



Local Government Air Quality Toolkit

Module 1: The science of air quality

Part 3: Measuring air quality

Acknowledgement of Country

Department of Climate Change, Energy, the Environment and Water acknowledges the Traditional Custodians of the lands where we work and live.

We pay our respects to Elders past, present and emerging.

This resource may contain images or names of deceased persons in photographs or historical content.

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Contents

1.	Measurement and management	1
1.1	Mass – the amount of matter	1
1.2	Volume – the space occupied by matter	1
1.3	Concentrations of air pollutants	1
1.4	Conversion tables for gaseous air pollutants	2
2.	Understanding air pollution measurements	3
2.1	Amount and rate of emissions	3
2.2	Pollutant concentrations	4
2.3	Discharge rates	4
3.	NSW Government air quality monitoring network	6
3.1	Monitored air pollutants and data	7
4.	Interpreting NSW Government air quality monitoring data	10
4.1	Air quality concentration data	10
4.2	Variability	11
4.3	Intermittent sampling	13
4.4	Averaging periods	13
4.5	Health and meteorological aspects of averaging	14
4.6	Health impacts, averaging times and exceedances	14
5.	Site-specific monitoring	14
6.	Source emission monitoring and measurement requested by councils	15
6.1	Calibrated in-stack measurements of smoke/dust	15
6.2	In-stack measurement of particles	16
6.3	Analysis and reporting of particulates from stacks	16
6.4	Sampling plane location and what to look out for	16
6.5	Continuous particulate measurement	18
6.6	Continuous gaseous measurement	18
6.7	Odour emission testing	18
7.	References and other resources	19

List of tables

Table 1	Conversion from ppm to $\mu\text{g}/\text{m}^{-3}$	2
Table 2	Conversion from $\mu\text{g}/\text{m}^{-3}$ to ppm	2
Table 3	NEPM air quality impact assessment criteria for common air pollutants	8
Table 4	Additional assessment criteria from the NSW modelling approved methods	9
Table 5	Air quality categories used in New South Wales	10

List of figures

Figure 1	Mass versus time	4
Figure 2	Mass versus volume	4
Figure 3	Air quality monitoring network for Greater Sydney Metropolitan Region	6
Figure 4	Air quality monitoring network across New South Wales	7
Figure 5	Maximum 24-hour average PM_{10} concentrations at Lower Hunter and Newcastle monitoring stations, 2019–2023	12
Figure 6	Daily maximum 1-hour average NO_2 concentrations at one background and one roadside monitoring station, 2023	12
Figure 7	Annual average $\text{PM}_{2.5}$ concentrations at Lower Hunter and Newcastle monitoring stations	13
Figure 8	Sampling plane for a gas stream duct	17

1. Measurement and management

It is important to measure air pollution to identify causes, impacts and develop solutions to reduce it or regulate it. Measuring air pollution ensures air quality is kept within legal limits or guidelines. To be able to manage air pollution, often referred to as managing 'air quality', it is necessary to understand the actual concentrations of pollutants in the air. Emissions can also be modelled (see the Local Government Air Quality Toolkit – Module 1 Part 5, *Predicting or modelling air pollution* for more information). The 2 physical properties used to quantify air pollution are mass and volume.

1.1 Mass – the amount of matter

The SI (metric) base unit of mass is the kilogram (kg). Other units of mass that are more commonly used in relation to air quality are the gram (g), the milligram (mg) and the microgram (μg), where:

- 1 gram (g) = 10^{-3} kg
- 1 milligram (mg) = 10^{-6} kg
- 1 microgram (μg) = 10^{-9} kg.

For some toxic pollutants the much smaller unit of the nanogram (ng) is used, where $1 \text{ ng} = 10^{-12}$ kg.

It is common to use the term 'weight' interchangeably with 'mass' to indicate the amount of matter, but this is not technically correct. Weight is the force of gravity on the mass.

1.2 Volume – the space occupied by matter

The SI derived unit of volume is the cubic metre (m^3). Other metric units of volume that are sometimes used in relation to air quality are the cubic centimetre (cm^3) and the litre (L):

- 1 cubic metre (m^3) = 1,000 litres (L)
- $1 \text{ cm}^3 = 0.001 \text{ L}$ (or 1 millilitre, mL).

For the litre, it is standard to use the capital 'L' to avoid confusion with the numeral '1'.

1.3 Concentrations of air pollutants

The most common ways of expressing the concentrations of air pollutants are:

- mass per unit volume of air
 - milligrams per cubic metre (mg/m^3 or $\text{mg}\cdot\text{m}^{-3}$)
 - micrograms per cubic metre ($\mu\text{g}/\text{m}^3$ or $\mu\text{g}\cdot\text{m}^{-3}$)
- volume per unit volume of air
 - parts per hundred million (pphm) (i.e. 1 part in 10^8)
 - parts per million (ppm) (i.e. 1 part in 10^6)
 - parts per billion (ppb) (i.e. 1 part in 10^9).

Gaseous pollutants can be expressed as the mass per unit volume or the volume per volume. Particulate matter is usually expressed as mass per unit volume, although other metrics can sometimes be used (such as the number of particles per unit volume).

1.4 Conversion tables for gaseous air pollutants

To convert the concentration of a gas from volume per volume to mass per volume, the temperature, pressure and relative molecular mass of the pollutant are required. Conversion tools are readily available online, and Table 1 and Table 2 provide conversion factors for some common pollutants.

Table 1 Conversion from ppm to $\mu\text{g}/\text{m}^{-3}$

Pollutant	At 0°C – multiply by	At 25°C – multiply by
Ozone (O ₃)	2,141	1,962
Nitrogen dioxide (NO ₂)	2,053	1,880
Sulfur dioxide (SO ₂)	2,858	2,619
Carbon monoxide (CO)	1,250	1,145

Table 2 Conversion from $\mu\text{g}/\text{m}^{-3}$ to ppm

Pollutant	At 0°C – multiply by	At 25°C – multiply by
Ozone (O ₃)	0.0004670	0.0005097
Nitrogen dioxide (NO ₂)	0.0004872	0.0005318
Sulfur dioxide (SO ₂)	0.0003499	0.0003819
Carbon monoxide (CO)	0.0008002	0.0008734

Changes in temperature or pressure cause the volumes of gases to change. Therefore, when using air pollution measurements, the conditions of pressure and temperature need to be defined.

