, dispersion, and transformation of air pollutants. The data entered into the models, and the algorithms in the models themselves, are often subject to uncertainty, or they simplify complex real-world processes. Some of these difficulties have come to be addressed using various conventions to provide a degree of consistency (see Appendix A). The general limitations of AQIAs, in relation to how they affect the description of impacts (and their significance) were stated by IAQM (2009):

> *The study of air pollutants in ambient air is not an exact science. The uncertainty is often increased further by the constraints on time and techniques that are typically associated with assessing air quality in the context of the planning process. Assessing the significance of impacts of development on air quality cannot be reduced to strict, formulaic methodology and judgement will always be required.*

A person conducting or reviewing an assessment should understand this context: an air quality assessment is not designed to give a perfectly accurate representation on the impacts of a project on the exposure of all individuals but is best viewed as a mechanism for assisting with decision-making, and one which, at some point, will require a subjective decision.

2.2 Health effects of road traffic pollutants

Road traffic is an important source of air pollution, especially in urban areas. The most important air pollutants from road transport are airborne particulate matter and nitrogen dioxide (NO_2). The two metrics that are most commonly used to describe particulate matter are $PM_{2.5}$ and PM_{10}.

Emissions of $PM_{2.5}$ from road vehicles are mainly from vehicle exhaust, but also contain non-exhaust emissions (brake wear, engine abrasion, tyre wear). PM_{10} emissions from traffic include $PM_{2.5}$, as well as a 'coarse' fraction between 2.5 µm and 10 µm that is mainly composed of non-exhaust particles. NO_2 is also produced by combustion.

Short-term and long-term exposure to elevated concentrations of $PM_{2.5}$ is linked to a variety of cardiovascular and respiratory diseases and contributes to premature death. Associations have also been observed between $PM_{2.5}$ exposure and adverse reproductive and developmental outcomes such as low birth weight. Exposure to PM_{10} is associated with similar health effects to those for $PM_{2.5}$, although there is some uncertainty about how much of the observed effect is due to $PM_{2.5}$ and how much is due to the coarse fraction.

Short-term exposure to NO_2 has been linked to cardiovascular and respiratory mortality, and respiratory disease such as asthma and chronic obstructive pulmonary disease (COPD). There is greater uncertainty as to the quantitative health impacts of long-term exposure to NO_2, although the evidence is growing. There is also likely to be considerable overlap between the health effects of long-term exposure to NO_2 and $PM_{2.5}$, as they are highly correlated.

The International Agency for Research on Cancer has also classified outdoor air pollution as carcinogenic to humans, with an emphasis on particulate matter (PM) in general and specifically PM in diesel engine exhaust (IARC 2012, 2013).

Some important points to note are:

- Epidemiological evidence shows that there is strong evidence of a relationship between long-term (ie annual) average $PM_{2.5}$ concentrations and premature mortality[1] (WHO 2021). The relationships for other air pollutants and non-mortality impacts are generally weaker and based on more limited evidence.
- For particulate matter (and possibly NO_2) a key feature is that no lower threshold has been identified below which exposure is not associated with adverse health effects.
- The relationships for both $PM_{2.5}$ and NO_2 have derived from studies of participants who were predominantly aged 30 and above.

It is important to note that the quantification of health effects of air pollutants (as stated above) has evolved to a point where there is reasonable confidence in the estimates **at the population level** (IAQM 2017). However, the understanding of health impacts in specific sub-groups of the population or at particular locations, and for a wide range of health endpoints and pollutant metrics, is less well advanced.

2.3 Previous tunnel portal studies

Notwithstanding the fact that the *overall* impacts of a new tunnel on air quality need to be assessed, the potential for the project to have portal emissions means that it is useful to consider the likely magnitude of these emissions, as observed in previous studies.

There have been a small number of studies in recent years which have assessed $PM_{2.5}$ concentrations around tunnel portals, both incrementally and cumulatively, although they have generally not been published. One of the studies was an initial investigation of a provisional design for the project (EMM 2021). The objective of a number of these studies was to investigate suitable hours for tunnel portal emissions whilst ensuring that emissions were not causing an unacceptable risk to human health at nearby sensitive receptors. Other studies included the modelling of existing or proposed tunnel portals as part of the cumulative assessment for the project. Many of the studies (particularly from overseas) were completed as a model testing or evaluation exercise.

Table 2.1 provides a summary of studies which have presented $PM_{2.5}$ concentrations around tunnel portals. The predicted annual mean concentration has generally been up to around 0.5 $\mu g/m^3$. These studies have either compared results against preliminary portal impact assessment criteria (based on health outcomes) or established cumulative air quality impact assessment criteria. To date, there has not been a consistent approach to interpreting predicted concentrations from portal emissions.

[1] 'Premature mortality' refers to deaths that occur at an age earlier than a selected cut-off, such as 75 years.

Table 2.1 Summary of selected previous portal studies (Australia and New Zealand)

Project name, location, and year	Project description	Summary of annual average portal only $PM_{2.5}$ results [(a)]	Portal assessment criteria used
GWH tunnel portal pollutant dispersion analysis, NSW, 2021 (EMM 2021)	Estimation of the incremental changes in pollutant concentrations at ground-level locations due to the tunnel portals, and comparison of results against pre-defined air quality risk criteria	0.001 – 0.544 µg/m³	• 0.018 µg/m³ (equating to a risk in all-cause mortality of 1 in 1,000,000) [(b)] • 0.18 µg/m³ (equating to a risk in all-cause mortality of 1 in 100,000) [(b)] • 1.8 µg/m³ (equating to a risk in all-cause mortality of 1 in 10,000) [(b)]
Iron Cove Link – preliminary air quality assessment, NSW, 2016 (Pacific Environment 2016)	Preliminary modelling assessment of road and tunnel portal emissions from the Iron Cove Link tunnel	• 0.018 µg/m³ exceeded at ~3,000 receptors • 0.18 µg/m³ exceeded at ~100 receptors • 1.8 µg/m³ exceeded at receptors within construction footprint only	• 0.018 µg/m³ (equating to a risk in all-cause mortality of 1 in 1,000,000) • 0.18 µg/m³ (equating to a risk in all-cause mortality of 1 in 100,000) • 1.8 µg/m³ (equating to a risk in all-cause mortality of 1 in 10,000)
Lane Cove Tunnel ventilation investigation, TfNSW, NSW, 2014 (Pacific Environment 2014)	Estimation of incremental ventilation and portal emissions using dispersion modelling for varying hours of the day	0.00001 – 0.375 µg/m³	Approved Methods impact assessment (cumulative) criterion of 8 µg/m³
Western Ring Route - Waterview Connection, NZ, 2010 (Beca and NIWA 2010)	Predictions of stack and portal emissions for the project	Annual average not modelled. 24-hour average $PM_{2.5}$ maximum of 0.8 µg/m³	Ministry for the Environment (MfE) 24-hour monitoring level of 25 µg/m³

1. Across all sensitive receptor (residences, workplaces and commercial properties) locations.

2. In the EMM study these values were rounded to 0.02, 0.2 and 2 µg/m³.

2.4 Existing air quality

To understand the existing air quality environment in the general vicinity of the project, and to understand the implications of using the AQIDs proposed in Section 4, monitoring data were obtained for the following locations:

- the Department of Planning and Environment (DPE) monitoring station at Katoomba; and
- the project monitoring stations at Blackheath and Browntown Oval.

The pollutants obtained were $PM_{2.5}$, PM_{10} and NO_2.

i DPE Katoomba AQMS

DPE operated the Katoomba air quality monitoring station (AQMS) as a research station between April 2019 and June 2020. The AQMS recorded meteorological data and concentrations of ozone, NO, NO_2, NO_x, CO, SO_2, $PM_{2.5}$ and PM_{10}. The station was located on 20–22 Valley Road, approximately 1 km to the west of Katoomba and 6 km to the south of the expected GWH tunnel southern portal[2].

The monitoring period for the Katoomba AQMS included the 'Black Summer' bushfires - the length, intensity, and scale of which was unprecedented. The Gospers Mountain 'mega blaze' in the Wollemi National Park (north of the Blue Mountains) commenced on 26 October 2019 and was finally contained on 12 January 2020, burning over one million hectares. The PM_{10} and $PM_{2.5}$ concentrations (and to a lesser extent NO_2 concentrations) recorded during this period were heavily influenced by these events, and not necessarily representative of longer-term average conditions. The concentrations of $PM_{2.5}$, PM_{10} and NO_2 from the Katoomba AQMS for the period before, during and after the Gospers Mountain fire are presented in Figure 2.1.

