Environment Protection Authority

Approved Methods for the Modelling and Assessment of Air Pollutants in NSW

DRAFT FOR CONSULTATION

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Acknowledgement of Country

The NSW Environment Protection Authority acknowledges the Traditional Custodians of the land on which we live and work, honours the ancestors and the Elders both past and present and extends that respect to all Aboriginal people.

We recognise Aboriginal peoples' spiritual and cultural connection and inherent right to protect the land, waters, skies and natural resources of NSW. This connection goes deep and has since the Dreaming.

We also acknowledge our Aboriginal and Torres Strait Islander employees who are an integral part of our diverse workforce and recognise the knowledge embedded forever in Aboriginal and Torres Strait Islander custodianship of Country and culture.

Aboriginal artwork by Worimi artist Gerard Black

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1 Introduction

1.1 Objective

This document, the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (Approved Methods), lists the statutory methods for modelling and assessing emissions of air pollutants from stationary sources in the State.

1.2 Purpose

The purpose of this document is to set the minimum requirements for modelling and assessment of air quality impacts for scheduled activities under the POEO Act. It provides guidance on the preparation of air quality impact assessments to support the EPA in making licensing decisions, taking into account the considerations outlined in section 45 of the POEO Act.

This document does not cover all possible assessment or modelling methods. The EPA recognises that certain situations may require alternative approaches. Alternative approaches may be considered in some specific circumstances, provided that the methods are justified, defensible and supported by scientific literature and using them would not contravene legislation. Where such circumstances arise, alternative approaches should be discussed with the EPA.

1.3 Core principles

The methods in this document are underpinned by a series of core principles, set out below.

Harmful pollutants must be minimised to the maximum extent achievable

Pollutants that are likely to cause harm to the environment are to be reduced to harmless levels. This is to reduce risks to human health and prevent the degradation of the environment (Object (d) of the POEO Act). Fine particles ($PM_{2.5}$) and principal toxic air pollutants must be minimised to the maximum extent achievable through the application of best-practice process design and/or emission controls. Long-term exposure to fine particle pollution shortens lives and hastens the development of cardiovascular and respiratory disease (DPE 2022). Principal toxic air pollutants, which are carcinogenic, mutagenic, teratogenic, highly toxic and/or highly persistent, are those defined in the Protection of the Environment Operations (Clean Air) Regulation 2022 (Part 1, Schedule 2).

Impact assessment criteria are not goals that activities or plant should pollute up to

The impact assessment criteria contained in this document are minimum design criteria for activities, plant and equipment. Activities, plant and equipment must also be designed in such a manner that all practicable means as necessary are used to prevent or minimise emissions. In exercising its licensing functions under the POEO Act (section 45) the EPA is required to take into consideration the practical measures that could be taken to prevent, control, abate or mitigate that pollution, and to protect the environment from harm as a result of that pollution (s 45). Modelling

results alone that are below impact assessment criteria should not be used to justify the exclusion of practicable emission control measures.

Emissions must be minimised in already constrained airsheds

In some locations, existing ambient air pollutant concentrations may exceed the impact assessment criteria from time to time. For activities in those locations, it must be demonstrated that best management practices will be implemented to minimise emissions of air pollutants by such practicable means as may be necessary.

Assessment scenarios must reflect reasonable worst case

Many factors influence the impacts of emissions of air pollutants, including the discharge parameters, the magnitude of the emission, and the local meteorological/geographic conditions. Impact assessments must be constructed in such a manner to ensure that reasonable worst-case impacts are assessed. All foreseeable operating scenarios must be included in the impact assessment.

Data, assumptions and inputs must be justified with supporting evidence

Impact assessments rely on various data, model parametrisation, and assumptions. Scientifically sound supporting evidence must be included in the impact assessment report to justify the selection of data, assumptions, or parameters utilised. Where there is uncertainty with a particular assumption, calculation, or methodology, a conservative approach must be applied to ensure the impacts are not underestimated. A sensitivity analysis can also be used to demonstrate the range of possible impacts and provide some certainty.

Assessment methods and data must be fit for purpose

The data and methods for any impact assessment must be appropriate for the situation being considered. This includes adopting emission data that reflects the source(s) being considered and using dispersion models that represent the meteorological and geographical conditions at the site under assessment.

Impact assessment report must be transparent to allow for replication of the assessment process

The impact assessment report must be transparent to enable of all steps of the assessment process to be replicated. This includes outlining all the parameters used to estimate emissions and undertake all the modelling, such that the assessment results and conclusions can be independently replicated.

2 Method overview

2.1 Types of assessment

Two approaches may be used to assess potential air quality impacts:

- **screening approach**: a conservative dispersion modelling approach using worst-case input data
- **refined approach**: a detailed dispersion modelling approach that uses site-specific input data.

Both the screening approach and the refined approach are valid forms of **air quality impact assessments**.

The refined approach is designed to be more accurate, detailed, and representative than the screening approach, which is more conservative and less specific. It is not intended that an assessment routinely progresses through both types of approaches. You may undertake a refined approach without first conducting a screening approach. Equally, if the screening approach conclusively demonstrates that adverse impacts will not occur, there is no need to progress to the refined approach.

This document primarily focuses on the requirements for conducting the refined approach, which is referred to throughout this document as an 'air quality impact assessment'. The Appendix has guidance on how to perform the screening approach, referred to as a 'screening air quality impact assessment'.

2.2 Air assessment method

The main stages in preparing an air quality impact assessment are outlined below and in a flow diagram in section 2.3.

1. **Characterising the activities and processes**

A critical phase of the air quality impact assessment process is to gain a sound understanding of the design, the processes, and the operating regime(s) for new or modified activities. Process flow diagrams and detailed descriptions of all unit operations and on-site activities should be sourced to support emissions characterisation of a premise. The minimum requirements for the characterisation/description of activities are outlined in section 10.

2. **Input data collection – sections 3, 4 and 5**

Once a thorough understanding of the processes and activities has been gained, the next step in the air quality impact assessment is to collect all the information required to complete the dispersion modelling. This includes development of an air emissions inventory and compilation of meteorological data, background air quality data, terrain data and sensitive receptor locations.

The development of the emissions inventory is one of the most important components of the assessment process. The inventory provides detailed information about all sources of air pollution at a premise. It must be demonstrated that emissions from the premises comply with the requirements of the POEO Clean Air Regulation before progressing through the other stages of the air quality impact assessment.

3. Dispersion modelling – section 6

AERMOD and CALPUFF are the approved dispersion models for use in most applications in NSW. The selected dispersion model must be justified with consideration to the topography, land use, meteorology and sources.

4. Interpretation of dispersion modelling results – section 7

Ground-level concentrations (glcs) of pollutants must be predicted within the area influenced by emissions from the premises. The predicted glcs of all pollutants must be compared against the:

- Significant Impact Level (SIL) outlined in section 7.2.1
- Degradation Prevention Threshold (DPT) outlined in section 7.2.2
- Impact assessment criteria outlined in sections 7.2.3, 7.3, 7.5 and 7.5.1.

The results of the comparisons determine the next steps.

SIL: If the predicted glcs comply with the SIL, there is no need to conduct a cumulative assessment.

DPT: If a premises exceeds the DPT, a site-specific mitigations options analysis must be undertaken.

Impact assessment criteria: Compliance with the impact assessment criteria indicates that the proposal is unlikely to result in adverse air quality impacts. If a premises does not comply with the impact assessment criteria, the assessment must be revised to incorporate additional control or mitigation measures until compliance is achieved. A site-specific mitigation options analysis must be undertaken to support the proposed additional mitigation measures to achieve compliance with the impact assessment criteria.

5. Undertaking a site-specific mitigation options analysis – section 9

A mitigation options analysis is a stepped process of information gathering, analysis and documentation to support and justify the selected air pollution control strategies.

6. Preparation of an impact assessment report – section 10

The air quality impact assessment report must be prepared in accordance with the requirements specified in section 10 of this document.

7. Additional supporting material

This document contains the following supporting material to assist with the development of refined assessments:

- modelling pollutant transformations – section 8
- worked examples – section 11
- setting licence conditions – section 12
- conversion factors – section 13.

2.3 Impact assessment methodology flow diagram

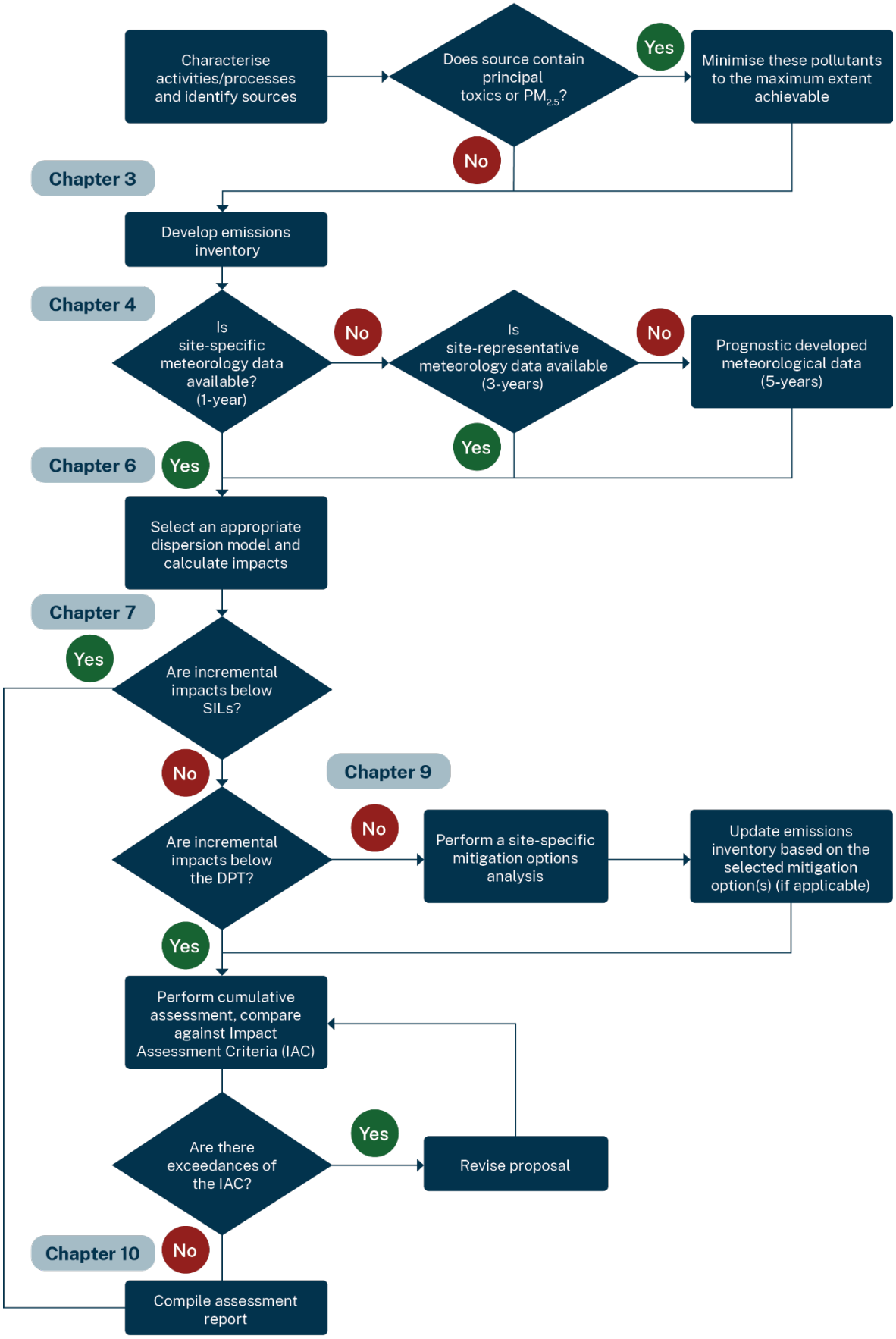

Figure 1 Impact assessment flow diagram methodology

3 Emissions inventory

The emissions inventory is the foundation of the air quality impact assessment. Developing a sound emissions inventory should be a priority task and requires the collation of a significant amount of data. An air emissions inventory for a premises must identify all sources of air pollution, the air pollutants emitted from each source, and the proposed mitigation measures; and estimate the emission concentration and rate of all air pollutants emitted.

The air quality impact assessment must clearly set out the information used to develop an emissions inventory, and must justify any assumptions and calculations.

3.1 Identify all sources of air pollution and potential emissions

Developing an emissions inventory starts with a thorough understanding of the premises. Visiting the existing premises or carefully reviewing engineering drawings for the proposed premises is useful to identify accurately all sources of air pollution and gain an understanding of the process and industry. This knowledge can be supplemented with a literature review of the industry and prevalent air pollution issues.

For all sources of air pollution at a premises, identify the following:

- release type
- potential for variability in process and emissions
- location (in metres relative to fixed origin, elevation and discharge geometry)
- potential air pollutants emitted.

3.1.1 Release type

The selection of source release type should realistically reflect the actual discharge from the proposed emission sources. If there is doubt regarding the type of source release in the dispersion model, sensitivity analysis of different source configurations should be considered to determine the most realistic representation. Source configuration may be one of the following types.

Point sources

For a point source, emissions emanate from a chimney, stack, pipe, vent or other similar kind of opening or release point. Stacks usually emit hot gases forcefully into the atmosphere at a fixed height above ground level.

Common types of point sources

- Tall point sources: A ‘tall’ point source usually refers to a source that protrudes out of the surface boundary layer (e.g. over 30–50 m tall).
- Wake-affected point sources: Where nearby buildings interfere with the trajectory and growth of the plume, the source is called a wake-affected point source. A point source is wake-affected if stack height is less than or equal to 2.5 times the height of buildings located within a distance of 5L (where L is the lesser of the height or width of the building) from the release point.

- **Wake-free point sources**: Wake-free point sources are more than 2.5 times the height of the largest nearby building, so surrounding buildings do not influence the stack top airflow.

Area sources

An area source has a more realistic two-dimensional structure but only a limited vertical extent. It is a source with a large surface area, such as a liquid surface (pond, lagoon) or a landfill surface.

Line sources

A line source is a special case of a long, thin area source. In practice, these sources are taken to be at ground level and thin. A line source becomes an area source if its breadth exceeds 20% of its length.

Volume sources

A volume source is essentially a three-dimensional source of pollutant emissions modelled with a uniform emission rate over the full source structure. They are fugitive sources, such as emissions from within a building, wheel-generated emissions from haul roads, and wind erosion emissions from material storage stockpiles.

3.2 Identify measures to mitigate pollution

The emissions inventory must identify the emissions control technology and techniques that will be implemented for each source of air emissions. For some sources, the identified emissions control technology must be supported by a site-specific mitigation options analysis, prepared in accordance with section 9.

The EPA's preferred sources for obtaining information on the available management techniques are:

- US EPA documentation
  - US EPA clearinghouse database
  - US State technology clearing house, such as the California Air Resources Board
  - US EPA fact sheets
- European Union documentation
  - Best Available Techniques (BAT) Reference documents, and Best Available Techniques (BAT) conclusion documents
- NSW EPA best-practice guidance documents
  - NSW coal mining benchmarking study – international best-practice measures to prevent and/or minimise emissions of particulate matter from coal mining (Katestone Environmental Pty Ltd, June 2011)
- Manufacturer specifications, plant and equipment suppliers, and/or control technology vendors.

Where a particular activity or emission unit is not covered in the sources listed above, it may be appropriate to use other information sources. They can include:

- industry-published, best-management-practice guideline documents.
- emission estimation technique manuals, such as the National Pollutant Inventory (NPI) Emission estimation technique manuals and US EPA's AP-42.

3.3 Determine source release parameters

Source release parameters must be clearly defined and documented in an air quality impact assessment. The release parameters for each source type are:

Point: stack height, stack diameter, temperature, discharge velocity, moisture, pressure, carbon dioxide and oxygen concentration

Diffuse area: surface area, side length and release height

Diffuse volume: side length, release height, and initial horizontal and vertical plume spread (σy and σz).

Source release parameter information may be obtained from:

- engineering drawings and plans for proposed sources
- site-specific sampling and analysis for existing sources.

3.4 Estimate emission rates

Several methods can be used to estimate the emission rate from each source. These emission estimates are preferentially summarised in Table 1. For existing point sources, direct measurement is the EPA's preferred method. For proposed point sources, manufacturers' design specification or performance guarantees are the EPA's preferred methods.

When deciding which emission estimation techniques to use, choose the most highly preferred methods that the available information allows. In some instances, multiple emission estimation techniques may be used for various scenarios. Emission factors are generally used when there is no other information available or when emissions can reasonably be demonstrated to be negligible. If you choose less-preferred techniques over more-preferred techniques, you must adequately justify this choice in the air quality impact assessment.

Table 1 Preferential hierarchy of emission estimation techniques for point sources

Ranking	Existing source	Proposed source
Most preferred	Direct measurement	Manufacturers' design specifications or performance guarantees
	Estimation from first principles	Estimation from first principles
		Direct measurement from similar sources
Least preferred	Emission factors	Emission factors

3.4.1 Manufacturers' design specifications or performance guarantees

Manufacturers' design specifications or performance guarantees can be used to estimate the emission rate of air pollutants from proposed sources. Such specifications provide a reliable means of determining the upper limit to the emission rate or concentration of air pollutants for sources that are maintained and operated in a proper and efficient manner.

Post-commissioning testing may be required to establish that sources comply with the manufacturers' design specifications and/or performance guarantees.

3.4.2 Direct measurement

For sources where manufacturers' design specifications or performance guarantees are unknown, emission rates and source release parameters should be established from the results of source emission sampling and analysis. All sampling of source emissions and analysis of air pollutants must be in accordance with the *Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales* (EPA 2022). Where source emission rates vary because of changes to inputs or parameters to a process, it may be necessary to consider direct measurement across a range of operating conditions. Test reports must be provided and must include information on the operating conditions (e.g. operating capacity, operating temperatures, process input types and throughputs) at the time measurements were made. This information should be compared with the operational variability of the source, to demonstrate emissions are representative.

3.4.3 'First principles' estimation techniques

'First principles' techniques are those techniques based on fundamental engineering calculations. The most common is mass balances. Where these techniques are identified as the preferred method, air quality practitioners should discuss the application of these methods with the design engineers. In some instances, such methods may have been conducted when preparing the design of specific plant or activity. Any data or assumptions used in these techniques must be clearly articulated and justified in the assessment report, along with the equations and calculations performed.

3.4.4 Emission factors

An emission factor is usually calculated by an equation that relates the quantity of a pollutant released to process throughput. These factors are generally averages of all available data of acceptable quality and are generally assumed to be representative of long-term averages for all facilities in the source category. As stated above, emission factors are generally used when there is no other information available or when emissions can reasonably be demonstrated to be negligible.

Databases of emission factors include:

- US EPA's AP-42 Emission Factors
- National Pollutant Inventory Emissions Estimation Technique Manuals.

