Guideline for assessing and minimising air pollution in Victoria

EPA Publication 1961.2

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Environmental Public Health Branch

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Executive Summary

The *Guideline for assessing and minimising air pollution* provides a framework to assess and control risks associated with air pollution. It is a technical guideline for air pollution practitioners and specialists with a role managing pollution discharges to air. This guideline may also be of interest to others such as planners, resource managers, lawyers and the broader community.

Emitters of pollution to air have a responsibility under the general environmental duty to apply controls to eliminate or minimise risks to human health or the environment, so far as reasonably practicable. This requires duty holders to understand their risks, implement controls and review performance of controls (please refer to section 25(4)(b) of the Environment Protection Act 2017). This guideline outlines a risk management approach that involves a repeating cycle of four steps: identifying hazards, assessing risks, implementing controls, and checking controls.

Identifying hazards

There are many types of emission sources. These need to be identified and documented when assessing and controlling risks. Once identified, it is often necessary to quantify source emission rates.

The next step is to characterise the receiving environment, including local topography, meteorology, background air pollution and nearby sensitive land uses.

Assessing risks

This guideline provides a tiered approach to the assessment of risks from air pollution, with three levels of assessment in order of increasing complexity.

- Level 1 assessments are qualitative or semiquantitative. They are used to assess risks from activities that either have intrinsically low risks, or have common, well-understood risks that can be controlled without extensive assessment.
- Level 2 screening assessments are the most common type of risk assessment. They usually involve the use of dispersion modelling or monitoring. Predicted or measured pollutant concentrations are benchmarked against pre-defined air pollution assessment criteria (APACs) to understand risks.
- Level 3 detailed risk assessments are used when a simple comparison of a pollutant's concentration to an APAC cannot adequately assess risks.

The APACs in this guideline are concentrations of air pollutants that provide a benchmark to understand potential risks. They are risk-based concentrations that help identify when or if an activity is likely to pose an unacceptable risk to human health and the environment. APACs are not concentrations one can 'pollute up to'. They are also not concentrations below which no action is required.

Implementing controls

Emitters of air pollution have a responsibility to prioritise the elimination of risks from these emissions. When this is not possible, emitters must implement appropriate controls to minimise or mitigate risks to human health or the environment. When risk cannot be eliminated, risk control options should be prioritised, based on the risk and waste management hierarchies. Emitters should demonstrate how existing or proposed risk controls minimise risks so far as reasonably practicable.

Checking controls

The development of risk controls is not the end of the risk management process. Ongoing performance evaluation through monitoring and continuous improvement ensures ongoing risk management. To evaluate performance, emitters should have clearly documented environmental performance objectives that can be monitored and reported on.

Publication Update

This update to Publication 1961 (1961.2) includes:

- Alignment with health-based APACs from other jurisdictions
- Separation of APAC tables into cumulative non-carcinogenic APACs (Table 3), APACs for criteria pollutants (Table 4), incremental carcinogenic APACs (Table 5) and environmental APACs (Table 6)
- Amendment to the list priority of sources for APAC derivation
- Minor editorial changes.

Contents

Glossary terms

Air toxic	A chemical pollutant other than criteria air pollutants.
Airshed	Geographical area within which the air is influenced by similar meteorological conditions, with all parts of the area being subject to similar air pollution conditions.
Amenity	Within the context of the environment, an amenity can include access to clean air or clean water, or the quality of any other environmental good that may reduce adverse health effects for people or increase their physical, social, or economic welfare.
Area of ecological significance	An area where the planning provisions or land use designation is for the primary intention of conserving and protecting the natural environment. This includes national parks, state parks, and wilderness areas and designated conservation areas.
Background air pollution	Air pollutant concentrations at any one location which are not directly affected by local activities, or specific identified sources.
Best available techniques and technologies	Techniques and technologies with the lowest impact on the environment without compromising the economic health of the (industrial) enterprises concerned.
Bioaerosol	Airborne material containing biological material from animals, plants or microorganisms.
Criteria air pollutant	Particulate matter (PM_{10} and $PM_{2.5}$), carbon monoxide, nitrogen dioxide, ozone and sulfur dioxide. In this guideline, lead is an air toxic rather than a criteria pollutant.
Cumulative non-carcinogenic APAC	An air pollution assessment criterion that is intended to be compared against the total concentration of a pollutant in air (that is, resulting from all sources of the pollutant). Cumulative non-carcinogenic APACs are based on critical effects other than cancer (e.g., respiratory irritation).
Cumulative effects	Refer to Section 5.5.
Current residual risk	The risk that remains once all currently existing controls are accounted for.
Exceptional event	Defined under Clause 18 of the NEPM AAQ as a 'fire or dust occurrence that increases air pollution levels 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: bushfire; jurisdiction authorised hazard reduction burning; or continental scale windblown dust'. When reporting compliance against NEPM goals for both PM_{10} and $PM_{2.5}$ daily averages, any exceedance day deemed to be exceptional is excluded. Where an exceedance day is determined to be a non-exceptional event, it is included.
Exposure scenario	A set of conditions or assumptions about sources, exposure pathways, amounts or concentrations of pollutants involved, and exposed organism, system, or (sub)population (i.e., numbers, characteristics, habits) used to aid in the evaluation and quantification of exposure(s) in a given situation.
Future residual risk	The risk that would remain if additional (proposed) risk controls were implemented.
Haber's Law	An approximation used to determine the relative exposure relationships for different averaging periods. Usually applied to assessing exposures for periods less than 1-hour, from 1-hour exposure data.
Highly hazardous pollutant	A pollutant that is listed on the Hazardous chemical information system (HCIS) database as category 1A or 1B for carcinogenicity, germ cell mutagenicity, reproductive toxicity, specific target organ toxicity (repeated exposure), acute toxicity or acute toxicity (inhalation), or is listed as a persistent bioaccumulative toxic substance in US EPA's Toxics Release Inventory Program.
Incremental carcinogenic APAC	An air pollution assessment criterion for carcinogens (critical effect is cancer), that is intended to be compared against the incremental concentration of a pollutant in air resulting from the activity being assessed, ignoring any existing background concentrations. The incremental carcinogenic APAC applies to substances that are genotoxic carcinogens.
Inherent risk	The risks that would be present if no controls were in place.
Mode of action	The type of physiological response of a biological organism upon exposure to a toxic pollutant.
Non-threshold (mode of action)	A linear dose-response function meaning that any exposure contributes to a proportional lifetime increased risk of harm. Refer to Section 13.2.2.
Plume strike	Term used to describe the event of a plume from a tall stack contacting the ground, sometimes occurring when the atmosphere is highly unstable.