The most common definition is STP = ‘standard temperature and pressure’ = 0°C and one atmosphere.

It should be noted that measurements of airborne particulate matter (PM) in Australia, as defined in the National Environment Protection (Ambient Air Quality) Measure (AAQ NEPM) and the *Approved methods for the sampling and analysis of air pollutants in NSW* (EPA 2022b), are standardised to STP (i.e. 273.15 K). In other countries particle measurements are standardised to different temperatures (i.e. 298.15 K in the US), or not standardised to temperature and pressure (EU/WHO).

2. Understanding air pollution measurements

In addition to mass, volume and concentration, 2 other parameters are important for the measurement and interpretation of source air emissions and concentrations of ambient air pollution:

- rate of emission from an activity or premises – this is in units of mass per unit time
- time periods over which concentrations of pollutants are measured, known as the ‘averaging period’.

The measurement process and technology also need to be considered, including:

- sampling – the collecting efficiency and methods used for sampling, representativeness of the sampling devices; for example, the locations and type of instruments
- analysis – the sensitivity of the analytical methods being used, either within the measuring instrument itself or ‘back in the laboratory’ compared to in the field
- data interpretation – the method or instrument suitable to adequately address the objective; that is, health risk, public nuisance or community concerns.

2.1 Amount and rate of emissions

The potential impacts of pollutant discharges from activities depend on:

- the type of pollutant
- where and how the discharges occur
- the temperature
- the rate of discharge
- the topography of the surrounding land
- the prevailing meteorological conditions
- the release height and speed of discharge.

For example, an acute event may occur in which an amount of a pollutant is discharged over a short period of time, maybe only a few minutes. This may result in a serious impact in the immediate vicinity – such as odours from a food outlet giving rise to complaints, wind-blown dust emissions near sensitive land use on neighbouring properties, or the discharge of a toxic chemical in an accident.

The discharge of the same amount of such pollutants over a long period of time – that is, at a much lower rate – may not have the same level of impact. However, if the pollutants have long-term health effects, such as exposure to fine particles or cumulative toxic materials, the reverse may be true: short-term higher-concentration exposures may have little effect while long-term lower-concentration exposures may have a damaging effect.

When assessing or regulating the discharges from any activity it is important to address management of both normal operations and the potential for acute events when the rate of emission may be high.

2.2 Pollutant concentrations

The discharge to the air of a given amount of pollutant may take place at different rates over a short or long period of time. When dispersed, this same amount of pollutant will then be mixed into another larger volume of air. This rate of pollutant discharge and volume of air mixing determines the pollutant concentration.

For example, 100 g of carbon monoxide (CO) emitted in a closed space like an unventilated basement carpark of volume 10,000 m³ has a concentration of 10 mg/m³. When dispersed into the open air, say into a volume that is one hundred thousand (10⁵) times greater, the same amount of CO has a concentration of only 0.1 µg/m³.

The concentration of a pollutant and the time over which this is measured or averaged are the significant parameters for determining the local environment and human health impact, and consequently, influence the regulatory standards for its management.

Figure 1 presents mass versus time and Figure 2 presents mass versus volume.

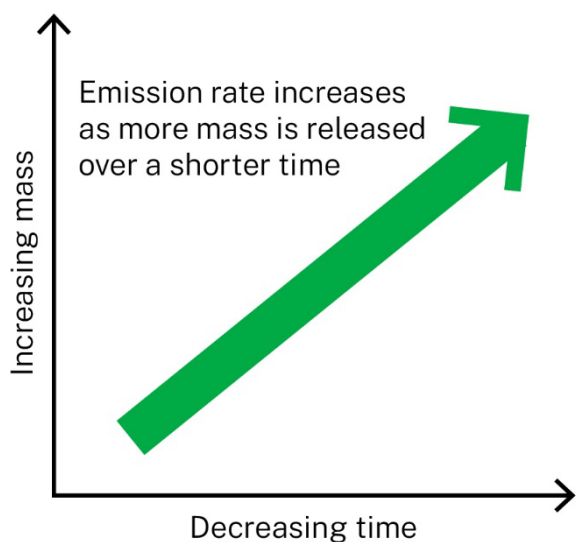


Figure 1 Mass versus time

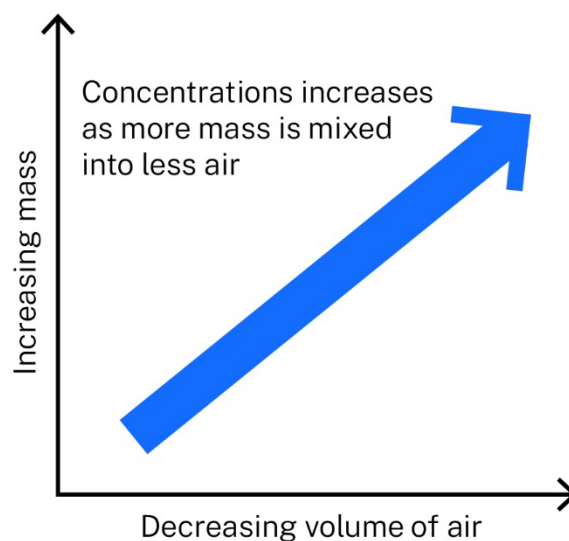


Figure 2 Mass versus volume

2.3 Discharge rates

Pollution controls such as filtration systems may be needed for pollutant discharges from premises to manage the surrounding air quality. Operators and regulators may need to consider the:

- rate at which inside air containing the pollutant is extracted to the outside atmosphere
- capacity of the premises' filtration system to remove the pollutant from the air being extracted.