Published emission factors will typically have a quality rating assigned to each emission factor. This rating is based on both the quality of the test(s) or information that is the source of the factor and how well the factor represents the emissions. When selecting emission factors, preference should be given to those emission factors with a higher quality rating.

Emission factors may require the use of site-specific data, such as moisture and silt content. Use professional judgement when selecting and applying data to ensure that emission estimates are not underpredicted. Where there is uncertainty, adopt a conservative approach. The NSW EPA recommends the following principles when considering and applying emission factors:

- Preferentially use US EPA AP-42 emission factors, unless they do not adequately represent NSW conditions.
- Preferentially use emission factors with a high rating.
- For an inventory of existing sources, use site-specific data from direct measurements for required emission input parameters (i.e. silt content, moisture content).

- For an inventory of proposed sources, justify non-site-specific data with supporting information to demonstrate that the chosen values are applicable. Apply reasonable worst-case assumptions.
- Use moisture content of the uncontrolled emission source when calculating emission estimates for a source controlled by surface treatment methods (wet suppression, chemical suppressants).
- Fugitive dust can also contain other air pollutants of concern, such as respirable crystalline silica (RCS), metals, and smaller particle size fractions that pose a risk to human health. For such projects, use site-specific material composition data if available.
- Link control efficiencies adopted in an assessment to measurable key performance indicators (KPIs) that are auditable.
- Make all inputs and assumptions transparent and clearly document calculation methodologies, to ensure reproducibility. Where variable emissions files are used, fully describe the calculation approach.

3.4.5 Accounting for variability in emission rates

Some processes or activities may have emissions that vary, or may operate through a clearly defined emission cycle. For processes where emission variability is clearly defined, variable emissions may be considered; if they are, it may be necessary to conduct multiple scenarios to ensure that instances of worst-case emissions at periods of worst-case meteorology are adequately represented. The number of scenarios would be dependent on the operating nature and variability of the process and emissions for the particular process or activity being assessed.

In cases where emissions vary but do not follow clearly defined cycles, the maximum emission rate must be used. Where proponents are seeking to operate at the maximum emission rate at any given time, then the maximum emission rate must also be used. Manufacturers' design specifications or performance guarantees can be useful for establishing the upper bounds of likely operational variability. If no data is available to describe the distribution of emission rates, use the maximum measured or calculated emission rate.

Where practicable, emission rate data should be constructed using an averaging period that is the lesser of (a) one hour, or (b) the sampling time used in the concentration calculations.

3.5 Calculate emission concentration for point sources

The concentration of a pollutant emitted from a source is calculated using Equation 1:

Equation 1

$$C_i = \frac{ER_i}{FR}$$

where:

C_i = the concentration of pollutant *i* emitted from a source, in mg/m^3

ER_i = the rate at which pollutant *i* is emitted from the source, in mg/s

FR = the gaseous volumetric flow rate, in m^3/s

The inventory should contain two emission concentrations:

1. actual concentration of a pollutant emitted from a source (mg/Am^3) calculated using the actual gaseous volumetric flow rate (Am^3/s) and measured emission rate in Equation 1
2. concentration of a pollutant emitted from a source corrected to the reference conditions, as specified in the POEO Clean Air Regulation (mg/Nm^3 @ O_2%). This is calculated using the gaseous volumetric flow rate, corrected to normal conditions (dry, 273K, 101.3 kPa), and the measured emission rate in Equation 1. The emission concentration (in mg/Nm^3) is then corrected to the appropriate oxygen reference condition. Further guidance on correcting to reference and equivalent values is provided in EPA (2022). (For the definitions of Am^3 and Nm^3, see the *Glossary*.)

3.6 Assess compliance with the POEO Clean Air Regulation

The inventory must be used to demonstrate compliance with the POEO Clean Air Regulation. All sources of air emissions must comply with the requirements of the POEO Clean Air Regulation. If a source does not comply, the emissions inventory must be revised to reflect the implementation of new technology and/or pollution control equipment that will comply with the POEO Clean Air Regulation.

For an application under section 48 or 53, the applicant can use the proposed legacy condition or proposed alternative standard for hydrogen sulfide, respectively, when demonstrating compliance with the requirements of the Clean Air Regulation.

3.7 Presentation of emissions inventory

The results of the emissions inventory must be presented in the air quality impact assessment report, including:

- all release parameters of stack and fugitive sources (e.g. temperature, exit velocity, stack dimensions, flow rate, pressure, and concentrations of carbon dioxide, oxygen, and moisture)
- pollutant emission concentrations and a comparison against the relevant requirements of the POEO Clean Air Regulation
- emission rates derived for each source, including presentation of any variable emission profiles.

The emission inventory must be underpinned by sound justification that data assumptions used in the emission estimation are 'fit for purpose'.

Table 2 and Table 3 show a suggested format for summarising and presenting the results of the emissions inventory in the impact assessment report. Table 4 shows the additional data that should be included in the impact assessment report for complex mixtures of odour and hydrogen sulfide. Table 5 shows example information that should be included when conducting a fugitive dust assessment.

Table 2 Stack source release parameters – example

Source	Release type	Stack height (m)	Exit temp (°C)	Exit diameter (m)	Exit velocity (m/s)	Oxygen conc. (%)	Moisture content (%)	Flow rate (Am^3/s)	Flow rate (Nm^3/s)
Boiler No. 1	Wake-affected	20	150	4	15	10	15	188.5	103.4

Table 3 Stack emission concentrations and POEO Clean Air Regulation limits – example

Pollutant	Emission rate (g/s)	Emission concentration (mg/Am^3)	Corrected emission concentration (mg/Nm^3 at reference conditions)	POEO Clean Air Regulation emission concentration limit (mg/Nm^3)
Sulfur dioxide	40	212.2	492.3	N/A
Total solid particulates	2	10.6	24.6	50
Oxides of nitrogen (as NO_2)	15	79.6	184.6	350

Table 4 Peak odour emission rates – example

Source	Source type	Odour emission rate (OUm^3/s)	Stability class	Peak odour emission rate (OUm^3/s) – Near-field	Peak odour emission rate (OUm^3/s) – Far-field
Lagoon No. 1	Area	20,000	A, B, C, D	50,000	46,000
"	"	"	E, F	46,000	38,000

Table 5 Fugitive dust emission rates – example

Source	Source type	Intensity	Variables	Control	Emission factor	Annual PM_{10} (kg/year)
Loading	Volume	5,000,000 t/y	Average of wind speed Moisture content	0% for no controls	0.00026 kg/t	1,300
Haul truck on unpaved road	Volume	5,000,000 t/y	Tonnes per load Vehicle gross mass Silt content Haul distance	75% for Level 2 watering	2.0 kg/VKT	33,000

4 Meteorological data

The meteorological data used in the dispersion model is of fundamental importance as meteorological factors drive the transport and dispersion of the air pollutants in the atmosphere. The most critical parameters are wind direction, wind speed and atmospheric turbulence.

Meteorological processing and configuration of models requires professional judgement made by suitably qualified and experienced air quality practitioners and meteorologists. Adequate quality analysis and control procedures must be included in the review process of data files. Meteorological information processed incorrectly or using inappropriate data can lead to significant under-prediction when input to dispersion models.

On-site weather station

An on-site weather station is an invaluable tool for obtaining site-specific meteorological information used in dispersion modelling. It is highly recommended that an on-site weather station is established as soon as practicable, so that at least one year of on-site data is available for inclusion in the air quality impact assessment.

4.1 Minimum data requirements

Air quality impact assessments are conducted using a meteorological data file. The following meteorological inputs for air quality dispersion models must be used in the following order, except as otherwise set out in this section (4.1):

1. one year of site-specific data
2. three years of site-representative data
3. five years of data generated by a prognostic model.

Site-specific data is the preferred option for an air quality impact assessment. It is constructed using data measured by a meteorological monitoring station that is located on the site of the source of emissions. The data must be obtained with appropriate instrumentation that:

- meets the relevant standard (see section 4.3.1)

and

- employs an anemometer with a minimum wind speed threshold of 0.5 m/s.

The site-specific data file must:

- be for the duration of at least one representative year
- be at least 90% complete (no more than 876 hours missing for each year)
- be evaluated for an appropriate year, which has been established as representative by using at least five years (preferred consecutive) of site-specific or site-representative data
- meet the requirements set out in section 4.3.1
- include extreme weather events.

The assessment report must **clearly establish** that the data adequately describes the expected meteorological patterns at the site under investigation (e.g. wind speed, wind direction, ambient temperature, atmospheric stability class, inversion conditions and katabatic drift).

Site-representative data must only be used for an air quality impact assessment when site-specific data is not available or is not of sufficient quality for dispersion modelling. A site-representative meteorological data file must be constructed using three consecutive years of measured meteorological data. The following must be considered when determining if the data is site representative:

- the proximity and relevance of the meteorological station to emission sources and within modelling domain
- the complexity of the local terrain and exposure of the meteorological monitoring site
- whether the data has been obtained over a period of time sufficient to capture seasonal variations and extreme weather events.

Prognostic data must only be used when no other adequate site-specific or site-representative data is available. Prognostic data is meteorological data driven by large-scale synoptic analysis models, used to determine local meteorological conditions. Five years of meteorological data must be assessed when only prognostic data is used. All prognostic, generated meteorological data files must be evaluated as per section 4.5.

4.2 Selecting a representative year

The year(s) of meteorological data selected for the assessment must be demonstrated to be representative. In addition to minimum data requirements, a representative year must be demonstrated to adequately describe the expected meteorological patterns, and to be comparable to long-term weather conditions for a period of no less than five years.

4.3 Preparation of a meteorological file for assessment

4.3.1 Sources of data

In NSW there are several sources of meteorological input data, each with varying parameters, averaging periods and accuracy. The assessment must be transparent about the data's sources and how it was processed.

On-site weather stations

On-site meteorological data typically measures the key parameters required for air dispersion modelling but some data (e.g. cloud information) may need to be sourced from elsewhere. An on-site weather station must be established, sited, operated and maintained in accordance Australian Standards (e.g. *AS/NZS 3580.14 Methods for Sampling and Analysis of Ambient Air: Meteorological Monitoring for Ambient Air Quality Monitoring Applications*). For the purposes of air dispersion modelling, an on-site weather station must be fit for purpose: for example, on-site weather stations for odour assessments must be capable of measuring low winds speeds, preferably down to 0.2 m/s using an ultrasonic anemometer.

Bureau of Meteorology

The Bureau of Meteorology (BoM) obtains data from a network of weather stations across Australia. The processing of sub-hourly (30-minute or ideally 1-minute) data is required as the hourly average data from BoM are readings from the last 10 minutes of the hour. For the averaging of wind speed and wind direction, guidance is provided in section 4.3.2. Some meteorological parameters such as cloud cover, ceiling height and rainfall apply across wide areas, so data from weather stations further afield may be incorporated into the meteorological inputs when necessary.

BoM data is available for download from the Weather Station Directory.[1]

NSW Government

The NSW Government operates a network of automatic weather stations across NSW. Most parameters for dispersion modelling are measured and the measurements are suitable for air quality impact assessments. A number of sites also measure a range of contemporaneous air quality monitoring data useful for cumulative assessments. NSW Government meteorological data is available from the Data download facility.[2]

Prognostic models

Prognostic models do not require input meteorological data to run. When such data is available, it is useful to exclude input from one weather station, so that this can be used to verify the model performance. Extracts from prognostic models are often in the format required for commonly used air dispersion models such as AERMOD or CALPUFF. The use of prognostic models is discussed further in section 4.4.3.

Upper air

In Australia, upper air data is limited spatially, with measurements only available from select locations. This data is available from the Integrated Global Radiosonde Archive.[3]

Upper air data is required for both CALPUFF and AERMOD. Upper air data can also be generated using prognostic models such as TAPM or WRF. Some commercial software applications include upper air estimation techniques.

4.3.2 Data processing

Meteorological input data for air dispersion modelling requires processing so that the data is in a suitable format for model pre-processors such as AERMET and CALMET. Often averaging of data is needed to convert 1-minute or 10-minute data to the 1-hour averages required for an air quality impact assessment. When required, sub-hourly data can be used for assessment purposes.

In dispersion modelling, surface wind is considered a two-dimensional vector quantity. Vector averaging is usually the preferred method for air dispersion modelling applications (AS/NZS 3580.14). Scalar averaging can be used as an approximation, and is accepted in AS/NZS 3580.14, but there are limitations associated with the frequency of measurements and fluctuation of the wind.

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[1] https://www.bom.gov.au/climate/data/stations/

[2] https://www.airquality.nsw.gov.au/air-quality-data-services/data-download-facility

[3] https://www.ncei.noaa.gov/products/weather-balloon/integrated-global-radiosonde-archive

4.3.3 Missing data

Missing data due to calibration or instrument outages can require filling or substitution to meet the completeness requirements. However, this process can introduce additional uncertainty in the assessment. Any filled or substituted data therefore must be adequately justified and demonstrated to be representative.

The following protocols can be followed to 'fill' data gaps:

- For gaps of 4 hours or less, use linear interpolation (do not adopt the previous hour). At transition periods (e.g. sunrise or sunset), use an appropriate interpolation technique for the parameter in question.
- For gaps greater than 4 hours, adopt data from a nearby site-representative dataset to fill in for the missing data. If no alternate dataset is available, use an appropriate interpolation method.
- For gaps greater than 6 hours, replace the entire day with the previous valid full day. Alternatively, use data from a nearby site-representative or prognostic dataset, if available and considered appropriate by a suitably qualified air quality professional.

See US EPA 2000 for further guidance.

4.3.4 Percentage of calms

Calm winds can occur at any time of day, but they are most common during the early hours of the morning just before sunrise. During winter months, calms are often associated with temperature inversions. The threshold speed for calm winds depends on the type of instrument used (e.g. cup and vane anemometer versus an ultrasonic anemometer). Wind speeds below 0.5 m/s typically indicate calm conditions.

A meteorological file must adequately capture calm periods. Dispersion is considered poor during these times, so missing calms can lead to predicted impacts being underestimated by dispersion modelling.

4.3.5 Other important parameters

Stability class

Stability class is a measure of the atmospheric turbulence and the dispersive properties of the atmosphere. It is used by Gaussian plume dispersion models. Based on the work of Pasquill and Gifford, seven stability categories have been defined:

A – very unstable

B – unstable

C – slightly unstable

D – neutral

E – slightly stable

F – stable

G – very stable conditions.

In most dispersion models, stability classes F and G are combined into one class, F.

The stability class at any given time depends on:

- static stability (vertical temperature profile of the atmosphere i.e. migrating high and low air-pressure masses)
- convective or thermal turbulence (caused by the rising of air heated at ground level)
- mechanical turbulence (a function of wind speed and surface roughness i.e. wind flow over rough terrain, trees or buildings).

In order of preference, the following methods outlined in USEPA (2000) should be used to determine stability class:

- Turner's 1964 method: This requires information on solar altitude or zenith angle, cloud cover, cloud ceiling height and wind speed. Solar altitude can easily be calculated, but cloud cover and ceiling height are generally determined through visual observations.
- Solar radiation–delta temperature method: This retains the basic structure and rationale of Turner's 1964 method but eliminates the need for observations of cloud cover and ceiling height. The method uses the surface-layer wind speed (measured at 10 m) in combination with measurements of total solar radiation during the day and a low-level vertical temperature difference (i.e. at 2 m and 10 m) at night.
- Sigma theta method (the standard deviation of the horizontal wind direction fluctuation): All modern meteorological data loggers include software to determine sigma theta.

Mixing height

Mixing height is the depth through which pollutants released to the atmosphere are typically mixed by dispersive processes. Dispersion of pollutants in the lower atmosphere is greatly aided by the convective and turbulent mixing that takes place. Mixing height determines the vertical extent of dispersion for releases occurring below that height. Releases occurring above that height are assumed to have no ground-level impact (with the exception of fumigation episodes). Therefore, the greater the vertical extent of the mixed layer, the larger the volume available to dilute pollutant emissions.

Air dispersion models typically calculate stability class and mixing height within the meteorological pre-processor (such as AERMET and CALMET).

4.4 Approved meteorological models

4.4.1 AERMET

AERMET is the meteorological pre-processor for the air dispersion model AERMOD. Meteorological input data from site-specific or site-representative weather and upper-air sounding stations are input to AERMET to generate an AERMOD-compatible surface and upper-air file.

The minimum requirements for the surface file include wind speed, wind direction, dry bulb temperature and cloud cover. Other parameters include cloud height, station pressure, precipitation and relative humidity.

4.4.2 CALMET

CALMET is a diagnostic meteorological model that produces three-dimensional wind fields based on parameterised treatments of terrain effects, such as slope flows and terrain blocking effects. Meteorological observations are used to determine the wind field in areas of the domain within which the observations are representative. Fine-scale terrain effects are determined by the diagnostic wind module in CALMET.

Guidance on the application and settings of the CALMET/CALPUFF model suite are given in EPA's *Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia'* (EPA 2011).

CALMET can be configured to run in four modes (outlined below). Air quality practitioners must use an appropriate mode for each situation and robustly justify the selected option. The modes are:

1. CALMET No-Obs mode. CALMET is run using only prognostic data from prognostic models such as TAPM or WRF.
2. CALMET hybrid mode. CALMET is run using gridded numerical meteorological data supplemented by surface and optional over-water buoy data.
3. CALMET observations-only mode. CALMET is run using observed surface and upper-air data, plus optional buoy data.
4. Single-station meteorological dataset. CALMET is not used but rather single-station meteorological data is passed directly into CALPUFF from a steady-state plume processor.

The advantages and limitations of each mode are discussed in EPA (2011).

When using CALMET with observational data, there are seven critical parameters specific to each application that must be carefully assessed and included in the assessment. These values are TERRAD, RMAX1, RMAX2, R1, R2, IEXTRP and BIAS. Full descriptions of each setting are available in EPA (2011). SVMIN and SWMIN are also included as these settings are crucial for odour modelling.

The no-observations (No-Obs) mode uses only one of the seven parameters (TERRAD), simplifying the setup and operation of CALMET.

4.4.3 Prognostic models

In some areas of NSW, neither site-specific nor site-representative meteorological data are available that are suitable for use in dispersion modelling. In such cases, prognostic meteorological models may be used to supplement observational data, or as a substitute for observational data.

Prognostic models (in order of preference) include:

- WRF – Weather Research & Forecasting Model (https://www.mmm.ucar.edu/models/wrf). This is a mesoscale numerical weather prediction system designed for both atmospheric research and operational forecasting applications.
- TAPM – The Air Pollution Model (Hurley et al. 2008). This is a three-dimensional prognostic meteorological and dispersion modelling system. TAPM has two significant limitations: (1) its development ended in 2008, and (2) it overestimates wind speeds in stable conditions (CASANZ 2020).