Pollutant	A substance associated with pollution or waste that has the potential to cause harm to human health or the environment through physical, chemical, biological or other hazardous properties.
Radionuclide	An unstable form of a chemical element that releases radiation as it breaks down and becomes more stable. Radionuclides may occur in nature or be made in a laboratory.
Reasonably practicable	A determination of viable option/s based on risk, available technologies and cost. Refer to Section 1.6.1.
Sensitive land use	A land use where is it plausible for humans to be exposed over durations greater than 24 hours, such as residential premises, education and childcare facilities, nursing homes, retirement villages, hospitals.
State of knowledge	The body of accepted knowledge that is known or ought to be reasonably known about the harm or risks of harm to human health and the environment and the controls for eliminating or reducing those risks.
Surface roughness	A characteristic of the ground surface associated with its efficiency as a momentum sink for turbulent flow. This is an important parameter for determining the rate of air pollution dispersion and is used in dispersion modelling.
Threshold (mode of action)	The point below which the effect on human health is negligible. Refer to Section 13.2.2.
Unacceptable risk of harm	The risk of harm to human health and/or the environment is too high. Refer to Section 13.2.6.
Upset conditions	A temporary failure of air pollution control equipment or another temporary event that results in a greater-than-expected release of pollutants into the air.

Acronyms and abbreviations

µg/m^3	Micrograms per cubic metre
µm	Micrometre
AAQC	Ambient Air Quality Criterion
ABS	Australian Bureau of Statistics
AMCV	Air monitoring comparison value
ANZEC	Australian and New Zealand Environment Council
AOT40	Accumulated dose of ozone over a threshold of 40 parts per billion
APAC	Air pollution assessment criterion
AS/NZS	Australian / New Zealand Standard
ATSDR	Agency for Toxic Substances and Disease Registry (United States)
BaP	Benzo(a)pyrene
BAT	Best available techniques
BFDs	Block flow diagrams
CEM	Continuous emission monitoring
CFR	Code of Federal Regulations (40 CFR 51 is the same as Title 40, Part 51 of the CFR) (United States)
CO	Carbon monoxide
COMEAP	Committee on the Medical Effects of Air Pollutants
CoPC	Chemical of potential concern
CRF	Concentration response function
DALY	Disability-adjusted life year
DH	Department of Health
EES	Environmental Effects Statement
ERS	Environment reference standard
EP Act	*Environment Protection Act 2017*
EPA	Environment Protection Authority Victoria
GED	General environmental duty
HCIS	Hazardous chemical information system
HI	Hazard index
HHRA	Human health risk assessment
HIA	Health impact assessment
HQ	Hazard quotient
ILCR	Incremental lifetime cancer risk
IRSD	Index of relative socio-economic disadvantage
MRL	Minimal risk level
mg/m^3	Milligrams per cubic metre
MW	Megawatt
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NEPM AAQ	National Environment Protection (Ambient Air Quality) Measure
NEPM ASC	National Environment Protection (Assessment of Site Contamination) Measure
NEPM Toxics	National Environment Protection (Air Toxics) Measure
NO	Nitric oxide
NO_2	Nitrogen dioxide

NO_x	Oxides of nitrogen (for example nitrogen dioxide and nitrous oxide)
NPI	National Pollutant Inventory
NZ AAQG	New Zealand Ambient Air Quality Guidelines
O_3	Ozone
OEHHA	Office of Environmental Health Hazard Assessment (California)
OMECC	Ontario Ministry of the Environment and Climate Change
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PEMS	Predictive emissions monitoring system
PFDs	Process flow diagrams
PFS	Process flow diagram
P&IDs	Piping and instrumentation diagrams
PIPS	Permission information and performance statement
$PM_{2.5}$	Particulate matter with an equivalent aerodynamic diameter of 2.5 micrometres or less
PM_{10}	Particulate matter with an equivalent aerodynamic diameter of 10 micrometres or less
ppb	Parts per billion
ppm	Parts per million
QHIA	Quantitative health impact assessment
QMRA	Quantitative microbial risk assessment
RfC	Reference concentration
RMMP	Risk management and monitoring program
SA1	Statistical area level
SCR	Selective catalytic reduction
SEIFA	Socio-economic indexes for areas
SEPP AQM	State Environment Protection Policy (Air Quality Management)
SO_2	Sulfur dioxide
SVOC	Semi-volatile organic compound
t	Metric tonne
TCDD	2,3,7,8-tetrachlorodibenzodioxin
TCEQ	Texas Commission on Environmental Quality
TDI	Toluene-2,4-diisocyanate and toluene-2,6-diisocyanate
TEQ	Toxic equivalency quotient
TRV	Toxicity reference value
TSP	Total suspended particulate
TWA	Time-weighted average
US EPA	United States Environmental Protection Agency
VOC	Volatile organic compound
WEL	Workplace exposure limits
WES	Workplace exposure standards
WHO	World Health Organization
YLL	Years of life lost
yr	Year

Introduction

The *Guideline for Assessing and Minimising Air Pollution in Victoria* provides a framework to assess and control risks associated with air pollution. It is a technical guideline for air pollution practitioners and specialists with a role managing pollution discharges to air.