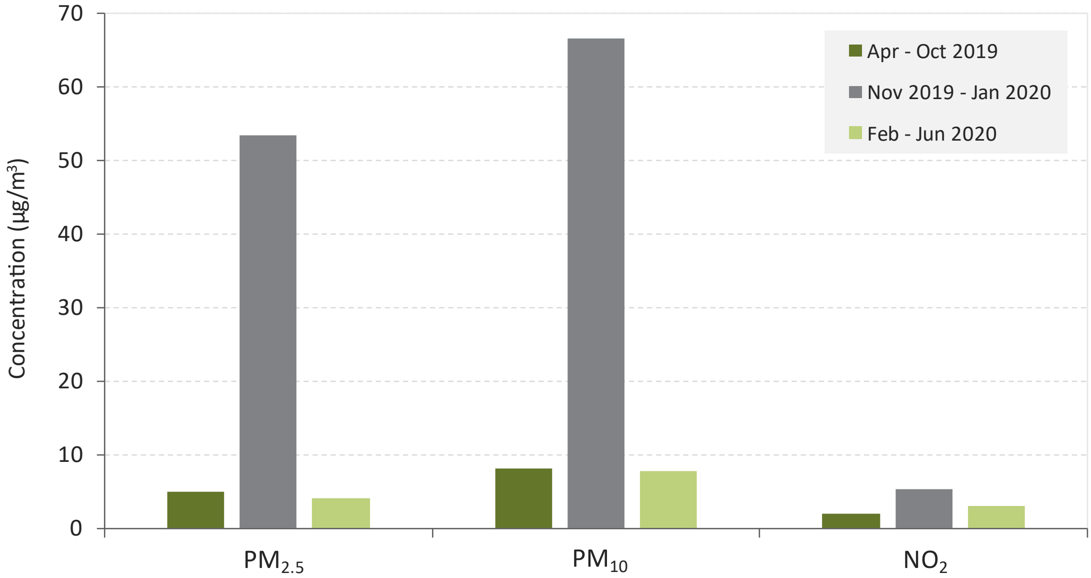

Figure 2.1 Period average $PM_{2.5}$, PM_{10} and NO_2 concentrations for the Katoomba AQMS

The average $PM_{2.5}$ and PM_{10} concentrations for a combined 12-month period before and after the bushfires were 4.6 µg/m^3 and 8.0 µg/m^3, respectively. These values represented 57% and 32% of the respective annual air quality impact assessment criteria of 8 µg/m^3 and 25 µg/m^3. The average NO_2 concentrations for the combined 12-month period before and after the bushfires was 2.5 µg/m^3, representing 4% of the annual air quality impact assessment criterion in NSW of 62 µg/m^3.

ii Project-specific monitoring

Project specific air quality monitoring is underway at three locations along the proposed project alignment:

- Blackheath (Evans Lookout Road);

[2] Portal location based on information provided for the GWH tunnel portal dispersion analysis (2021). The location may be changed as part of the GWH Environmental Impact Statement (EIS).

- Mount Victoria (Browntown Oval); and
- Little Hartley (Western Gantry).

At the time of writing, limited data were available for Blackheath (3 months) and Mount Victoria (2 months). No data were available for Little Hartley.

The period average concentrations of $PM_{2.5}$, PM_{10} and NO_2 at Blackheath and Mount Victoria, based on the available data, are presented in Figure 2.2. The corresponding values for the DPE Katoomba AQMS are also shown for comparison. Broadly speaking, and allowing for the differences in the time period, the measured $PM_{2.5}$ and PM_{10} concentrations across the three sites were comparable. It is noted that for the Blackheath station, the $PM_{2.5}$:PM_{10} ratio was 1.1 (PM_{10} was slightly lower than $PM_{2.5}$). The Mount Victoria and Katoomba stations had a $PM_{2.5}$:PM_{10} ratio of 0.4 and 0.6 respectively. The reason for this difference is unknown at this point. The period average NO_2 concentration at Blackheath was markedly higher that at the other sites. Again, without further investigation the reason for this is unknown. In the light of the patterns in the data from the project monitoring stations, and in particular the Blackheath data, the project-specific measurements should be viewed as provisional.

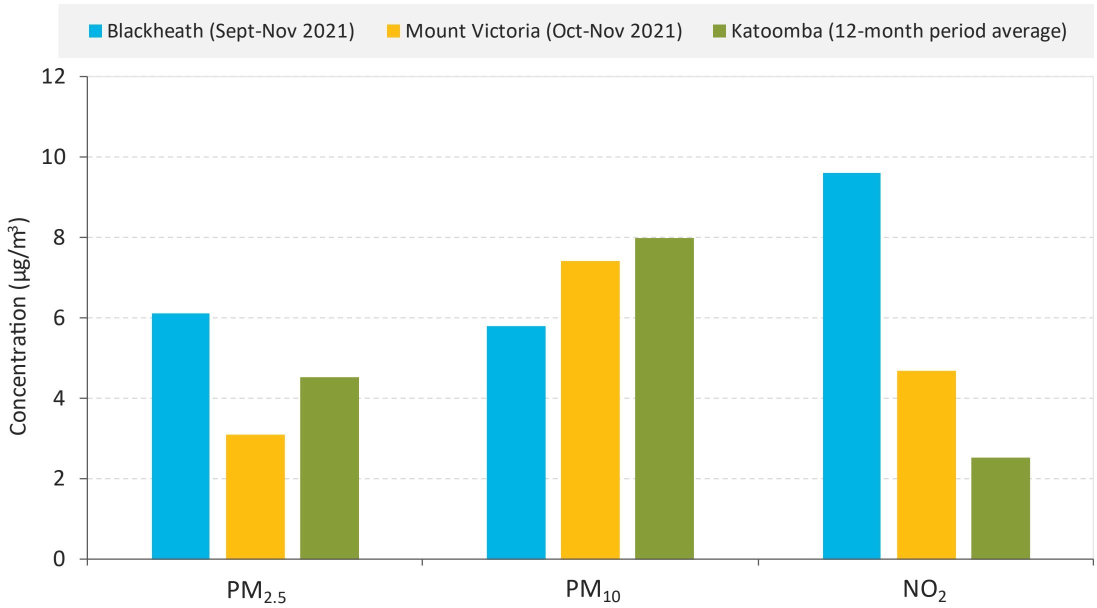

Figure 2.2 Period average $PM_{2.5}$, PM_{10} and NO_2 concentrations for project-specific and DPE Katoomba monitoring stations

2.5 General considerations

Describing air quality impacts (and their acceptability) for locations near roads and tunnel portals can be difficult. One of the reasons is due to the nature of the source, and in particular the strong pollutant gradient and rapid changes in the atmosphere that exists near portal exits. There are a range of other aspects which may need to be considered, such as specific health-related impacts, the nature of the existing background, the community perspective, and the financial implications of alternative project designs, such as tunnel ventilation stacks.

When developing AQIDs, the following general considerations apply:

- Pollutants – which pollutants should the AQIDs be developed for? $PM_{2.5}$ is a commonly used indicator, as its links to health outcomes are well established. However, given the rapidly changing atmosphere and strong pollutant gradients near portals, should NO_2 also be considered?

- Averaging periods – annual average concentrations have historically been the focus of recent tunnel portal investigations in NSW. However, should 24-hour concentrations be considered?
- Expected concentration ranges – how do these fit within the proposed AQIDs, and do such criteria need to be adapted to suit the local conditions?
- Assessment of increment or cumulative concentrations – should the AQIDs allow for assessment of the project increment or with all sources included (as portal emissions will not occur independently of changes on the road network)? If incrementally only, how are other sources assessed?
- Acceptability – does the method consider already established views on health acceptability? And if not, how can it be adapted?
- Significance of impacts – how do the AQIDs allow for interpretation of the results and for decision-making to be made? Are there set categories leading to decision-making outcomes, or is it left up to assessor discretion?
- These considerations have been taken into account as far as possible when adapting the AQIDs for the project.

3 Review of existing approaches

3.1 Overview

This section contains a brief review of some approaches that have been devised to support AQIAs by informing the description and interpretation of the predicted impacts. The emphasis in the review is on road projects, including tunnel portals where possible. The review covers the approaches that are currently used in Australia, or have been used previously, as well as methods from overseas. The advantages and disadvantages of the different approaches are summarised at the end of the section. The review is not designed to be comprehensive, but rather to provide an overview of the different concepts that have been used.

3.2 'Standard' assessments

Firstly, it is useful to consider the 'standard' approach to AQIA in NSW. This is, in principle, applicable to tunnel portal emissions, although there is no reference to tunnel portals in the existing NSW guidance.

The NSW *Environmental Planning and Assessment Act* (1979) is the principal piece of legislation used in NSW for the approval of new development. Under the Act, environmental assessment is required for new or modified development applications. Where an activity involves emissions to air, typically an AQIA is required as part of an Environmental Assessment (EA) or EIS.

The specific requirements for impact assessment are outlined in the SEARs, issued by DPE with input from the relevant state regulators. The EPA provides advice to the DPE on the requirements for AQIA, and these requirements typically reference the Approved Methods (NSW EPA 2017). New or modified development is generally required to comply with the impact assessment outlined in the Approved Methods and for criteria pollutants, both incremental and cumulative impacts need to be presented in an AQIA.

In general terms, NSW EPA has historically assessed the acceptability of impacts from a project using a summary of exceedances of air quality impact assessment criteria at receptors, and considering the change in the number of exceedances between 'with' and 'without' project scenarios. Project increments (particularly for stacks) have also been a point of consideration in recent major infrastructure projects.