Site-specific or site-representative data can be used to 'nudge' a prognostic model towards observed data at specific locations, which may improve the representativeness of all meteorological fields within the domain. Care must be taken in using this approach, as nudging can cause distortion

of the wind fields where the observations and prognostic data do not align. When using TAPM prognostic data, it is preferable to assimilate observational data within the CALMET model to overcome such issues.

4.5 Meteorological file verification and validation

Model data inputs and outputs must be validated and evaluated as part of the assessment process. There are many statistical procedures and graphical display methods for doing this; EPA (2011) provides a number for validating and evaluating model outputs. Careful evaluation and quality control procedures are required to confirm the accuracy of the input meteorological data and the proper behaviour of models.

Examples of useful analytical tools are wind roses, time series plots, scatter plots, spatial distribution plots and wind field diagrams. The preferred way to assess model performance is to evaluate it using a meteorological station that has not provided data for the model.

Benchmarks are useful for comparing prognostic model simulations with meteorological observations. The *International Handbook on the Assessment of Odour Exposure using Dispersion Modelling* (AMIGO & Olores.org 2024) provides meteorological benchmarks that may be useful to air quality practitioners in understanding model performance. The benchmarks are not intended as a pass/fail for model performance, but rather to add further context to results.

5 Background air quality

Background air quality refers to the ambient levels of air pollutants from industry, transport, and domestic and natural sources. Incorporating background concentrations in a cumulative assessment allows the total impact of the proposal on existing air quality to be evaluated.

5.1 Representative background

The data used to inform the background air quality for a cumulative assessment must be representative of the pollutants and local airshed under assessment. Background data must be demonstrated to be site representative: this is done by analysing spatial and temporal variation in air quality, and considering factors such as land use and local emissions sources.

For impact assessments of sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3), $PM_{2.5}$, PM_{10}, total suspended particulates (TSP), deposited dust, lead (Pb), carbon monoxide (CO) and hydrogen fluoride (HF), the existing background concentrations of the pollutants in the vicinity of the premise should be included in the assessment as follows.

- The analysis of five years of background data must be presented to demonstrate the natural variability in the monitoring data. However, when background data is limited, it is permitted to supplement the data that does exist with data from other sources.
- The selected background data must be contemporaneous with the selected meteorological data used in the dispersion modelling. One to five years of data may be required, depending on the requirements of the meteorological assessment.

In some locations, existing ambient air pollutant concentrations can exceed the impact assessment criteria from time to time. In such circumstances, it must be demonstrated that best management practices will be implemented to minimise emissions of air pollutants by such practicable means as may be necessary to prevent or minimise those air pollutant emissions.

Exceptional events are considered valid and must not be removed from the background dataset. Refer to the worked example included in section 11.5.

5.2 Preparation of background data

5.2.1 Sourcing ambient monitoring data

When selecting a monitoring dataset, the purpose and the location of the monitor must be considered to ensure it is fit for purpose. Background monitoring data should capture the influence of surrounding sources while excluding the contributions from the project being assessed. Ideally, background concentrations of air pollutants are obtained from ambient monitoring data collected at the site under assessment (i.e. site-specific data). However, in the absence of such data, suitably representative alternative sources may be used.

5.2.2 Site-specific monitoring data

The installation of an on-site air quality monitoring station is an invaluable tool for site-specific air quality information used in establishing background concentrations, contributions from nearby sources and for use in on-site emission control management. On-site air quality monitoring should

be established as soon as practicable, so that at least one year of on-site data is available for inclusion in the air quality impact assessment.

All monitoring data used to establish background concentrations must be gathered in accordance with an appropriate Australian Standard. The *Ambient air guidance note* (EPA 2021a) includes further guidance on appropriate methodology and the establishment of a monitoring network.

5.2.3 Alternative sources

In the absence of site-specific data, monitoring data are typically obtained from the nearest available monitoring site, where air pollution sources, population density and meteorology are representative of the existing sources at the proposal site. The assessment must justify why the data is suitable for use.

The NSW Government operates a network of air quality monitoring stations across NSW; data from this is available from the Data download facility.[4] These monitoring stations provide a reliable benchmark for the background levels of pollution in the surrounding area. A number of sites also measure a range of contemporaneous meteorological data useful for cumulative assessments.

5.2.4 Missing data

The assessment must outline how missing data is accounted for in assessing cumulative impacts. Missing data due to calibration or instrument outages may need to be filled in or substituted for with the next most site-representative background dataset to meet completeness requirements. Further guidance regarding missing data is included in NEPC (2001).

Not all monitoring stations will measure all pollutants relevant to an assessment. Professional judgement is required in selecting the most appropriate alternative site-representative background data. Alternative data should provide a conservative estimate and may be sourced from a site-representative monitoring station located further afield.

5.2.5 Estimating average concentrations

Adequate quality analysis and control procedures are vital for the measurement and processing of air quality data. Using unvalidated, incorrectly processed or inappropriate background data can lead to a cumulative assessment significantly under-predicting impacts.

The impact assessment report must address the minimum data requirements; any assumptions made to complete the data set must be presented and justified. Further guidance regarding averaging data is included in NEPC (2001).

5.3 Accounting for non-project sources not included in background data

When nearby sources within the domain are not captured by ambient monitoring, they must be explicitly included in the dispersion modelling. This applies to all pollutants assessed, including common pollutants (Table 9) and, in certain circumstances, also principal and individual toxic air

[4] https://www.airquality.nsw.gov.au/air-quality-data-services/data-download-facility

pollutants (Table 10 and Table 11). Emission concentrations can be sourced from the Planning Portal[5] or EPA Public Registers.[6] If a nearby source is exempted, the assessment must adequately justify this to the satisfaction of the EPA. In situations where the background is likely to change in future – most commonly through new nearby sources being added or existing ones modified – then these future sources must also be addressed in the modelling.

[5] https://www.planningportal.nsw.gov.au/major-projects

[6] https://www.epa.nsw.gov.au/Licensing-and-Regulation/Public-registers

6 Dispersion modelling

Dispersion models mathematically simulate atmospheric conditions and behaviour. They are used to calculate spatial and temporal sets of concentrations and particle deposition of emissions from various sources. Dispersion models can be used to determine the affected zone around an emitter by producing results that can be compared against impact assessment criteria.

Dispersion models can provide concentration/deposition estimates over an almost unlimited grid of user-specified locations and can be used to evaluate both existing and forecast emission scenarios. Air dispersion modelling is therefore a useful tool for assessing the air quality impacts of both existing and proposed emission sources. Modelling results can be used to develop control strategies to comply with the assessment criteria. They can also be used to estimate the cumulative impacts of various industries that are located close to one another.

The configuration of dispersion models requires professional judgement made by suitably qualified air quality practitioners. Professional judgement must recognise that there are limitations to the scope of a model's application and to the accuracy of model predictions. A model applied improperly or with inappropriate data can lead to serious misjudgements in the impact of an emission source or the effectiveness of control methods. Appropriate guidance should be used to configure an air dispersion model; further information is provided in section 6.3.

6.1 Model selection

The appropriate model to use for an assessment must be considered on a case-by-case basis. The most suitable model is typically one that most accurately estimates ground level pollutant concentrations in the study area. While some degree of overestimation may be acceptable, impacts must not be underestimated in an air quality impact assessment.

Gaussian plume models are steady-state models based on the assumption that cross-sections of plumes from point sources have a Gaussian (or normal) distribution of concentration. Gaussian plume models must not be used for:

- complex terrain, non-steady-state conditions

Gaussian plume models are unable to adjust the winds to reflect the effects of terrain. The straight-line trajectory assumption of the plume model is unable to handle the curved flow associated with terrain-induced deflection of channelling. These models must not be used for terrain where the height of any receptor exceeds the lowest release height

- buoyant line plumes

(e.g. discharges from the roof vents of aluminium smelters)

- coastal effects such as fumigation

(because large changes in meteorological conditions can occur over short distances across a coastline)

- high frequency of stable, calm night-time conditions

Pollutants can accumulate under such conditions or will flow downwind with the drainage flow. Gaussian plume models have no memory of the previous hour's weather conditions; each hour is

treated independently of the next and material is carried away instantaneously, to the edge of the grid, even if only light winds are prevailing

- high frequency of calm conditions

Gaussian plume models are unable to simulate calm conditions because of the inverse wind-speed dependence plume equation. Some models address this issue by assuming a minimum wind speed, which shoots the plume out to the edge of the grid even though the plume may not have moved at all

- inversion break-up fumigation conditions.

Gaussian Lagrangian puff models are a non-steady-state model that treat emissions as a series of puffs that vary in time and space across the domain. Gaussian Lagrangian puff models can be used for both near field and far field applications and are typically used for relatively inert pollutants. Gaussian Lagrangian puff models should generally be used for:

- near field impacts in complex flow or dispersion conditions:
  - complex flow terrain by allowing curvature of the plume
  - stagnation, inversion, recirculation, and fumigation conditions
  - over-water transport and coastal conditions
  - light wind and calm wind conditions
- long range transport
- buoyant area and line sources.
- Secondary particle matter.

Model selection must consider the capabilities of the model and the limitations of model type. The two key factors to be considered in evaluating model type are:

a) Is the steady-state assumption in the plume model valid?

b) Do the technical parameterisations in the plume model adequately treat the situation to be modelled?

The decision for model choice must be clearly justified in the air quality impact assessment report. General guidance on the selection of an appropriate dispersion model is provided in the following section. Additional guidance can be found in the *Guideline on Air Quality Models* (US EPA 2024a).

6.2 Approved dispersion models in NSW

This section provides an overview of the approved air dispersion models in NSW. AERMOD is approved for air quality impact assessments in NSW when a Gaussian plume model is appropriate. CALPUFF may be suitable for air quality impact assessments in NSW when a Gaussian plume model is not appropriate.

6.2.1 AERMOD

AERMOD is a steady-state Gaussian plume model developed by the US EPA and the American Meteorological Society. AERMOD employs parameterisations for characterising meteorological conditions and dispersion. Pre-processors include AERMET, which prepares the meteorological data, and AERMAP, which prepares the terrain and land-use information. AERMOD is suitable for use in

both urban and rural environments. It includes features for gas and particle deposition, and building wake effects, and allows for time-varying emissions.

AERMOD version 23132 or later must be used for assessments in NSW.

6.2.2 CALPUFF

CALPUFF is a multi-layer, multi-species, non-steady-state Lagrangian Gaussian puff dispersion model capable of simulating the effects of temporally and spatially varying meteorological conditions on pollutant transport. This enables the model to account for a range of effects, including:

- causality effects
- dry deposition
- dispersion over a variety of land surfaces
- plume fumigation, low wind-speed dispersion
- pollutant transformation
- wet removal.

CALPUFF has various algorithms for parameterising dispersion processes, including the use of turbulence-based dispersion coefficients derived from similarity theory or observations.

CALPUFF settings must follow the recommendations detailed in *Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling' and Assessments of Air Pollutants in NSW, Australia* (EPA 2011).

CALPUFF v.5.8, CALMET v.5.8 and CALPOST v.6.2 or later must be used.

6.2.3 Alternative models

In circumstances where the AERMOD and CALPUFF models are not suitable for use, other dispersion models may be appropriate. The NSW EPA accepts the use of alternative models for certain applications; however, the choice of a dispersion model must be discussed with the EPA's air technical team. The alternative model must be publicly available, and its use must be justified in the assessment. Justification must include:

- a description of the model
- documentation showing that the alternative model performs better than approved models in similar applications
- a sensitivity analysis showing that the alternative model is more suitable than approved models for the assessment.

For the calculation of site-specific emission limits for hydrogen sulfide and sulfur dioxide, written approval must be obtained from the EPA for the use of a dispersion model other than AERMOD or CALPUFF. The application must show that the alternative dispersion model is scientifically sound for the proposed application.

6.3 Model inputs

6.3.1 Model domain and grid resolution

The model domain must at minimum:

- be sufficient to include all emissions sources and potential impacts from the project. The EPA accepts that on occasion more than one domain may be required
- capture emissions from cumulative sources
- consider sensitive receptor areas
- capture potential recirculation of pollutants where relevant
- capture impacts of the plume when it touches the ground.

The grid resolution must be sufficient to ensure that maximum pollutant concentrations are captured within the modelling domain. However, professional judgement is expected to be applied to balance the number of receptors against computational demands. Other considerations may include the distance from the plant boundary to the nearest receptor.

6.3.2 Terrain

Dispersion modelling requires information about the surrounding terrain. Terrain files provide digital elevation data to represent topography that influences plume behaviour. A range of terrain datasets is available in Australia; a commonly used one is the Shuttle Radar Topography Mission (SRTM). The EPA recommends a terrain resolution of 30 metres for data to be put into dispersion models.

In some cases, site-specific terrain files are developed and refined over the lifetime of a project. However, the use of these datasets must be transparent and appropriately justified in the assessment.

6.3.3 Land use

Land-use classification influences several key parameters in dispersion modelling, such as albedo, surface roughness and soil moisture content. As these variables can vary seasonally, it is important that the user accounts for these factors, particularly as dispersion models are often configured for the northern hemisphere.

Generic land-use datasets available in Australia have limited spatial resolution. EPA recommends that the model user adopts satellite imagery to define land-use type over these generic datasets. As with terrain, pre-processing is needed to format the land-use data for input to the dispersion model.

6.3.4 Receptors

Receptors are points representing physical locations at which the model will predict pollutant concentrations in the receiving environment. The dispersion modelling input file requires information regarding receptors, including (but not limited to) the location and height (in metres) relative to a fixed origin. Receptors are usually represented as gridded receptors or discrete receptors.

- Gridded receptors are placed at regular or irregular intervals across a defined area, forming a grid pattern. Grids should be more densely located across areas where maximum impacts are expected.

- **Discrete receptors** are needed to identify specific locations of interest, such as sensitive receptors.

6.3.5 Sensitive receptors

A sensitive receptor is a location where people are likely to be present, including (but not limited to):

- residences, including permanent dwellings and temporary accommodation
- educational facilities, including schools, day care centres and universities
- healthcare and aged-care facilities, including hospitals and medical centres
- workplaces, including offices, workshops, factories and commercial premises
- recreational spaces, including public parks, gardens, playgrounds, and gyms
- places of worship and sites of cultural significance.

An air quality impact assessment must also consider future sensitive receptors, both known and likely. For hydrogen fluoride, a sensitive receptor includes land-use areas with vegetation sensitive to hydrogen fluoride, such as grapevines and stone fruit.

6.3.6 Building wake effects

PRIME is the EPA's preferred building wake algorithm. AERSCREEN, AERMOD and CALPUFF include the PRIME building wake algorithm and the Building Profile Input Program (BPIP) for entering the location and dimension of buildings. Specifically, what needs to be entered into BPIP is the location and dimensions of buildings located within a distance of 5L from each release point, where L is the lesser of the height or width of the building. This applies to buildings with a height greater than 0.4 times the stack height.

Practitioners designing new stacks should take into account the US EPA's guidelines in the document *Stack Height* (US EPA 1985), to avoid building wake effects.

6.4 Calculate peak concentrations

The evaluation of odour impacts requires the estimation of short-term or peak concentrations on a time scale of less than one second. Dispersion model predictions are typically valid for averaging periods of one hour and longer. Dispersion models therefore need to be supplemented to accurately simulate atmospheric dispersion of odours and the instantaneous perception of odours by the human nose.

Peak concentrations can be predicted from estimates of ensemble means, by using a defined ratio of extreme short-term concentration to longer-term average. Properly defined peak-to-mean ratios depend upon the type of source, atmospheric stability and distance downwind. Table 7 shows the EPA-recommended factors for estimating peak concentrations (for different source types, stabilities and distances), as developed by Katestone Scientific (1995 and 1998).

The P/M60 ratios in Table 7 are for an idealised situation: one source, in flat terrain, where the receptor is located along the centreline of the single plume. The ratios do not consider fluctuations away from the centre line, terrain influences, or plume interaction from multiple sources.

The EPA requires peak ground-level concentrations to be calculated for:

- hydrogen sulfide

- complex mixtures of odour.

A screening-level assessment of peak glcs can be undertaken by applying the ratios in Table 7 to multiple sources at a premises. These ratios can be applied to the emission rates entered into the dispersion model, in the following way:

1. Determine the source type, the stability class, and whether the receptors are near-field or far-field or both.
2. Select the appropriate P/M60 ratios from Table 6.
3. For wake-affected point sources, determine the meteorological conditions (i.e. wind speed and stability class) under which the source is wake-affected and wake-free.
4. Apply P/M60 ratios to odour and hydrogen sulfide emission rates so they vary with wind speed and stability class.

More detailed procedures for estimating peak glcs from multiple sources are discussed in Katestone Scientific (1995 and 1998).

Table 6 Factors for estimating peak concentrations in flat terrain

(Source: Katestone Scientific 1995 and 1998)

Source type	Pasquill–Gifford stability class	Near-field P/M60*	Far-field P/M60*
Area	A, B, C, D	2.5	2.3
Area	E, F	2.3	1.9
Line	A–F	6	6
Surface wake-free point	A, B, C	12	4
Surface wake-free point	D, E, F	25	7
Tall wake-free point	A, B, C	17	3
Tall wake-free point	D, E, F	35	6
Wake-affected point	A–F	2.3	2.3
Volume	A–F	2.3	2.3

* Ratio of peak 1-second average concentrations to mean 1-hour average concentrations

6.5 Availability of dispersion modelling software and guidance documents

AERMOD is available for download from the US EPA website.[7]

The CALPUFF dispersion modelling package and guidance documents can be electronically downloaded, free of charge, from Lakes Software.[8]

Commercial software packages are also available that provide a graphical user interface for the above software.

[7] https://www.epa.gov/scram/air-quality-dispersion-modeling-preferred-and-recommended-models

[8] www.calpuff.org

At the time of writing TAPM software is no longer available for purchase. Guidance documents and information about TAPM are still available and can be obtained from the CSIRO website.[9]

The US EPA website also provides links to download a range of dispersion models for air quality impact assessments.[10]

[9] www.cmar.csiro.au

[10] https://www.epa.gov/scram/air-quality-dispersion-modeling-alternative-models

7 Evaluation of impacts

The primary purpose of an air quality impact assessment is to determine whether emissions from a premises will comply with appropriate environmental outcomes. This section includes the assessment criteria for air pollutants that reflect the environmental outcomes adopted by the EPA. The assessment criteria are used to evaluate modelled impacts against the risk of environmental harm to inform regulatory decision-making. The purpose of the assessment criteria is to protect human health and the environment; however, they are not intended as targets that may be polluted up to.

To ensure the environmental outcomes are achieved, predicted impacts from a premises must be assessed against the assessment criteria in this section.

- Impacts of common pollutants (Table 9) must be combined with existing background levels before they are compared with the relevant impact assessment criteria.
- If the total maximum incremental impact of a premises is less than the Significant Impact Level for the pollutants in Table 7, an assessment does not need to include cumulative impacts.
- If the Degradation Prevention Threshold in Table 8 is exceeded, a site-specific mitigation options analysis must be conducted to justify the mitigation measures being implemented at the premises and demonstrate emissions are being minimised to the maximum extent practicable.