Air pollutants like dust and solvent vapours are customarily taken out of work areas within premises by means of extractor fans and ducting through filters or adsorbers to stacks. It is important that the rate of flow (air volume per unit time) through these is large enough to remove enough air to keep the concentration of pollutants inside a facility at a level that reduces the impact on workers from a work health and safety (WHS) perspective. Removing the pollutants from the workplace into the outside air may solve the occupational problem but leaves the ambient air pollution problem. The environmental impact of these discharges should be managed.

Indoor air quality is a work health and safety issue rather than an environmental one.

Some local council officers have found it helpful to work in collaboration with SafeWork NSW when addressing the related air quality issues within and arising from premises and activities.

The filtration system being used must be able to remove enough of the pollutants so their concentrations in the stack, and subsequently outside, are also acceptable so there is no environmental pollution issue. When any extracted air is discharged to the outside atmosphere from a stack, the location and height of the stack must allow for acceptable dispersion.

Pollutant discharge and dispersal is discussed in more detail in Part 1 of this module.

3. NSW Government air quality monitoring network

The NSW Government operates an extensive ambient air quality monitoring network in New South Wales.

Figure 3 and Figure 4 show the current air quality monitoring network for Greater Sydney Metropolitan Region, and New South Wales, respectively. Information on the NSW Government air quality monitoring network and up to date air quality data is available on the *Current air quality in New South Wales* webpage (NSW Government 2024b).

The NSW air quality monitoring network:

- measures pollutant concentrations in outdoor (ambient) air to which the general community is exposed
- provides information needed for daily alerts and forecasts (e.g. regional air quality categories) and health warnings
- demonstrates progress in air quality management
- provides inputs to planning.

Monitoring stations are located according to accepted standards to allow for consistency of measurement of the general atmosphere in an area over time. Each location takes account of regional meteorology and the proximity of sources.

Air quality monitoring is also carried out to understand the potential impacts from specific sources; for example, emergency monitoring for bush fires, roadside monitoring, and monitoring during incidents at industry facilities.

Monitoring is conducted for both National Environment Protection Measures (NEPM) compliance and for regulatory purposes.



Figure 3 Air quality monitoring network for Greater Sydney Metropolitan Region
Source: NSW Government (2024a)

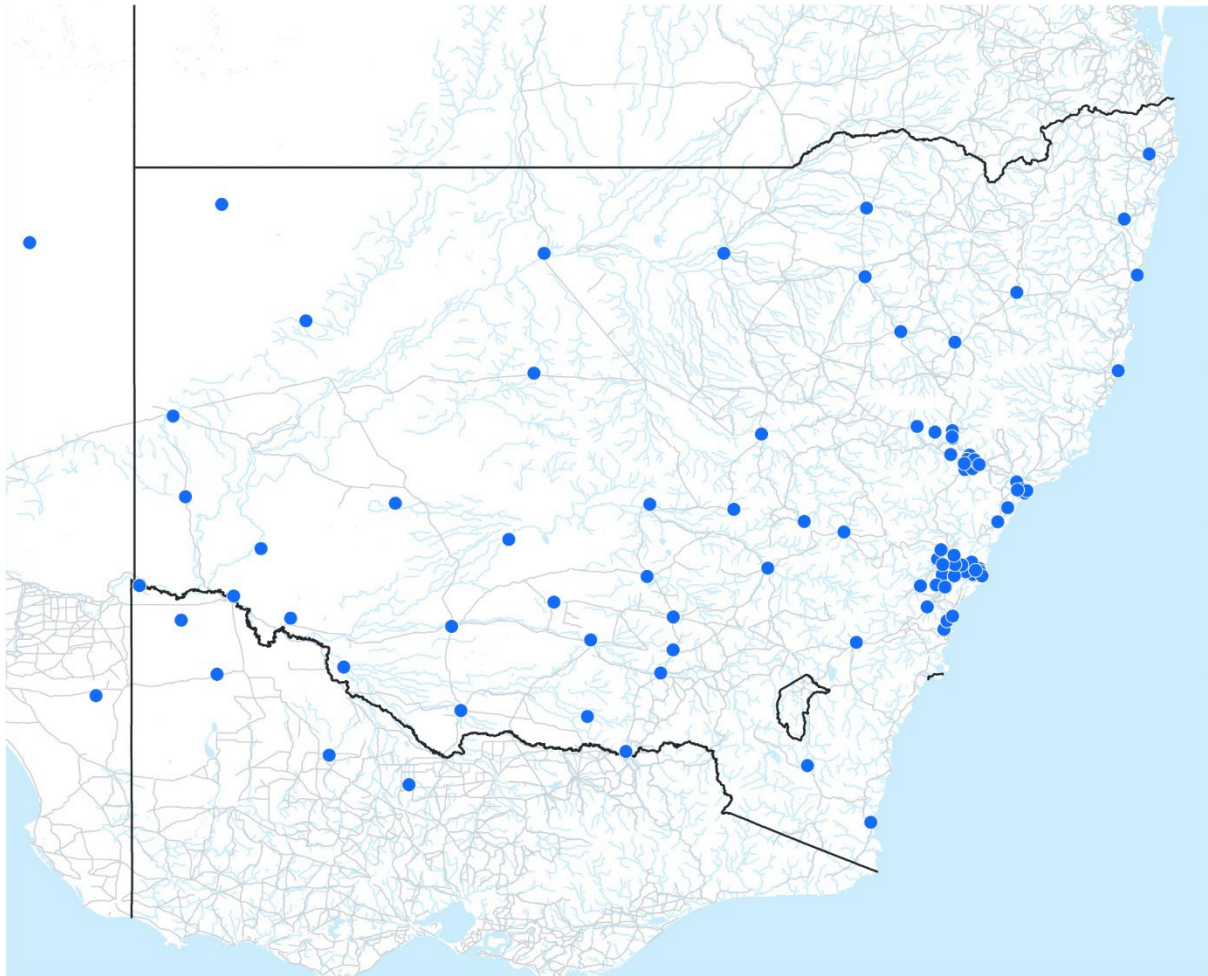


Figure 4 Air quality monitoring network across New South Wales
Source: NSW Government (2024a)

3.1 Monitored air pollutants and data

The air pollutants routinely measured in the NSW Government air quality monitoring network include:

- ozone (O_3)
- nitrogen oxides (NO_x)
- sulfur dioxide (SO_2)
- carbon monoxide (CO)
- ammonia (NH_3)
- particulate matter as:
 - total suspended particles (TSP)
 - particulate matter smaller than $10\ \mu m$ in diameter (PM_{10})
 - particulate matter smaller than $2.5\ \mu m$ in diameter ($PM_{2.5}$)
 - visibility effect measured by nephelometry (a nephelometer measures light scattering due to particles in the air, also known as scattering potential).