3.3 Australian guidance

3.3.1 Sydney tunnel project criterion

In the AQIAs for the three WestConnex tunnel projects in Sydney (M4 East, New M5 and M4-M5 Link), a key metric was the change in the annual mean $PM_{2.5}$ concentration ($\Delta PM_{2.5}$) (Boulter et al 2015; Manansala et al 2015; Pacific Environment 2017). The basis for this approach was that a change in annual mean $PM_{2.5}$ is associated with a well-defined change in the risk of mortality in the population. According to an approach developed by TfNSW (then Roads and Maritime Services) for the WestConnex projects, the highest acceptable increase in risk was an increase in annual mortality of 1 in 10,000. This equated to a value for $\Delta PM_{2.5}$ of between around 1.5 µg/m^3 and 1.8 µg/m^3, depending on the situation.

The actual value of the criterion varied depending on the baseline incidence of all-cause mortality for ages 30 and over, and it was calculated as follows:

$$R = \beta \times \Delta PM_{2.5} \times B$$

Where:

R = additional risk

β	=	slope coefficient relevant to the % change in response to a 1 μg/m^3 change in exposure (β = 0.0058 for $PM_{2.5}$ all-cause mortality)
$\Delta PM_{2.5}$	=	change in annual mean concentration in μg/m^3 at the point of exposure
B	=	baseline incidence of a given health effect per person (eg annual mortality rate) (eg 976.6 per 100,000 for mortality all causes ≥ 30 years for the New M5 project)

This can be rewritten as:

$$\Delta PM_{2.5} = R \;/\; (\beta \times B)$$

As an example, for the WestConnex New M5 project, the $PM_{2.5}$ increment for a risk of 1 in 10,000 was:

$$\Delta PM_{2.5} = 0.0001 / 0.0058 \times 0.00976 = 1.8\ \mu g/m^3$$

This approach was applied to general changes in air quality around surface roads and tunnel ventilation stacks only (portal emissions were not permitted for the WestConnex project).

It is important to note that, as a simplification, the approach was applied to all receptors in the same way, and it was therefore assumed that the underlying concentration-response function would be applicable to all sub-groups (ages) of the population, and not just those aged 30 and above. However, it is known, for example, that older people are at substantially greater risk than population average.

3.3.2 ACTAQ tunnel portal criterion

In a draft discussion paper, ACTAQ (2016) proposed a risk-based criterion for the assessment of tunnel portal emissions. Although the criterion was never implemented, it is included for completeness.

The approach used was similar to that described above for $\Delta PM_{2.5}$.

Two key factors were considered in arriving at the risk criterion:

- Any increase in risk to the community due to portal emissions is an involuntarily risk. Any increase in risk due to portal emission is outside of the exposed individual's control and controlled by the tunnel operator.
- There are practicable measures that can be implemented to eliminate any risk due to portal emissions. While portal emissions are common practice internationally, the standard practice in NSW is that all new tunnels over 1 km in length are designed and operated with no portal emissions.

For the WestConnex projects the 'acceptable' level of risk was defined as 1 in 10,000, whereas for portal emissions the criterion proposed by ACTAQ corresponds to an increase in risk of less than one in one million (or 10^{-6}). ACTAQ considered this to represent a 'negligible' risk level. The increased stringency for portals was considered to be more appropriate, given that the technology is available to minimise portal emissions. The proposed risk criterion of 10^{-6} equated to a change in annual mean $PM_{2.5}$ concentration of approximately 0.02 μg/m^3, or in other words less than 0.3% of existing background levels and the existing (8 μg/m^3) and future (7 μg/m^3) national air quality standards. As with the criterion used for the WestConnex project, it is assumed that the underlying concentration-response function would be applicable to all sub-groups of the population, and not just those aged 30 and above, as well as all locations.

3.3.3 Western Australia Screening Concentrations

In 2019, WA Department of Water and Environmental Regulation (DWER) released a *Draft Guideline for Air Emissions* (DWER 2019), which prescribes ambient air quality guideline values (AGVs) as the basis for assessment of air emissions on receptors. The draft guideline also proposes screening concentrations, which are expressed as a percentage of the AGV and compared against the project increment only.

If an emission source contributes less than the screening concentrations at a receptor, it can be considered insignificant, and no further analysis or assessment is required.

It is noted that the screening concentrations are applied to a prescribed screening analysis approach, which is technically only applicable to stack sources. The DWER AGV and screening concentrations for $PM_{2.5}$ are presented in Table 3.1.

Table 3.1 DWER AGV and screening concentrations

Pollutant	Averaging period	AGV (µg/m³) [1]	Screening concentration (SC) as % of AGV
$PM_{2.5}$	24-hour	25	<3% (0.75 µg/m³)
	Annual	8	<1% (0.08 µg/m³)

3.4 Overseas guidance

3.4.1 US methods

New Source Review (NSR) Permitting (for new or modified source) includes the provision for assessing against a Prevention of Significant Deterioration (PSD) increment. A PSD increment is designed to prevent the air quality in 'clean areas' from deteriorating to the level set by the National Ambient Air Quality Standards (NAAQS). The PSD process is therefore only applicable for attainment areas (areas that currently meet the NAAQS). The NSR permitting process for non-attainment areas is different and requires demonstration of lowest achievable emission rate (LAER) and emission offsets.

The PSD increment is the maximum increase in concentration that is allowed to occur above a baseline concentration for a pollutant. The baseline concentration is defined for each pollutant and, in general, is the ambient concentration existing at the time that the first complete PSD permit application affecting the area is submitted. The baseline concentration is not required to determine the PSD increment, however the change in emissions (increase or decrease) from sources in operation since the baseline date is required. The change in emissions is then calculated as the difference between the emissions at the baseline date and the actual emissions for the period of modelling. The modelled increment is the change in predicted concentration attributable to this emission change.

The permitting process for attainment areas also allows for a screening assessment, against a Significant Impact Level (SIL). A SIL is a *de minimis* threshold applied to individual facilities. NSR permitting requires an air quality analysis (AQA), to demonstrate compliance with both the NAAQS and PSD increments. The AQA can begin with the preliminary impact determination, whereby the maximum predicted concentrations for the project emissions alone are compared against the SIL. If the SIL is not exceeded, no further assessment may be required. If the increase in emissions results in impacts greater than the SIL, the permit applicant would be required to perform additional analyses to determine if those impacts will be more than the PSD increment and NAAQS. It is noted that air quality cannot deteriorate beyond the NAAQS, even if not all the PSD increment is used.

A summary of the SIL, PSD and NAAQS are shown in Table 3.2.

Table 3.2 SIL, PSD Increment and NAAQS

Pollutant	Averaging period	SIL (µg/m³)	NAAQS (µg/m³)	Class I PSD increment (µg/m³)[a]	Class II PSD increment (µg/m³)[b]
$PM_{2.5}$	Annual	0.2	12	1	4
	24-hour	1.2	35	2	9
PM_{10}	Annual	1	NA	4	17
	24-hour	5	150	8	30
NO_2	Annual	1	109[c]	2.5	25
	1-hour	7.5	205[c]	NA	NA

1. Class I areas are pristine wilderness areas and afforded the greatest degree of protection.
2. Class II areas are virtually all non-class I areas and allow for a moderate degree of emissions growth.
3. Converted from ppm at 0°C.

3.4.2 London Councils Air Pollution Exposure Criteria

The London Councils' Air Quality and Planning Guidance provides planning guidance for developers, consultants, and local authorities (London Councils 2007). The document includes guidance for determining significance of impacts and the level of mitigation required through the use of Air Pollution Exposure Criteria (APEC). The APEC are provided in Table 3.3.

Table 3.3 London Councils Air Pollution Exposure Criteria (APEC)

APEC	Applicable range nitrogen dioxide annual mean	Applicable range PM_{10}	Recommendation
APEC - A	> 5% below national objective	**Annual mean:** > 5% below national objective **24-hour:** > 1-day less than national objective	No air quality grounds for refusal; however, mitigation of any emissions should be considered.
APEC - B	Between 5% below or above national objective	**Annual mean:** Between 5% above or below national objective **24-hour:** Between 1-day above or below national objective.	May not be sufficient air quality grounds for refusal, however appropriate mitigation must be considered eg maximise distance from pollutant source, proven ventilation systems, parking considerations, winter gardens, internal layout considered, and internal pollutant emissions minimised.
APEC - C	> 5% above national objective	**Annual mean:** > 5% above national objective **24-hour:** > 1-day more than national objective.	Refusal on air quality grounds should be anticipated, unless the Local Authority has a specific policy enabling such land use and ensure best endeavours to reduce exposure are incorporated. Worker exposure in commercial/industrial land uses should be considered further. Mitigation measures must be presented with air quality assessment, detailing anticipated outcomes of mitigation measures.

3.4.3 IAQM guidance on significance in air quality (2009)

The guidance on *Significance in air quality* guidance by IAQM (2009) relates to the task of describing local air quality impacts and assessing their significance.

This guidance was replaced by the IAQM's land-use planning guidance (see Section 3.4.4). Nevertheless, some of the concepts are still relevant to this review and therefore the document has been summarised below.

The guidance considers the following:

- descriptors for the magnitude of changes and the physical sensitivity of receptors;
- descriptors for impact; and
- the assessment of significance.

i Describing magnitude

IAQM developed generic descriptors for the magnitude of changes in air quality due to a project, as shown in Table 3.4. The percentage change is defined in relation to the air quality standard (objective or limit value in the UK), and not the existing ambient concentration, so that a common approach could be applied to any assessment and pollutant. The use of 1% as the threshold for an 'imperceptible' change provided consistency with existing screening methods in the UK. According to IAQM, there is no need to explicitly define the sensitivity of receptors when using these descriptors. No distinction should be made between the sensitivity of dwellings, hospitals, schools, etc.