Under the *Environment Protection Act 2017* (EP Act), all risks to human health and environment from pollution and waste must be minimised so far as reasonably practicable. The contents of this guideline constitute guidance under this Act. This guideline provides duty holders with an approach to minimising risks in a proportionate way.

1.1. Users of the Guideline

This guideline provides guidance to people who are involved in commercial, industrial, agricultural, transport, mining or extractive activities and who have responsibilities under relevant environment legislation to eliminate or minimise their risks associated with air emissions. The content of this guideline is drafted to a technical standard designed to support air pollution practitioners and specialists with a role advising on or managing pollution discharges to air, including consultants, environmental managers and regulators.

This guideline may also be of interest to others such as planners, resource managers, lawyers and the broader community. For these stakeholders, this guideline can support them in building their knowledge on approaches to assess and minimise the risks of harm to human health and the environment from air pollution.

1.2. Guideline objectives

The objective of the *Guideline for Assessing and Minimising Air Pollution* is to help those responsible for commercial, industrial, agricultural, transport, mining and extractive activities understand, minimise and manage their air emissions, so that risks of harm to human health and the environment can be effectively minimised.

This guideline aims to achieve this objective by providing:

- A clear framework for air pollution assessment and management that protects the environmental values of air (as defined in the Environment reference standard (ERS)) to ensure risks of harm to human health and the environment are minimised so far as reasonably practicable.
- Guidance on methods for assessing risk of harm from air pollution to human health and the environment. This includes a broad risk-based assessment framework, site-specific risk assessment methods, and risk-based air pollution assessment criteria (APACs).
- A conceptual framework for identifying and selecting risk management techniques and technologies to ensure that risks are minimised so far as reasonably practicable.
- Clarity on EPA's expectations for the minimum reporting standards related to the assessment and management of air pollution in Victoria.

1.3. Guideline scope

This guideline addresses potential human health and environmental impacts associated with outdoor air pollution emitted from commercial, industrial, agricultural, transport, mining and extractive activities.

This guideline does not address indoor air pollution or occupational exposures (indoor or outdoor). It also does not address odour impacts as these should be assessed and managed in line with *Guidance for Assessing Odour* (EPA publication 1883). This guideline does not address the potential for climate change impacts associated with emissions of pollutants to air.

This guideline outlines a range of ways to identify, assess and minimise risks. Where other approaches may be suitable depending on the circumstance, advice should be sought from EPA Victoria (EPA) where this may apply.

1.4. How to use this guideline

This guideline contributes to and establishes a baseline for assessing risks from air pollution. EPA expects users to refer to this guideline to help them identify, assess and minimise the risks created by any activity that has potential to produce air pollution.

This guideline is divided into four parts, which link directly to the risk management framework adopted by EPA for the assessment and control of risk:

Step 1 – Identify hazards (chapters 3 to 4).

Step 2 – Assess risks (chapters 5 to 6).

Step 3 – Implement controls (chapter 7).

Step 4 – Check controls (chapter 8).

See Section 2.3 for a description of how each step relates to assessing and managing risk from air pollution.

1.5. How this guideline fits with existing air pollution management criteria

This guideline presents APACs for the assessment and management of air emissions. These criteria supersede those in the State Environment Protection Policy (Air Quality Management) 2001 (SEPP AQM) and the Protocol for Environmental Management: Mining and Extractive Industries (the Mining PEM) 2007.

However, it is not simply a case of replacing one set of air assessment criteria numbers with a new set of numbers. Rather, the criteria in this guideline are designed to be used within a broader air pollution management framework so that risks can be minimised so far as reasonably practicable (see Section 1.6.1). The framework (explained below) effectively replaces SEPP AQM and the Mining PEM.

1.6. Regulatory context

The Environment Protection Act 2017

General environmental duty

The cornerstone of the EP Act 2017 is the general environmental duty (GED).

The GED requires anyone engaging in any activity that may give rise to risks of harm to human health or the environment from pollution or waste to minimise those risks, so far as reasonably practicable. This requires such risks to either be eliminated, or if it is not reasonably practicable to eliminate such risks, to be reduced so far as reasonably practicable.

In determining whether it is reasonably practicable to minimise risks of harm to human health and the environment, the following matters are relevant:

- the likelihood of the risk eventuating.
- the degree of harm that would result if the risk eventuated.
- what the person knows, or ought reasonably to know about the harm or risks of harm and any ways of eliminating or reducing those risks. This is the state of knowledge.
- the availability and suitability of ways to eliminate or reduce the risk.
- the cost of eliminating or reducing the risk.

Under the GED, when a person or company is conducting a business or undertaking, they must use and maintain systems for identification, assessment and control of risks of harm to human health and the environment from pollution and waste that may arise in connection with their activities, and for the evaluation of the effectiveness of their controls. Where they fail to do so, they will contravene the GED.

In this guideline, anyone with a duty under the GED is referred to as a 'duty holder'. The GED applies to the air environment as it does to all elements of the environment. It applies to anyone whose activities have the potential to pose a risk of harm through emissions to air.

This guideline is primarily intended to assist duty holders who have emissions to air in a commercial, industrial or mining context. However, many of the risk-based principles in this guideline can be applied more broadly to other types of sources or activities that create emissions to air and present potential risk of harm.

Complying with the GED is about taking proactive steps to assess risks posed by the emissions and using appropriate environmental work practices and controls to prevent harm to human health and the environment from the activities in question.

