Local Government Air Quality Toolkit

Module 1: The science of air quality

Part 2: Air pollutants and effects on human health

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This resource may contain images or names of deceased persons in photographs or historical content.

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1. Introduction

Air pollution is the build-up of substances in air, in sufficient concentrations to cause a measurable effect on humans, animals, vegetation or materials.

In 1998, Australia adopted a National Environmental Protection (Ambient Air Quality) Measure (AAQ NEPM) that established national standards for 6 pollutants (NEPC 1998). The AAQ NEPM was extended in 2003 to include advisory reporting standards for particulate matter with an aerodynamic diameter of less than 2.5 µm ($PM_{2.5}$).

In 2016 the National Environment Protection Council (NEPC) approved a variation to the AAQ NEPM and strengthened standards for particles to reflect the latest scientific understanding of their health risks. On 15 April 2021, the NEPC agreed to vary the AAQ NEPM, approving an amending instrument to incorporate more stringent standards for nitrogen dioxide (NO_2), sulfur dioxide (SO_2) and ozone. The tightening of standards for SO_2 and $PM_{2.5}$ is also planned for 2025.

This section deals with these NEPM pollutants as well as other pollutants commonly encountered in urban and regional areas, including their chemical and physical properties and recent trends in their occurrence in New South Wales. Emphasis is given to the pollutants that are most commonly managed and regulated by local government.

2. Make-up of the atmosphere

The atmosphere is mainly composed of nitrogen (78%), oxygen (21%) and argon (1%). The content of water vapour in the atmosphere varies with temperature. Various trace gases are present, including the greenhouse gases carbon dioxide, methane, nitrous oxide, and compounds that are commonly considered to be air pollutants, such as sulfur dioxide, carbon monoxide, nitrogen oxides, ozone (a pollutant at ground level) and ammonia. The atmosphere also contains solid and liquid particles produced both naturally and by human activities.

Air pollutants can generally be grouped into 2 key categories:

- gases
- particles.

2.1 Gaseous pollutants

The following gaseous pollutants are described in further detail below:

- sulfur dioxide (SO_2) – NEPM criteria pollutant
- carbon monoxide (CO) – NEPM criteria pollutant
- nitrogen oxides (NO_x) – NEPM criteria pollutants
- ozone (O_3) – NEPM criteria pollutant
- ammonia (NH_3) – non-NEPM criteria pollutant monitored at Stockton.

Sulfur dioxide (SO_2)

SO_2 is a colourless gas with a sharp odour. It is one of the 7 key air pollutants for which national air quality criteria have been set.

Sources

Human activities contribute to emissions of SO_2, mainly from the combustion of coal, the production of aluminium and other metals, and combustion of fuel oils (including shipping transport). In New South Wales, the largest contribution is from coal-fired power stations.

Impacts of SO_2 on human health

Regarding human health, SO_2 irritates the nose, throat and airways causing coughing and shortness of breath. It aggravates asthma and chronic bronchitis and increases susceptibility to respiratory tract infections. The molecules can attach themselves to particles and if these are then inhaled they can cause more serious effects such as emphysema from long-term exposure.

A concern with SO_2 is short-term exposure to high concentrations in the near vicinity of activities that emit significant amounts of the gas, which under some meteorological conditions may be brought to ground level in high concentrations. Infrequently, high concentrations may also occur due to abnormal conditions within a facility – through industrial accidents or breakdown of poorly maintained equipment.

While SO_2 is the principal sulfur compound that is introduced into the atmosphere through human activities, it is only one of several sulfur compounds that participate in a global sulfur cycle. Others are hydrogen sulfide (H_2S, 'rotten egg' gas), dimethyl sulfide $(CH_3)_2S$, and sulfur trioxide (SO_3). These all participate in complex chemical reactions in the atmosphere.

These reactions can result in the oxidation of SO_2 to sulfate ions in rainfall, a component of acid deposition. Another chain of reactions results in the formation of sulfate salts as fine particles that contribute to haze and may play a role in climate change.

Figure 1 shows the contributors to 'natural' and anthropogenic SO_2, and the resultant issues formed by reaction of SO_2 in the atmosphere.

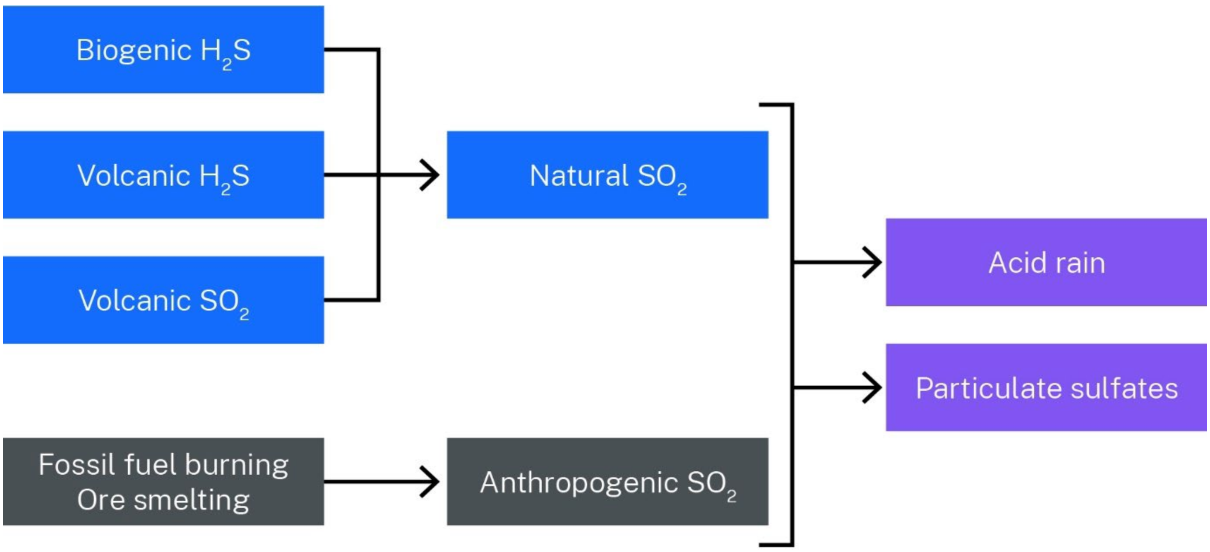

Figure 1 Contributors to SO_2 and resultant issues

Trends in ambient SO_2 levels

Concentrations of SO_2 are generally below the national air quality standards set in the AAQ NEPM in most areas (EPA 2020). Figure 2 shows maximum 24-hour average SO_2 concentrations for several NSW regions from 2000 to 2023. The data shows a general reduction over time, with few exceedances of the criterion in recent decades in most regions. SO_2 monitoring in the Upper Hunter began in 2011, with data showing exceedances occurring, mostly due to emissions from nearby coal-fired power stations.