These pollutants are described in Part 2 of this module.

The measurements are generally continuous except for TSP, which is measured on a 1-day-in-6 repeating cycle, giving 61 samplings per year.

Meteorological conditions are also routinely measured in the network, including temperature, humidity, rainfall, wind speed and direction. This is discussed further in Part 1 of this module.

The methods and instruments used to monitor these pollutants are scientifically complex but you do not need to understand them to use the monitoring data.

Table 3 and Table 4 give the air quality impact assessment criteria for common air pollutants from the *Approved methods for the modelling and assessment of air pollutants in NSW* (EPA 2022a). The pollutants, averaging periods and numerical values of the air quality impact assessment criteria are mostly taken from the AAQ NEPM; however, application of the criteria (such as where they apply) is different in the modelling approved methods and the NEPM, and Table 4 gives additional criteria included in the modelling approved methods.

Table 3 NEPM air quality impact assessment criteria for common air pollutants

Source: EPA (2022a, p.27)

Pollutant	Averaging period	Concentration	
		Ppb	µg/m ³
SO ₂	1 hour	100	286
	1 hour (from 1/1/2025)	75	215
	24 hours	20	57
NO ₂	1 hour	80	164
	Annual	15	31
O ₃	8 hours	65	139
Lead	Annual	-	0.5
PM _{2.5}	24 hours	-	25
	Annual	-	8
	7 hours (from 1/1/2025)		
	24 hours (from 1/1/2025)		20
PM ₁₀	24 hours	-	50
	Annual	-	25
CO	8 hours	9,000	10,000

Table 4 Additional assessment criteria from the NSW modelling approved methods

Source: EPA (2022a, p.27)

Pollutant	Averaging period	Concentration	
		Ppb	$\mu\text{g}/\text{m}^3$
TSP	Annual	-	90
CO	15 minutes	87,000	100,000
	1 hour	25,000	30,000

These assessment criteria must not be used as limit conditions for air pollutants. Compliance with the assessment criteria (i.e. in the ambient air at the boundary of the premises or nearest sensitive receptor) cannot be readily determined for regulatory purposes.

4. Interpreting NSW Government air quality monitoring data

The NSW Government provides hourly air quality monitoring data collected across the network. The data can be downloaded from the *Air quality data download facility* (NSW Government 2024c). The raw data is updated monthly and annually depending on the parameter. The raw data is run through a quality assurance/quality control procedure to produce validated data.

Air pollutant data, meteorological parameters (including wind speed, wind direction, rainfall, temperature and relative humidity) can also be downloaded from the facility.

4.1 Air quality concentration data

Air quality data is updated hourly and a daily air quality forecast is made for the Greater Metropolitan Region at 4 pm each day. Data is provided for the pollutants mentioned in Section 3.1 above. An air quality category (AQC) is provided for each pollutant. Table 5 shows the criteria for the AQCs for specific air pollutants, from the *Air quality categories* webpage (NSW Government 2024d). A ‘station’ AQC is derived by taking the highest pollutant AQC at each station. The highest station AQC in each region is chosen as the regional AQC.

AQCs are colour indicators used to summarise air quality measurements. In New South Wales, 5 colour indicators are used to classify air quality as either ‘good’ (green), ‘fair’ (yellow), ‘poor’ (orange), ‘very poor’ (red) or ‘extremely poor’ (maroon).

Table 5 Air quality categories used in New South Wales

Source: NSW Government (2024d)

Air quality categories (AQCs)							
Air pollutant	Averaging period	Units	GOOD	FAIR	POOR	VERY POOR	EXTREMELY POOR
Ozone O ₃	1-hour	pphm	<6.7	6.7–10.0	10.0–15.0	15.0–20.0	20.0 and above
	8-hour rolling	pphm	<5	5–6.5	6.5–9.75	9.75–13	13.0 and above
Nitrogen dioxide NO ₂	1-hour	pphm	<8	8–12	12–18	18–24	24 and above
Visibility neph.	1-hour	bsp	<1.5	1.5–3.0	3.0–6.0	6.0–18.0	18.0 and above
Carbon monoxide CO	8-hour rolling	ppm	<6.0	6.0–9.0	9.0–13.5	13.5–18.0	18.0 and above

Air quality categories (AQC)s							
Air pollutant	Averaging period	Units	GOOD	FAIR	POOR	VERY POOR	EXTREMELY POOR
Sulphur dioxide SO ₂	1-hour	pphm	<13.3	13.3–20.0	20.0–30.0	30.0–40.0	40.0 and above
	24-hour	µg/m ³	<33.5	33.5–50	50–75	75–100	100 and above
Particulate matter <10 µm PM ₁₀	1-hour	µg/m ³	<25	25–50	50–100	100–300	300 and above
	24-hour	µg/m ³	<16.75	16.75–25	25–37.5	37.5–50	50 and above

4.2 Variability

The observed variability for different pollutants arises from many different factors, including:

- the physical and chemical behaviour of the pollutants in different seasonal weather conditions throughout the year
- changes in people's travel and energy use patterns at different times of the year
- seasonal patterns in the use of wood heaters
- seasonal cycles in farming practices
- hazard reduction burning in cooler months
- the occurrence of natural events and those exacerbated by climate change such as drought, dust storms, rainfall and bushfires.

If the total amount of air pollution discharged by sources only changes slowly, as is the case for large urban or industrial areas, then the main variability in air quality will depend on daily and weekly patterns of discharge and daily and seasonal variations in meteorology and weather.