7.1 Applicability of impact assessment criteria

Impact assessment criteria must not be used as limit conditions in environment protection licences. This is because compliance with assessment criteria cannot be readily determined for regulatory purposes at the boundary or at the nearest sensitive receptor. Ambient air monitoring at the boundary or nearest sensitive receptor would measure air pollutants from other sources in the surrounding area, not just the premises.

For point sources, a site-specific stack emission limit can be calculated so that the assessment criteria are not exceeded at and beyond the boundary of a premises because of emissions from those sources. (See sections 10 and 11.1.) For fugitive sources, the required site-specific mitigation measures (e.g. minimum moisture content, or a TARP) can be determined to ensure assessment criteria will not be exceeded from such sources. (See section 9.)

7.2 Common pollutants: SO_2, NO_2, O_3, Pb, $PM_{2.5}$, PM_{10}, TSP, deposited dust, CO and HF

7.2.1 Significant Impact Level (SIL)

The Significant Impact Levels (SILs) represent a concentration of a pollutant at or below which no significant change in the airshed is likely to be observed. The incremental contributions of SO_2, NO_2, $PM_{2.5}$ and PM_{10} from a project must first be evaluated against the values provided in Table 7. If a proposal can demonstrate that the maximum incremental impact at all receptors is below the SILs, generally no further evaluation of cumulative impacts will be required for those pollutants.

Table 7 Significant Impact Levels for SO_2, NO_2, $PM_{2.5}$ and PM_{10}

Pollutant	Averaging time – 1 year	Averaging time – 24 hours	Averaging time – 1 hour
SO_2	-	5 µg/m^3	10 µg/m^3
NO_2	1 µg/m^3	-	7 µg/m^3
$PM_{2.5}$	0.4 µg/m^3	1.1 µg/m^3	-
PM_{10}	1.1 µg/m^3	2.1 µg/m^3	-

Note: Gas volumes are expressed at 0°C and at an absolute pressure of 1 atmosphere (101.325 kPa) (NEPC 2021).

Application of Significant Impact Level

The Significant Impact Levels in Table 7 must be applied:

- at all existing or likely future off-site sensitive receptors
- to the total incremental impact of a premises (predicted impact due to all existing and proposed emission sources)
- as the 100th percentile concentration
- for all averaging periods and units consistent with the SILs
- to trigger the requirement to progress to a cumulative impact assessment (see section 11.3).

7.2.2 Degradation Prevention Threshold (DPT)

Incremental impacts must be assessed against the Degradation Prevention Thresholds (DPTs) in Table 8 for any premises where predicted impacts exceed the SIL, and for lead and carbon monoxide. The DPTs align with the core principles (section 1.3) that harmful pollution must be minimised and impact assessment criteria are not goals to pollute up to. The DPTs also address the Objects (s 3) of the POEO Act to protect, restore and enhance the environment and to prevent the degradation of the environment.

Table 8 Degradation Prevention Threshold for SO_2, NO_2, lead, $PM_{2.5}$ and PM_{10} and CO

Pollutant	Averaging time 1 year	Averaging time 24 hours	Averaging time 8 hours	Averaging time 1 hour
SO_2	-	14 µg/m^3	-	54 µg/m^3
NO_2	6 µg/m^3	-	-	41 µg/m^3
Lead	0.1 µg/m^3	-	-	-
$PM_{2.5}$	1.6 µg/m^3	6 µg/m^3	-	-
PM_{10}	5 µg/m^3	12.5 µg/m^3	-	-
CO	-	-	3 mg/m^3	-

Note: Gas volumes are expressed at 0°C and at an absolute pressure of 1 atmosphere (101.325 kPa) (NEPC 2021).

Application of the Degradation Prevention Threshold (DPT)

The Degradation Prevention Thresholds in Table 8 must be applied:

- at all existing or likely future off-site sensitive receptors
- to the total incremental impact of a premises (predicted impact due to all existing and proposed emission sources)

- as the 100th percentile concentration
- for all averaging periods and in units consistent with the DPTs
- to trigger the requirement to conduct a mitigation options analysis (section 9).

7.2.3 Impact assessment criteria

Table 9 Cumulative impact assessment criteria for SO_2, NO_2, O_3, Pb, $PM_{2.5}$, PM_{10}, TSP, deposited dust, CO and HF

Pollutant	Averaging period	Concentration (ppm)	Concentration (mass/vol) [f]	Source
Sulfur dioxide (SO_2)	1 hour	0.075 ppm	215 µg/m^3	NEPC (2021)
	24 hours	0.02 ppm	57 µg/m^3	NEPC (2021)
Nitrogen dioxide (NO_2)	1 hour	0.08 ppm	164 µg/m^3	NEPC (2021)
	1 year	0.015 ppm	31 µg/m^3	NEPC (2021)
Photochemical oxidants (as ozone)	8 hours	0.065 ppm	139 µg/m^3	NEPC (2021)
Lead	1 year	-	0.5 µg/m^3	NEPC (2021)
$PM_{2.5}$	24 hours	-	25 µg/m^3	NEPC (2021)
	1 year	-	8 µg/m^3	NEPC (2021)
PM_{10}	24 hours	-	50 µg/m^3	NEPC (2021)
	1 year	-	25 µg/m^3	NEPC (2021)
Total suspended particulates (TSP)	1 year	-	90 µg/m^3	NHMRC (1996)
Deposited dust [c]	1 year	-	2 g/m^2/month [a]	NERDDC (1988)
			4 g/m^2/month [b]	
Carbon monoxide (CO)	15 minutes	87 ppm	109 mg/m^3	WHO (2000)
	1 hour	25 ppm	31 mg/m^3	WHO (2000)
	8 hours	9 ppm	11 mg/m^3	NEPC (2021)
Hydrogen fluoride	90 days	-	0.5 µg/m^3 [d]	ANZECC (1990)
			0.25 µg/m^3 [e]	
	30 days	-	0.84 µg/m^3 [d]	ANZECC (1990)
			0.4 µg/m^3 [e]	
	7 days	-	1.7 µg/m^3 [d]	ANZECC (1990)
			0.8 µg/m^3 [e]	
	24 hours	-	2.9 µg/m^3 [d]	ANZECC (1990)
			1.5 µg/m^3 [e]	

Notes

a. Maximum increase in deposited dust level

b. Maximum total deposited dust level

c. Dust is assessed as insoluble solids as defined by AS 3580.10.1

d. General land use, which includes all areas other than specialised land use

e. Specialised land use, which includes all areas with vegetation sensitive to fluoride, such as grapevines and stone fruits

f. Gas volumes are expressed at 0 °C and at an absolute pressure of 1 atmosphere (101.325 kPa) (NEPC 2021)

Application of impact assessment criteria

The assessment criteria in Table 9 must be applied:

- at **all existing or likely future off-site sensitive receptors** (refer to section 6.3.5).
- to the **cumulative impact** (total incremental impact plus background)
- the **total incremental impact of a premises** (predicted impact due to all existing and proposed emission sources) must be reported
- with the **background concentrations** included, using the procedures specified in section 5
- as the **100th percentile** in concentration
- for all averaging periods, units, and reference temperature consistent with the impact assessment criteria
- for each modelled year.

Where background concentrations already exceed the impact assessment criteria, it must be demonstrated that **no additional exceedances** of the impact assessment criteria will occur as a result of the proposed activity or premises.

7.3 Individual toxic air pollutants

7.3.1 Impact assessment criteria

Criteria for the principal toxic pollutants are in Table 10 and for other individual toxic air pollutants in Table 11. The principal toxic air pollutants are defined in Schedule 2 Part 1 of the POEO Clean Air Regulation on the basis that they are carcinogenic, mutagenic, teratogenic, highly toxic or highly persistent in the environment.

The impact assessment criteria for the principal and individual toxics were developed based on protection of human health. National and international criteria, guidelines and health exposure studies and assessments were considered in the selection of toxics criteria. Where the health evidence indicates acute and chronic impacts, both short-term (1-hour) and long-term (annual) criteria were developed. An assessment must demonstrate compliance with both the 1-hour and annual average criteria.

Table 10 Impact assessment criteria (µg/m^3 and ppb) for principal toxic air pollutants

Substance	CAS number	Averaging period	Impact assessment criterion (µg/m^3) [a]	Impact assessment criterion (ppb)	Source
Acrolein (propenal)	107-02-8	1 hour	7	**3**	ATSDR
		1 year	**0.02**	0.009	USEPA
Acrylonitrile	107-13-1	1 hour	**330**	150	TCEQ
		1 year	**0.5#**	0.23	WHO

Substance	CAS number	Averaging period	Impact assessment criterion (µg/m³) [a]	Impact assessment criterion (ppb)	Source
Alpha-chlorinated toluenes and benzoyl chloride	100-44-7 98-87-3 98-07-7 98-88-4	1 hour	**8**	**1**	TCEQ
		1 year	**0.2#**	0.039	OEHHA
Arsenic and arsenic compounds	7440-38-2	1 hour	**0.2**	-	OEHHA
		1 year	**0.0066#**	-	WHO
Benzene	71-43-2	1 hour	29	**9**	ATSDR
		1 year	1.7#	**0.5**	WHO
Beryllium and beryllium compounds	7440-41-7	1 hour	**0.02**	-	TCEQ
		1 year	**0.001**	-	ATSDR
1,3-butadiene	106-99-0	1 hour	**660**	300	OEHHA
		1 year	**0.3#**	0.14	USEPA
Cadmium and cadmium compounds	7440-43-9	1 hour	**0.03**	-	ATSDR
		1 year	**0.005**	-	WHO
Hexavalent chromium (CrVI) and compounds	7440-47-3	1 hour	**0.39**	-	TCEQ
		1 year	**0.00025#**	-	WHO
1,2-dichloroethane (ethylene dichloride)	107-06-2	1 hour	**700**	0.2	WHO
		1 year	**0.4#**	0.1	USEPA
Dioxins and furans[b]	1746-01-6 (2,3,7,8-TCDD)	1 hour	**0.0013**	-	DOE
		1 year	**0.00000026#**	-	OEHHA
Epichlorohydrin (chloromethyl oxirane)	106-89-8	1 hour	**1300**	340	OEHHA
		1 year	**1**	0.3	USEPA
Ethylene oxide	75-21-8	1 hour	720	**400**	ATSDR
		1 year	**0.002#**	0.001	USEPA
Formaldehyde	50-00-0	1 hour	49	**40**	NEPM/ ATSDR
		1 year	**0.9#**	0.7	USEPA
Hydrogen cyanide	74-90-8	1 hour	**340**	310	OEHHA
		1 year	**0.8**	0.7	USEPA
MDI (diphenylmethane diisocyanate)	101-68-8	1 hour	**12**	1.2	OEHHA
		1 year	**0.6**	0.06	USEPA
Nickel and nickel compounds	7440-02-0	1 hour	**0.2**	-	OEHHA
		1 year	**0.025#**	-	WHO
Polycyclic aromatic hydrocarbons (as benzo[a]pyrene)	50-32-8	1 hour	**0.5**	-	TCEQ
		1 year	**0.0003**	-	NEPM
Pentachlorophenol	87-86-5	1 hour	**5**	0.46	TCEQ
		1 year	**2#**	0.18	OEHHA

Substance	CAS number	Averaging period	Impact assessment criterion (µg/m³) [a]	Impact assessment criterion (ppb)	Source
Phosgene (carbonyl dichloride)	75-44-5	1 hour	**4**	1	OEHHA
		1 year	**0.3**	0.07	USEPA
Propylene oxide	75-56-9	1 hour	**3,100**	1,300	OEHHA
		1 year	**3#**	1	USEPA
TDI (toluene-2,4-diisocyanate; toluene-2,6-diisocyanate)	26471-62-5	1 hour	0.07	**0.01**	ATSDR
		1 year	0.02	**0.003**	ATSDR
Trichloroethylene	79-01-6	1 hour	**540**	100	TCEQ
		1 year	**2**	0.4	USEPA
Vinyl chloride (chloroethene)	75-01-4	1 hour	1300	**500**	ATSDR
		1 year	**10#**	4	WHO

Notes

a. Gas volumes are expressed at 25°C and at an absolute pressure of 1 atmosphere (101.325 kPa) (NEPC 2011).

b. Toxic equivalent as defined in clause 61 of the POEO Clean Air Regulation

Where criteria are provided in µg/m³ and ppb, values in **bold** represent the original unit form of the criterion.

Criteria based on unit risk (1 in 100,000) of carcinogenic effects being lower than available non-cancer health impacts

Table 11 Impact assessment criteria (µg/m³ and ppb) for individual toxic air pollutants

Substance	CAS number	Averaging period	Impact assessment criterion [a] (µg/m³)	Impact assessment criterion (ppb)	Source
Acetaldehyde	75-07-0	1 year	**5#**	3	USEPA
Acetone	67-64-1	1 hour	19,000	**8,000**	ATSDR
Acrylic acid (propenoic acid)	79-10-7	1 hour	**6,000**	2,000	OEHHA
		1 year	**1**	0.3	USEPA
Ammonia	7664-41-7	1 hour	1,184	**1,700**	ATSDR
		1 year	**500**	720	USEPA
Aniline	62-53-3	1 hour	**80**	21	TCEQ
		1 year	**1**	0.3	USEPA
Antimony and antimony compounds	7440-36-0	1 hour	**1**	-	ATSDR
		1 year	**0.3**	-	ATSDR
Asbestos [b]	1332-21-4 12172-73-4 81133-20-2 12001-28-4	1 hour	**0.01 f/mL**	-	NEPM
		1 year	**0.00005 f/mL**	-	WHO
Barium and barium compounds	7440-39-3	1 hour	**5**	-	TCEQ
Biphenyl	92-52-4	1 hour	**13**	2	TCEQ
Boron	7440-42-8	1 hour	**0.3**	-	ATSDR

Substance	CAS number	Averaging period	Impact assessment criterion [a] (µg/m³)	Impact assessment criterion (ppb)	Source
Bromoform (tribromomethane)	75-25-2	1 hour	**50**	5	TCEQ
Carbon black	1333-86-4	1 hour	**35**	-	TCEQ
Chlorine	7782-50-5	1 hour	170	**60**	ATSDR
		1 year	0.14	**0.05**	ATSDR
Chlorine dioxide	10049-04-4	1 hour	**3**	**1**	TCEQ
		1 year	**0.2**	0.07	USEPA
Chloroform (trichloromethane)	67-66-3	1 hour	5	**1**	ATSDR
		1 year	**0.4#**	0.08	USEPA
Chloromethane (methyl chloride)	74-87-3	1 hour	1000	**500**	ATSDR
		1 year	**90**	44	USEPA
Trivalent chromium (CrIII) and compounds	16065-83-1	1 hour	**3.6**	-	TCEQ
		1 year	**0.041**	-	TCEQ
Cobalt	7441-48-4	1 hour	**0.3**	-	ATSDR
Copper and copper compounds	7440-50-8	1 hour	**100**	-	OEHHA
Crotonaldehyde	4170-30-3 (E/Z)	1 hour	**8.6**	**3**	TCEQ
Cyclohexane	110-82-7	1 hour	**3,400**	**1,000**	TCEQ
Dibromoethane	106-93-4	1 hour	**150**	**19**	TCEQ
1,2-dichloroethylene (1,2-dichloroethene)	540-59-0 (E/Z)	1 hour	12,000	**3,000**	ATSDR
Dichlorvos (2,2-dichlorovinyl dimethyl phosphate)	62-73-7	1 hour	18	**2**	ATSDR
		1 year	**0.5**	0.06	USEPA
Ethylbenzene	100-41-4	1 hour	21,700	**5,000**	ATSDR
		1 year	**1,000**	230	USEPA
Ethyl chloride (chloroethane)	75-00-3	1 hour	34,000	**13,000**	ATSDR
		1 year	**10,000**	3,790	USEPA
Ethylene glycol	107-21-1	1 hour	**2,000**	790	ATSDR
		1 year	**400**	160	OEHHA
n-hexane	110-54-3	1 hour	21,000	**6,000**	ATSDR
		1 year	**700**	200	USEPA
2-hexanone (methyl butyl ketone)	591-78-6	1 hour	**40**	10	TCEQ
Hydrogen chloride	7647-01-0	1 hour	**2,100**	1,400	OEHHA
		1 year	**20**	13	USEPA
Maleic anhydride	108-31-6	1 hour	**10**	**2.5**	TCEQ
		1 year	**0.7**	0.17	OEHHA
	7439-96-5	1 hour	**2.7**	-	TCEQ

Substance	CAS number	Averaging period	Impact assessment criterion [a] (µg/m³)	Impact assessment criterion (ppb)	Source
Manganese and manganese compounds		1 year	**0.15**	-	WHO
Mercury and mercury compounds	7439-97-6	1 hour	**0.6**	-	OEHHA
Methyl acrylate	96-33-3	1 hour	**60**	**17**	TCEQ
Methyl bromide (bromomethane)	74-83-9	1 hour	**3,900**	1,000	OEHHA
		1 year	**5**	1.3	USEPA
Methylene chloride (dichloromethane)	75-09-2	1 hour	**3,000**	860	WHO
Nitric acid	7697-37-2	1 hour	**86**	33	OEHHA
Nitrobenzene	98-95-3	1 year	**0.25#**	0.05	USEPA
n-pentane	109-66-0	1 hour	**59,000**	**20,000**	TCEQ
		1 year	**7,100**	**2,400**	TCEQ
Phthalic anhydride	85-44-9	1 hour	**60**	**10**	TCEQ
		1 year	**20**	3.3	OEHHA
Propylene glycol monomethyl ether	107-98-2	1 hour	**3,700**	**1,000**	TCEQ
Silica (respirable crystalline)	14808-60-7	24-hour	**14**	-	TCEQ
		1 year	**3**	-	OEHHA
Sulfuric acid	7664-93-9	1 hour	**120**	**30**	OEHHA
		1 year	**1**	0.25	OEHHA
1,1,2-trichloroethane	79-00-5	1 hour	160	30	ATSDR
Triethylamine	121-44-8	1 year	**7**	2.9	USEPA
Trimethylbenzene (mixed isomers)	25551-13-7	1 hour	**2,400**	490	OEHHA
		1 year	**4**	0.8	OEHHA
Vinyl toluene	25013-15-4	1 hour	**2,420**	**500**	TCEQ
Zinc and zinc compounds	7440-66-6	1 hour	**20**	-	TCEQ

Notes

a. Gas volumes are expressed at 25 °C and at an absolute pressure of 1 atmosphere (101.325 kPa).

b. The impact assessment criteria for asbestos are reported in fibres per millilitre (f/mL).

Where criteria are provided in µg/m³ and ppb, values in **bold** represent the original unit form of the criterion.

#criteria based on unit risk (1 in 100,000) of carcinogenic effects being lower than available non-cancer health impacts.