Subordinate legislation

The EP Act establishes a permissioning framework to regulate activities that pose significant risks of harm to human health and the environment. Where the consequences of these risks are greatest. EPA's permissioning framework consists of licences, permits and registrations (see Permissions scheme policy (EPA Publication 1799.3)). In considering whether or not to issue licences, EPA must consider a range of factors, including:

- compliance with the GED.
- the impact of and risks of the activity on health and the environment.
- the best available techniques and technologies.

The EP Act also establishes the concept of 'unacceptable risk'. The Authority must refuse to issue development and operating licences and permits if it considers that the activity poses an unacceptable risk of harm to human health or the environment.

The Environment Protection Regulations 2021 prescribe activities that require a development or operating licence under the framework. EPA has released Implementing the general environmental duty: a guide for licence holders (EPA Publication 1851) () to inform licence holders of their obligations under the GED.

The EP Act's environment protection framework includes the ERS. This identifies environmental values, air indicators and objectives that set the benchmark for the quality of the air environment needed to protect the environmental values. The ERS is a reference standard, not a 'compliance standard' for businesses (Guide to the Environment Reference Standard (EPA Publication 1992)). However, some government decision-makers must take the ERS into account when making certain decisions. ERS objectives for air are health-based and as such, some are incorporated into this guideline, with the aim of informing how to assess and control risks from air emissions.

The ERS replaces SEPP (AQM) and generally adopts the objectives in the National Environment Protection Measure (Ambient Air Quality) (NEPM AAQ) with some modifications. The ERS also contains other environmental values, indicators and/or objectives that are not in the NEPM AAQ.

Other guidance

These guidelines form part of the 'state of knowledge' which persons subject to the GED need to be aware of. The state of knowledge includes information on the risks of harm arising from air pollution, and ways of eliminating or reducing those risks through the identification, assessment and control of such risks. EPA's website also contains guidance for businesses to manage their odour impacts (https://www.epa.vic.gov.au/for-business/find-a-topic/odour). Figure 1 summarises how this guideline interacts with the key components of the environment protection framework established under the EP Act.

EPA has developed a range of guidance for business, much of which is relevant to activities that emit pollutants into the air environment. Guidance by topic can be found on EPA's website (www.epa.vic.gov.au/for-business/find-a-topic).

Figure 1 – Interaction of guideline with environment protection framework

Other relevant duties under the EP Act

While they are not a focus of this guideline, it is important to note other relevant duties established by the EP Act that relate to the air environment:

- The **duty to notify** requires that a person who is engaging in or has engaged in an activity that results in a pollution incident that causes or threatens to cause 'material harm' has a responsibility to notify EPA. Failure to notify as prescribed by the EP Act attracts criminal liability.
- The **duty to take action to respond to harm caused by a pollution incident** requires the person responsible for generating pollution to restore the affected area to the state it was in before the pollution occurred, so far as reasonably practicable. The duty links to the principle of 'polluter pays', as set out in the EP Act. EPA may issue a remedial notice requiring the duty holder to take steps to comply with the duty. Criminal enforcement may apply if they fail to comply with a notice.

Other relevant legislation

This guideline is intended to be relevant to air assessments conducted under other legislative processes such as:

- Environmental Effects Statements (EES) under the *Environment Effects Act 1978*.
- Strategic and statutory planning proposals applications under the *Planning and Environment Act 1987*.
- Work plans prepared under the *Mineral Resources (Sustainable Development) Act 1990* and a range of other plans (e.g. operation plans) under the *Petroleum Act 1998*, *Offshore Petroleum and Greenhouse Gas Storage Act* 2010, *Greenhouse Gas Geological Sequestration Act 2008* are administered by Earth Resources Regulation (ERR).

Air pollution risk management framework

Emitters of pollution to air have a responsibility to put in proportionate controls to eliminate or minimise risks to human health or the environment. Being proportionate and preventative requires duty holders to:

- **understand their risks.**
- **actively seek out ways to eliminate or minimise these risks, so far as reasonably practicable.**
- **ensure any risks remaining after the implementation of all controls are within acceptable limits.**

This guideline outlines a risk management approach that duty holders can take to reduce the risks posed by their air emissions. This involves an ongoing cycle of four steps: identifying hazards, assessing risks, implementing controls, and checking controls.

2.1. How does air pollution impact human health and the environment?

Air pollution can harm human health and the environment, posing a risk to the environmental values of air specified in the ERS. Air pollution can also pose an indirect risk to other related elements of the environment, such as when contaminated dust settles onto a water body or soil.

Impacts of air pollution to human health

The extent to which air pollution poses a risk of harm to human health is dependent on many factors, including:

- **The toxicity of the pollutant**: toxicity varies between pollutants, meaning that they are hazardous at different concentrations and exposure periods.
- **The concentration of the pollutant in the environment**: the likelihood that health effects will be experienced, and the degree of harm increase as the concentration of a pollutant in air increases.
- **The exposure scenario**: exposure to air pollutants is mainly via inhalation. Indirect exposure may occur from deposition of air pollutants onto soil or water. Pollutants are then subsequently taken up by direct or indirect exposure to soil, water or biota (such as crops or caught fish).
- **The frequency and duration of exposures**: exposure to pollutants may result in acute and/or longer-term (cumulative) effects. For example, nose irritation, headaches or coughing can occur over exposures in the order of minutes or hours. Chronic disease and cancer risks are increased by sustained exposures over many years.
- **The presence of other pollutants**: ambient air is often a complex mixture of many substances. These can increase the risk of cumulative adverse health in people exposed to the air and environments.
- **The characteristics of exposed individuals and populations**: different people are vulnerable in different ways to health risks from air pollution. At a population scale, some groups are particularly sensitive to air pollution, such as people older than 65, children younger than 14, pregnant women and people with underlying health conditions, such as heart and lung conditions. A key objective of air pollution management is to specifically protect these sensitive populations.