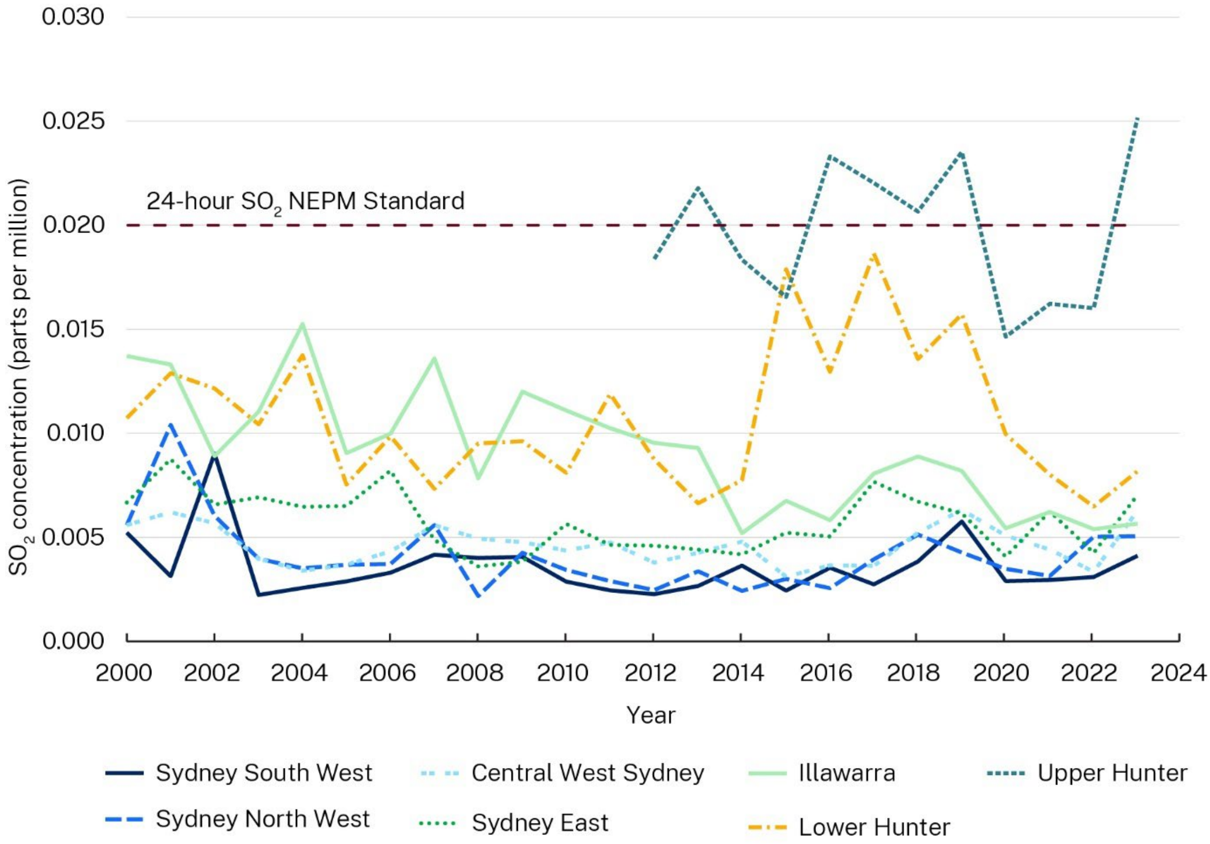

Figure 2 **NSW air quality trends for maximum 24-hour average SO_2 concentrations from 2000 to 2023**

Source: NSW Government (2024a)

Carbon monoxide (CO)

CO is another key air pollutant for which national air quality criteria have been set. It is a colourless and odourless gas.

Sources of CO

CO is a product of the incomplete combustion of organic material and its main natural sources are bushfires. Sources associated with human activities are motor vehicle emissions, some industrial activities such as steel making, and agricultural burning. Elevated levels of CO in ambient air are primarily encountered in areas with high traffic density with poor dispersion, the primary source being motor vehicle usage.

Impacts of CO on human health

High concentrations of CO are poisonous to humans, affecting both healthy and unhealthy people alike. It acts by combining with haemoglobin, preventing normal uptake of oxygen and so reducing the oxygen carrying capacity of blood. This means that at high CO concentrations, vital bodily organs may be deprived of oxygen and therefore cannot function properly. Fortunately, in the ambient environment the effects are reversible when the person is no longer exposed to the gas. People with cardiovascular disease are particularly susceptible to exposure to high CO concentrations.

Trends in ambient CO levels

In most Australian towns and cities, concentrations of CO in air are now well below those that are hazardous to human health (EPA 2020). The AAQ NEPM goal of less than 9 ppm (or 10 mg/m^3) set for 2008 was achieved by 2000 through implementing catalytic converters to meet vehicle emission standards. The highest concentrations of CO are likely to be experienced in the 'street canyons' created by multi-storey buildings adjacent to busy roads.

Figure 3 shows maximum annual 8-hour rolling average CO concentrations for several NSW regions from 2000 to 2023. The trend shows that CO concentrations have generally decreased over the last 23 years. A spike in Sydney East in 2021 occurred due to the proximity of the monitoring station to a hazard reduction burn, demonstrating the potential air quality impacts of smoke. CO spikes in 2019 and 2020 across all regions are attributed to smoke from bushfires during the 2019–2020 bushfire season. CO monitoring in the Upper Hunter began in mid-2020, after the bushfire season.