Application of impact assessment criteria

The impact assessment criteria for principal and individual toxic air pollutants in Table 10 and Table 11 must be applied as follows:

- at and beyond the boundary of the facility.
- to the total incremental impact of a premises (predicted impact due to all existing and proposed emission sources)

- for the averaging periods specified and in concentration units and reference temperature consistent with the criteria, and
- as the 100th percentile of dispersion model predictions for each modelled year.

7.3.2 Assessment of substances with no listed criteria

The absence of listed impact assessment criteria for a substance does not remove the requirement for assessment of emissions and ground-level concentrations for that substance. If a substance of concern (i.e. one that has the potential to cause health or environment impacts) is not listed in the tables above, and is expected to or has the potential to be emitted from an activity or plant, then it must be considered in the assessment and every effort made to evaluate the potential impacts. Preference to the sources of criteria used in this chapter should be given to deriving appropriate impact assessment criteria. Seek guidance from the EPA's air technical team regarding substances with no listed criteria.

7.4 Individual odorous air pollutants

7.4.1 Impact assessment criteria

Table 12 lists the impact assessment criteria for individual odorous air pollutants.

Table 12 Impact assessment criteria (µg/m^3 and ppb) for individual odorous air pollutants (Victorian Government Gazette 2001)

Substance	CAS number	Averaging period	Impact assessment criterion [a] (µg/m^3)	Impact assessment criterion (ppb)
Acetaldehyde	75-07-0	1 hour	42	23
Acetic acid	64-19-7	1 hour	270	110
n-butanol	71-36-3	1 hour	500	160
n-butyl acetate	123-86-4	1 hour	1020	210
Butyl acrylate	141-32-2	1 hour	100	19
Butyl mercaptan	109-79-5	1 hour	7	2
Carbon disulfide	75-15-0	1 hour	70	23
Chlorobenzene	108-90-7	1 hour	100	23
Cumene (isopropyl benzene)	98-82-8	1 hour	21	4
Cyclohexanone	108-94-1	1 hour	260	70
Diacetone alcohol	123-42-2	1 hour	700	150
Diethylamine	109-89-7	1 hour	30	10
Dimethylamine	124-40-3	1 hour	9	5.2
Diphenyl ether	101-84-8	1 hour	80	10
Ethanol	64-17-5	1 hour	2100	1100
Ethyl acetate	141-78-6	1 hour	12100	3500
Ethyl acrylate	140-88-5	1 hour	0.4	0.1
Hydrogen sulfide	7783-06-4	1 hour	See Table 17	
Methanol	67-56-1	1 hour	3000	2400

Substance	CAS number	Averaging period	Impact assessment criterion [a] (µg/m³)	Impact assessment criterion (ppb)
Methylamine	74-89-5	1 hour	2.7	2.3
Methyl ethyl ketone	78-93-3	1 hour	3200	1100
Methyl isobutyl ketone	108-10-1	1 hour	230	50
Methyl mercaptan	74-93-1	1 hour	0.46	0.23
Methyl methacrylate	80-62-6	1 hour	120	27
Methylstyrene	98-83-9	1 hour	140	28.563
Nitrobenzene	98-95-3	1 hour	2.6	0.52
Perchlorethylene (tetrachloroethylene)	127-18-4	1 hour	3500	520
Phenol	108-95-2	1 hour	20	5.2
Phosphine	7803-51-2	1 hour	3.1	2.3
n-propanol	71-23-8	1 hour	41	16
Pyridine	110-86-1	1 hour	7	2.3
Styrene (monomer)	100-42-5	1 hour	120	27
Toluene	108-88-3	1 hour	360	90
Triethylamine	121-44-8	1 hour	200	50
Xylenes	1330-20-7	1 hour	190	40

Note

a. Gas volumes are expressed at 25°C and at an absolute pressure of 1 atmosphere (101.325 kPa)

Equation 2 must be used to select the appropriate impact assessment criterion for hydrogen sulfide as a function of population density.

Equation 2

Impact assessment criterion (µg/m³) = ($\log_{10}$ (population) – 4.5) / –0.87

Table 13 provides a summary of example impact assessment criteria for hydrogen sulfide as a function of population density.

Table 13 Example of impact assessment criteria for hydrogen sulfide (nose-response-time average, 99th percentile) (AWT, 2001)

Population of affected community	Impact assessment criterion (µg/m³)
Urban (≥~2000)	1.38
~500	2.07
~125	2.76
~30	3.45
~10	4.14
Single residence (≤~2)	4.83

Application of impact assessment criteria

The impact assessment criteria for individual odorous air pollutants in Table 12 and hydrogen sulfide (derived using Equation 2) must be applied:

- at all existing or likely future off-site sensitive receptors
- to the incremental impact of the premises (predicted impact due to all existing and proposed emission sources)
- as the 100th percentile concentration, except for hydrogen sulfide, which must be reported as the 99th percentile
- in concentration units consistent with the impact assessment criteria ($\mu g/m^3$) for an averaging period of one (1) hour, except for hydrogen sulfide, which must be reported as peak concentrations (i.e. approximately one (1) second average) in accordance with the requirements of section 6.4.

7.5 Complex mixtures of odorous air pollutants

7.5.1 Impact assessment criteria

The impact assessment criteria for complex mixtures of odours have been designed to take into account the range of sensitivity to odours within the community and to provide additional protection for individuals with a heightened response to odours. This is achieved by using a statistical approach dependent upon population size. As the population density increases, the proportion of sensitive individuals is also likely to increase, indicating that more stringent criteria are necessary in these situations.

All facilities located within 'Urban Centres' as defined by the Australian Bureau of Statistics (ABS, 2022 or updates) must use an odour impact assessment criterion of 2 OU.

To determine the odour performance criterion for a new or modified activity located outside 'Urban Centres', use the following method:

1. Conduct odour dispersion modelling for the new or modified activity to predict odour concentrations in the local area.
2. Generate a 1 OU (nose-response time average, 99th percentile) contour surrounding the premises.
3. Estimate the total population within the 1 OU contour. Receptors located less than one (1) grid cell distance outside of the 1 OU contour are to be included in the total population for calculating the criterion.
4. Calculate the odour performance criterion using the estimated population and Equation 3.

Equation 3

Odour assessment criterion (OU) = (log10 (population) – 4.5)/-0.6

Table 14 provides appropriate impact assessment criteria for various population densities.

Table 14 Impact assessment criterion for complex mixtures of odorous air pollutants (nose-response-time average, 99th percentile) (EPA 2001)

Population of affected community	Impact assessment criterion for complex mixtures of odorous air pollutants (OU)
Urban (≥~2000) and/or schools and hospitals	2.0
~500	3.0
~125	4.0
~30	5.0
~10	6.0
Single rural residence (≤~2)	7.0

Application of impact assessment criteria

The impact assessment criteria for complex mixtures of odorous air pollutants must be applied:

- at all existing or likely future off-site sensitive receptors
- to the incremental impact of a premises (predicted impact due to all existing and proposed emission sources)
- as peak concentrations (i.e. approximately 1 second average), in accordance with the requirements of section 6.4 and the 99th percentile of dispersion model predictions for refined impact assessments
- in units and significant figures consistent with the impact assessment criteria (OU).

Assessing odour risk

The licensee of a premises that emits odour is responsible for managing and minimising any impacts of the operation beyond its boundary and complying with section 129 of the POEO Act. A proposal's proponent should therefore take a risk management approach and, at the project planning stage, consider the compatibility of the proposal with current and future land uses.

Odour risk is assessed by considering the modelling result along with additional information. This additional information includes the:

- robustness and appropriateness of the assessment input data
- degree of compliance with the assessment criteria
- results of any sensitivity analysis
- proposed odour mitigation measures
- availability of additional feasible mitigation measures.

Section 6.2 of the *Technical Framework: Assessment and management of odour from stationary sources in NSW* (EPA 2006a) lists the information that must be included in an air quality (odour) impact assessment report; this includes information that informs the odour risk of an activity.

7.6 What if impact assessment criteria are exceeded?

If the EPA's impact assessment criteria are exceeded, the dispersion modelling must be revised to include various pollution control strategies until compliance is achieved.

To determine incremental increases in the cost of air pollution abatement, a sensitivity analysis can be carried out by varying:

- source release parameters
- separation distance
- efficiency of pollution control equipment
- level of management practice.

The results can be used to select the most cost-effective and environmentally effective control strategy.

8 Modelling pollutant transformations

Oxides of nitrogen (NO_X) are typically formed during high-temperature combustion processes by the oxidation of nitrogen present in the air or fuel. NO_X emissions from combustion sources consist largely of nitrogen oxide (NO) and partly of nitrogen dioxide (NO_2). Once released into the atmosphere, NO is transformed to NO_2 through oxidation with atmospheric ozone (O_3).

Photochemical smog is a complex mixture of chemicals and is sometimes visible as a white haze during the warmer months. In the Greater Metropolitan Region of NSW (Sydney, the Lower Hunter and Illawarra), its most significant components are ground-level O_3 and NO_2. These pollutants are formed in the atmosphere when volatile organic compounds (VOCs) and NO_X react under the influence of sunlight.

The formation of O_3 and NO_2 in the atmosphere can be assessed by various methods. Minor sources of NO_X and VOCs may need only a simple assessment to demonstrate compliance with impact assessment criteria, while larger sources or a source located where background NO_2 and O_3 are high may need a more detailed scientific assessment. To account for chemical transformation in an air quality impact assessment, use one of the methods described below.

8.1 Nitrogen dioxide assessment

The transformation of NO to NO_2 in the atmosphere can be assessed by various methods, which range from simple to complex relative to the requirements of input data and accuracy of atmospheric chemistry. However, increasing the complexity of the atmospheric chemistry corresponds to increasing data input requirements. When selecting a method, consider the quality, availability, and the site-representativeness of the data; and the method's suitability for the assessment scenario (e.g. source type, impact domain). The initial in-stack ratio of NO_2/NO_X must also be considered and included in the applicable methods.

8.1.1 Method 1: Total conversion of NO to NO_2

The total or 100 % conversion method is the most conservative approach, and requires no additional data inputs. It provides an absolute upper bound of NO_2 concentrations.

1. Use a dispersion model to predict 1-hour and annual average ground-level concentrations of NO_X (as NO_2).
2. Assume that 100% of the NO_X emitted is converted to NO_2.
3. Determine the total ground-level concentration of NO_2 by adding the modelled 1-hour and annual average ground-level concentrations to the background 1-hour and annual average concentrations respectively.
4. If the impact assessment criteria are exceeded, a more refined assessment should be undertaken and/or additional management practices or emission controls applied.

8.1.2 Method 2: Ambient Ratio Method (ARM)

The US EPA's Ambient Ratio Method 2 (ARM2) (Podrez 2015; US EPA 2024a) applies a varying ratio of NO_2/NOx to modelled NO_X concentrations. The ARM2 equation was derived from evaluation of a

large dataset of US ambient air quality monitoring stations to modelled NOx concentrations. This method may be used when data on background ozone concentrations are not available.

Incremental ground-level concentrations of NO_2 can be predicted using Figure 2 and Equation 4, which are derived from NSW NO and NO_2 air quality data.

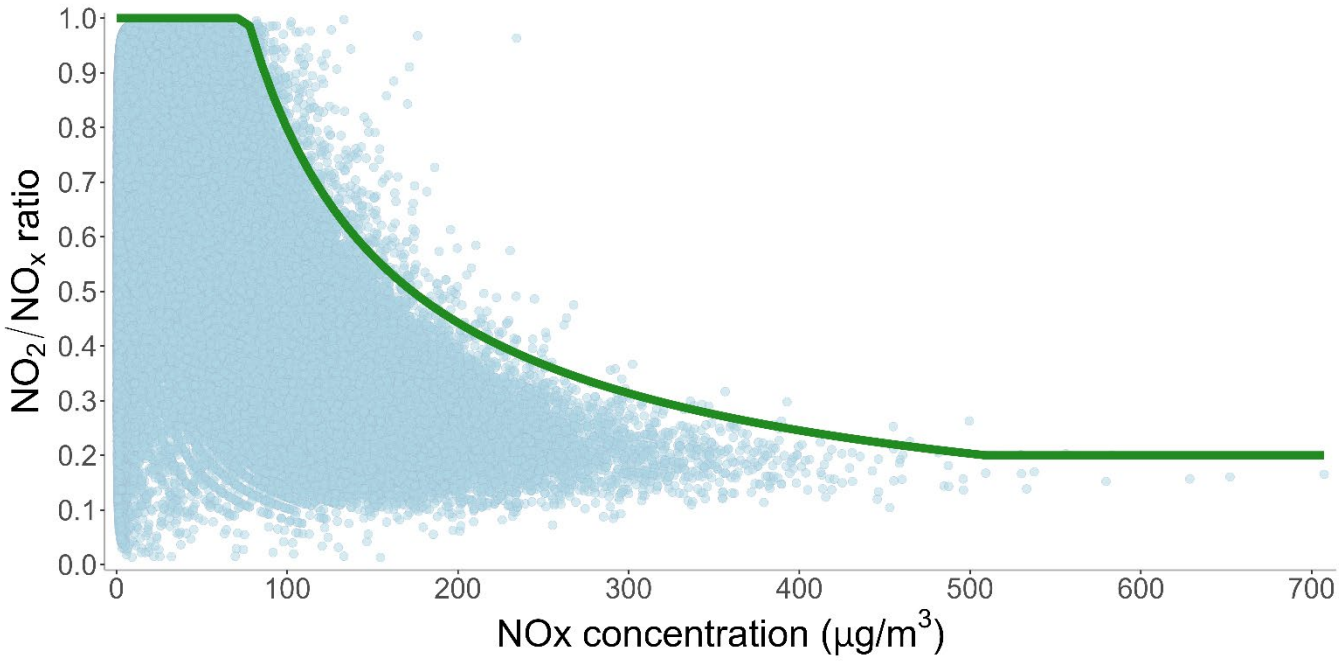

Figure 2 Default NSW Ambient Ratio Method NO_2/NO_X ratio with fitted curve

Equation 4

$$NO_2/NOx = 40 \times [NOx]^{-0.85} \text{ for } 0.2 \leq NO_2/NOx \leq 1$$

1. Use a dispersion model to predict 1-hour and annual average ground-level concentrations of NO_X (as NO_2).
2. Use the default ARM equation for NSW (Equation 4) to determine the NO_2/NO_X ratios above the Minimum Ambient Ratio (MAR) of 0.2.
3. For 1-hour impacts, determine the incremental ground-level NO_2 concentrations by applying the NO_2/NO_X ratio determined by Equation 4 to each hourly predicted NO_X concentration and adding the result to the corresponding hourly background NO_2 concentration.
4. For annual impacts, determine the ground-level NO_2 concentration by applying the average NO_2/NO_X ratio to the average predicted NO_X.
5. A site-specific ARM equation may be used where at least five years' worth of site-specific or site-representative NO_X data is available. Use of a site-specific ARM equation must include:
    a. a plot of the hourly varying measured ambient NO_2/NO_X ratio as a function of the total NO_X concentration (see Figure 2) of site-specific or site-representative background NO and NO_2 concentrations
    b. the determined equation that describes the upper-bound relationship of the NO_2/NOx ratio as a function of NO_X, included on the plot

c. reasonable upper and lower bounds of NO_X concentrations at which the NO_2/NO_X ratio remains constant. These bounds must consider an appropriate in-stack ratio and must not extend beyond measured NO_X concentrations.

6. If additional exceedances of the impact assessment criteria, a more refined assessment should be undertaken and/or additional management practices or emission controls applied.

8.1.3 Method 3: Ozone Limiting Method (OLM)

The USEPA's Ozone Limiting Method (OLM) (Cole and Summerhays 1979; US EPA 2024a) assumes that all the available ozone in the atmosphere will react with NO in the plume until either all the O_3 or all the NO is used up. This approach assumes that the atmospheric reaction is instantaneous. In reality, the reaction takes place over a number of hours.

Total ground-level concentrations of NO_2 can be predicted using Equation 5, using hourly background ozone concentration and in-stack ratios to account for thermal conversion.

Equation 5

$$[NO_2]_{total} = \{ISR \times [NO_X]_{pred}\} + MIN\{(1 - ISR) \times [NO_X]_{pred} \text{ or } (46/48) \times [O_3]_{bkgd}\} + [NO_2]_{bkgd}$$

where:

$[NO_2]_{total}$ = the total (increment + background) predicted concentration of NO_2 in $\mu g/m^3$

ISR = the in-stack ratio of NO_2/NO_X

$[NO_X]_{pred}$ = the dispersion model prediction of the incremental ground-level concentration of NOx in mg/m^3

MIN = the minimum of the two quantities within the braces

$[O_3]_{bkgd}$ = the background ambient O_3 concentration in mg/m^3

(46/48) = the molecular weight of NO_2 divided by the molecular weight of O_3 in mg/m^3

$[NO_2]_{bkgd}$ = the background ambient NO_2 concentration in mg/m^3

1. Use a dispersion model to predict 1-hour average and annual ground-level concentrations of NO_X (as NO_2).
2. Obtain site-specific or site-representative background NO_2 and O_3 concentrations.
3. Determine the in-stack ratio (ISR) of NO_2/NO_X. Where direct measurements are not available the value used must be suitably justified.
4. Determine the total ground-level concentration of NO_2 ($[NO_2]total$ in Equation 5) by substituting $[NO_X]_{pred}$, $[NO_2]_{bkgd}$ and $[O_3]_{bkgd}$ into Equation 5 for each hour of the dispersion model simulation.
5. If the impact assessment criteria are exceeded, a more refined assessment should be undertaken and/or additional management practices or emission controls applied.

8.1.4 Method 4: Janssen empirical relationship

Janssen et al. (1988) developed an empirical equation for estimating the oxidation rate of NO in power plant plumes. This method considers oxidation from ozone, photodissociation, wind speed and

distance from source. This method is applicable to large stationary sources with a large domain of impacts.

Total ground-level concentration of NO_2 can be predicted using Equation 6 and the parameters A and α with varying distances downwind from the source.

Equation 6

$$NO_2 / NO_X = A(1 - \exp(-\alpha x))$$

where:

x = the distance from the source (km)

A and α are classified according to O_3 concentration, wind speed and season. See Figure 3 for values for A and α replicated from Janssen et al. (1988).