Exposure to air pollution can cause a spectrum of health effects in a population. More severe health effects affect a smaller proportion of a population whereas less severe health effects affect a larger proportion of the population (Figure 2). This is particularly true of criteria pollutants like fine particles but applies also more generally to many air toxics as well.

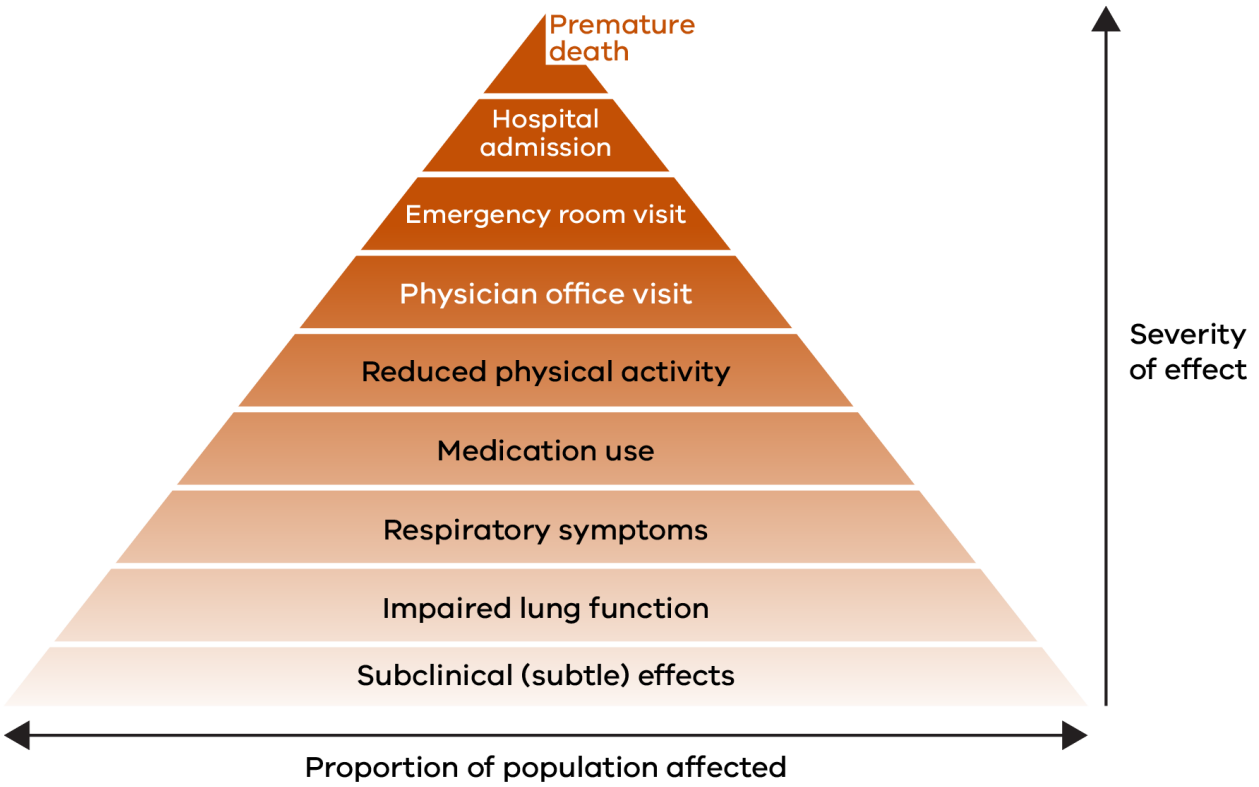

Figure 2 – Air pollution health pyramid (WHO 2016)

Impacts of air pollution on the environment

Air pollutants can have toxic effects on ecological receptors, including plants, animals and ecosystem processes. Such impacts can interfere with the ecological or recreational value of the receiving environment. These impacts can also affect agricultural productivity. There are three main ways air pollution can affect the environment:

- **Direct toxicity:** the concentrations of a pollutant in air may be elevated enough to directly affect ecological receptors. For example, mortality in animals or damage to the leaves of plants.
- **Pollution loads:** the accumulated deposition of certain pollutants over extended periods of time can result in impacts. For example, the build-up of toxic substances in soil or water, soil acidification or nitrogen enrichment. These effects typically occur only near very large sources of emissions and over long durations, often over decades.
- **Bioaccumulation:** some pollutants can bioaccumulate up food chains, resulting in greater concentrations (and greater toxic impacts) in organisms higher up the food chain.

Much of what is known about the environmental impacts of pollutants is based on international research, primarily from the northern hemisphere. This means there are uncertainties about how air pollution impacts Australian ecosystems.

Impacts of air pollution to amenity

'Amenity' is a broad term used to describe people's ability to enjoy and conduct activities in the environment. In the context of air pollution, there are two main ways in which amenity can be impacted: odour and visible pollution (such as dust deposition or visible plumes). As noted in Section 1.3, this guideline does not address odours. However, it does deal with the issue of visual amenity due to suspended or deposited nuisance dust.

Dust can result in unsightly soiling of surfaces, can create visible plumes and reduce visibility. All of these are amenity impacts that can impact people's wellbeing.

2.2. A risk-based approach to minimising air pollution

Objectives of air pollution minimisation

There are two primary types of risk when managing air pollution:

- Pre-control risk (inherent risk): the risks that would be present if no controls were in place.
- Post-control risk (residual risk): the risks that remain following the implementation of controls. In assessing matters related to air pollution, it is useful to consider both:
    - current residual risk: the risk that remains once all currently existing controls are accounted for.
    - future residual risk: the risk that would remain if additional (proposed) risk controls were implemented. When considering additional controls, it is useful to compare future residual risks for various control options to identify the most appropriate control.