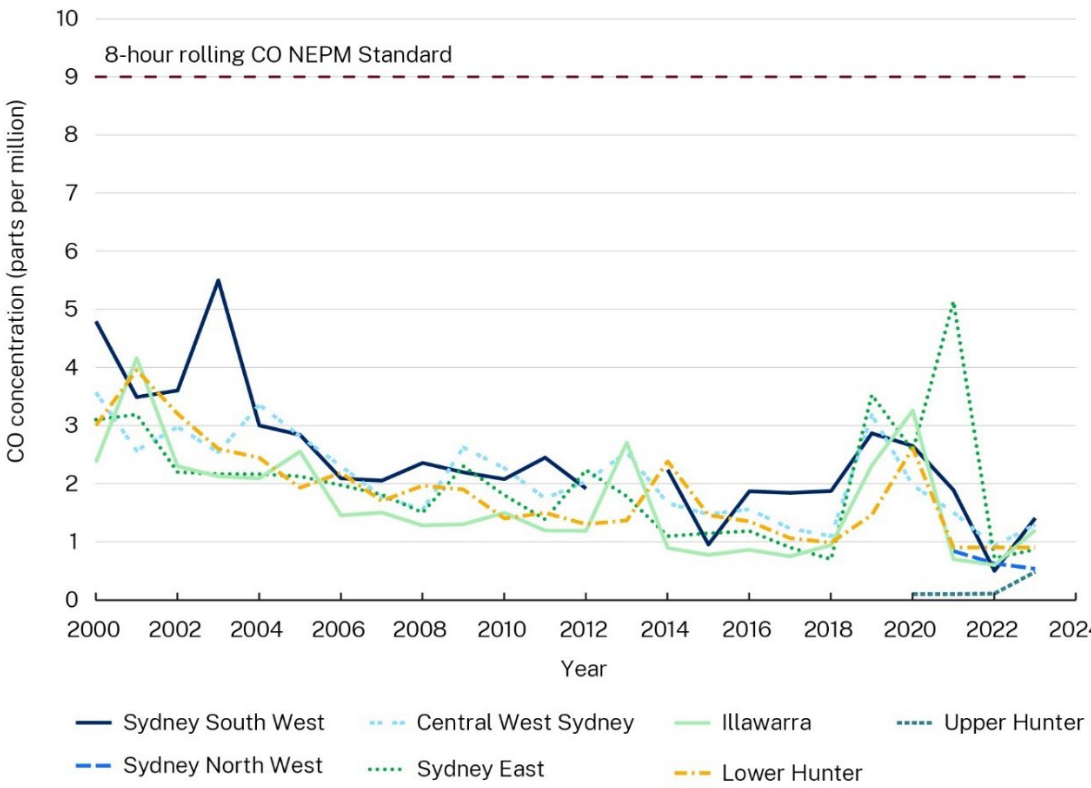

Figure 3 **NSW air quality trends for maximum annual 8-hour rolling CO concentrations from 2000 to 2023**

Source: NSW Government (2024a)

Nitrogen oxides (NO_x)

The 2 nitrogen oxides that are air pollutants of concern are nitric oxide (NO) and nitrogen dioxide (NO_2), collectively called NO_x. NO is a colourless, odourless gas. NO_2 is a brownish, highly reactive gas with an acrid smell when in very high concentrations; however, it is normally neither smelt nor visible in the atmosphere.

NO is the primary form in which NO_x is emitted, but it is usually converted relatively rapidly in the atmosphere to the more reactive NO_2, which is one of the 7 key pollutants included in the AAQ NEPM. Nitrogen oxides are pollutants of concern because they contribute to the formation of photochemical smog, which can have significant impacts on human health. This is treated in more detail in the next section.

Sources of NO_x

Some NO is formed naturally in the atmosphere by lightning and some is formed biologically. However, these natural sources contribute only about 1% of the NO_2 found in urban air. Sources of NO_x in urban and regional areas of New South Wales include coal-fired power stations, motor vehicles, and diesel combustion from heavy machinery. However, there are significant differences between the large cities and rural areas with Sydney, Newcastle and Wollongong accounting for most of the state's aggregate from motor vehicle emissions.

Impacts of NO_x on human health

The major impacts of NO_x are:

- reaction with volatile organic compounds (VOCs) to form photochemical smog (see 'Ozone and photochemical oxidants' below)
- direct impact of NO_2 on human health as NO_2 is an irritant and oxidant that has been linked to a range of adverse health effects including decreases in measures of lung function, increases in respiratory symptoms such as airway inflammation, lung infections and breathing difficulties, and asthma prevalence and incidence.

Trends in NO_2 levels

Concentrations of NO_2 are consistently below national air quality standards set in the AAQ NEPM in all regions (EPA 2020).

Figure 4 shows annual average NO_2 concentrations for several NSW regions from 2000 to 2023. The data shows a general reduction over time. Concentrations dipped slightly in 2020, likely due to lower traffic volumes as a result of COVID-19 lockdowns. In some regions, these NO_2 concentrations have begun to stabilise over recent years.

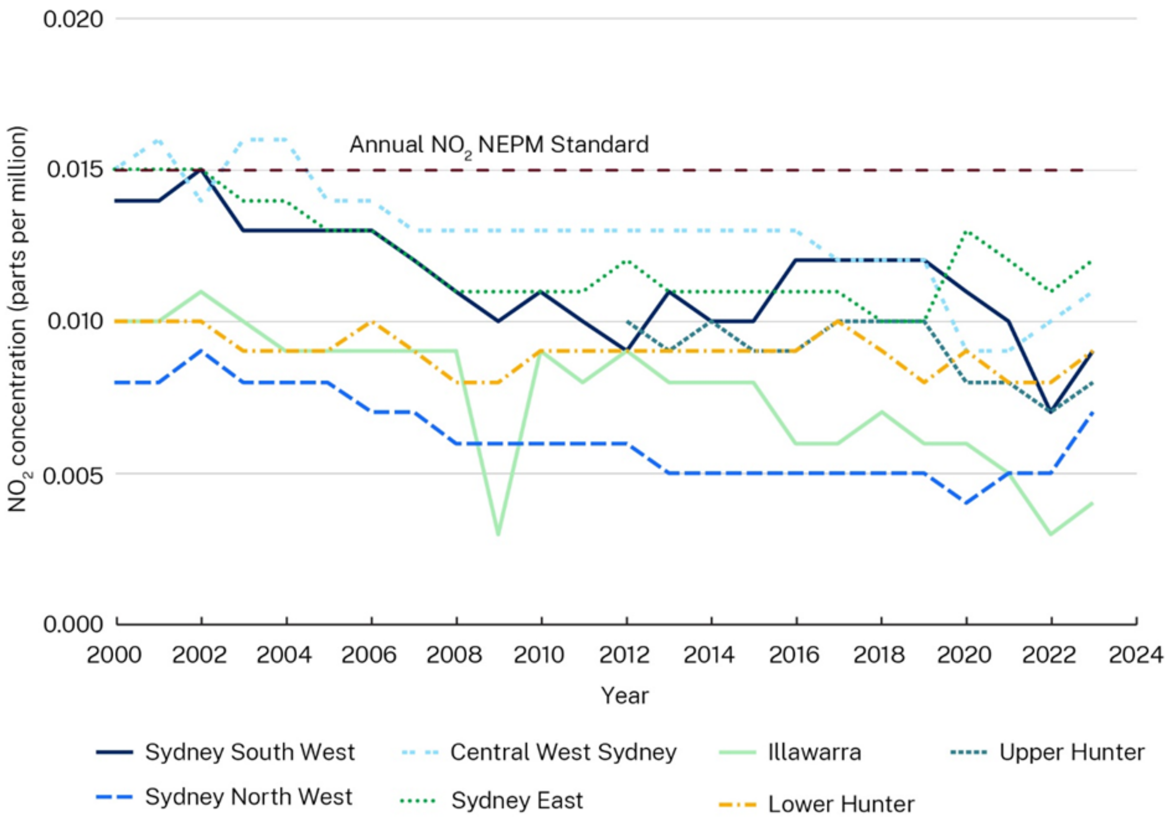

Figure 4 **NSW air quality trends for annual average NO_2 from 2000 to 2023**
Source: NSW Government (2024a)

Ammonia (NH_3)

Ammonia is a colourless gas with a distinctive, pungent odour.

Sources

Ammonia is produced both naturally and by industrial processes, most commonly for use in fertilisers. It is also used as a refrigerant gas, as a water purifier, and in the manufacture of plastics, explosives, fabrics, pesticides, dyes and other chemicals. It is also contained in many household and industrial-strength cleaning products.