Table 3.4 Generic definitions of the magnitude of impacts

Magnitude of change	Change in annual mean concentration[(a)]
Large	>10%
Medium	5-10%
Small	1-5%
Imperceptible	<1%

Source: Adapted from Table 1 of IAQM (2009).

1. Change in concentration as a percentage of air quality standard.

ii Describing impacts

Once the magnitude of the change is known, the next step is to describe the impact at each relevant receptor.

In terms of describing impacts at an individual receptor, IAQM provides an approach based on the change in concentration and the absolute concentration relative to an air quality standard. It could be argued that the inclusion of the absolute concentration and the air quality standard effectively represents a benchmark in relation to public acceptance of air pollution. In other words, people are likely to be more concerned about an increase in pollution where it is already relatively high, than by an increase in pollution where existing levels are low.

An example of this approach for annual mean NO_2 is show in Table 3.5 (note that the NO_2 concentrations are relevant to the UK). Descriptors include 'moderately adverse', 'slightly adverse', 'negligible', 'slightly beneficial', etc. In discussions with IAQM authors, it was noted that these category descriptors are not specifically related to concentration ranges or specific impacts but were adopted based on consistent terminology used in assessments in Environmental Impact Assessments in the UK.

The rows labelled 'Just below standard' represent a band from 100% to 90% of the standard, and the rows labelled 'Well below standard' represent a band of 75% of the standard or less. IAQM notes that it may be appropriate to use the same 90% and 75% levels for other pollutants and standards.

IAQM notes that this table should not be used to assess the overall significance of a development project in one step.

Table 3.5 Descriptors of air quality impacts at a receptor (annual mean NO_2)

Absolute concentration in relation to air quality standard (40 µg/m³)	Total concentration (µg/m³)	Change in concentration		
		Small	Medium	Large
Increase with project				
Above standard with project	>40	Slight adverse	Moderate adverse	Substantial adverse
Just below standard with project	36-40	Slight adverse	Moderate adverse	Moderate adverse
Below standard with project	30-36	Negligible	Slight adverse	Slight adverse
Well below standard with project	<30	Negligible	Negligible	Slight adverse
Decrease with project				
Above standard without project	>40	Slight beneficial	Moderate beneficial	Substantial beneficial
Just below standard without project	36-40	Slight beneficial	Moderate beneficial	Moderate beneficial
Below standard without project	30-36	Negligible	Slight beneficial	Slight beneficial
Well below standard without project	<30	Negligible	Negligible	Slight beneficial

Source: Adapted from Table 2 of IAQM (2009).

iii Describing significance

Once the magnitude of the change is known and the impact has been described at each relevant receptor, the next step is to assess the **overall significance** of the air quality impacts. In all but the most straightforward of circumstances this will require the weighing of adverse and beneficial changes.

IAQM recognises that the assessment of significance is difficult, and notes that '*…as a discipline, air quality is not well suited to the rigid application of generic significance matrix to determine the overall significance* [of project impacts]'. Although IAQM does not support the adoption of a single method for determining overall significance, it states that where a descriptor is required then it should be based on professional judgement, taking into account factors such as the size of the changes, descriptions of the impacts, the number of people affected, numbers of exceedances, the magnitude of exceedances and uncertainties in the assumptions. IAQM states that Table 3.5 should not be used as a generic significance matrix that could be used to assess the overall significance of a development project in one step.

3.4.4 IAQM guidance on land-use planning (2017)

As noted earlier, ACTAQ has recommended that the existing approach from the UK, as contained in the *Guidance on land-use planning and development control: Planning for air quality* (IAQM 2017) be investigated for suitability in developing assessment criteria for portal emissions be specifically for the project.

This document effectively replaces the 2009 guidance and condenses the approach from three steps into two steps.

i Describing impacts

To describe project impacts, IAQM uses the magnitude of the **modelled** incremental change as a proportion of the air quality standard, and then examines this change in the context of the new total concentration (**model plus background**) and its relationship with the standard. As with the IAQM's 2009 approach, the inclusion of the absolute concentration and the air quality standard represents a benchmark in relation to public acceptance of air pollution.

The method was initially developed for annual mean NO_2 concentrations in the UK. However, as with the 2009 approach, the advantage of this method is that it can be applied (in principle) to any pollutant, any type of development and any location, although some slight modifications made be required.

The method does not take into account any differences in receptor[3] sensitivity.

The framework suggested by IAQM for describing the impacts is shown Table 3.6. The table is only applicable to annual mean[4] concentrations at individual receptors. It is suggested that percentage changes in concentration should be rounded to whole numbers; changes of less than 0.5% are described as negligible.

NB: Impacts may be adverse or beneficial, depending on whether the change in concentration is positive or negative.

Table 3.6 Project impact descriptors for individual receptors

Long-term average concentration at receptor in assessment year[(a)]	% change in concentration relative to standard[(b)]			
	1	2-5	6-10	>10
75% or less of standard	Negligible	Negligible	Slight	Moderate
76-94% of standard	Negligible	Slight	Moderate	Moderate
95-102% of standard	Slight	Moderate	Moderate	Substantial
103-109% of standard	Moderate	Moderate	Substantial	Substantial
110% or more of standard	Moderate	Substantial	Substantial	Substantial

Source: Adapted from Table 6.3 of IAQM (2017).

1. IAQM states that, when defining the concentration as a percentage of the AQAL, use the 'without project' concentration where there is a decrease in pollutant concentration and the 'with project' concentration for an increase.

IAQM refers to this as the Air Quality Assessment Level (AQAL), which may be an air quality objective, EU limit or target value, or an Environment Agency Environmental Assessment Level (EAL). According to IAQM, the long-term average concentration categories reflect the 'degree of potential harm'. At exposures below 75% of the standard, the degree of harm is likely to be small. As the exposure approaches and exceeds the standard, the degree of harm increases. The change associated with the project becomes more important when the result is an exposure that is approximately equal to, or greater than the standard.

[3] Although IAQM (2017) does not directly define 'receptor', it states that 'receptors will represent locations where people are likely to be exposed for the appropriate averaging time (dependant on the air quality objective being assessed against)'. Other IAQM guidance documents define a receptor as a location experiencing an 'effect'.

[4] IAQM states that for road transport projects, long-term average concentrations are the most useful for evaluating the severity of impacts, with short-term concentrations being more relevant to industrial point sources.

For the long-term average concentration, one of the reasons why IAQM uses a range around the standard, and not an exact cut-off at the standard, is to reflect the uncertainty in assessments and to minimise over-interpretation. IAQM also notes that the descriptors should not be applied too rigidly, and assessors should recognise the inevitable uncertainties in the process.

ii Describing significance

The IAQM (2017) guidance expands upon the approach to describing significance from the 2009 guidance, but essentially follows the same principles.

The assessment framework for describing impacts can be used as a starting point to make a judgement on significance of effect, but there will be other influences that might need to be accounted for. The impact descriptors set out in Table 3.6 are not, of themselves, a clear and unambiguous guide to reaching a conclusion on significance. These impact descriptors are intended for application at a series of individual receptors. Whilst it may be that there are 'slight', 'moderate' or 'substantial' impacts at one or more receptors, the overall effect may not necessarily be judged as being significant in some circumstances where for example, these impacts are confined to a small area or lasting for a short duration (IAQM 2017).

In some cases, a judgement on 'slight' or 'substantial' results may be very clear, however, where results fall into the 'moderate' category, a judgement on significance is likely to be more difficult to make.

IAQM also notes that it can also be helpful to present the changes in concentrations across the study area using contour plots, as this will help to inform the decision as to whether the effect is significant or not (by describing the geographical extent over which impacts occur and by helping identify the sensitive receptors that might be affected).

IAQM (2017) notes that a judgement of the overall significance of effect of a development will need to take into account factors including:

- the existing and future air quality in the absence of the development;
- the extent of current and future population exposure to the impacts; and
- the influence and validity of any assumptions adopted when undertaking the prediction of impacts.

iii Short-term impacts

As stated previously, the IAQM methodology outlined in Table 3.6 is relevant to annual average impacts only. IAQM (2017) notes that impact assessments of a development are governed by the long-term exposure at a receptor and that defining the significance of effects for short-term impacts is not a necessity. The guidance does recognise, however, that short-term impacts may be considered particularly in the case of point sources (ie stacks) where peak concentrations could be significant.

IAQM provides the following guidance for assessing 24-hour and 1-hour impacts:

24-hour impacts:

Consideration of the 24-hour criterion can be given using a derived value for the annual average based on the number of days exceeding a 24-hour concentration being no more than 35 times per year. For example, in the UK, the 24-hour AQAL for PM_{10} is 50 µg/m^3 being exceeded no more than 35 times per year. Therefore, an annual mean of 32 µg/m^3 equates to 35 days at or above 50 µg/m^3.