Based on these definitions of risk, the objectives of air pollution management can be described as:

- understanding inherent and current residual risks to inform appropriate action.
- eliminating or minimising all risks so far as reasonably practicable.
- ensuring future residual risks to relevant environmental values are not unacceptable.

For more information, refer to – *Assessing and controlling risk: a guide for business* (EPA Publication 1695) (https://www.epa.vic.gov.au/about-epa/publications/1695-1).

Minimising risk of harm 'so far as reasonably practicable'

In order to comply with the GED, it is important that duty holders understand what is 'reasonably practicable' when considering measures to minimise risks. For more information, refer to *Reasonably practicable* (EPA Publication 1856) (https://www.epa.vic.gov.au/about-epa/publications/1856).

To determine which controls are reasonably practicable, the following questions should be considered:

- **Eliminate first**: can the risk be eliminated? If it is not reasonably practicable to eliminate the risk, how can it be minimised?
- **Likelihood**: what is the chance harm will occur? Has the harm occurred before on the site or has it commonly occurred on other similar sites?

- **Degree of harm**: how severe could the harm be to human health or the environment? Are the substances being emitted particularly hazardous or are they being released in particularly large volumes? Are sensitive land uses present near the emission sources?
- **The duty holder's knowledge about the risks**: what is known, or what can be found out, about the risks posed by the activities? How can one reduce those risks to human health and the environment?
- **Availability and suitability of technology**: what technology, processes or equipment are available to control the risk? What controls are suitable for use in the given circumstances?
- **Cost**: how much does the control cost compared to how effective it would be in reducing risk? The most effective solution might not always be the most expensive. Likewise, a cheaper solution may not be the most appropriate to control the risk.

In complying with the GED, persons who are conducting a business or undertaking must also do all of the following, so far as reasonably practicable:

- Use and maintain plant, equipment, processes and systems in a manner that minimises risks of harm to human health and the environment from pollution and waste.
- Use and maintain systems for identification, assessment and control of risks of harm to human health and the environment from pollution and waste that may arise in connection with the activity, and for the evaluation of the effectiveness of controls.
- Use and maintain adequate systems to ensure that if a risk of harm to human health or the environment from pollution or waste were to eventuate, its harmful effects would be minimised.
- Ensure that all substances are handled, stored, used or transported in a manner that minimises risks of harm to human health and the environment from pollution and waste.
- Provide information, instruction, supervision and training to any person engaging in the activity to enable those persons to comply with the duty.

2.3. Steps in controlling air pollution risks

The risk management framework provided in this guideline is directly comparable to the framework adopted across all elements of the environment and involves the following four stages (Figure 3):

Step 1 – Identify hazards: what hazards are present that might cause harm

This initial step requires duty holders to develop a sound understanding of their air discharges and of their surrounding environment. This is to provide a clear context for the impacts they are having (or could be having) on human health or the environment. For Step 1, see Sections 3 to 4.

Step 2 – Assess risks: what is the level of inherent risk, based on likelihood and consequence

The second step involves the duty holder undertaking a tiered level of assessment of the inherent risks associated with air pollution discharges. Assessment requirements are minimal for simple emission points, and progressively increase for more and more complex sites. A good understanding of risks is important to ensure they are minimised in a proportionate manner. For Step 2, see Sections 5 to 6.

Step 3 – Implement controls: what measures are suitable and available to eliminate or reduce a risk

This third step in the management of air pollution must be carried out regardless of whether risks are low or high. If it is reasonably practicable to minimise a risk, the GED requires that this be done. For Step 3, see Section 7.

Step 4 – Check controls: review controls to make sure they are effective

In the context of air pollution, it is critical that controls are regularly checked to ensure they are operating as planned. It is also important duty holders have a sound understanding of any remaining residual risks to ensure they are low and acceptable. A key component of checking controls and evaluating performance is appropriate reporting and documentation. See Step 4, see Section 8.

Figure 3 – Steps in controlling air pollution hazards and risks (from EPA Publication 1695).

Step 1 – Identify hazards

What hazards are present that might cause harm?

Emission sources

The first step in minimising risks from air pollution is to understand emission sources and the types of pollutants and quantity being released.

There are three key groups of air pollutants:

- **Criteria air pollutants** are widely distributed in the environment and contribute incrementally to the potential for health impacts in the population, meaning that even small increases in concentrations contribute to the overall risk.
- **Air toxics** are usually less common than criteria pollutants. They are associated with specific sources and do not pose a significant risk when present at sufficiently low concentrations. This group of pollutants broadly comprises most airborne toxic substances that are not criteria air pollutants.
- **Other pollutants** are substances other than criteria pollutants or air toxics, such as radioactive substances or bioaerosols.

There are many types of emission sources, such as stacks, leaking pipes, application of chemicals in a range of settings, areas prone to wind erosion and pools of chemicals. Sources need to be correctly identified and documented when assessing and controlling risks. Once all emission sources have been adequately identified, it is often necessary to quantify their emission rates. Various methods are listed in this section to assist with this task.

3.1. Introduction to emission sources

A good understanding of emission sources is key to managing risks. This section is intended to help duty holders better identify, characterise and report on the sources of emissions associated with their activities.

The material in this section applies to both existing sites that are being assessed, and new sites being considered for development.

3.2. Types of pollutants

This guideline deals with three broad groups of pollutants:

- criteria pollutants.
- air toxics.
- other pollutants.

Even though these three types of pollutants share many characteristics, it is useful to categorise them separately as they often pose different challenges in terms of their assessment, impacts and controls.

3.2.1. Criteria air pollutants

The term 'criteria air pollutants' refers to common air pollutants that are widely distributed and have been identified as having the potential to pose a significant public health risk at a population-wide scale. In this guideline, the criteria pollutants are particles ($PM_{2.5}$ and PM_{10}), carbon monoxide, nitrogen dioxide, ozone and sulfur dioxide.