Impacts of NH_3 on human health

Exposure to typical environmental concentrations of ammonia will not affect human health. However, exposure to elevated levels can cause eye and throat irritation, and burns on the skin, in the mouth, and in the lungs. In even higher concentrations, it can lead to reduced liver function, corneal disease, glaucoma, respiratory diseases, and death. Ammonia also contributes to the formation of secondary particulate matter, which represents a risk to human health.

Trends in NH_3 levels

Ammonia has been monitored at the Stockton air quality monitoring station since 2015. There have been no exceedances of the NSW 1-hour assessment goal for ammonia, and Figure 5 shows the concentrations have been relatively stable over the last 9 years.

Trend data is available for Stockton on the *Current air quality in Stockton* webpage (NSW Government 2024b).

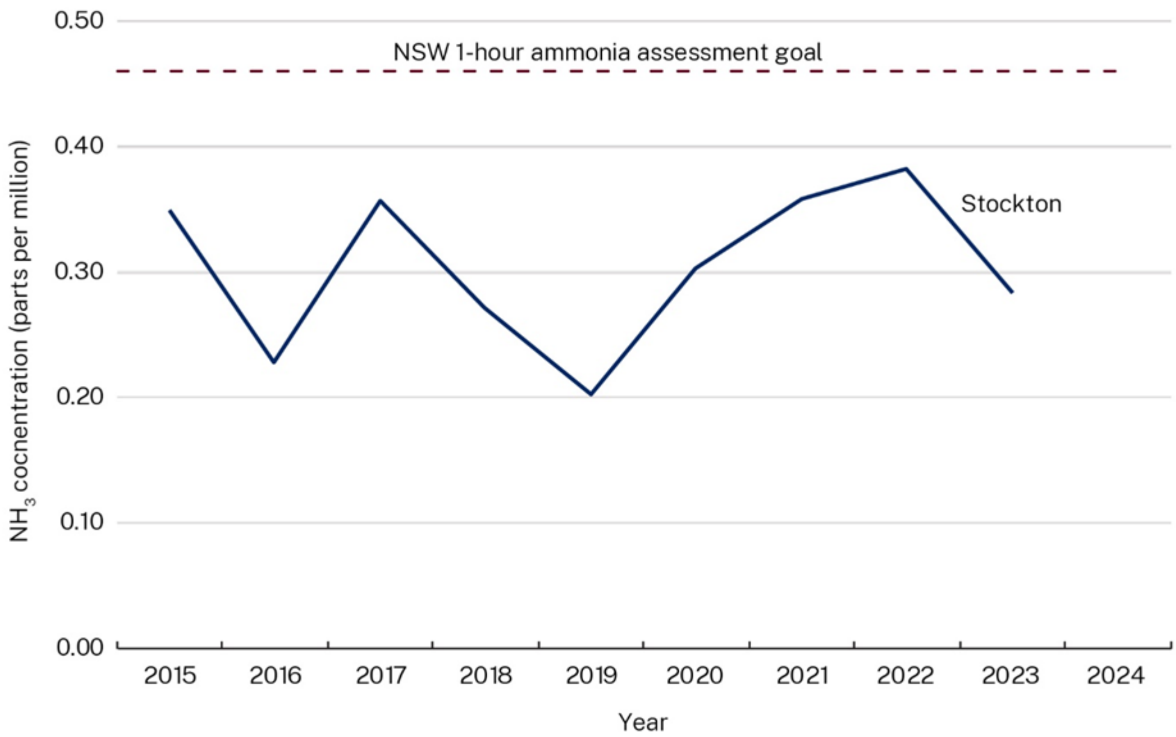

Figure 5 **NSW air quality trends for maximum annual 1-hour NH_3 concentrations from 2015 to 2023, as measured at Stockton**

Source: NSW Government (2024b)

Ozone and photochemical oxidants

Ozone

Ozone is important at 2 levels in the atmosphere: in the troposphere (the air layer next to the Earth's surface) and in the stratosphere (a higher air layer, above the troposphere).

In the troposphere high concentrations of ozone are harmful to health, vegetation and materials. It is the main constituent of photochemical air pollution (smog) and is a very reactive gas causing deterioration of all types of organic materials it comes into contact with. Gaseous ozone is the measured indicator of photochemical smog and is used to set the ambient standard for this type of pollution in the AAQ NEPM.

In the stratosphere, high concentrations of ozone are beneficial as ozone shields the Earth's surface from damagingly high levels of ultraviolet radiation from the sun.

Upper-level (stratospheric) ozone is destroyed by the release of ozone-depleting substances such as chlorofluorocarbon refrigerants. The release of these materials is internationally controlled under the Montreal Protocol on Substances that Deplete the Ozone Layer (UNEP 1987) and locally controlled in New South Wales under the *Ozone Protection Act 1989*.

Ozone is an ephemeral gas at both the tropospheric and stratospheric levels, being continually formed and destroyed by dynamic, light-catalysed reactions. The concentration at any time depends on the competing rates of destruction and formation. It is more difficult to measure accurately than most other gaseous pollutants since standard calibration gases cannot be stored.

Figure 6 shows ozone and the atmospheric levels.