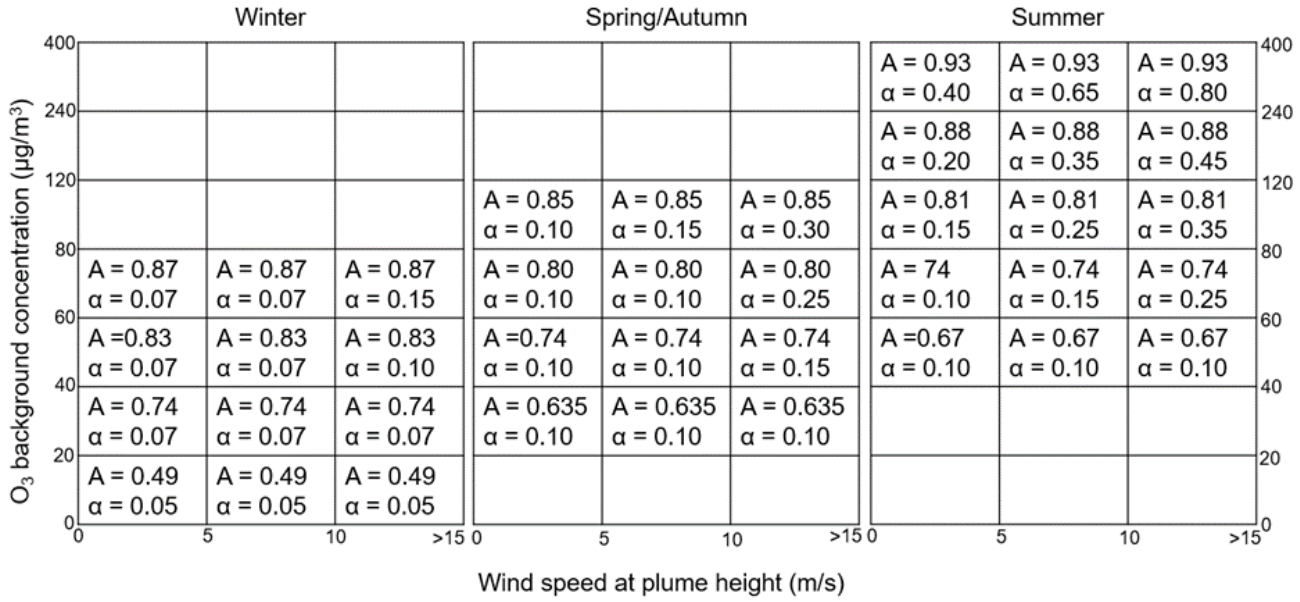

Figure 3 A and α values from Janssen et al. 1988 for use in NO_X conversion

1. Use a dispersion model to predict 1-hour average and annual ground-level concentrations of NO_X.
2. Obtain site-specific or site-representative background NO_2 and O_3 concentrations
3. Determine the distances from the source to a range of receptors representing, as a minimum, near-field, mid-field and far-field impacts (x in Equation 6).
4. For each receptor and hour of the dispersion model simulation, calculate the ratio of NO_2 to NO_X by substituting the relevant x and appropriate values for A and α (from Figure 3) into Equation 6 based on the season, background ozone concentrations and wind speed.
5. Determine the total ground-level concentration of NO_2 for each hour of the dispersion model simulation by applying the NO_2/NO_X ratio to the predicted 1-hour average NOx ground-level concentration and adding the result to the 1-hour average NO_2 background concentration.
6. The range of distances used and the receptors they represent and an appropriate level of information on the background ozone concentrations must be included in the assessment.
7. If the impact assessment criteria are exceeded, a more refined assessment should be undertaken and/or additional management practices or emission controls applied.

8.2 Detailed photochemical assessment

The emissions of precursors NO_X and VOCs can lead to the formation of ground level O_3 and secondary particles on a regional scale. These complex photochemical interactions can require detailed assessment using advanced regional models. Detailed information on advanced models and assessment process is provided in the *Tiered Procedure for Estimating Ground-Level Ozone Impacts from Stationary Sources* (EPA 2011). Screening procedure tools are available from the EPA website.[11] Before undertaking a quantitative photochemical assessment, seek advice from the EPA's air technical team.

[11] https://www.epa.nsw.gov.au/Your-environment/Air/industrial-emissions/Approved-methods-for-the-modelling-and-assessment-of-air-pollutants

9 Mitigation options analysis

A site-specific mitigation options analysis must be undertaken and presented in the air quality impact assessment if:

- the proposal emits principal toxic air pollutants and/or $PM_{2.5}$
- the EPA's Degradation Prevention Threshold (Table 8) for any pollutant is exceeded
- the existing ambient air pollutant concentrations exceed the EPA's impact assessment criteria from time to time for any pollutant

  or

- the EPA's impact assessment criteria are exceeded for any pollutant.

The purpose of the mitigation options analysis is to document the considerations that have been applied to reach decisions on the selection of the pollution control strategies. This must be accompanied with robust justification on why particular strategies have not been incorporated into the design of a premises.

This section does not override any legislative requirements that apply, including those in Part 5.4 of the POEO Act.

Decisions with respect to whether a particular pollution control strategy is practicable may have regard to technical, logistical and financial considerations. Technical and logistical consideration include a wide range of issues that will influence the feasibility of an option: for example, whether a particular technology is compatible with an enterprise's production processes.

Financial considerations relate to the financial viability of an option This will need to be considered on a case-by-case basis through discussions with the EPA.

Decisions around the identification, assessment and selection of pollution control strategies should have regard to, but are not strictly limited to:

- emission reductions, emission discharges, and/or control efficiencies that can be achieved for various control strategies
- the successful implementation of various control strategies at similar facilities to the premises being considered
- the 'hierarchy of control' tool for risk management, to inform preferential application of measures to reduce the likelihood of exposure to air pollution.

A dispersion modelling sensitivity analysis could be used to help choose the most cost-effective and environmentally effective control strategy.

9.1 Risk management principles

General risk management principles can be used to minimise risks to the environment. The 'hierarchy of control' tool that is applied in the occupational health and safety setting – Figure 4 shows an example – can also be applied when considering measures to prevent or minimise emissions and potential impacts on the environment.

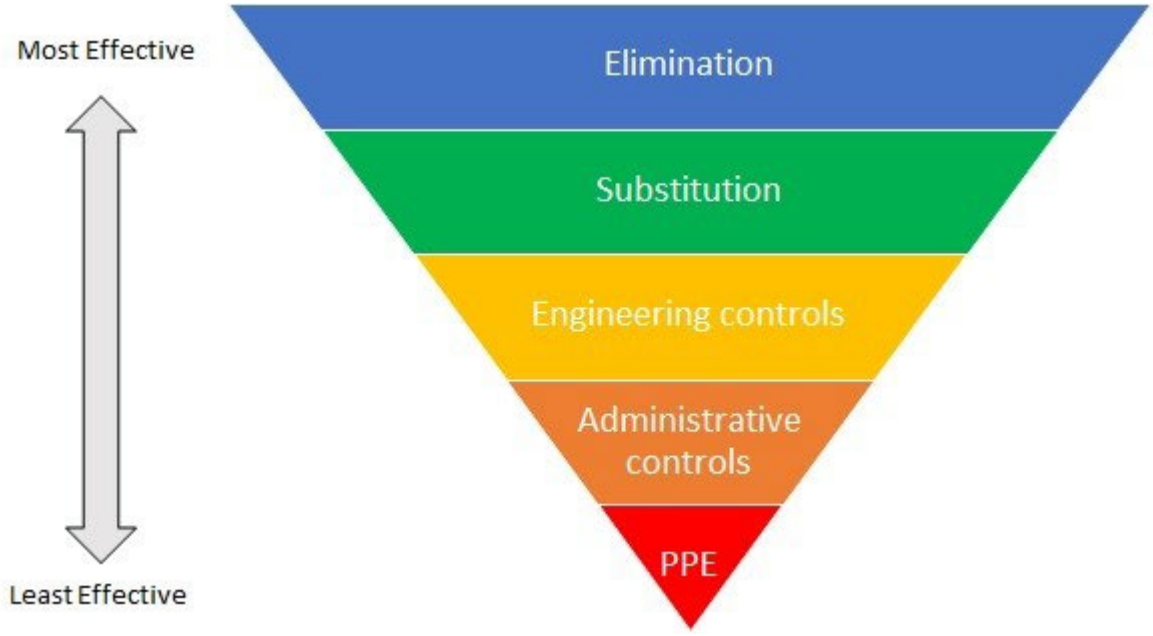

Figure 4 Hierarchy of controls (NIOSH, 2022)

When considering different types of mitigation measures, options that eliminate emissions or reduce the emissions as far as practicable – i.e. those options at the upper ends of the hierarchy should generally be preferred over options that require more human intervention or oversight – i.e. those at the lower ends of the hierarchy. For context, Table 15 shows typical mitigation options that could be implemented to reduce air quality impacts and how they would be considered in the risk management hierarchy.

Table 15 Examples of methods for reducing air emissions

Option	Plant and equipment (point sources)	Fugitive sources
Elimination	Using electrically powered plant and equipment to eliminate combustion pollutant emissions from the premises	Incorporating design elements (such as specific layouts) to eliminate the need for multiple material handling methods.
Substitution	Using alternative or more environmentally sound fuels or process inputs	Replace manual material handling methods with alternatives (i.e. conveyors)
Engineering controls	End-of-pipe controls, such as filters, scrubbers or oxidisers	Fugitive emissions capture with ventilation systems and end-of-pipe controls. Sealed hardstand areas or haul roads rather than unsealed surfaces.
Administrative controls (generally requiring a degree of human intervention)	Operator controls/procedures to maintain process parameters (e.g. temperature) at specific ranges.	Manually applied water or chemical wet suppressants on haul roads.

Option	Plant and equipment (point sources)	Fugitive sources
PPE	Acquiring land or sensitive receptors. This option, while reducing exposure risk at individual locations, will not reduce potential health burdens at other locations, and can limit the potential use of the land/receptor being acquired.	Acquiring land or sensitive receptors. This option, while reducing exposure risk at individual locations, will not reduce potential health burdens at other locations, and can limit the potential use of the land/receptor being acquired.

9.2 Site-specific analysis

Figure 5 shows a five-step process for undertaking a site-specific mitigation options analysis. Carry out the steps (described in detail below Figure 5) for each emission source or activity.

Where there are multiple emission units and/or activities, the analysis can target the most significant sources; where this is done, supporting evidence must be presented to justify the selection of the sources. The sources selected should cover a high proportion of total emissions from the site and/or be a high portion of the sources that contribute the most to off-site impacts.

Figure 5 Steps for undertaking a site-specific mitigation options analysis

9.2.1 Step 1 – Identify all mitigation options

The first step is to identify mitigation options. For each air pollutant and each emission unit being analysed, **all** available control options should be compiled. This includes technologies that have been applied to similar sources, and which could reasonably be expected to be transferable to the emission unit and air pollutant being considered. Analysis during subsequent stages may rule out one or more options as not practicable, but in this initial step all options should be listed for further consideration.

Section 3.2 provides the EPA's preferred sources for obtaining information on the available mitigation options. The information obtained when undertaking the identification step must be documented in the air quality impact assessment. This should include descriptions of the mitigation options, their operational principals, and the references consulted.

9.2.2 Step 2 – Eliminate technically infeasible options

Once all options have been compiled, technically infeasible options can be eliminated. Reasons why specific options are technically infeasible must be documented. This includes articulating how (based on physical, chemical and/or engineering principles) technical difficulties would preclude the successful use of the control options. At this stage no option should be eliminated due to cost. The focus at this step is on the specific technical factors that could preclude the implementation of specific technologies.

A specific control technology may simply be considered technically feasible on the basis that:

- the control technology is commercially available and can be transferred to the emission unit or activity
- the mitigation option has been successfully implemented at similar facilities that have been operating for a reasonable period of time.

Manufacturer specifications or guarantees may provide an indication of the technical feasibility of a control technology. Control technology providers or plant engineers may also be useful sources of information.

For each mitigation option that has been assessed as being technically infeasible, a sound justification with supporting evidence must be documented in the impact assessment report.

9.2.3 Step 3 – Rank remaining mitigation options

After technically infeasible options have been eliminated, the next step is to rank the remaining mitigation options in terms of emission reduction potential and/or reduction in ground-level concentrations. The expected performance of all options should be based on contemporary site-specific or source-specific data. Various kinds of data can be used to do the ranking, which may include (but is not limited to):

- control efficiencies for end-of-pipe controls, or management measures
- discharge concentrations that could be achieved and potentially used as limits in environment protection licences
- emission rates
- emission factors such as
  - mass of emissions per ton of product
  - mass of emission per unit of heat input/output
  - mass of emissions per unit of electric power produced
- estimated annual emission levels
- predicted ground-level concentrations
- cost effectiveness (i.e. cost per mass of emission reductions), which includes estimated capital, labour, materials and other costs on an annual basis. Any cost savings that would result from implementing the mitigation measure are also to be included.

The ranking exercise should also factor in the hierarchy of control described in section 9.1. This would be undertaken on a case-by-case basis. As a general principle, engineering controls should be preferentially ranked higher than administrative controls, particularly where emission reductions between these types of controls are similar.

The final ranking of the mitigation measures must be documented together with the method and rationale for reaching the final ranking. For example, the ranking could be set out in a table that includes:

- each mitigation option considered
- a description of the mitigation option and its operational mechanisms
- the type of each mitigation option, in terms of the hierarchy of controls

- the data metrics used to inform the performance of each mitigation option (i.e. control efficiency, emission rate or emission performance)
- the data metric used to rank the options considered.

The documentation must include references, and justification for the data used in the ranking process.

9.2.4 Step 4 – Identify the mitigation options that will be implemented

Once technically feasible options have been identified and ranked using steps 1 to 3, the next step is to identify which mitigation options will be implemented. The mitigation options that will be implemented must be clearly identified in the documentation.

9.2.5 Step 5 – Justify the selected options

Where some mitigation options have ranked higher than those selected for implementation, those higher-ranking options must be further assessed. A detailed, evidence-based justification must be provided to evaluate whether higher-ranking options are practicable means that may be necessary to prevent or minimise air pollution. Supporting information must be included when performing this evaluation and various factors need to be considered, including (but not limited to):

- environmental risks and impacts; including actual, likely, potential or possible risks of harm. This includes the nature and cause of those risks and impacts. This can include quantifying new, additional, or changes in environmental impacts that may arise from applying a particular mitigation option
- any relevant scientific or industry knowledge regulatory requirements
- safety implications
- compatibility with current processes and proposed future developments
- financial impacts – where costs have been considered.

10 Impact assessment report

An air quality impact assessment report must clearly document how the assessment has been carried out and its result. This chapter specifies the EPA's minimum requirements for the information in an impact assessment report.

Any and all AI-assisted and AI-generated content must be disclosed and the AI tool referenced in an air quality impact assessment.

10.1 Site plan

- Layout of the site clearly showing all unit operations
- All emission sources clearly identified, including any relevant off-site cumulative sources
- Plant boundary/licensed boundary
- Sensitive receptors
- Topography
- Weather and air quality monitoring locations

10.2 Description of the activities carried out on the site

- Plans, process flow diagrams and descriptions that
  - clearly identify and explain all emission units and activities on the premises
  - clearly identify and explain all pollution control equipment and techniques for all processes on the premises
- A detailed discussion of all operations carried out on the site, including all possible operational variability (e.g. hours of operation, product variability)
- A description of all aspects of the air emission control system, with particular regard to any fugitive-emissions capture systems (e.g. hooding, ducting), treatment systems (e.g. scrubbers, bag filters) and discharge systems (e.g. stacks)
- The operational parameters of all emission sources, including all operational variability i.e. location, release type (point, volume or area) and release parameters (e.g. stack height, stack diameter, exhaust velocity, temperature, emission concentration and rate, sigma y, sigma z, release height)

10.3 Emissions inventory

- A detailed discussion of the methodology used to calculate the expected pollutant emission rates for each source
- All supporting reports of source emission tests. All analytical reports must contain all the information specified in EPA (2022).
- Methods used to sample and analyse for each of the pollutants considered

- Detailed calculations of pollutant emission rates for each source
- Tables showing all release parameters of stack and fugitive sources (e.g. temperature, exit velocity, stack dimensions, and emission concentrations and rates, sigma y, sigma z, release height), and all pollutant emission concentrations with a comparison of the emission concentrations against the relevant requirements of the POEO Clean Air Regulation. A suggested format for the tables is given in section 3.7.
- Annual totals of emissions for all investigation scenarios.

10.4 Meteorological data

- A detailed discussion of the prevailing dispersion conditions at the proposed site, ideally drawing on data from at least five years in the recent past. The report should typically include:
  - wind rose diagrams
  - an analysis of wind speed including calms, wind direction, stability class, ambient temperature and mixing height
  - joint frequency distributions of wind speed and wind direction as a function of stability class.
- A demonstration that the site-representative data adequately describes the expected meteorological patterns at the site under investigation (e.g. wind speed, wind direction, ambient temperature, atmospheric stability class, inversion conditions and katabatic drift)
- A description of the techniques used to prepare the meteorological data into a format for use in the dispersion modelling, including information on missing or supplemented data.
- A summary table of meteorological model inputs and settings. Examples are provided in Table 16, Table 17 and Table 18.
- A quality assurance and quality control analysis of the meteorological data used in the dispersion modelling. Provide and discuss any relevant results of this analysis, including an evaluation of any prognostic data and/or any modelled meteorological data. Statistical and visual aids such as wind fields can provide transparency on model performance. Examples are provided in EPA's *Generic Guidance and Optimum Model Settings for the CALPUFF Modeling System for Inclusion into the 'Approved Methods for the Modeling and Assessments of Air Pollutants in NSW, Australia*' (EPA 2011).
- The meteorological data, model input, outputs and configuration files used in the dispersion modelling, supplied in a Microsoft Windows-compatible format

Table 16 Example model settings and inputs for meteorological models

Parameter	Input
Model version	CALMET 6.334
Terrain data source(s)	30-m Shuttle Research Topography Mission (SRTM)
Land-use data source(s)	Aerial imagery
Meteorological grid domain	10 km x 10 km
Meteorological grid resolution	0.2 km
Meteorological grid dimensions	100 x 100 x 9

Parameter	Input
Meteorological grid origin	660,000 m E; 6,123,000 m N. MGA Zone 55
Surface meteorological stations	Sydney Airport
Upper air meteorological stations	Derived by TAPM
Bias	(-1, 0, 0, 0, 0, 0, 0, 0, 0)
Simulation length	8,760 hours (2025)
R1, R2	0.5, 1
RMAX1, RMAX2	5, 20
TERRAD	6

Table 17 Example TAPM settings for generating prognostic meteorological data

Parameter	Example input
TAPM version	4.0.5
GEODATA	9 seconds
Land use	default
Domain	25 x 25
Vertical levels	30
Nesting	30 km, 10 km, 3 km, 1 km
Advanced meteorological inputs	default

Table 18 Example WRF settings (adapted from Monk et al 2019)

Parameter	Parameter	Example Input
Version	WRF	3.6.1
Domain	Nx	80,73,97,103
	Ny	70,90,97,103
	Vertical layers	33
	Thickness of first layer (m)	33.5
Initial boundary conditions	Met input/BCs	ERA Interim
	Topography/Land use	Geoscience Australia
	SST	High-res SST analysis (RTG_SST)
	Integration	4-h simulations, with 12-h spin-up
	Data assimilation	Grid-nudging outer domain above the PBL
Parameterisations	LW and SW radiation	NOAH
	Land surface	RRTMG
	PBL	MYJ
	UCM	Off
	Convections	Cumulus
	Aerosol feedback	No
	Cloud feedback	No
	Surface layer	Revised MM5