Even though lead is listed in the NEPM AAQ, it is considered in this guideline to be an air toxic rather than a criteria pollutant because it is no longer ubiquitous since the introduction of unleaded petrol. Lead can still pose a risk at a local scale near specific emission sources and is therefore included in this guideline as an air toxic.

Criteria pollutants pose several challenges in terms of their assessment and management:

- Criteria pollutants are widespread in the environment, meaning background concentrations are often significant. When many emission sources are present near to one another, their cumulative effects on air pollution can sometimes be significant, even if each individual source only contributes a small amount to the overall concentration.
- Criteria pollutants often have no threshold below which no adverse health effects are expected to take place, and even when they do have a threshold, they exert a gradually greater impact on affected populations as their concentrations increase. This means that for several criteria pollutants there is no clear or universal definition of what constitutes an 'acceptable risk'.
- Criteria pollutants often have sources that cannot be eliminated in the foreseeable future. For example, particles from bushfires and dust storms.
- Some criteria pollutants (such as particles) are often released by fugitive sources, which are particularly difficult to assess quantitatively through either monitoring or modelling.

Due to these challenges, carrying out a detailed assessment of risks from criteria pollutants can be complex and prone to uncertainty. In some limited cases (such as fugitive emissions from a small and/or remote site), it is more efficient to simply focus on minimising emissions rather than invest significant resources into a highly uncertain predictive assessment.

Particulate matter

'Primary' particulates are emitted directly from sources such as motor vehicles or wood fires, while 'secondary particulates are formed through atmospheric reactions of sulfur dioxide, nitrogen oxides and certain organic compounds. Particles are generally classified into four categories based on their size (Figure 4):

- Total suspended particles (TSP) include suspended particles larger than 10 µm and are currently addressed as an amenity issue (see Section 7.3.2). Current health research indicates that the smaller size fractions have a greater influence on human health.
- PM_{10} – 'thoracic' particles smaller than 10 µm in diameter that can penetrate into the lower respiratory system.
- $PM_{2.5}$ – 'respirable' particles smaller than 2.5 µm that can penetrate into the gas-exchange region of the lungs.

- Ultrafine particles – particles smaller than 0.1 µm, which contribute little to particle mass due to their small size but have the greatest ability to enter the lungs.

Particles larger than 2.5 µm are often produced by mechanical processes that occur in industry or agriculture, dust from roads and wind-blown particles from uncovered soil or mining operations. Smaller particles (<2.5 µm) are largely formed from gases and combustion processes, and the smallest (<0.1 µm, ultrafine) are formed by combustion processes and nucleation due to condensation or chemical reactions that form new particles.

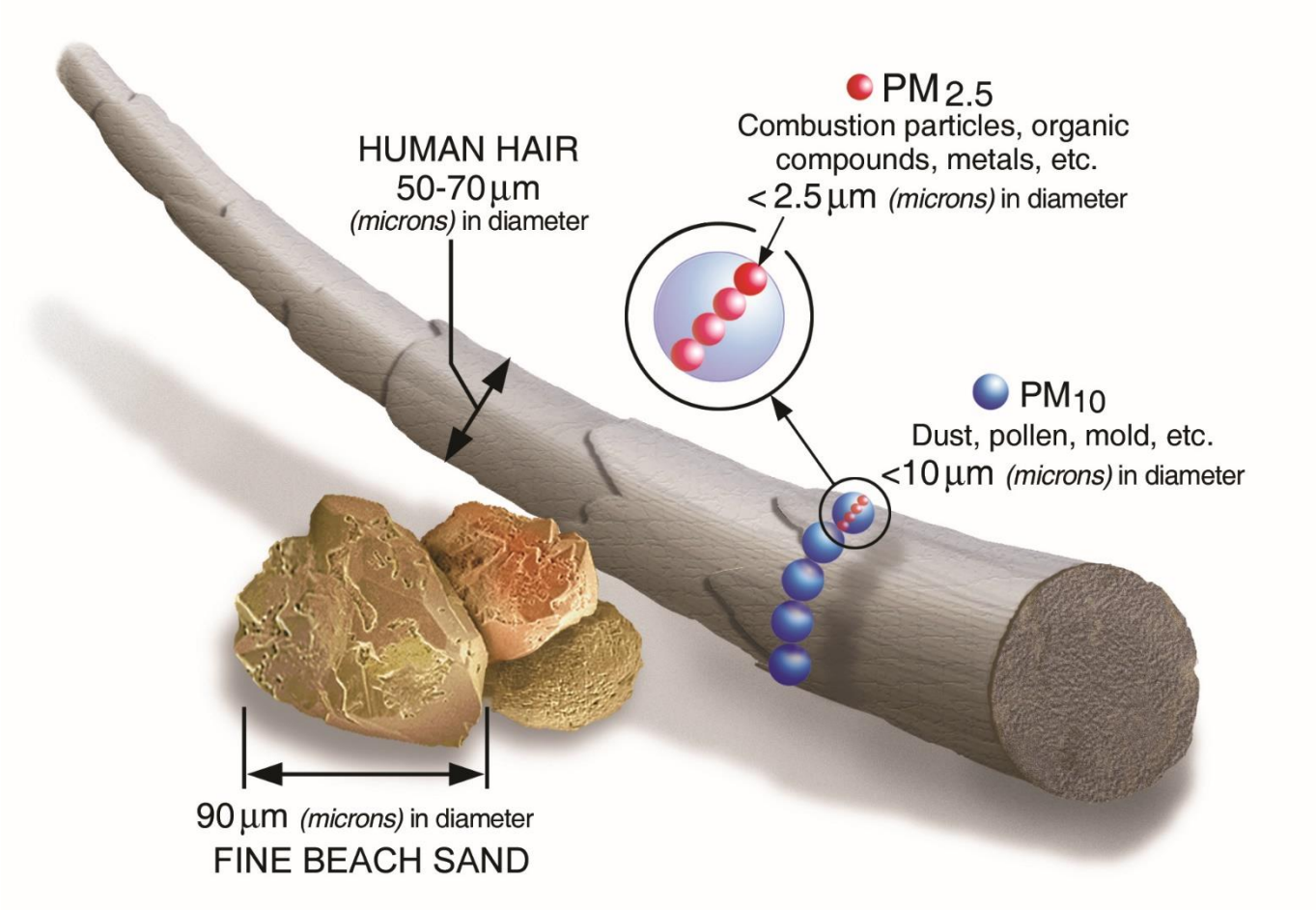

Figure 4 – Size comparison for particulate matter particles (from epa.gov/pm-pollution/particulate-matter-pm-basics)