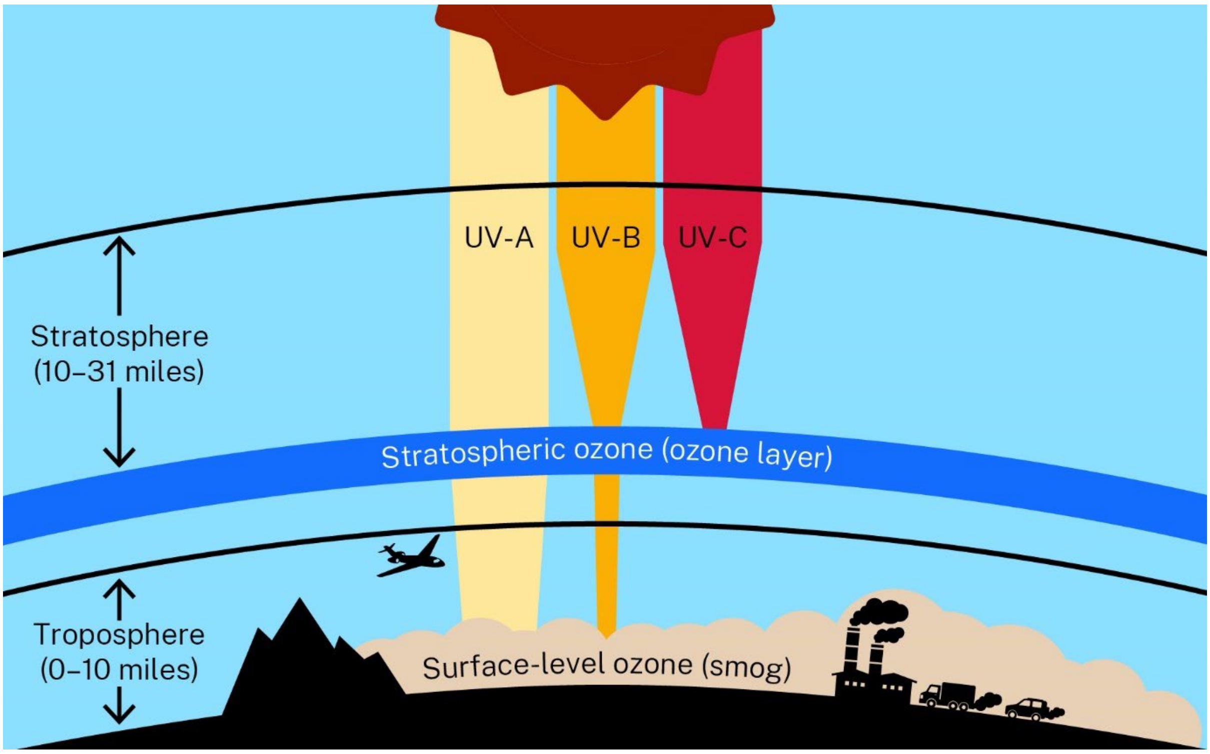

Figure 6 Ozone and atmospheric levels

Health impacts of tropospheric (low-level) ozone

Ozone is a very strong oxidising agent. It damages sensitive tissues of the body, such as in the lungs, airways and eyes. Ozone is used as a surrogate for other products of oxidant reactions, including peroxyacetyl nitrate (PANs) and fine particles.

The health effects include shortness of breath and chest pains, especially in people exercising or working hard outdoors, increased incidence of asthma, and eye irritation. Fine particles and aerosols are also created during the formation of photochemical smog and have an impact on health and visibility, as described below.

It is difficult to isolate the effects of ozone gas from the other constituents of the smog in health studies. PANs, for example, are probably the main promoters of eye irritation. While the effects of ozone exposure tend to be short-term, laboratory studies have also shown effects on lung tissue for longer-term and repeated exposures.

The strong oxidising capability of ozone also causes damage to vegetation. Some commercial and ornamental plant species are particularly sensitive to ozone damage. Many modern products exposed to the atmosphere such as rubbers and polymers suffer deterioration when exposed to the oxidants of this smog.

Photochemical air pollution

Photochemical oxidants are products of the reaction of VOCs and NO_x in the atmosphere. The reaction is promoted by exposure of the mixture to strong sunlight. It is a seasonal phenomenon, since concentrations of ozone and oxidants only reach levels of concern in summer, when the sun's radiation is strongest.

Figure 7 shows the process for the creation of ground-level ozone.

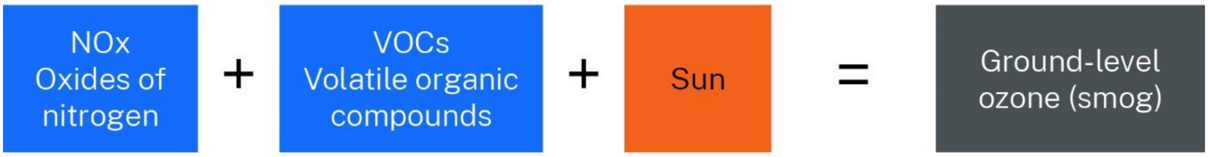

Figure 7 Creation of ground-level ozone

Photochemical oxidant pollution tends to be identified primarily with car and vehicle pollution, but there is a significant contribution from industry and other urban activities, both commercial and individual.

The photochemical reaction between the 2 oxides of nitrogen occurs naturally in sunlight but does not result in levels of ozone being formed above concentrations of concern if no significant concentrations of VOCs are present.

The reactions usually take 3–4 hours for the concentrations of oxidants (as indicated by ozone) to build up to significant concentrations. Therefore, smog is only formed on days with appropriate meteorological conditions, such as morning trapping of NO_x and VOC pollutants, relatively light air movements and strong sunlight.

Volatile organic compounds

VOCs enter the atmosphere from many diffuse sources including petrol vapour from unburned fuel from motor vehicles, service station pumps, spills from lawn mowers and evaporation of solvents in industrial activities.

Trend data are not available for VOCs in New South Wales.

Control of photochemical oxidants

Care is needed in monitoring ozone. If the monitors are located too close to concentrated sources of nitrogen oxide emissions, such as heavy traffic lanes or near large industrial combustion sources or in central business districts (CBDs), then low values are likely to be measured. This is because the dominant form of nitrogen oxides from combustion is nitric oxide (NO). This reacts very rapidly with ozone already formed to convert it to NO_2 (Figure 8). As the air parcel ages the nitrogen oxides become more dispersed and NO will be preferentially converted to NO_2 by a reaction with ozone and existing photochemical reactions (VOCs and oxidants). This keeps NO limited. These conditions can contribute to elevated ozone levels and reduced NO.

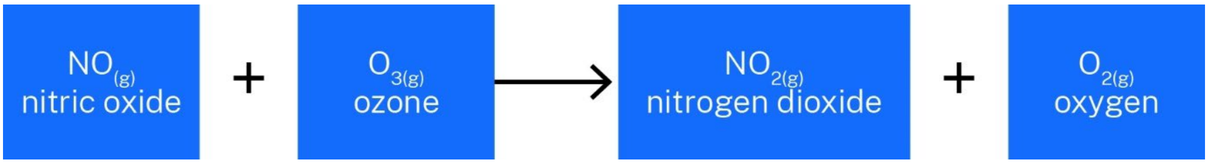

Figure 8 **Conversion of nitric oxide to nitrogen dioxide**

Ozone can be managed by controlling the VOC and NO_x precursors to greater or lesser extents. For example:

- Motor vehicle emissions are regulated nationally for both NO_x and VOC emissions, the latter from both tail pipes and evaporative emissions. This aims to limit the amount of pollutant for a kilometre travelled, not the distance the vehicle travels in a day.
- Evaporative emissions of VOCs from distribution of petroleum products and some solvents are controlled in large storage facilities.
- Combustion emissions of NO_x from large industrial facilities and power plants are controlled in New South Wales by the Protection of the Environment Operations (Clean Air) Regulation 2022.
- The wider adoption of electric vehicles (EVs) is anticipated to reduce NO_x and VOC emissions from road transport.

Traffic management

Where local government can influence traffic congestion and generation, it can have a significant impact on the potential for ozone and oxidant pollution within the broader air basin in which it is located.

Traffic generation and congestion can be influenced by sustainable urban planning for walking and cycling facilities, and by good planning to reduce local trips; for example, for shopping or schools. These can all contribute to the reduction of vehicle kilometres travelled (VKT) in the region.

Similarly, incentivising the adoption of EVs by providing infrastructure such as free EV charging stations can have a tangible local air quality benefit.

Emissions of the precursors of photochemical smog in one local government area, and actions taken to manage them, have regional impacts on the air quality, including in other local government areas.

Trends in ambient concentrations of ozone

While significant improvements have been achieved in the Sydney, Illawarra and Lower Hunter air basins following early vehicular and industrial controls, and the introduction of catalyst equipped vehicles, ozone levels have remained stable over recent decades. The AAQ NEPM standard is exceeded regularly by stations in Sydney as well as those in the Illawarra and Lower Hunter.