10.5 Background air quality data

- Methods used to sample and analyse for each of the pollutants
- Demonstration that background data is site-representative, by using an analysis of spatial variation and taking into account influencing factors such as land use, local emissions sources, population density etc.
- Demonstration of compliance with the relevant standards
- A detailed discussion of the method used to calculate the background concentrations for each pollutant, including missing or supplementary data
- Tables and other useful graphical means summarising the ambient monitoring data to the relevant pollutants averaging periods

10.6 Dispersion modelling

- A detailed discussion and justification of
  - all parameters used in the dispersion modelling
  - the manner in which topography, building wake effects, calms and other site-specific peculiarities that may affect plume dispersion have been treated
- A summary table of dispersion model inputs and settings. (Table 19 shows an example.)
- A detailed discussion of the method used to account for any atmospheric pollutant transformation and chemistry
- All input, output and configuration files used in the dispersion modelling, available in a Microsoft Windows-compatible format and suitably stored electronically to provide to EPA if requested

Table 19 Example model setting and inputs for CALPUFF or AERMOD

Parameter	CALPUFF input	AERMOD input
Model version	6.42	23132
Computational grid domain	100 x 100	100 x 100
Grid spacing	0.2 km	0.2 km
Domain centre	-31°, 150°	-31°, 150°
Chemical transformation	None	None
Dry deposition	Yes	Yes
Wind speed profile	ISC Rural	ISC Rural
Puff element 8	Puff	-
Dispersion option	Turbulence from micrometeorology	n/a
Time step	1 hour	1 hour
Terrain adjustment	Partial plume adjustment	-
Number of volume sources	10	10
Number of discrete receptors	15	15
Non-default settings	MPDF = 2	-

Parameter	CALPUFF input	AERMOD input
Run length	2025 (8760 hours)	2025 (8760 hours)

10.7 Results and discussion

- A detailed discussion of air quality impacts for all relevant pollutants, based on predicted ground-level concentrations at the premises boundary and beyond, and at all sensitive receptors
- Mapped concentration contours (isopleths) that include
  - site boundary
  - receptors
  - clearly labelled contour lines, including a criterion line where applicable, and appropriate concentration levels
- Tabled concentration predictions for
  - incremental and cumulative concentrations
  - existing and likely future sensitive receptors
  - maximum exposed off-site receptor
  - maximum outside the boundary of the premises
- Where an assessment relies on SILs, the results must be presented to clearly demonstrate the requirement for a cumulative assessment. Where the incremental glcs exceed the DPT, the assessment must clearly state that a mitigations option analysis has been triggered. (Table 20 shows an example.) **Note**: For $PM_{2.5}$, a mitigations options analysis (section 9) is required if SILs are exceeded, regardless of DPT.
- Contemporaneous cumulative assessment impacts must be presented to clearly demonstrate no additional exceedances. Where there is any exceedance, graphical presentation including source apportionment for a suitable number of impacted receptors should be provided. An example is provided in Figure 6.

Table 20 Example of assessing incremental results against (1) SILs to progress to cumulative assessment and (2) DPTs to undertake a mitigations options analysis

Pollutant	Max 1 hour	Max 24-hour	Annual	Cumulative assessment required?	Mitigations options analysis required?
NO_2	47 µg/m^3 (Above SIL) (Above DPT)	N/A	4.9 µg/m^3 (Above SIL)	Yes	Yes
SO_2	9.7 µg/m^3 (Below SIL)	4.6 µg/m^3 (Below SIL)	N/A	No	No
$PM_{2.5}$	N/A	2.5 µg/m^3 (Above SIL)	0.35 µg/m^3 (Below SIL)	Yes	Yes
PM_{10}	N/A	5.2 µg/m^3 (Above SIL)	1.5 µg/m^3 (Above SIL)	Yes	No

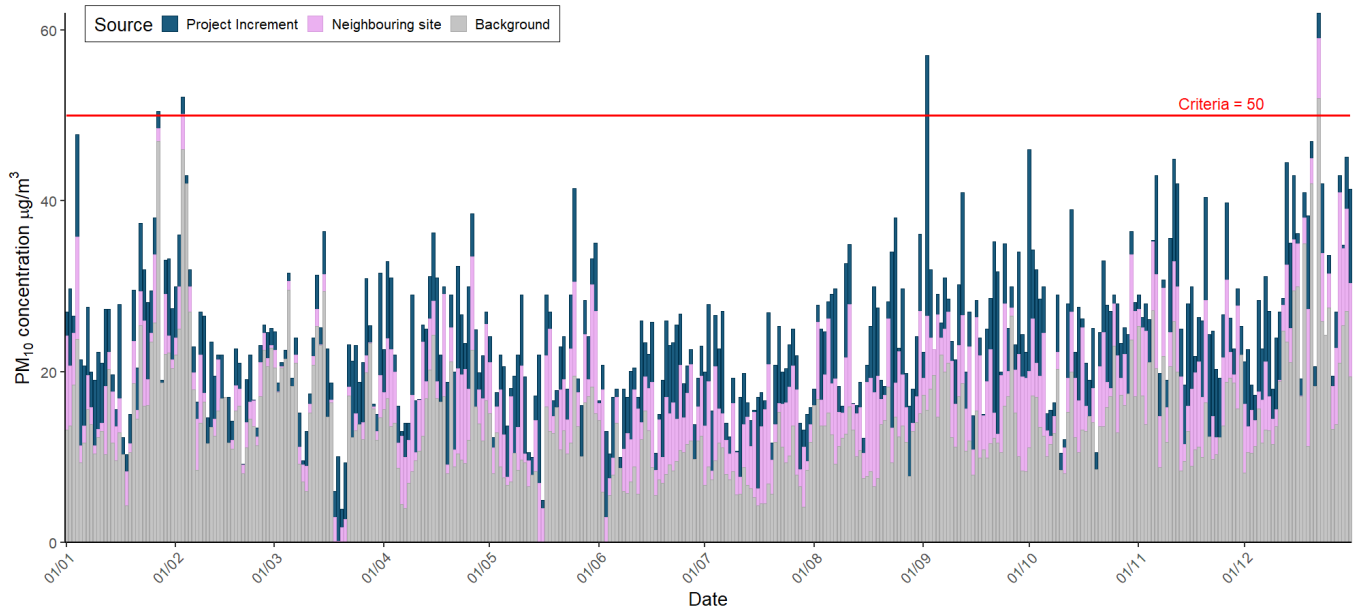

Figure 6 Example time series to demonstrate transparency when background is elevated

10.8 Mitigation options analysis

- A detailed discussion of the sources chosen for inclusion in the mitigation options analysis. Include supporting evidence to justify the sources selected.
- Discussion on the mitigation options that have been compiled for inclusion into the options analysis. Provide references where appropriate.
- Detailed justification for each mitigation options that has been identified as technically infeasible. Document supporting evidence where appropriate.
- A detailed ranking of the technically feasible mitigation options considered. The ranking must clearly articulate:
  - each mitigation option considered
  - metrics used to the inform the ranking, with supporting data, calculations and references where appropriate
  - the mitigation options proposed, and where they sit in terms of the ranking.
- Detailed justification for each mitigation options that has been identified as not practicable for implementation. Provide supporting evidence, including any:
  - detailed cost analysis
  - analysis of environmental impacts, or changes in environmental impacts.

11 Emission limits

11.1 Legislation

The POEO Act is the key piece of environment protection legislation that regulates pollution in NSW. The POEO Act is administered by the EPA.

Section 128 of the POEO Act makes it an offence for emissions of air impurities to exceed 'standards of concentration' as prescribed by the POEO Clean Air Regulation. These standards are limits for point source emission and are the maximum emissions permissible for an industrial source anywhere in NSW. These limits are based on levels that are achievable through the application of reasonably available technology and good environmental practices. In some circumstances, other legal instruments may impose tighter emissions limits.

The emission limits in the POEO Clean Air Regulation do not take into account site-specific features such as meteorological conditions and background air quality, and therefore do not necessarily protect against adverse air quality impacts in the areas surrounding the premises. An objective of the POEO Act is to reduce the risks to human health and the environment by reducing to harmless levels the discharge of substances into the air (s 6 of the *Protection of the Environment Administration Act 1991* and s 3 of the POEO Act). The impact of emissions on local air quality from a premises is determined through an air quality impact assessment for the purposes of this Method document.

11.2 How does the EPA set air emission limits in environment protection licences?

Emission limits for an environment protection licence are set for a point source by taking into account the following three considerations.

Emission limits reflect reasonably available technology and good environmental practice. The POEO Clean Air Regulation sets the maximum emissions permissible for an industrial source located in NSW. The POEO Clean Air Regulation limits are based on levels that are achievable through the application of reasonably available technology and good environmental practices.

Emission limits reflect proper and efficient operation. Consistent with the requirement of the POEO Act (s 124), it is EPA policy to prescribe emission limits that are consistent with the proper and efficient operation of plant and equipment. Depending on the plant and equipment, these levels can be lower than those prescribed by the POEO Clean Air Regulation.

Emission limits protect the health and amenity of the surrounding community. This document sets out:

1. health- and amenity-based impact assessment criteria for the protection of ambient air quality
2. the process for assessing the impacts of air pollutant emissions on ambient air quality and the surrounding community.

Proponents of new or expanding developments must use these principles to demonstrate that a proposed development will not adversely affect human health and amenity or the surrounding air quality.

The three considerations also allow for emission limits in a licence to be even more stringent than the requirements of the POEO Clean Air Regulation.

The information submitted by the proponent or licensee in the impact assessment is used to set the emission limits in an environment protection licence. This includes the emission concentration(s) and emission rate(s) used in the dispersion modelling.

This section does not override any legislative requirements that apply, including those in Part 5.4 of the POEO Act.

12 Fugitive dust

Additional requirements apply to the assessment, mitigation and documentation of fugitive dust, including dust from metalliferous and other mines and quarries as well as dust that could include respirable crystalline silica.

Modelling and assessment must consider the core principles detailed in section 1.3. Fugitive dust emissions comprise particulate matter, including $PM_{2.5}$. Where principal air toxics might be present, special consideration of the core principles must be given to ensure emissions are minimised to the maximum extent achievable.

12.1 Assessment requirements

Core principles

Project design must consider the core principles detailed in section 1.3. Fugitive dust emissions comprise particulate matter, including $PM_{2.5}$. Where dust could include principal air toxics this must be specifically considered, modelled and assessed, consistent with the core principles to ensure emissions are minimised to the maximum extent achievable.

Emissions inventory and estimation

The calculation methodology must follow the guidance provided in section 3 and adopt site-specific material composition data, including as a minimum silt content, moisture content, metals and silica composition, with information to support the adopted values. All control measures must consider section 3 and section 9. When using control factors, additive measures must be supported by evidence. To ensure that the short-term impacts from a proposal are adequately considered, the inventory must include a scenario based on the maximum (peak) daily production rate.

The emissions inventory must be supported by a site-specific mitigations options analysis, prepared in accordance with Chapter 9, which demonstrates that control measures will minimise emissions to the maximum extent achievable.

Meteorological verification

Site-specific or site-representative meteorological conditions must be adequately justified and evaluated in accordance with section 4. Prognostic data by itself is not accepted for any mining project without reasonable justification. Most existing mines and mining areas have weather stations installed. A weather station should be installed early enough to allow for one year of data to be used in the assessment.

Dispersion modelling

Approved models are to be configured in accordance with section 6 and settings provided in accordance with section 10. The settings must be sufficiently transparent so that the configuration is reproduceable. All model configuration and input files must be digitally stored for a minimum of five years after approval and be made available to EPA on request.

Baseline air quality and verification

Site-specific or site-representative air quality data is to be used for the background and must be adequately justified and evaluated in accordance with section 5. A modelled background with negative or null values is not acceptable. Baseline monitoring should be installed early enough to allow for one year of data to be used in the assessment.

Evaluation of impacts

Modelling results are to be evaluated in accordance with section 7 and must consider the requirements detailed in section 10. Results must be provided for incremental, background, cumulative and include neighbouring sources. If the Degradation Prevention Threshold is exceeded, the mitigation options analysis in section 9 must be completed to demonstrate that emissions have been minimised as far as practicable.

12.2 Assessment report requirements

Assessment reports must be prepared in accordance with the requirements in section 10. The outcomes of the assessment will be incorporated into the approval conditions and licence. The assessment must be transparent about the control and mitigation measures, triggers and actions required to achieve the appropriate environmental outcomes consistent with regulatory responsibilities described above.

Reactive actions

When an assessment scenario uses a reactive approach to dust mitigation or management (such as a Trigger Action Response Plan (TARP)) to demonstrate compliance with impact assessment criteria, this scenario must be documented in the assessment report and comply with section 7. Specifically, the following must be detailed in the assessment report regarding the TARP:

- control efficiencies as adopted in modelling
- the specific triggers to initiate the reactive management. This could include ambient air and meteorological monitoring triggers such as wind speed and wind direction as well as pollutant concentration thresholds from monitoring
- the actions and responses that will be taken when triggers are reached. Actions can include ceasing or reducing particular activities.

Schedule of management and mitigation actions

The assessment report must include a separate and specific schedule of management and mitigation actions that have been used for the assessment of impacts. For each source of air emissions, the schedule must include:

- control efficiencies as adopted in the emissions inventory calculations and modelling used to demonstrate compliance with the impact assessment criteria
- corresponding actions that will be implemented on site for each source to ensure the control efficiencies assumed in the assessment are achieved in practice (i.e. measurable and auditable performance indicators). Examples include, but are not limited to,
  - haul road watering frequency rates

  - frequency of chemical suppressant application
  - speed limits on specific roads
- measurement of site-specific material properties including surface moisture contents, silt content, metals and silica composition
- hours of operation of material handling equipment, and material drop height
- stockpile management, including areas actively disturbed, and frequency of water spray application
- enclosure dimensions and conveyor transfer points
- the meteorological conditions under which certain activities will be shut down.

Ambient air monitoring

The assessment report must set out any ambient air monitoring and:

- its purpose – how it will be used (i.e. for compliance or management of operations)
- its location (including coordinates)
- pollutants measured
- averaging period(s)
- equipment type, operation and calibration in accordance with the relevant with the Australian Standard.

Where monitoring is used for performance indicators or triggers for specific actions this must be set out in the schedule also.

12.3 How does the EPA use the information in a fugitive dust assessment?

A fugitive dust assessment is a clear statement and commitment by the proponent to manage fugitive dust emissions through the implementation of specific measures.

The commitment by a proponent to implement certain measures to manage fugitive dust emissions must be replicated in any air quality or fugitive dust management plan for the site.

Generally, the EPA will also use the assessment information and commitment to implement specific management measures by:

- replicating in the licence the commitments to managing fugitive dust
- reviewing those commitments on an as-needs basis when considering a site's performance under the POEO Act – for instance, with regard to:
  - section 126 of the POEO Act, which requires handling, transport, storage and disposal of materials in a proper and efficient manner
  - section 128(2) of the POEO Act, which requires activities to be carried on, and plant to be operated, in or on premises by such practicable means as may be necessary to prevent or minimise air pollution
- determining whether to impose any further specific requirements in licence conditions.

Any licence conditions that the EPA imposes will not affect any legislative requirements that also apply, including those in Part 5.4 of the POEO Act.

13 Worked examples

13.1 Developing site-specific emission limits

The EPA sets emission limits at or below those specified in the POEO Clean Air Regulation where they reflect expected performance of current technology. Under section 53 of the POEO Clean Air Regulation, alternative emission limits for H_2S may be approved where compliance with such limits cannot be met and certain criteria are met. The criteria include that the EPA must be satisfied that the alternative standard of concentration for H_2S has been calculated in accordance with these Approved Methods.

This section demonstrates how a site-specific emission limit may be calculated in accordance with these Approved Methods.

13.1.1 Scenario

A major industrial site is proposed to be located near Deniliquin. Hydrogen sulfide will be released via a stack 40 metres high. The stack height is more than 2.5 times that of all buildings within a 200 m radius. Since the distance of 200 m is five times the stack height, building wake effects are not likely to occur. The topography of the site is dominated by flat terrain, and the nearest sensitive receptor is located 2950 m from the proposed site. A weather station is not available at the site; however, an appropriate weather station is located within 4000 m of the site and is deemed to be site representative. Source characteristics are summarised in Table 22.

It is not practicable for this industry type to meet the POEO Clean Air Regulation emission limit for hydrogen sulfide of 5 mg/m^3.

13.1.2 Source characteristics

Table 21 Worked example 1 – source characteristics

Source characteristic	Value
Stack height (m)	40
Stack diameter (m)	1
Exhaust temperature (°C)	180
Exhaust velocity (m/s)	20
Building wake effects	No
Exhaust flow rate – Am^3/s	15.71
Exhaust flow rate – Nm^3/s	9.47
Hydrogen sulfide emission concentration – mg/Am^3	21.0
Hydrogen sulfide emission concentration – mg/Nm^3	34.8
Hydrogen sulfide emission rate (g/s)	0.33
Location	Rural
Terrain	Flat
Roughness height (m)	0.3
Location of nearest sensitive receptor (m)	2,950

13.1.3 Method

Dispersion modelling was conducted using AERMOD. Since site-representative meteorological data was available, three years of data were required for the project. A meteorological data file was prepared in accordance with section 4.

Since the nearest sensitive receptor is located at a distance that is greater than 10 times the largest source dimension (i.e. 2,950 m > 400 m or 10 times the stack height), far-field peak-to-mean ratios for a tall wake-free point from Table 6 (section 7) are appropriate.

13.1.4 Results

A hydrogen sulfide emission concentration of 34.8 mg/Nm^3 gave a maximum ground-level concentration of 4.22 µg/m^3 at a distance of 2,950 m from the stack. This is less than the impact assessment criterion for hydrogen sulfide of 4.83 µg/m^3 at a single residence (see Table 13).

Hence, an appropriate site-specific emission limit for hydrogen sulfide would be approximately 35 mg/Nm^3.

13.2 Dealing with elevated background concentrations

13.2.1 Scenario

A mine is proposed to be located in a sparsely populated rural area. The nearest sensitive receptor is a resident located 1000 m north of the proposed mine site.

13.2.2 Method

Since site-specific meteorological data is available, a one-year period was modelled. Modelling showed that incremental glcs exceeded SILs at the nearest sensitive receptor. Therefore, a cumulative assessment was conducted to predict 24-hour PM_{10} concentrations, incorporating both background and incremental contributions at that receptor.

Background monitoring data for PM_{10} was available from a site-specific monitor located within the proposed mine site. This data can be summarised as:

- maximum 24-hour average: 55 µg/m^3
- annual average: 16 µg/m^3.