1-hour (or less) impacts:

IAQM (2017) supports the approach taken by the UK Environment Agency that adopts a threshold criterion of 10% of the short-term AQAL as a screening criterion for the maximum short-term impact from the project.

Where peak short-term concentrations from an elevated source range between 11 and 20% of the AQAL, the magnitude is described as small. Where concentrations range between 21 and 50% of the AQAL, the impact is described as medium, and those above are described as large. Using IAQM guidance terminology, these are translated to slight, moderate, and substantial respectively.

3.5 Summary of methods and recommended approach

A summary of the advantages and disadvantages of the different approaches is presented in Table 3.7. Further evaluation of the applicability of each approach, based on relevant evaluation criteria, is presented in Table 3.8.

It is clear from Table 3.7 and Table 3.8 that each approach has advantages and disadvantages across various aspects, and that some methods may be suitable in some circumstances and not in others.

Some important points regarding the approaches investigated are made below:

- the $\Delta PM_{2.5}$ methods assume that all receptors have an occupancy/activity that is the same as that of the general population aged 30+ (the population on which much of the epidemiological evidence is based);
- some approaches (such as the $\Delta PM_{2.5}$), provide a hard criterion for decision-making but do not take into account existing background levels;
- only the IAQM and US EPA methods account for existing background concentrations (as well as the increment);
- the $\Delta PM_{2.5}$ (Sydney tunnels), IAQM and US EPA methods can be applied to all source types;
- the IAQM, US EPA and WA methods can be applied across all pollutants;
- the $\Delta PM_{2.5}$ and IAQM methods account for an improvement in air quality (ie impacts from the project can be beneficial);
- all methods are applicable to annual mean concentrations;
- only the US EPA and WA methods can be applied to short-term concentrations (although it is noted that the WA approach is applicable to stack sources only);
- the $\Delta PM_{2.5}$ and IAQM methods are considered more stringent than the US EPA and WA methods, but this depends largely on what is considered to be acceptable in terms of risk and impact;
- only the IAQM method provides a way to assist with interpreting significance through the use of standard impact terminology (ie ‘negligible’, ‘slight’, ‘moderate’ and ‘substantial’); and
- none of the methods investigated account for individual receptor sensitivity. It is noted that this is not commonplace in standard AQIA.

Based on the comparison of approaches, a method based on that presented by IAQM (2017) is recommended for assessing the air quality impacts of the project. The advantages of this approach are:

- its applicability to all pollutants and sources;
- its consideration of total concentrations as well as project-related changes;
- its consideration of improvements in air quality, which can be useful when weighing up the distribution of results and assessing overall significance;

- its level of stringency in terms of protecting community health (given that it considers cumulative concentrations); and
- the extensive experience in its application in the UK, including for many road projects.

In addition, the method provides assistance with interpreting the overall significance of a project through the use of standardised terminology. It is noted that predicted project concentrations will still be assessed against impact assessment criterion (from the Approved Methods etc).

The IAQM approach has therefore been adapted for purposes of describing the air quality impacts of the project (see Section 4).

Table 3.7 Advantages and disadvantages of different approaches

Method	Advantages	Disadvantages
$\Delta PM_{2.5}$ method (Sydney tunnel projects)	• Provides a precise, hard criterion for decision-making. Even if the precision is difficult to accept from the epidemiological evidence, the conventions can be accepted. • Easy to apply, as a simple change in concentration at each receptor. • Useful where many receptors (eg thousands) are being assessed, and it is not practicable to consider every receptor in detail. • Enables changes to project design to be quantified and optimised.	• The implicit assumption is that all receptors have an occupancy/activity that is the same as that of the general population aged 30+ (the population on which much of the epidemiological evidence is based). The method is not valid (without further adaptation) for specific individual receptors where the occupancy/activity differs from that of the general population (good examples include childcare centres and aged care facilities). However, for large-scale and complex AQIAs, with a large number of receptors which cannot be considered individually, it is reasonable to accept the general applicability of the method as a convention (with appropriate caveats) to support decision-making. This would just be one of several conventions that are used in AQIAs (see Appendix A). • Risk is stated in proportional terms (eg 1 in 10,000). This is understandable for an absolute $PM_{2.5}$ concentration where the existing background concentration is included. However, the metric relates to a change in concentration, and it should therefore relate to a change in risk. It is not clear how this works numerically and takes into account the existing level of risk associated with the background concentration. • Does not take into account existing background levels. • Epidemiological evidence may not support extension to other pollutants.
$\Delta PM_{2.5}$ method (tunnel portals)	• Provides a precise, hard criterion for decision-making. • Useful where many receptors are being assessed, although for areas around tunnel portals the number of receptors is often quite low. • Allows for flexible decision making when considering all of the relevant aspects of the project. • Enables changes to project design to be quantified and optimised.	• Not valid for specific individual receptors (see above). • Unclear how the existing risk associated with the background concentration is taken into account in the definition of risk for tunnel portals (see above). • It is not stated whether the criterion refers to the contribution from tunnel portals only or includes the combined effects of portals and surface roads. For the purposes of this report it is assumed that the criterion would apply to both the total overall change in $PM_{2.5}$ and the contribution of portals only.

Table 3.7 Advantages and disadvantages of different approaches

Method	Advantages	Disadvantages
		• Not tested for projects outside of major Sydney infrastructure projects. • Epidemiological evidence may not support extension to other pollutants.
IAQM (2017)	• The method takes into account both the total concentration and the change in concentration with a project. • Allows for consideration of improvements in air quality. • The criteria ranges are clearly defined and developed based on extensive experience in the UK. • The method is easy to apply to a given receptor. • Avoids the need for individual pollutants to have their own tailored method of assessment	• The method is not tried and tested in Australia. • The impact descriptors are subjective (although based on standard terminology). • Each receptor must be processed individually, and the mix of outcomes must be interpreted. • The method does not allow for receptors having different sensitivity.
US EPA SIL and PSD Increments	• The method takes into account both the total concentration and the change in concentration with a project (ie if the SIL is exceeded, additional analyses including cumulative assessment is required). • More stringent PSD increments (and in some cases SIL) can be applied to areas requiring more protection. • Applicable to short-term and long-term averaging periods. • The SIL is easy to apply and includes a simple and unambiguous impact descriptor.	• The method is not tried and tested in Australia. • The method does not allow for receptors having different sensitivity. • Does not allow for consideration of improvements in air quality.
WA DWER SC	• Applicable to short-term and long-term averaging periods. • The method is easy to apply and includes a simple and unambiguous impact descriptor.	• The method is designed for screening assessment of stack sources only. The applicability to other sources has not been investigated. • The method does not account for background concentrations. • Does not allow for consideration of improvements in air quality.

Table 3.8 Evaluation of different approaches

Evaluation	$\Delta PM_{2.5}$ method (Sydney tunnel projects)	$\Delta PM_{2.5}$ method (tunnel portals)	IAQM (2017)	US EPA SIL and PSD Increments	WA DWER SC
Provides a hard criterion for decision-making	Yes	Yes	Yes and no. The impact descriptors are subjective and still need to be interpreted (although they are based on defined concentration ranges and standard terminology).	Yes	Yes
Stringent (high level of protection)	Yes (depends on level of acceptable risk)	Yes (depends on level of acceptable risk)	Yes (depends on what is considered to be an acceptable outcome)	Yes and no. In the case of portals for example, the SIL is unlikely to be exceeded and no further assessment would be required.	Yes and no. If the portal contribution is less than the screening concentration, no further assessment is required.
Considers improvements in air quality from the project	Yes	Yes	Yes	No	No
Applicable across multiple pollutants	No – applicable to $PM_{2.5}$ only.	No – applicable to $PM_{2.5}$ only.	Yes – for all pollutants with a prescribed AQ standard.	Yes – for all pollutants with a prescribed AQ standard.	Yes – for all pollutants with a prescribed AQ standard.
Considers ambient background concentrations	No	No	Yes	Yes	No
Applicable to local conditions for the project	Would have to be adapted using information on the local population and baseline health data.	Would have to be adapted using information on the local population and baseline health data.	Yes	Yes	Yes
Assists with determining significance	No	No	Yes. Whilst the method does not provide prescriptive guidance on assessing significance, results are expressed using common terminology (ie 'negligible', 'slight', 'moderate' and 'substantial') which is likely to assist in interpreting results.	No	No

Table 3.8 Evaluation of different approaches

Evaluation	$\Delta PM_{2.5}$ method (Sydney tunnel projects)	$\Delta PM_{2.5}$ method (tunnel portals)	IAQM (2017)	US EPA SIL and PSD Increments	WA DWER SC
Considers total concentration and change in concentration	No – change only.	No – change only.	Yes	Yes	No – increment only.
Applicable to annual mean concentrations	Yes	Yes	Yes	Yes	Yes
Applicable to short-term concentrations	No	No	No	Yes	Yes
Accounts for receptor sensitivity	No - not valid for specific individual receptors where the occupancy/activity differs from that of the general population.	No - not valid for specific individual receptors where the occupancy/activity differs from that of the general population.	No	No	No
Easy to apply	Yes	Yes	Yes	Depends – if SIL is exceeded, requires detailed cumulative analysis.	Yes
Applicable to different types of sources	Yes	No – specific to portals only.	Yes	Yes	No – prescribed for stack sources only.
Directly related to health risk	Yes	Yes	No – although based on ambient air quality standards.	No – although based on ambient air quality standards.	No – although based on ambient air quality standards.