Figure 9 shows the annual maximum 8-hour rolling average O_3 concentrations in New South Wales from 2000 to 2023. Annual average ozone concentrations have remained relatively consistent over time. However, after a peak in 2019 due to the 2019–2020 bushfire season, concentrations have reduced following successive years of above average rainfall, culminating in no ozone exceedances in any of the regions for the first time in more than 20 years.

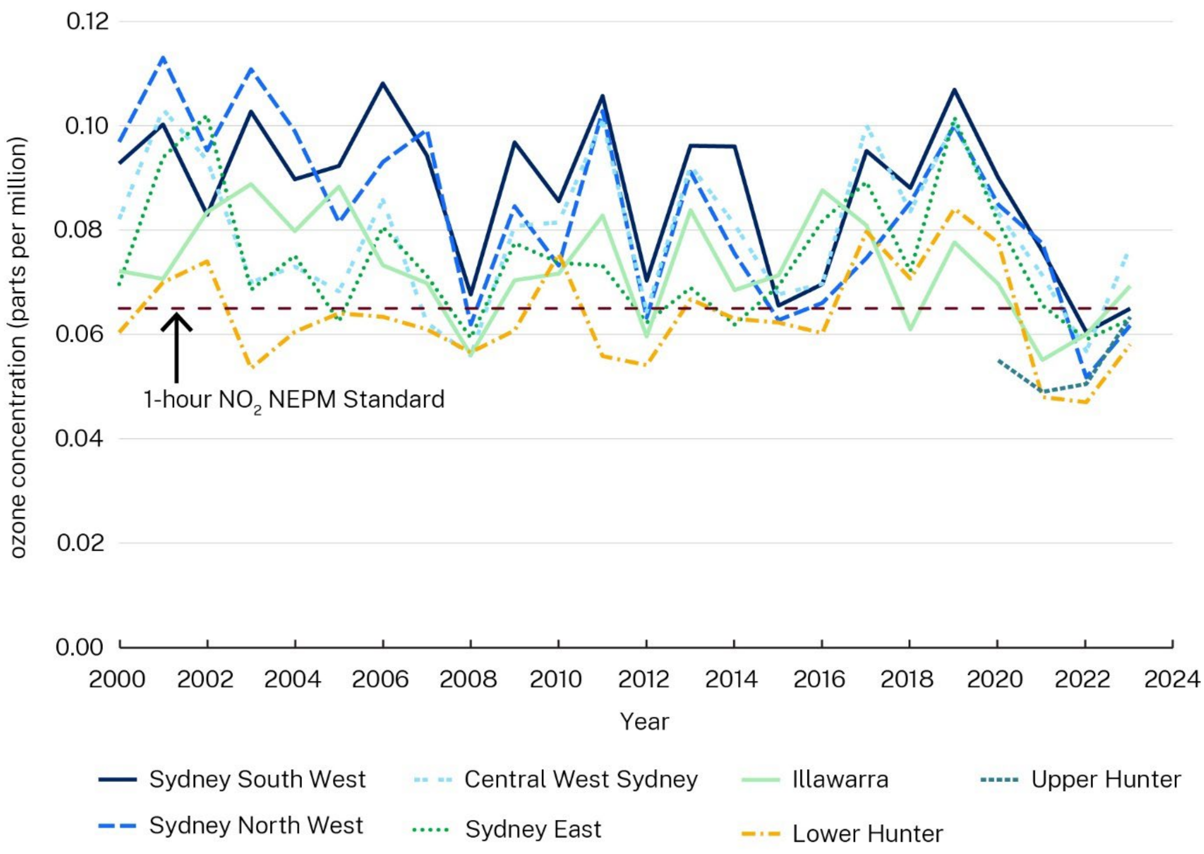

Figure 9 **NSW air quality trends for annual maximum 8-hour rolling O_3 concentrations from 2000 to 2023**

Source: NSW Government (2024a)

2.2 Particulate matter

New South Wales monitors PM_{10} and $PM_{2.5}$ against NEPM criteria standards. Particulate matter is also known as PM and describes extremely small solid particles and liquid droplets suspended in air. PM can be made up of various components including nitrates, sulfates, organic chemicals, metals, soil or dust particles, and allergens (such as fragments of pollen or mould spores). PM pollution mainly comes from motor vehicles, wood burning heaters and industry. During bushfires or dust storms, particle pollution can reach very high concentrations, when they appear as haze over a region or city. This is one of the most visible forms of air pollution.

Size and shape of airborne particles

Particles emitted from air pollution sources and formed by natural processes have many different sizes and shapes, and a range of densities; for example, water (1 g/cm^3) to some minerals (about 3 g/cm^3). Unlike the other pollutants, which can be unambiguously defined in terms of their chemical composition, ‘particles’ can be composed of a diverse range of elements and compounds that may be of natural or anthropogenic origin.

In managing particulates in air it is necessary to use a definition of particle size that relates directly to how the particles enter the human respiratory system. The idea of ‘aerodynamic diameter’ has been developed to provide such a definition. It takes account of the particle’s physical size, density and shape.

Particles of different shapes and densities can have the same aerodynamic diameter and so be grouped in the same size category. In the same way, particles that look very similar in size under a microscope, may be in different size categories as a result of their densities.

Atmospheric particulates are microscopic, so a very small unit of length is needed to indicate their size. In the metric system the unit is the ‘micrometre’, which is one millionth of a metre and has the symbol ‘μm’.

> Whenever a particle ‘size’ is specified in air quality management it refers to the aerodynamic diameter of the particle. The ‘aerodynamic diameter’ of a particle of any size, shape and density is the diameter of a spherical particle with a density of 1 g/cm^3 that behaves the same way in air.

Figure 10 presents the relative sizes of PM_{10} and $PM_{2.5}$ particles.