For example, the changes in traffic flow throughout the day, with morning and evening peak periods, will markedly change the rates of emissions of nitrogen oxides (NO_x). Likewise, activity patterns on weekdays will be significantly different from those on weekends.

Dispersion is affected by variation in synoptic conditions. During the day some synoptic patterns favour conditions where dispersion is governed by synoptic winds or regional sea breezes, while at night, dispersion can be influenced by regional topography and 'stable drainage' flows. More of these aspects are considered in Part 1 of this module, which is about meteorology.

There will also be significant seasonal influences due to weather. Dispersion tends to be greater in summer than in winter as there is more mixing of air and less temperature inversions. However, the higher temperatures and stronger solar radiation during summer makes this the principal season for photochemical smog and ozone formation. Bushfires generally occur during the warmer months and contribute significantly to particulate pollution.

The graphs below show the variations in maximum 24-hour average PM_{10} concentrations at Lower Hunter and Newcastle monitoring stations (Figure 5), daily maximum 1-hour average NO_2 concentrations at one background (Rozelle) and one roadside (Bradfield Highway) monitoring station in Sydney (Figure 6), and annual average $PM_{2.5}$ concentrations at several Lower Hunter monitoring stations (Figure 7). The peaks in concentrations are clear to see in the shorter averaging periods (24-hour and 1-hour). Elevated concentrations in 2019 and the beginning of 2020 were the result of the widespread bushfires in New South Wales at that time.

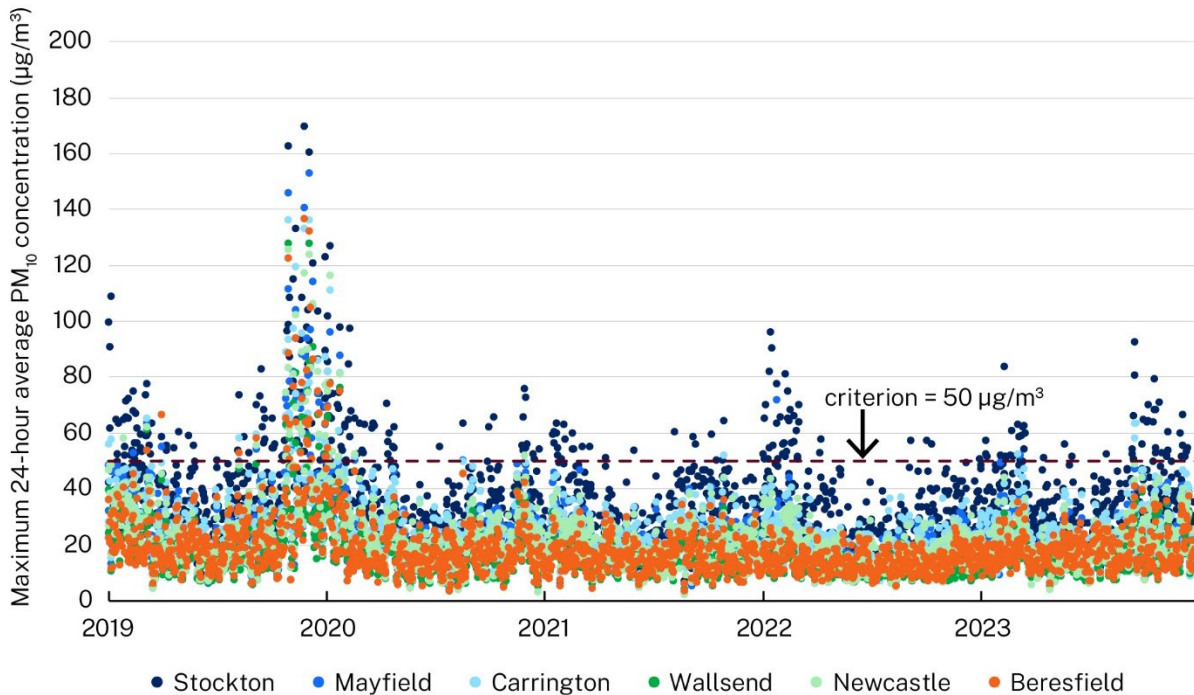


Figure 5 Maximum 24-hour average PM_{10} concentrations at Lower Hunter and Newcastle monitoring stations, 2019–2023