4 Development of AQIDs for the project

4.1 Background

As a first step in the adaptation of the IAQM method for use in the project, EMM held a discussion with Stephen Moorcroft, one of the lead authors of the guidance, to gain insight into the method and its intended application. The following points provide a summary of the discussion:

- The method is not tied to a specific pollutant or standard, and therefore can be applied to any annual average pollutant and air quality impact assessment criterion.
- The categories and ranges used in the IAQM (2017) method (Table 3.6) were not developed on the basis of background monitoring datasets or in relation to a standard; but rather were developed using a pragmatic approach. IAQM (2017) states:

  Since air quality standards are set on the basis of harm, it is reasonable to assume that the degree of harm is represented by the margin by which the AQAL is exceeded. This concept is not universally true and many pollutants exert an effect on human health at exposures that are below the standard. It does, however, provide a sound and consistent basis for a framework for the assessment of impacts.
- The method is applied to cumulative concentrations (ie all sources related to the project plus background) and is also therefore not tied to a particular type of source.
- The method does not account for health or mortality risk levels and is not linked to epidemiological factors.
- The method does not consider receptor sensitivity levels (eg the difference between a residence or an aged care centre).

4.2 Method for the project

Given the general applicability of the IAQM method across different pollutants and air quality criteria, it was considered appropriate, as a first step, to retain the percentage ranges and descriptors from the IAQM method, and to modify the corresponding concentrations to reflect the criteria that would apply to the project.

The emphasis here is on annual mean $PM_{2.5}$ and NO_2, and the criteria for these pollutants that currently apply to AQIAs in NSW[5]. Short-term impacts are excluded from the method for the following reasons:

- The health impacts of annual mean concentrations (especially $PM_{2.5}$) are well established.
- The certainty in the results of an AQIA is greater for annual mean concentrations than for short-term concentrations.
- The Inclusion of short-term impacts could potentially confuse and bias the overall outcome. For example, the outcomes for 1-hour NO_2 could be given the same weight as those for annual mean $PM_{2.5}$ when evaluating the overall distribution of results across receptors, whereas from a health perspective annual mean PM2.5 would be more important.

[5] As defined in the Approved Methods (NSW EPA 2017).

- The IAQM guidance states that for most road transport project the long-term average concentration is the most useful for evaluating the severity of impacts. The guidance does note that, for point sources, some consideration must also be given to the impacts resulting from short-term, peak concentrations. This could be considered to include tunnel ventilation stacks. However, emissions from these would tend to be relatively small compared with those associated with surface roads (at near-road locations), as well as the general variation in background concentrations.

Table 4.1 sets out the assessment method for annual mean $PM_{2.5}$ and an air quality impact assessment criterion of 8 µg/m^3, and Table 4.2 gives the method for annual mean NO_2 and an air quality impact assessment criterion of 62 µg/m^3. The following modifications have been made to the IAQM approach (Section 3.4.4):

- The actual concentration ranges corresponding to the air quality impact assessment criterion have been added for clarity.
- The intervals of the values have been defined explicitly to avoid any ambiguity. In the IAQM approach, the changes in concentration are rounded to the nearest whole percent. Here, the range values for the columns have been made explicit (eg 2 to 5% becomes ≥1.5% to <5.5%).
- An additional column has been included for changes in concentration of less than 0.5% of the air quality impact assessment criterion, for which the impact descriptor is always 'negligible'. This is based on the advice from Stephen Moorcroft. Any change in concentration of less than 0.5% would be rounded down to zero in the IAQM approach, and this is reflected in the table.

When stating the results using the tables below, the impacts should be given as either 'adverse' or 'beneficial' depending on whether the change in concentration is positive or negative (eg a 'slight adverse' impact or a 'slight beneficial' impact).

When calculating the total concentration as a percentage of the air quality impact assessment criterion, use the higher of the 'without project' and 'with project' concentrations. That is:

- where the total concentration decreases with the project, use the 'without project' concentration; and
- where the total concentrations increases with the project, use the 'with project' concentration.

This means that, even where the background concentration is low but the increase in concentration with the project is large, the impact would tend to be 'substantial'.

For example, in the case of $PM_{2.5}$ in Table 4.1,if the background concentration is 6 µg/m^3 and the increase with the project is 2 µg/m^3, the total concentration is 8 µg/m^3, and therefore the third row and fifth column of the table are selected, giving a 'substantial' impact.

There could potentially be a large increase with the project that only gives a 'moderate' outcome. This could happen where, say, the background is 5 µg/m^3 and the project increase is 2.6 µg/m^3. However, in this case the total concentration would be 95% of the air quality impact assessment criterion of 8 µg/m^3, and this is the rationale for the 'moderate' impact.

Table 4.1 Project AQIDs for individual receptors – annual PM2.5 (AQC of 8 µg/m3)

Total annual average concentration at receptor Use the higher of the 'without project' or 'with project' concentration	Absolute[(a)] change in concentration relative to air quality impact assessment criterion (AQC)				
	<0.5% (<0.04 µg/m³)	≥0.5% to <1.5% (≥0.04 to <0.12 µg/m³)	≥1.5% to <5.5% (≥0.12 to <0.44 µg/m³)	≥5.5% to <10.5% (≥0.44 to <0.84 µg/m³)	≥10.5% (≥0.84 µg/m³)
≤75% of AQC (≤6.0 µg/m³)	Negligible	Negligible	Negligible	Slight	Moderate
>75% to ≤95% of AQC (>6 to ≤7.6 µg/m³)	Negligible	Negligible	Slight	Moderate	Moderate
>95% to ≤103% of AQC (<7.6 to ≤8.2 µg/m³)	Negligible	Slight	Moderate	Moderate	Substantial
>103% to ≤110% of AQC (>8.2 to ≤8.8 µg/m³)	Negligible	Moderate	Moderate	Substantial	Substantial
≥110% of AQC (≥8.8 µg/m³)	Negligible	Moderate	Substantial	Substantial	Substantial

1. The change can be either an increase or a decrease. The absolute magnitude of the change is used here.

Table 4.2 Project AQIDs for individual receptors – annual NO2 (AQC of 62 µg/m3)

Total annual average concentration at receptor Use the higher of the 'without project' or 'with project' concentration	Absolute change[(a)] in concentration relative to air quality impact assessment criterion (AQC)				
	<0.5% (<0.31 µg/m³)	≥0.5% to <1.5% (≥0.31 to <0.93 µg/m³)	≥1.5% to <5.5% (≥0.93 to <3.41 µg/m³)	≥5.5% to <10.5% (≥3.41 to <6.51 µg/m³)	≥10.5% (≥6.51 µg/m³)
≤75% of AQC (≤46.5 µg/m³)	Negligible	Negligible	Negligible	Slight	Moderate
>75% to ≤95% of AQC (>46.5 to ≤58.9 µg/m³)	Negligible	Negligible	Slight	Moderate	Moderate
>95% to ≤103% of AQC (<58.9 to ≤63.9 µg/m³)	Negligible	Slight	Moderate	Moderate	Substantial
>103% to ≤110% of AQC (>63.9 to ≤68.2 µg/m³)	Negligible	Moderate	Moderate	Substantial	Substantial
≥110% of AQC (≥68.2 µg/m³)	Negligible	Moderate	Substantial	Substantial	Substantial

1. The change can be either an increase or a decrease. The absolute magnitude of the change is used here.

In addition to the air quality impact assessment criteria in Table 4.1 and Table 4.2, the following have also been considered:

- a value for $PM_{2.5}$ of 7 µg/m³, which would be in accordance with the national goal for 2025 in the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) (not yet adopted in the Approved Methods);

- a value for PM_{10} of 25 µg/m^3, which is the current air quality impact assessment criterion in NSW; and
- a value for NO_2 of 31 µg/m^3, which is the current air quality standard in the AAQ NEPM (not yet adopted in the Approved Methods).

The corresponding tables are given in B.1. It should be noted that the percentage ranges and impact descriptors are identical to those for $PM_{2.5}$ in all cases. Only the concentrations corresponding to the percentage ranges and air quality impact assessment criteria have been modified.

4.3 Worked examples for the project

4.3.1 Context

For any given scenario, pollutant and receptor, the annual mean concentration will have up to three[6] components:

- a background component (based on measurements);
- a surface road component (based on model predictions); and
- a tunnel portal component (based on model predictions).

The receptors used in the AQIA for the project will be at different types of location with respect to air quality. Without the project, some receptors will be at background locations, where the contribution from surface roads is negligible. Other receptors may be close to a road with a significant amount of traffic (such as the Great Western Highway), where there is a significant road traffic component to the concentration.

In terms of how the project affects the three components:

- the background component is the same with and without the project;
- the surface road component can either increase or decrease with the project, depending on:
  - the position of the receptor relative to the existing road network, and the traffic on the existing road network;
  - the position of the receptor relative to the new road network with the project, and the traffic on the new road network; and
- the tunnel portal component is, zero by definition without the project, and zero or non-zero with the project.