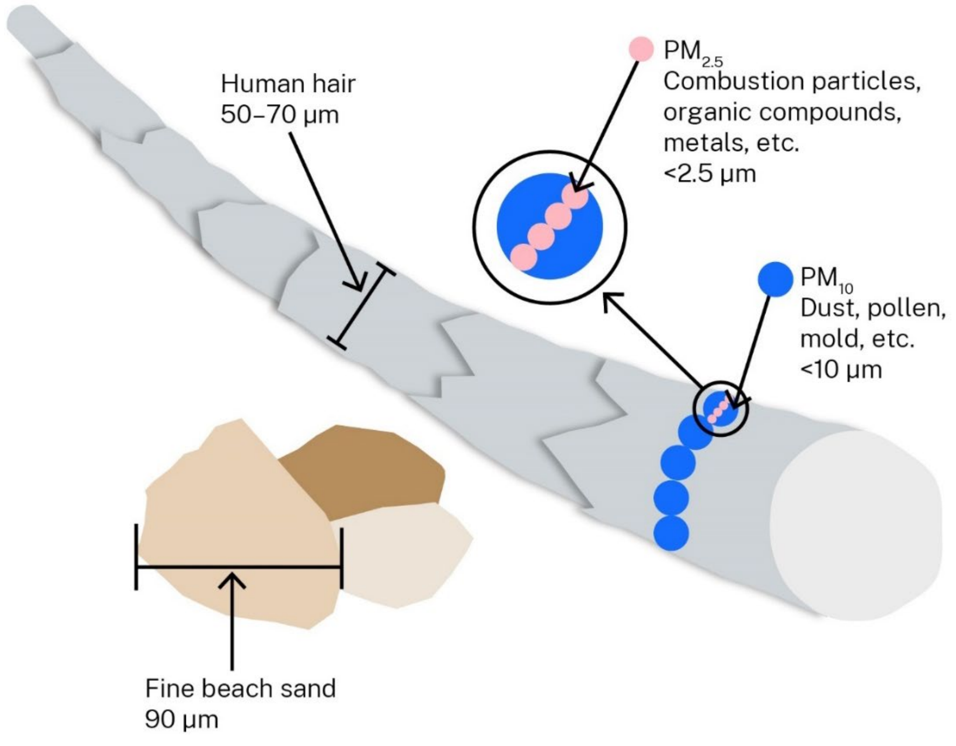

Figure 10 Relative sizes of PM_{10} and $PM_{2.5}$ particles

Particle size terminology

The terminology used to describe and categorise particles of concern for air quality management is somewhat complex. There are 2 common classification schemes for particles based on size and category (see Table 1 and Table 2). There is a wide range of particle sizes that relate to their potential impact on human health.

Particulate matter is also categorised by how it is regulated and tested for under the NEPM. These categories indicate how far particles typically penetrate the human respiratory system where they can have potential health impacts.

Table 1 **Particle description based on range of particle sizes**

Description	Particle size
Super coarse	10 µm–100 µm
Coarse	2.5 µm–10 µm
Fine	0.1 µm–2.5 µm
Ultrafine	less than 0.1 µm

Table 2 **Particle categories**

Category	Description
TSP (total suspended particulate)	All particles from 0.1 µm up to about 100 µm or more in diameter – in practice the major contribution to TSP is from particles significantly less than 100 µm
PM_{10}	All particles with an aerodynamic diameter less than or equal to 10 µm (sometimes called 'inhalable' particles)
$PM_{2.5}$	All particles with an aerodynamic diameter less than or equal to 2.5 µm (sometimes called 'respirable' particles)
PM_1	All particles with an aerodynamic diameter less than or equal to 1 µm

The larger PM_{10} particles generally stay in the air for minutes or hours and travel as little as 100 m or as much as 50 km.

The smaller $PM_{2.5}$ particles can sometimes persist in the air for days or weeks and can travel for hundreds of kilometres.

Sources of particulate matter

Some typical sources of particles are summarised in Table 3.

Table 3 **Typical sources of particulate matter**

Coarse & super coarse particles TSP & PM_{10}	Fine & ultrafine particles $PM_{2.5}$ & PM_1
Wind erosion of exposed surfaces (bare agricultural fields and salt pans)	Secondary formation from gaseous pollutants (e.g. photochemical smog)
Activities on construction sites	Motor vehicle emissions
Wheel generated dust (mining activities, unsealed roads)	Inefficient burning (wood burning)
Crushing and grinding rocks and metals	Smelting and purifying metals

Impacts of particulate matter

Health effects

The respiratory system of a healthy person is normally able to deal with most inhaled particles without long-term effects or undue stress. However, in cases of extreme exposure and more generally for sensitive individuals, the presence of airborne particles is associated with increased rates of respiratory illnesses and symptoms.

When particulate matter is breathed in, it travels into the respiratory system. Generally, the smaller the particles the further they can penetrate into the lungs and the worse their effect.

If the smaller $PM_{2.5}$ particles contain more toxic substances like trace metals and carcinogenic compounds, these may be carried deeper into the lungs than the normal bronchopulmonary defences would allow – with adverse effects. The finest particulate size fractions have even been shown to enter the blood stream.

Epidemiological studies have shown that exposure to particulate matter leads to increased use of medication, more visits to doctors or hospital outpatient services, and more deaths of medically-at-risk individuals.

The known health effects of exposure to particulate matter include:

- coughing, wheezing and shortness of breath
- aggravated asthma
- damage to the lungs that results in decreased function
- lifelong respiratory disease such as chronic bronchitis and emphysema
- premature death in people with existing heart or lung conditions.

Further explanation of these health effects:

- Asthma – this is caused by the periodic constriction of the bronchi and bronchioles making breathing more difficult. It is triggered by airborne irritants and chemicals.
- Chronic bronchitis – any small particle reaching the bronchi and bronchioles in the lungs stimulates increased secretion of mucus to try and remove the irritation. In chronic bronchitis these air passages become clogged with mucus leading to a persistent cough.
- Emphysema – when very small $PM_{2.5}$ particles penetrate deep into the lungs they are trapped and cause the delicate walls of the alveoli to break down. This progressively reduces the gas exchange area of the lungs, which in turn forces the heart to pump ever larger volumes of blood to the lungs to satisfy the body's needs. The added strain can lead to heart failure.

Other effects

Particulate matter in the air can cause various forms of damage to surfaces and materials, as well as being a significant nuisance. Examples include the need for more frequent cleaning and the sped-up abrasion of surfaces by dust particles. Over the years many car yards adjacent to dust-generating premises have been badly impacted, leading to costly reparation.

Unlike other common pollutants, there is no threshold concentration below which health effects don't occur as a result of exposure to PM_{10} and $PM_{2.5}$.

This means that all particulate goals are made based on judgements around acceptable levels of risk. It also means that exposure to particulates should be reduced as much as possible, regardless of ambient concentration.

Additionally, if the particles are themselves corrosive or have other pollutants, such as SO_2/sulfate, attached to them, they may corrode sensitive surfaces to which they adhere, especially if there is overnight condensation on the particles lying on the sensitive surfaces. In coastal areas wind-blown suspended sea salt particles are corrosive.

Local government can help manage particles by:

- making sure premises within their control are operating and maintaining air pollution control devices satisfactorily
- managing woodsmoke from domestic heaters
- strategic planning for the location of new industrial and commercial facilities within their area – in relation to local roads, residential areas and schools
- consent conditions on emissions for new premises and activities
- consent conditions on developments to influence motor vehicle use associated with new developments.

Trends in ambient concentrations of PM_{10} and $PM_{2.5}$

Exceedances of standards for particulate matter vary across seasons and years. The more moderate of these generally occur during the cooler months, with the highest concentrations observed during the early evening and early morning. They tend to be associated with stable atmospheric conditions that are conducive to clear cold nights and the development of inversions and drainage flows, which can result in the trapping of pollutants close to the surface and their transport, like in the Sydney region. This can be due to smoke from domestic wood heaters, or hazard reduction burning that is conducted during the cooler months as fires are less likely to burn out of control.