Each 24-hour incremental dispersion model prediction was added to the corresponding measured background concentration for every day of the year modelled.

13.2.3 Results

As the background PM_{10} concentrations already exceed the impact assessment criterion, the air quality impact assessment needs to transparently demonstrate that the proposal would cause no additional exceedances.

Table 22 shows the total predicted concentrations ordered by the highest predicted incremental ground-level concentrations. The maximum incremental concentrations were compared against the PM_{10} DPT (Table 8), which found that both 24-hour and annual PM_{10} predictions were below the DPT. As a result, the DPT threshold was not triggered.

Table 23 shows the total predicted concentration on days ordered by the highest background. Three exceedances of the impact assessment criterion have been identified (**bolded**). While the proposal is not predicted to cause any additional exceedances, it must be demonstrated that air emissions from the proposed mine are being minimised as far as is practical, given that the airshed already exceeds the impact assessment criteria. Further guidance on the minimisation of emissions can be found in section 9.

Table 22 Worked example 2 – summary of contemporaneous impact and background – days with highest predicted increment

Date	Background – PM_{10} 24-hour average ($\mu g/m^3$)	Highest predicted increment –PM_{10} 24-hour average ($\mu g/m^3$)	Total
31/05/21	36	10	46
04/03/21	38	8	46
09/10/21	34	8	42
24/02/21	28	7	35
04/01/21	25	7	32
12/04/21	29	6	35
27/01/21	**55**	5	**60**
13/02/21	30	5	35

Table 23 Worked example 2 – summary of contemporaneous impact and background – days with highest background

Date	Background – PM_{10} 24-hour average ($\mu g/m^3$)	Predicted increment – PM_{10} 24-hour average ($\mu g/m^3$)	Total
27/01/21	**55**	5	**60**
26/01/21	**52**	3	**55**
08/10/21	**51**	2	**53**
04/03/21	38	8	46
02/02/21	37	1	38
31/05/21	36	10	46
06/08/21	34	2	36
09/10/21	34	8	42

13.3 SILs and when to perform a cumulative assessment

13.3.1 Scenario

A manufacturing facility is proposing to replace an old coal-fired boiler with a new, larger, solid-fuel boiler. To minimise particulate emissions, it is proposed to add a fabric filter to the emission unit. The manufacturer's emission guarantees were used in the dispersion modelling.

Significant Impact Levels (SILs) may be used to determine if a cumulative assessment is required for applicable pollutants. Further assessment may be required for other pollutants that are not listed under SILs.

13.3.2 Results of modelling

The modelled incremental impacts for $PM_{2.5}$, PM_{10} and NO_2 at all sensitive receptors were compared against Table 7. As the results in Table 24 show, the incremental impacts of $PM_{2.5}$ and PM_{10} are below the SILs at the most impacted sensitive receptor. While the annual NO_2 SIL is met, the maximum 1-hour SIL was not met for NO_2. Therefore, a cumulative impact assessment is required for NO_2.

Table 24 Examples of SILs scenarios to trigger cumulative assessment – most impacted sensitive receptor

Pollutant	Max 1-hour increment	Meets SIL	Max 24-hour increment	Meets SIL	Annual increment	Meets SIL	Cumulative assessment required
$PM_{2.5}$	N/A	-	1.0 µg/m^3	Below SIL	0.1 µg/m^3	Below SIL	No
PM_{10}	N/A	-	2.0 µg/m^3	Below SIL	0.9 µg/m^3	Below SIL	No
NO_2	20 µg/m^3	Above SIL	N/A	-	0.9 µg/m^3	Below SIL	Yes

13.3.3 Reporting requirements

In cases where an assessment does not progress to a cumulative assessment based on SILs, the assessment must clearly state the outcome(s) of the SILs evaluation. Incremental-only assessments (those that meet the SILs) must still provide all the information required under sections 3, 4 and 6.

13.4 Developing fugitive dust performance indicators

13.4.1 Scenario

An existing quarry is proposing to increase capacity from 1,000,000 tonnes per annum (tpa) to 1,500,000 tpa. The increase in capacity will result in a significant increase in vehicle movements on unsealed haul roads. The air quality impact assessment has identified that an 80% control efficiency for particulate matter emissions from the haul roads is required to achieve the appropriate environmental outcomes.

13.4.2 Method

A wet suppression control strategy was developed by the proponent to achieve the required 80% control efficiency. The strategy was developed in line with Chapter 13.2.2 of US EPA AP-42, which provides guidance on the moisture ratio needed to achieve an 80% control efficiency. Using the relationships in US EPA AP-42, a moisture ratio of ~3 was assumed to correspond to an estimated control efficiency of 80%: this is shown in Figure 7 (next page).

Another useful tool in for such situations is Equation 6 (USEPA 1987), which is an empirical model for calculating emissions control efficiency for haul road particulate matter.

Equation 6

$$C = 100 - \left(\frac{0.8 \times P \times D \times T}{I}\right)$$

Where:

C = Average control efficiency (%)

P = Potential average hourly daytime evaporation rate (mm/hr)

D = Average hourly daytime traffic rate (vehicle/hr)

T = Time between applications (hr)

I = Application

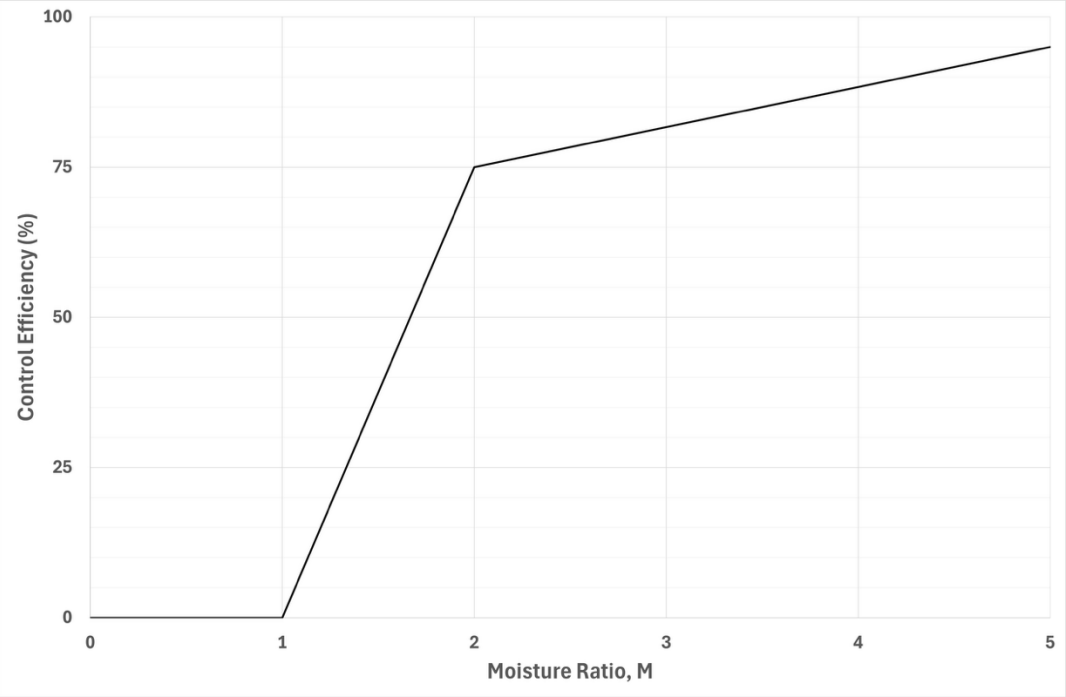

Figure 7 Haul road control efficiency as a function of moisture content (USEPA, 2006)

The moisture ratio is the moisture content of controlled haul road divided by moisture content of uncontrolled haul road.

The wet suppression control strategy has several key performance indicators that can be monitored and audited to show that the required 80% control efficiency is being achieved on an ongoing basis. The assessment report provides details on the wet suppression control strategy, and outlines options for monitoring against these performance indicators.

Options include:

- Moisture content, to be sampled and recorded. Where the moisture ratio of 3 is not being achieved, the time and amount of water applied is adjusted.
- Times and intensity of water application. The operator of the on-site water truck could record the times when water is applied and the quantity of water used. (Such records could be confirmed with GPS data.)

These options could be included as licence conditions and/or could form a component of the air quality management plan for the premises.

14 Conversion factors

The physical state of gaseous air pollutants at atmospheric concentrations may be described by the ideal gas law:

Equation 7

$PV = nRT$

where:

P = absolute pressure of gas (atm)

V = volume of gas (L)

n = number of moles of gas (mol)

R = universal gas constant (L.atm/mol.K)

T = absolute temperature (K)

The number of moles (n) may be calculated from the weight (mass) of a pollutant (W) and its molar mass (MM) by:

Equation 8

$n = W/MM$

Substituting Equation 8 into Equation 7 and rearranging terms yields:

Equation 9

$V = WRT/(P \cdot MM)$

Parts per million (ppm) refers to the volume of pollutant (V_{poll}) per million volumes of air (V_{air}):

Equation 10

$ppm_{vol} = V_{poll}/(V_{air} \cdot 10^6)$

Substituting Equation 9 into Equation 10 converts volume to mass units of concentration:

Equation 11

$\text{mass concentration} = ((W/V_{air}) \cdot RT)/(P \cdot MM \cdot 10^6)$

Using the appropriate values for the variables in Equation 11, below is a conversion from volume to mass units of concentration for carbon monoxide:

T = 298.15K (25°C)

P = 1 atm

MM = 28 g/mol

R = 0.08205 L.atm/mol.K

1 ppm = 1.15 mg/m^3

1 mg/m^3 = 0.873 ppm

Table 25 contains some common conversion factors for the common air pollutants.

Table 25 Common conversion factors for common air pollutants

Pollutant	Units	To convert to:	Multiply by:
Ozone (O_3)	pphm	µg/m^3 (0°C)	21.4
		µg/m^3 (25°C)	19.6
Nitric oxide (NO)	pphm	µg/m^3 (0°C)	13.4
		µg/m^3 (25°C)	12.3
Nitrogen dioxide (NO_2)	pphm	µg/m^3 (0°C)	20.5
		µg/m^3 (25°C)	18.8
Sulfur dioxide (SO_2)	pphm	µg/m^3 (0°C)	28.6
		µg/m^3 (25°C)	26.2
Carbon monoxide (CO)	ppm	mg/m^3 (0°C)	1.25
		mg/m^3 (25°C)	1.15

Glossary

Term	Explanation
AERMOD	The American Meteorological Society/US EPA Regulatory Model Dispersion Modelling System version 23132 or later
Affected zone	The area within which the impact assessment criteria is likely to be exceeded, and unacceptable air quality impacts may result
Air quality impact assessment	References to this term in the document are to be read as 'air pollutant impact assessment' for the purposes of section 48 of the Clean Air Regulation.
Am³	Actual cubic metre; the volume of gas that occupies a volume of 1 m^3 at stack discharge conditions
ARM	Ambient Ratio Method
AS/NZS	Australia/New Zealand Standard
Background levels	Existing concentrations of pollutants in the ambient air
BoM	The Australian Government's Bureau of Meteorology
BPIP	Building Profile Input Program (US EPA software used to generate data for dispersion models to account for building wake effects)
Building wake effects	The effect on plume dispersion caused by the presence of buildings near a stack, usually resulting in increased ground-level concentrations of pollutants
C	Convective atmospheric conditions
°C	Temperature in degrees Celsius
C_p	Peak concentration
CALPUFF	A multi-layer, multi-species, non-steady-state Gaussian puff dispersion model that is able to simulate the effects of time- and space-varying meteorological conditions on pollutant transport.
Clean Air Regulation	*Protection of the Environment Operations (Clean Air) Regulation 2022*
Common air	The pollutants sulfur dioxide, nitrogen dioxide, ozone, $PM_{2.5}$, PM_{10}, lead and carbon monoxide
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Deposition velocity	The ratio of deposition at the surface ($g/m^2/s$) to its concentration in the atmosphere (g/m^3) for a particular substance
Dispersion modelling	Modelling by computer to mathematically simulate the effect on plume dispersion under varying atmospheric conditions; used to calculate spatial and temporal fields of concentrations and particle deposition due to emissions from various source types
DPT	Degradation Prevention Threshold
Ensemble mean	The average of a predicted variable over an ensemble of forecasts
EPA	NSW Environment Protection Authority
Exceptional event	Defined under Clause 18 of the AAQ NEPM; means a fire or dust occurrence that adversely affects air quality at a particular location, and causes an exceedance of 1 day average standards in excess of normal historical fluctuations and background levels, and is directly related to: wild fire; jurisdiction authorised hazard reduction burning (excluding forestry post-harvest burning); or continental scale windblown dust.

Far-field	The far-field region is the zone where plume rise and meandering have fully occurred and the plume is well mixed in the vertical plane from ground level to the base of the first temperature inversion
Fugitive source	Activities that are generally dominated by fugitive area or volume-source emissions of odour, which can be relatively difficult to control, such as wastewater treatment plants
g	Mass in grams
glc	Ground-level concentration
glc criteria	Criteria for individual odorous or toxic air pollutants; specified in mg/m^3 or ppm
IARC	International Agency for Research on Cancer
Incremental impact	The impact due to an emission source (or group of sources) from a premises in isolation i.e. without including background levels
K	Temperature in kelvins
kPa	Pressure in kilopascals
L	Monin–Obukhov length, which characterises the stability of the surface layer
m	Length in metres
m^3	Volume in cubic metres
µg	Mass in micrograms
Mid-field	The mid-field region is the zone where source characteristics are important but not dominant
MAR	Minimum ambient ratio
mg	Mass in milligrams
Near-field	The near field is the zone where source structure directly affects plume dispersion. The near field is typically 10 times the largest source dimension, either height or width.
Nm^3	Normal cubic metre; the volume of dry gas that occupies a volume of 1 m^3 at a temperature of 273.15 K (0°C) and an absolute pressure of 101.3 kPa
NOx	Oxides of nitrogen, including NO and NO_2
OLM	US EPA's Ozone Limiting Method
OU	Odour units; indicates concentration of odorous mixtures. The number of odour units is the concentration of a sample divided by the odour threshold or the number of dilutions required for the sample to reach the threshold. This threshold is the numerical value equivalent to when 50% of a testing panel correctly detect an odour. For complex mixtures of odours, odour is specified in OU/m^3 (odour units per cubic metre) as a nose-response-time average.
OU/m^3	Odour units per cubic metre
PAH	Polycyclic aromatic hydrocarbon
Peak-to-mean ratio	A conversion factor that adjusts mean dispersion model predictions to the peak concentrations perceived by the human nose
ppb	Concentration in parts per billion
ppm	Concentration in parts per million
PM_{10}	Particulate matter less than 10 µm in aerodynamic equivalent diameter
$PM_{2.5}$	Particulate matter less than 2.5 µm in aerodynamic equivalent diameter
Point source	Source of emissions of odour, generally a stack. Emissions can generally be relatively easily controlled by using waste reduction, waste minimisation and cleaner production principles or conventional emission control equipment.

Principal air toxics	An element, compound or class of compound defined in Part 1, Schedule 2 of the POEO Clean Air Regulation
Refined assessment	A detailed dispersion modelling technique using site-specific input data
Screening	A conservative dispersion modelling technique using worst-case input data
Sensitive receptor	A location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area. An air quality impact assessment should also consider the location of known or likely future sensitive receptors. For hydrogen fluoride, a sensitive receptor includes land-use areas with vegetation sensitive to hydrogen fluoride, such as grapevines and stone fruit.
Separation distance	The distance between a source and sensitive receptors (or likely future sensitive receptors)
SIL	Significant Impact Level
Source separation	The distance between two emission sources
σ	Standard deviation
σy	Initial horizontal plume spread for volume sources
σz	Initial vertical plume spread for volume sources
Stack	A vertical pipe used to vent pollutants from a process
Stationary source	Any premises-based activity; does not include motor vehicles
TAPM	CSIRO's PC-based, 3-D prognostic model for air pollution studies
Total impact	The total impact of an emission source (or group of sources) and existing ambient levels of a pollutant i.e. total impact = background levels + incremental impact
TSP	Total suspended particulate [matter]
US EPA	United States Environmental Protection Agency
VOC	Volatile organic compound
Wind speed threshold	The minimum wind speed required for the instrument to start operating and accurately measure wind
WRF	Weather Research & Forecasting Model

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Appendix: Requirements for conducting a screening air quality impact assessment

When an assessment approach requires more detail than a qualitative assessment but less than a refined modelling assessment, a screening air quality impact assessment may be appropriate. Screening air quality impact assessments are generally suitable for projects where the emission sources and/or receiving environment are considered low risk, and when decisions can be made based on an estimate of the worst-case air quality impacts. The minimum requirements for conducting screening air quality impact assessments in NSW are outlined in the following sections of this Appendix.

Emissions inventory (section 3)

The emissions inventory of a screening air quality impact assessment must be reflective of the worst-case scenario(s) of a project/assessment. All sources (including potential sources) of air pollution must be identified, and worst-case input data must be demonstrated.

Meteorological data (section 4)

Screening air quality impact assessments are generally conducted using 'synthetic' worst-case meteorological data. Models that generate such data include AERSCREEN or SCREEN3, which are available on the US EPA website.

For reference, example calculation methodology for a screening meteorological file (including hourly stability class estimations) is provided in Appendix B.

Background air quality (section 5)

A screening air quality impact assessment must evaluate the combined impact of existing background air quality, and the emissions anticipated from the proposed activity.

For assessments that predict impacts of common pollutants (SO_2, NO_2, O_3, $PM_{2.5}$, PM_{10}, TSP, deposited dust, Pb, CO and HF), background concentrations should be incorporated into the assessment as follows:

- Obtain ambient monitoring data that covers an appropriate averaging period, which must be at least 1 year.
- Determine the maximum background concentration (below the relevant criterion) of the pollutant being assessed for that period.
- At the maximum exposed off-site receptor, add the maximum background concentration to the 100^{th} percentile dispersion model prediction. The predicted cumulative impact must then be compared against the corresponding criterion.
- In cases where results of this level of assessment indicate the potential for non-compliance with the corresponding air quality criteria, a refined approach must be conducted.

Dispersion modelling (section 6)

Screening models (e.g. AERSCREEN or SCREEN3) provide conservative air quality impact estimates for sources based on simplified assumptions of the model inputs. It can be desirable to commence an air quality impact assessment using screening models to understand if progressing to a refined model is required.

Note: There are screening techniques available that can be used in place of a screening model, such as the basic equations for odour in *Technical Notes: Assessment and Management of Odour from Stationary Sources in NSW* (EPA 2006).

The USEPA also provides links to download a range of screening models for air quality impact assessments at https://www.epa.gov/scram/air-quality-dispersion-modeling-alternative-models.

Interpretation of dispersion modelling results (section 7)

For screening air quality impact assessments, both incremental and cumulative impacts must be reported using the 100th percentile dispersion model predictions for all pollutants, including individual and complex odorous air pollutants.

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