The two worked examples below illustrate how the method would be applied to receptors in the project area. The examples are for hypothetical receptors that are at background and near-road locations without the project, taking into account the three components of the concentration. The examples are for annual mean $PM_{2.5}$ and NO_2 only, and the assumptions are summarised in Table 4.3.

[6] Assuming that emission from any tunnel(s) are released from the portals and not from ventilation stacks.

Table 4.3 Assumptions in worked examples

	$PM_{2.5}$	NO_2
Background concentration[(a)]	4.5 µg/m³	2.5 µg/m³
Surface road component[(b)]	0.2 to 0.5 µg/m³	3 to 6 µg/m³
Tunnel portal component©	0.1 µg/m³	2 µg/m³

1. Background concentrations are based on the DPE Katoomba dataset, excluding the bushfire period (see Section 2.4).
2. Estimated based on the experience of the authors from other road projects in NSW, but in practice will be site-specific.
3. Estimated. For PM2.5, the assumed value is higher than the maximum result at any receptor7 (0.02 µg/m3) in the dispersion modelling work for a provisional tunnel design (EMM 2021). For NO2, the assumed value is estimated from Pacific Environment (2014).

4.3.2 Example 1: Receptor at a background location

This example is for a receptor that is effectively at a background location without the project, where the contribution from the surface road network is zero. With the project, there is a contribution from a new tunnel portal and the associated surface road.

i $PM_{2.5}$

Step 1 – determine the total concentration at the receptor with and without the project

The following assumptions have been made:

- the background concentration is 4.6 µg/m³;
- the surface road component without the project is zero;
- the surface road component with the project is 0.2 µg/m³;
- the tunnel portal component without the project is zero;
- the tunnel portal component with the project is 0.1 µg/m³.

Therefore, the total concentrations are:

- without project = 4.6 µg/m³
- with project = 4.6 + 0.2 + 0.1 = 4.9 µg/m³

Step 2 – determine the change in concentration at the receptor with the project

The change in concentration with the project is:

- 4–9 - 4.6 = 0.3 µg/m³

[7] Southern Portal (National Park) model scenario.

Step 3 – determine the total concentration and change in concentration as a percentage of the air quality impact assessment criterion

For $PM_{2.5}$, the annual mean air quality impact assessment criterion is currently 8 µg/m^3.

In this example, there is an increase in concentration with the project, and therefore the 'with project' total concentration of 4.9 µg/m^3 is used.

Therefore:

- for the total concentration, 4.9 µg/m^3 as a % of the criterion of 8 µg/m^3 = 62%
- for the change in concentration, 0.3 µg/m^3 as a % of the criterion of 8 µg/m^3 = 4%

Step 4 – identify the impact descriptor

By referencing Table 4.1, it can be seen that the total concentration corresponds to the first row of the table, and the change in concentration corresponds to the third column, resulting in an impact description of 'negligible'.

If the annual mean air quality impact assessment criterion of 8 µg/m^3 is replaced with the NEPM goal of 7 µg/m^3, the impact description remains 'negligible'.

ii NO_2

Step 1 – determine the total concentration at the receptor with and without the project

The following assumptions have been made:

- the background concentration is 2.5 µg/m^3;
- the surface road component without the project is zero;
- the surface road component with the project is 3 µg/m^3;
- the tunnel portal component without the project is zero;
- the tunnel portal component with the project is 2 µg/m^3.

Therefore, the total concentrations are:

- without project = 2.5 µg/m^3
- with project = 2.5 + 3 + 2 = 7.5 µg/m^3

Step 2 – determine the change in concentration at the receptor with the project

The change in concentration with the project is:

- 7.5 – 2.5 = 5 µg/m^3

Step 3 – determine the total concentration and change in concentration as a percentage of the air quality impact assessment criterion

For NO_2, the annual mean air quality impact assessment criterion is currently 62 µg/m^3.

In this example, there is an increase in concentration with the project, and therefore the 'with project' total concentration of 7.5 µg/m^3 is used.

Therefore:

- for the total concentration, 7.5 µg/m^3 as a % of the criterion of 62 µg/m^3 = 12%
- for the change in concentration, 5 µg/m^3 as a % of the criterion of 62 µg/m^3 = 8%

Step 4 – identify the impact descriptor

By referencing Table 4.1, it can be seen that the total concentration corresponds to the first row of the table, and the change in concentration corresponds to the fourth column, resulting in an impact description of 'slight adverse'.

If the annual mean air quality impact assessment criterion of 62 µg/m^3 (currently used in NSW) is replaced with the current NEPM standard of 31 µg/m^3, the impact description becomes 'moderate adverse'.

4.3.3 Example 2: Receptor at a near-road location

This second worked example considers a receptor at a near-road location without the project, where the contribution from the surface road network is non-zero. With the project, there is a contribution from a new tunnel portal and the associated surface road, but the contribution from the existing road decreases, giving in a net reduction in the surface road component.

i $PM_{2.5}$

Step 1 – determine the total concentration at the receptor with and without the project

The following assumptions have been made:

- the background concentration is 4.6 µg/m^3;
- the surface road component without the project is 0.5 µg/m^3;
- the surface road component with the project is 0.3 µg/m^3;
- the tunnel portal component without the project is zero;
- the tunnel portal component with the project is 0.1 µg/m^3.

Therefore, the total concentrations are:

- without project = 4.6 + 0.5 = 5.1 µg/m^3
- with project = 4.6 + 0.3 + 0.1 = 5.0 µg/m^3

Step 2 – determine the change in concentration at the receptor with the project

The change in concentration with the project is:

- 5.0 - 5.1 = -0.1 µg/m^3 (ie an absolute change of 0.1 µg/m^3)

Step 3 – determine the total concentration and change in concentration as a percentage of the air quality impact assessment criterion

In this example, there is a decrease in concentration with the project, and therefore the 'without project' total concentration of 5.1 µg/m^3 is used.

Therefore:

- for the total concentration, 5.1 µg/m^3 as a % of the criterion of 8 µg/m^3 = 64%
- for the change in concentration, 0.1 µg/m^3 as a % of the criterion of 8 µg/m^3 = 1.3%

Step 4 – identify the impact descriptor

By referencing Table 4.1, it can be seen that the total concentration corresponds to the first row of the table, and the change in concentration corresponds to the second column, resulting in an impact description of 'negligible'.

If the annual mean air quality impact assessment criterion of 8 µg/m^3 is replaced with the NEPM goal of 7 µg/m^3, the impact description remains 'negligible'.

ii NO_2

Step 1 – determine the total concentration at the receptor with and without the project

The following assumptions have been made:

- the background concentration is 2.5 µg/m^3;
- the surface road component without the project is 6 µg/m^3;
- the surface road component with the project is 2 µg/m^3;
- the tunnel portal component without the project is zero;
- the tunnel portal component with the project is 2 µg/m^3.

Therefore, the total concentrations are:

- without project = 2.5 + 6 = 8.5 µg/m^3
- with project = 2.5 + 2 + 2 = 6.5 µg/m^3

Step 2 – determine the change in concentration at the receptor with the project

The change in concentration with the project is:

- 8.5 – 6.5 = -2 µg/m^3 (ie an absolute change of 2 µg/m^3)

Step 3 – determine the total concentration and change in concentration as a percentage of the air quality impact assessment criterion

In this example, there is a decrease in concentration with the project, and therefore the 'without project' total concentration of 8.5 µg/m^3 is used.

Therefore:

- for the total concentration, 8.5 µg/m^3 as a % of the criterion of 62 µg/m^3 = 14%
- for the change in concentration, 2 µg/m^3 as a % of the criterion of 62 µg/m^3 = 3.2%

Step 4 – identify the impact descriptor

By referencing Table 4.1, it can be seen that the total concentration corresponds to the first row of the table, and the change in concentration corresponds to the third column, resulting in an impact description of 'negligible'.

If the annual mean air quality impact assessment criterion of 62 µg/m^3 is replaced with the current NEPM standard of 31 µg/m^3, the impact description becomes 'slight beneficial'.

4.4 Assessing receptor sensitivity

The assessment method provided in Section 4.2 does not factor in receptor sensitivity (ie there is no distinction between the sensitivity of dwellings, hospitals, schools, etc). Currently, air quality assessments in NSW also generally do not account for receptor sensitivity.

IAQM 2009 states that if receptor sensitivity is required, the following should be considered:

- The sensitivity, value or importance of ecological or built heritage receptors should established by an ecologist or built heritage specialist.
- If the receptor is the facade of a residential building, then it should be assumed that any member of the general public could be present within the building including the elderly, infants or other vulnerable groups. No distinction should be made between the sensitivity of dwellings, hospitals, schools, etc. and all should be considered as being of equal sensitivity for the purposes of the assessment.

Whilst assessing receptor sensitivity may not be required as a formal part of the project's AQIA, it may be useful when assessing significance of the method's results and also overall project impact significance.

One option would be to develop additional AQIDs for higher sensitivity receptors (eg stricter impact categories for schools, aged care centres, etc). However, this would require further subjective changes to the AQIDs, and could become overly complex.

A simpler approach is therefore recommended, whereby the AQIA defines a range of receptor types, and summarises the result of the impact assessment for each receptor type in turn.