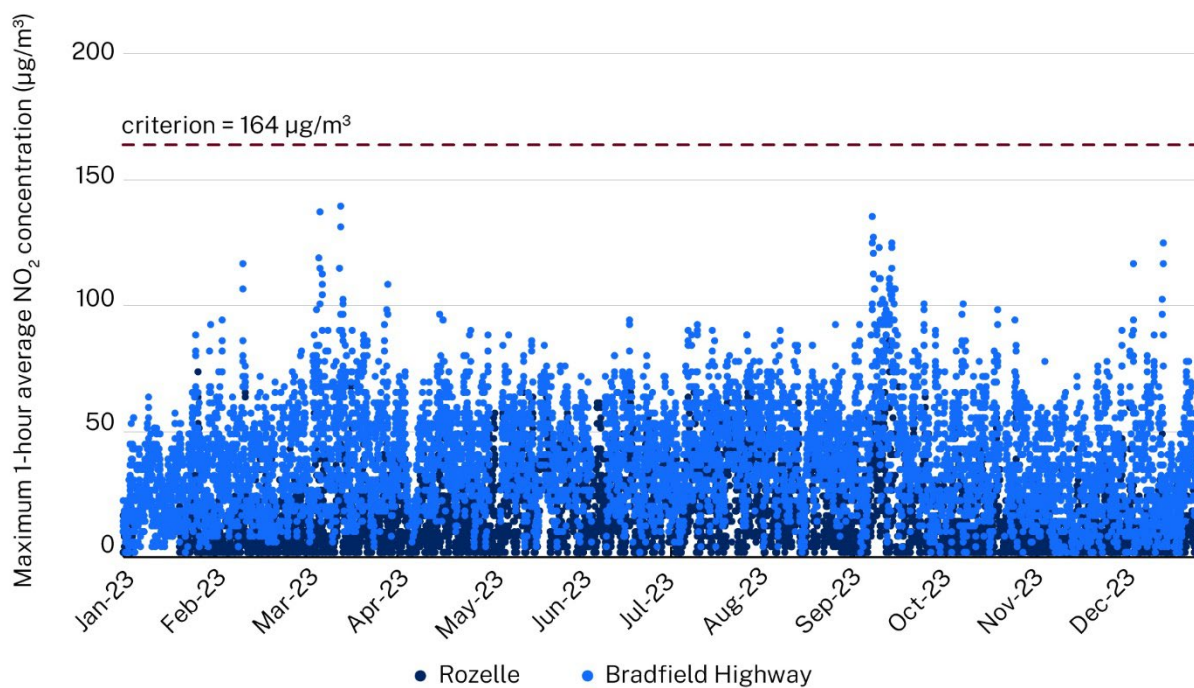


Figure 6 Daily maximum 1-hour average NO_2 concentrations at one background and one roadside monitoring station, 2023

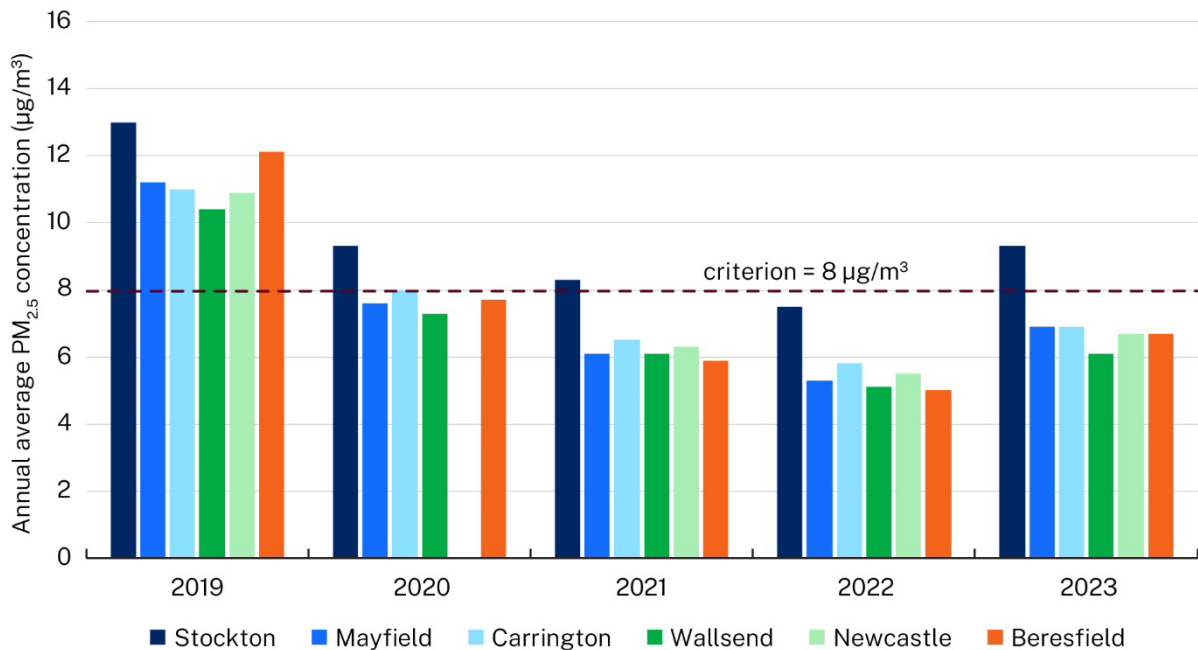


Figure 7 Annual average PM_{2.5} concentrations at Lower Hunter and Newcastle monitoring stations

4.3 Intermittent sampling

In the case of particulate matter, some instrumentation takes samples intermittently. For example, the high-volume air sampler (HVAS) samples 24-hour averages every sixth day. This method reveals trends in particulate pollution over longer periods of months, seasons and years but can miss acute events that occur on days when sampling is not done. Typically, the trend is for real-time continuous monitoring.

Intermittent sampling is less common since affordable real-time particulate monitoring instruments have been developed. However, they form an important source of historical data and the material collected on such filter methods may become useful in future analyses. Alternatively, such methods may still be the industry standard for measurement of certain parameters, such as concentrations of metals in the air.

4.4 Averaging periods

It is important to consider the averaging period for air pollution monitoring data. Ambient monitoring is usually carried out in accordance with NEPM monitoring protocols; that is, for the following time periods for different pollutants:

- 1 hour (clock hour average)
- 4 hours (rolling 4-hour average of 1-hour averages)
- 8 hours (rolling 8-hour average of 1-hour averages)
- 24 hours (rolling 24-hour average of 1-hour averages)
- 1 day (calendar day)
- 1 year (calendar year).

In general, existing pollution and meteorological patterns result in the maximum measured concentrations becoming lower with longer averaging times; that is, a maximum daily average is generally lower than a maximum 8-hour or maximum 1-hour average for the same parameter.

Data for different averaging periods cannot, therefore, be directly compared, but can be used to understand patterns.

Longer averaging times tend to relate to pollutants that can have longer-term cumulative effects on health, vegetation or property.

Shorter sampling times tend to relate to acute, immediately detected pollutants, such as sulfur dioxide and ozone.

4.5 Health and meteorological aspects of averaging

It is important to appreciate that there are 2 factors associated with the averaging times specified for air pollutants in standards:

- health impacts – pollutants that have chronic impacts (e.g. toxic heavy metals) tend to be specified by longer averaging times, while those that have acute effects tend to be specified by shorter averaging times
- meteorological conditions – variability in air movements generally results in ambient concentrations being lower for longer averaging times for a constant rate of emission from a point source.

4.6 Health impacts, averaging times and exceedances

For some pollutants, clinical and epidemiological research indicates their health impact is chronic (i.e. long-term) and mainly due to prolonged exposure causing cumulative damage to some body organs or tissues. If this is the case, the air quality criterion is likely to be expressed as a long averaging period of one year. This is appropriate only on the assumption that the human body can effectively deal with somewhat higher peak concentrations over shorter exposure times, and without either irreversible damage or permanent accumulation of the pollutant within some part of the body.