On the higher end, exceedances occur during warmer months, when conditions are favourable for bushfires and dust storms due to periods of hot and dry weather and drought. These conditions lower moisture in vegetation, making it easier to burn, as well as exposing more topsoil to windy conditions, allowing dust to become airborne more readily.

Figure 11 and Figure 12 show the maximum 24-hour average PM_{10} and $PM_{2.5}$ concentrations respectively from 2000 to 2023 for several NSW regions. Most of the data are above the 24-hour criteria due to smoke from bushfires, hazard reduction burning or wood heaters, as well as dust. The elevated concentrations in 2009 are due to a large dust storm in September, known as the Red Dawn dust storm. Concentration peaks in 2019 and early 2020 were the result of widespread bushfires and drought across New South Wales.

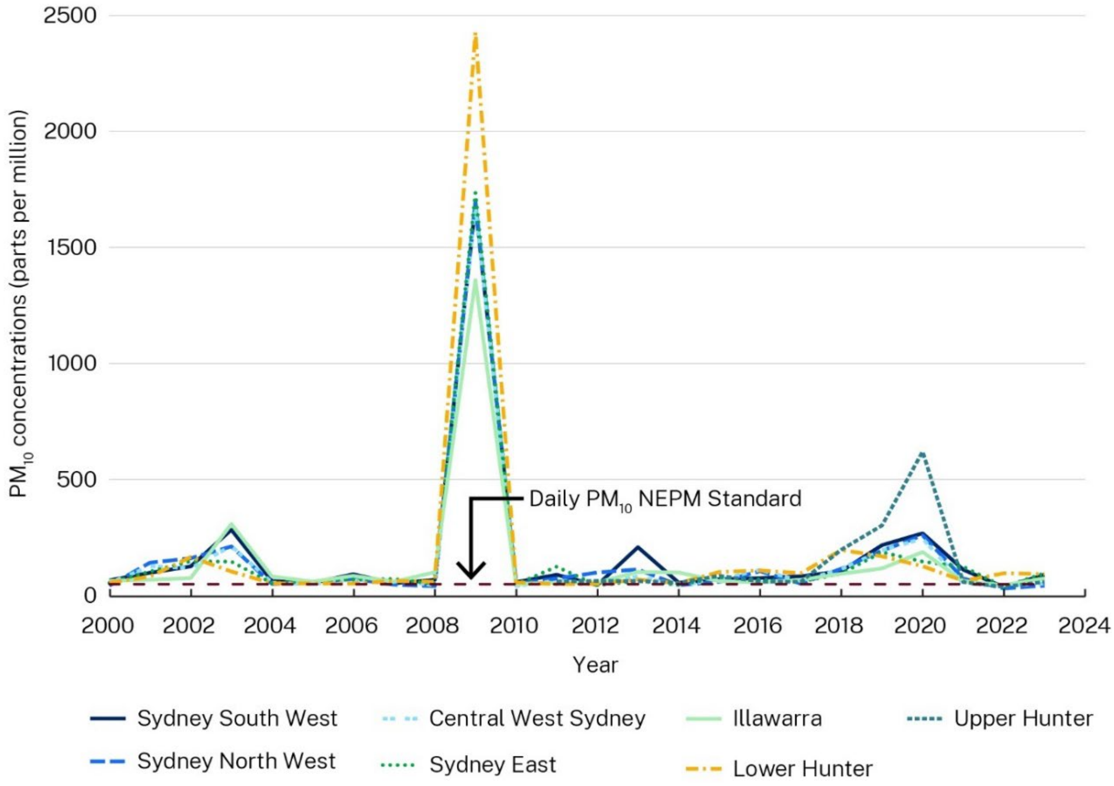

Figure 11 **NSW air quality trends for maximum 24-hour average PM_{10} concentrations from 2000 to 2023**

Source: NSW Government (2024a)

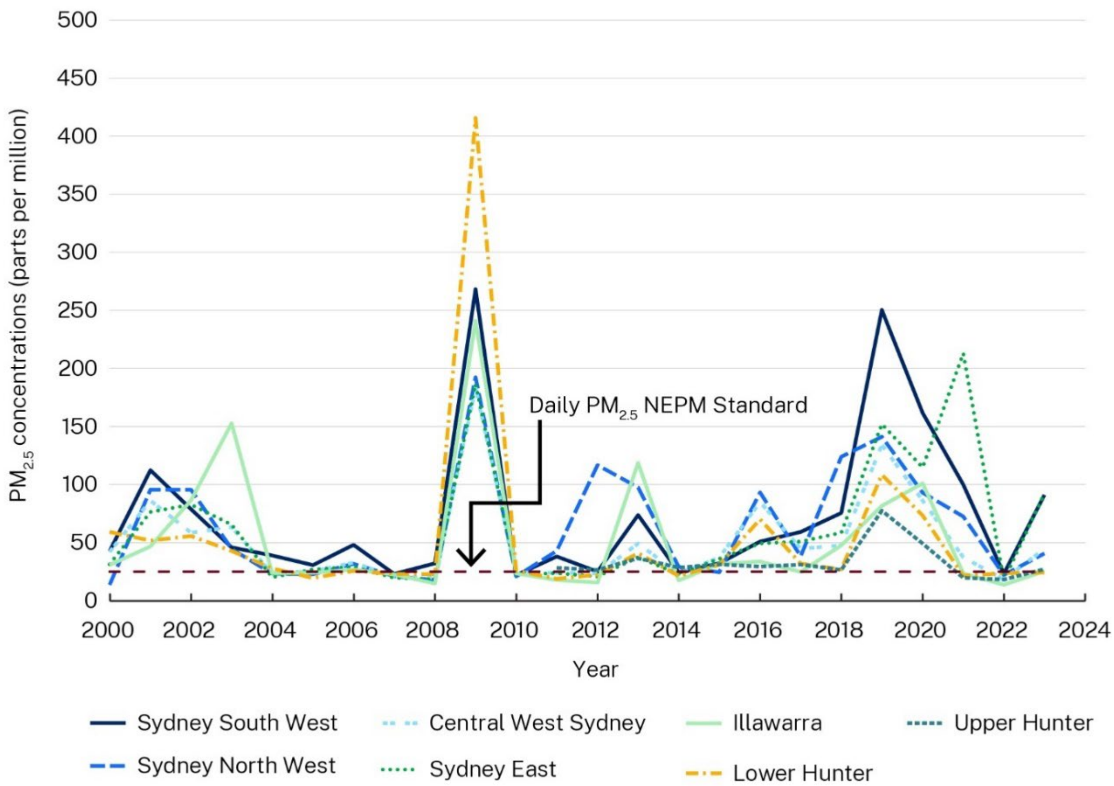

Figure 12 **NSW air quality trends for maximum 24-hour average $PM_{2.5}$ concentrations from 2000 to 2023**

Source: NSW Government (2024a)

3. References and other resources

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

DPE (Department of Planning and Environment) (2022) *NSW Clean Air Strategy 2021–2030*, NSW Department of Planning and Environment, Parramatta NSW, www.environment.nsw.gov.au/topics/air/clean-air-strategy.

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

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