Receptor sensitivity could also be taken into account at the end of the assessment when weighing up the distribution of results. For example, an analysis could be completed to determine types and number of receptors falling into the various method categories and also weighing up those that are predicted to experience an increase in concentrations vs a decrease. This is discussed further in Section 4.5.

4.5 Assessing significance

In a standard AQIA, determining significance is typically limited to an assessment of the distribution of predicted concentrations across the model domain, and a comparison of increases and decreases in concentration at discrete receptors as a result of the project. Judgements on the significance of the project from a health perspective forms part of a health risk assessment.

The following are examples of factors that could be considered in an analysis of significance:

- From the air quality modelling:
  - How many receptors (by receptor type) have an increase in concentration with the project?
  - How many receptors (by receptor type) have a decrease in concentration with the project?
  - What duration of the modelling period are receptors expected to experience higher concentrations (eg how many hours in the year)?
- From the impact assessment:
  - How many receptors (by receptor type) have a result of ‘negligible’, ‘slight’, etc?

5 Conclusions

This study has provided an overview of considerations for the development of AQIDs, a summary of existing approaches, and details development of AQIDs to be used when assessing changes to air quality as result of the project.

The review of existing approaches covers those that are currently used in Australia, or have been used previously, as well as methods from overseas. The advantages and disadvantages of the different approaches were summarised and an evaluation of the applicability of each approach based on various evaluation criteria was presented. Based on the comparison of approaches completed, IAQM (2017) was the recommended method for assessing air quality impacts from the project.

Advantages of adopting the method specific to assessing air quality impacts from the project are:

- its applicability to all pollutants and sources;
- its consideration of existing background levels;
- its level of stringency in terms of protecting community health (given that it considers cumulative concentrations;
- although it does not provide numerical results, it provides a way to assist with interpreting significance through the use of standard impact terminology. It is noted that predicted project concentrations will still be assessed against air quality impact assessment criteria (from the Approved Methods etc); and
- it considers improvements in air quality from the project which can be useful when weighing up the distribution of results and assessing overall significance.

The IAQM (2017) approach was recommended and adapted for purposes of assessing air quality impacts from the project. Worked examples have been provided for $PM_{2.5}$ and NO_2 for hypothetical receptor locations drawing on existing data collected or modelled for the project and using some assumptions.

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Appendix A
Conventions in air quality impact assessment

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A.1 Conventions in air quality impact assessment

Within the framework of an AQIA, the difficulties involved have come to be addressed through the use of various conventions, some examples of which include the following:

- Receptor definition. Receptors are defined as locations and not as individuals, although receptors may be defined for different types of occupancy, where appropriate. For example, a common type of a receptor is a residence. In an AQIA, little or no consideration is given to the specific movements of individual people within the residence, or even if they are there at all.

- Receptor placement. Given the pollution gradients near roads, the selection of the exact coordinates for receptors can influence the results of the modelling, and in practice some different approaches have been used. For example, air quality may be assessed at the centroid of a property, at the boundary of a property that is the closest to the road, or at the building façade that is the closest to the road. In AQIAs where a large number of receptors is being considered, it may be impractical to identify boundaries and building facades. In large recreational areas the movements of people are not known, and in this case several receptors may be used to give spatial coverage.

- Ambient (outdoor) air quality as a proxy for exposure. Air quality standards (and measurements) are defined for outdoor locations, and the modelling reflects this (eg there is usually no consideration of indoor vs outdoor air quality).

- Averaging periods. Pollutant concentrations are assessed for several different time periods that are selected by convention (eg 1 hour, 24 hours, annual). The uncertainty in the results of an AQIA is generally greater for shorter averaging periods.

- Pollutant metrics. One of the most important pollutants ($PM_{2.5}$) is itself a convention. $PM_{2.5}$ is a mixture of components that varies according to where, when, and how it is measured. It is based on a unit convention (mass), a size parameter convention (aerodynamic diameter)[8], and a size cut-off convention[9] to reflect the imperfect nature of instrumentation; $PM^{2.5}$ will always exclude some particles smaller than 2.5 µm and will always include some particles larger than 2.5 µm.

[8] There are other parameters for characterising particle size, such as electrical mobility diameter.

[9] The International Standards Organisation defines $PM_{2.5}$ as particles which pass through a size-selective inlet with a 50% efficiency cut-off at 2.5 µm aerodynamic diameter.

Appendix B
Pollutant impact descriptor tables

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B.1 Pollutant impact descriptor tables

Table B.1 Project AQIDs for individual receptors – annual $PM_{2.5}$ (AQC of 7 µg/m³)

Total annual average concentration at receptor Use the higher of the 'without project' or 'with project' concentration	**Absolute change in concentration relative to air quality impact assessment criterion (AQC)**				
	<0.5% (<0.04 µg/m³)	**≥0.5% to <1.5%** (≥0.04 to <0.12 µg/m³)	**<0.5%** (<0.04 µg/m³)	**≥5.5% to <10.5%** (≥0.44 to <0.84 µg/m³)	**<0.5%** (<0.04 µg/m³)
≤75% of AQC (≤5.3 µg/m³)	Negligible	Negligible	Negligible	Slight	Moderate
>75% to ≤95% of AQC (>5.3 to ≤6.7 µg/m³)	Negligible	Negligible	Slight	Moderate	Moderate
>95% to ≤103% of AQC (<6.7 to ≤7.2 µg/m³)	Negligible	Slight	Moderate	Moderate	Substantial
>103% to ≤110% of AQC (>7.2 to ≤7.7 µg/m³)	Negligible	Moderate	Moderate	Substantial	Substantial
≥110% of AQC (≥7.7 µg/m³)	Negligible	Moderate	Substantial	Substantial	Substantial

Table B.2 Project AQIDs for individual receptors – annual PM10 (AQC of 25 µg/m3)

Total annual average concentration at receptor Use the higher of the 'without project' or 'with project' concentration	**Absolute change in concentration relative to air quality impact assessment criterion (AQC)**				
	<0.5% (<0.13 µg/m³)	**≥0.5% to <1.5%** (≥0.13 to <0.38 µg/m³)	**≥1.5% to <5.5%** (≥0.38 to <1.38 µg/m³)	**≥5.5% to <10.5%** (≥1.38 to <2.63 µg/m³)	**≥10.5%** (≥2.63 µg/m³)
≤75% of AQC (≤18.8 µg/m³)	Negligible	Negligible	Negligible	Slight	Moderate
>75% to ≤95% of AQC (>18.8 to ≤23.8 µg/m³)	Negligible	Negligible	Slight	Moderate	Moderate
>95% to ≤103% of AQC (<23.8 to ≤25.8 µg/m³)	Negligible	Slight	Moderate	Moderate	Substantial
>103% to ≤110% of AQC (>25.8 to ≤27.5 µg/m³)	Negligible	Moderate	Moderate	Substantial	Substantial
≥110% of AQC (≥27.5 µg/m³)	Negligible	Moderate	Substantial	Substantial	Substantial

Table B.3 Project AQIDs for individual receptors – annual NO_2 (AQC of 31 µg/m³)

Total annual average concentration at receptor Use the higher of the 'without project' or 'with project' concentration	Absolute change in concentration relative to air quality impact assessment criterion (AQC)				
	<0.5% (<0.16 µg/m³)	**≥0.5% to <1.5%** (≥0.04 to <0.12 µg/m³)	**<0.5%** (<0.16 µg/m³)	**≥5.5% to <10.5%** (≥0.44 to <0.84 µg/m³)	**<0.5%** (<0.16 µg/m³)
≤75% of AQC (≤23.3 µg/m³)	Negligible	Negligible	Negligible	Slight	Moderate
>75% to ≤95% of AQC (>23.9 to ≤29.5 µg/m³)	Negligible	Negligible	Slight	Moderate	Moderate
>95% to ≤103% of AQC (<29.5 to ≤31.9 µg/m³)	Negligible	Slight	Moderate	Moderate	Substantial
>103% to ≤110% of AQC (>31.9 to ≤34.1 µg/m³)	Negligible	Moderate	Moderate	Substantial	Substantial
≥110% of AQC (≥34.1 µg/m³)	Negligible	Moderate	Substantial	Substantial	Substantial

Australia

SYDNEY
Ground floor 20 Chandos Street
St Leonards NSW 2065
T 02 9493 9500

NEWCASTLE
Level 3 175 Scott Street
Newcastle NSW 2300
T 02 4907 4800

BRISBANE
Level 1 87 Wickham Terrace
Spring Hill QLD 4000
T 07 3648 1200

CANBERRA
Suite 2.04 Level 2
15 London Circuit
Canberra City ACT 2601

ADELAIDE
Level 4 74 Pirie Street
Adelaide SA 5000
T 08 8232 2253

MELBOURNE
Suite 8.03 Level 8
454 Collins Street
Melbourne VIC 3000
T 03 9993 1900

PERTH
Suite 9.02 Level 9
109 St Georges Terrace
Perth WA 6000
T 08 6430 4800

Canada

TORONTO
2345 Younge Street Suite 300
Toronto ON M4P 2E5
T 647 467 1605

VANCOUVER
60 W 6th Ave Suite 200
Vancouver BC V5Y 1K1
T 604 999 8297

linkedin.com/company/emm-consulting-pty-limited

emmconsulting.com.au