For some pollutants (including those with chronic impacts), the medical evidence indicates that short-term exposures do in fact have acute detrimental effects on people's health, particularly the vulnerable in the community such as children, the elderly and those with existing medical conditions. In these cases, air quality standards are specified for much shorter averaging periods.

As clinical and epidemiological research continues to identify the health impacts of both long-term and short-term exposures to different concentrations of different pollutants, the air quality standards and goals, and other regulations, may be adjusted to reflect this new knowledge.

5. Site-specific monitoring

Some large industries are required to install ambient air quality monitors in locations affected by their operations, to measure the specific impact from their emissions. The results from such monitoring activities are typically required to be reported to the NSW Government or the NSW Environment Protection Authority (EPA), or both.

There may also be requirements established through development consent conditions for these monitoring results to be made available to the public.

6. Source emission monitoring and measurement requested by councils

Occasionally councils will want to specify testing for toxic and odorous emissions. Most emissions testing requested by councils will relate to smoke and particulate matter for which emission concentration limits are specified for non-scheduled premises in Schedule 2, Part 3 of the Protection of the Environment (Operations) Clean Air Regulation 2022 (Clean Air Regulation).

The need for compliance testing should be considered in each situation, balancing the potential expense incurred by the operator against likely sensitivity and the extent of likely impact.

A typical compliance testing condition would require:

- tests to be carried out in accordance with the EPA *Approved methods for the sampling and analysis of air pollutants in NSW* (EPA 2022b) by an accredited testing body (NATA or equivalent), and within a reasonable time of commissioning (typically 3 months)
- results to be reported to council within a specified time (typically one month from the testing)
- interpretation and commentary on the test results to be provided to council.

It is noted that, once a system has been optimised, compliance may be readily demonstrated by ensuring regular maintenance of pollution control equipment such as filtration, carbon adsorption and scrubbers.

Details of further standards to be met are given in Module 2, *Legislative and policy framework for air quality management*.

6.1 Calibrated in-stack measurements of smoke/dust

The Clean Air Regulation allows for opacity to be measured by a calibrated in-stack instrument. In-stack instruments operate on the principle of suspended particles scattering and absorbing a beam of light. The light transmitted through the gas carrying smoke or other particles is measured.

The *Approved methods for the sampling and analysis of air pollutants in NSW* (EPA 2022b) sets rigorous requirements for instruments measuring opacity for enforcement purposes. Note that these instruments, called 'transmissometers', work on the principle of measuring light transmission. With appropriate situation-specific calibration, transmissometers can be used to measure particulate emissions continuously (see Section 6.5 'Continuous particulate measurement' of this module). They are an order of magnitude more expensive than commonly installed 'dust monitors', which work by inducing an electrodynamic signal when moving particles hit the sensor probe.

Stack instruments can be required as conditions of consent or as part of a notice or direction in industries where maintaining clean combustion is a priority. However, high-quality 'transmissometer' instruments can be relatively expensive and should not be required for most small-to-medium installations that are not likely to present combustion problems in operation, especially if gas fired. A simple dust monitor can give the operator adequate warning of a combustion or dust problem.

The percentage 'opacity' of a gas stream is the percentage of incident light scattered and absorbed by the particles in the gas:

$\% \text{ opacity} = 100 - \% \text{ transmittance}$.

Thus, an opacity of 0% means there is no light obstruction, while at 100% opacity no light passes through the gas stream.

6.2 In-stack measurement of particles

Particulate emissions within a stack may be measured using an isokinetic technique to obtain an accurate reading. This requires that a stack test be organised and set up with the necessary standard fittings in the flue or stack and with appropriate and safe access platforms for the testing team.

Isokinetic testing is important if an accurate and legally acceptable test is to be obtained for any gas stream containing particles or liquid droplets. Purely gaseous pollutants do not need to be sampled isokinetically. Isokinetic sampling can add substantially to the difficulty and cost of testing.

Many of the tests for toxic pollutants (e.g. metals, dioxins, polyaromatic hydrocarbons) may involve isokinetic sampling since some of the pollutants will be present in particulate, aerosol or droplet form. Also, if the gases are very hot or contain much moisture, it may be necessary to use a heated probe for the testing (to avoid condensation on the probe).

Isokinetic sampling requires that measurements of gas velocity be completed at each testing point in the stack or duct, and the suction into the sampling probe maintained at a rate to ensure the velocity of the gas entering the probe is the same as the velocity of the gas passing the probe – hence the term iso (meaning the same) and kinetic (meaning movement). If the sample is not taken in this way, it will not be representative of the particulate concentration being sampled.

6.3 Analysis and reporting of particulates from stacks

The sample gases drawn from the stack are passed through a pre-weighed filter and the particles collected on the filter are post-weighed and analysed as required. Reporting of stationary source emissions should follow the reporting inclusions as specified in Section 5.2 of the *Approved methods for the sampling and analysis of air pollutants in NSW* (EPA 2022b).

6.4 Sampling plane location and what to look out for

It is important to ensure sampling is conducted in a location within the gas stream duct that is in a straight, preferably vertical, section of stack away from flow obstructions such as bends, junctions, fans, louvers or the stack exit. This will provide a relatively even flow distribution. Ideally this is more than 8 stack diameters downstream from a bend, connection, junction or fan outlet, and greater than 2 diameters upstream of an exit. This cannot always be achieved and compromises may need to be considered, such as increasing the number of sampling points on the sampling traverse. Refer to Figure 8, which shows the sampling plane.

The criteria for sampling plane compliance and selection of sampling points is found in AS 4323.1:2021 *Stationary source emissions Selection of sampling positions and measurement of velocity in stacks*.

The testing methods are detailed in the *Approved methods for the sampling and analysis of air pollutants in NSW* (EPA 2022b) and tests should only be carried out by accredited and experienced testers. The testing team should be familiar with the requirements of the regulation and testing standard being used and the situations in which the various techniques should be applied.

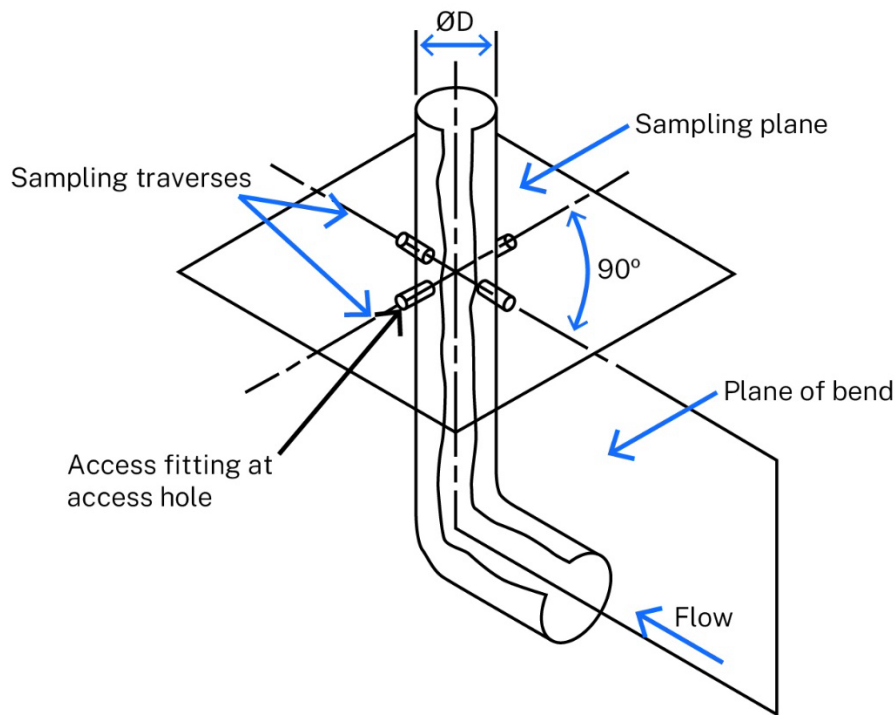


Figure 8 Sampling plane for a gas stream duct

If local government officers specify particulate testing, the inherent methodology of in-stack measurement of particles is relatively difficult and requires considerable time and effort to organise and carry out.

Therefore, stack tests for particulate emissions or requiring isokinetic sampling should only be specified when there is a clear justification. Typically, a one-off test may cost in the region of \$10,000 depending on the set-up costs involved (e.g. stack openings, platforms, ladders).

It should be evaluated whether such costs may be better allocated elsewhere (e.g. housekeeping or engineering solutions) to achieve the desired pollution control outcome.

6.5 Continuous particulate measurement

The technique and instruments used for measuring opacity for compliance (transmissometers) described in Section 6.1 can also be used for indirect continuous measurement of particulate concentrations.

There is not a simple relationship between the mass of particulate matter present in a gas being discharged and the light interference properties of the particles; thus a correlation must be made for each situation before mass emissions of particulates can be reliably monitored. However, once such site-specific relationships are established; that is, the instruments are calibrated to the situation, continuous monitoring can be valuable for managing environmental performance, especially for a process that is inherently variable.

6.6 Continuous gaseous measurement

Local government will only rarely have to consider gaseous monitoring of pollutant emissions but should be aware that there are many well-developed techniques for monitoring gaseous pollutants both on a specific-testing basis and continuously.

Typical gases that can be monitored continuously include:

- nitrogen oxides (NO_x)
- sulfur dioxide (SO₂)
- volatile organic compounds (VOCs) (as hydrocarbons)
- acid gases
- carbon monoxide (CO)
- carbon dioxide (CO₂)
- oxygen.

See Part 2 of this module for further discussion about the nature, trends and impacts of gaseous pollutants.

6.7 Odour emission testing

There is no reliable method of directly measuring odour using scientific instruments. The best odour detecting instrument is the human nose. Odour tests involve taking samples of air at the point of emission and quickly transferring the samples to a panel of carefully selected odour observers. The panel determines the degree of dilution of the odour required to reach the point of non-detection, which in turn awards a number of 'odour units' to the odorous air sample.

There are several methods for this type of testing and it is highly specialised, and therefore relatively expensive. Even then significant differences persist between the various methods used to measure odours. For relatively minor problems, careful field assessment of the odours might be more practical and effective than calling for expensive odour testing. Such techniques can be completed by council officers and are described in Chapter 3 of the Local Government Air Quality Toolkit – *Resource pack*.

Local government officers should be aware of the uncertainties and expense involved in odour concentration testing, which usually needs to be interpreted in terms of atmospheric dispersion modelling, another potentially expensive component of the assessment.

Odour testing is discussed further in Part 4 of this module. The guidelines in the Local Government Air Quality Toolkit – Module 3 address particular types of premises or activities where odour problems typically arise.

7. References and other resources

All documents and webpages that are part of the Local Government Air Quality Toolkit are available from the EPA website.

EPA (2022a) *Approved methods for the modelling and assessment of air pollutants in NSW*, NSW Environment Protection Authority, Parramatta NSW, www.epa.nsw.gov.au/your-environment/air/industrial-emissions/approved-methods-for-the-modelling-and-assessment-of-air-pollutants.

EPA (2022b) *Approved methods for the sampling and analysis of air pollutants in NSW*, NSW Environment Protection Authority, Parramatta NSW, www.epa.nsw.gov.au/your-environment/air/industrial-emissions/sampling-analysing-air-emissions/approved-methods-sampling-analysing-air-pollutants.

NSW Government (2024a) *Air quality in my area*, NSW Government, www.airquality.nsw.gov.au/air-quality-in-my-area.

NSW Government (2024b) *Current air quality in New South Wales*, NSW Government, www.airquality.nsw.gov.au.

NSW Government (2024c) *Air quality data download facility*, NSW Government, www.airquality.nsw.gov.au/air-quality-data-services/data-download-facility.

NSW Government (2024d) *Air quality categories*, NSW Government, www.airquality.nsw.gov.au/health-advice/air-quality-categories.