Background sources of particulate matter include natural sources such as bushfires, wind erosion and sea spray, as well as industrial emissions and diffuse anthropogenic sources like motor vehicles, wood stoves and lawn mowers.

Exposure to particulate matter is associated with health effects, particularly related to the respiratory and cardiovascular system. The smaller the size of the particles, the deeper they can penetrate into the lungs and the more damage they can do. Therefore, the finer particulate fractions are better predictors of health effects than coarser ones. Short-term exposure to fine particles can result in the following:

- increased daily mortality.

- increased rates of hospital emergency presentations and admissions for respiratory and cardiovascular disease.
- increased bronchodilator use.
- increased prevalence of cough and shortness of breath.

Long-term exposure to airborne particles is also associated with premature mortality, reduced lung function, progression of existing respiratory or cardiovascular conditions and development of respiratory disease (including asthma). Sensitive groups at a greater risk of effects from particulate air pollution include people over 65, those with pre-existing respiratory and heart conditions, pregnant women, smokers, infants and children under 14.

Carbon monoxide

Carbon monoxide is a colourless, odourless and flammable gas formed from the incomplete combustion of carbon-containing fuels, including petrol and diesel. Carbon monoxide is absorbed from the lungs into the blood stream, which then reacts with haemoglobin molecules in the blood to form carboxyhaemoglobin. This reduces the oxygen carrying capacity of blood, which in turn impairs oxygen release into tissue and adversely affects the brain and heart.

In most urban areas, motor vehicles are the main contributor to background concentrations of carbon monoxide. In general, ambient carbon monoxide concentrations have been declining over time as a result of improved emissions control systems, such as catalytic converters being fitted to motor vehicles.

Nitrogen dioxide

Nitrogen oxides (NO_x) primarily include nitric oxide and nitrogen dioxide. These gases are formed by oxidation of nitrogen in air at high combustion temperatures. Nitric oxide (NO) is oxidised to nitrogen dioxide (NO_2) in ambient air. This has a major role in atmospheric reactions associated with the formation of photochemical oxidants (such as ozone) and secondary particles (such as particles containing nitrate).

Nitrogen dioxide contributes both to morbidity and mortality, especially in susceptible groups such as young children, people with asthma and other chronic respiratory conditions. Exposure during very early childhood can increase the risk of development of asthma induced by other allergens.

Motor vehicles are usually the major contributor to ambient background concentrations in urban areas. In addition, the combustion of fossil fuels from sources like heating and power generation are also major sources of anthropogenic nitric oxide emissions.

Sulfur dioxide

Sulfur dioxide (SO_2) is formed by the oxidation of sulfur contaminants in fuel on combustion. Sulfur dioxide is a potent respiratory irritant and has been associated with increased hospital admissions for respiratory and cardiovascular disease, as well as mortality. People with asthma are particularly susceptible to the inflammatory effects of sulfur dioxide on the lungs.

While sulfur dioxide concentrations are relatively low in much of Australia, they can be elevated in some industrial areas. The contribution from motor vehicles and shipping is low.

Ozone

Tropospheric ozone (O_3) is a secondary air pollutant formed by reactions of nitrogen oxides and volatile organic compounds (VOCs) in the presence of strong sunlight. These primary emissions arise mainly from motor vehicles. Ozone is a photochemical oxidant; it is the predominant component of photochemical smog.

Ozone contributes both to morbidity and mortality, especially in susceptible groups such as those with asthma and chronic lung disease and people over 65. Ozone can also affect healthy young adults undertaking active outdoor exercise over extended periods.

3.2.2. Air toxics

Unlike criteria pollutants, air toxics are generally not widespread in high concentrations in the environment and are emitted by specific activities or processes. Many air toxics can pose a risk close to their source when there is potential for high concentrations in air. Air toxics encompass hundreds of substances such as volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs), heavy metals, acid gases and other toxic airborne substances. These substances range widely in their toxicity and associated health effects, and include hazardous substances like carcinogens, mutagens and may cause health effects at low doses.

Based on the definition above, the term 'air toxic' is used in this guideline and has a different meaning to that in the National Environment Protection (Air Toxics) Measure (NEPM Air Toxics), which is limited to benzene, formaldehyde, toluene, xylenes and benzo(a)pyrene.

The assessment of air toxics includes many chemicals for which there are clearly defined thresholds or concentrations that pose an 'acceptable risk'. Below this threshold, the risk of health impacts becomes negligible (see Section 13.2.6). However, these thresholds are not intended to be used as levels that emitters can 'pollute up to' as this is inconsistent with the intent of minimising risks so far as reasonably practicable.

3.2.3. Other pollutants

Visible plumes and deposited dust

Visible plumes and deposited dust can impact on the visual amenity of a place and can affect people's wellbeing. Nuisance dust is a common issue that is often associated with fugitive emissions generated from activities on a site.

Bioaerosols

Industrial activities that involve the transport, storage and handling of plant matter, human and animal materials are likely to produce aerosolised biological particles (bioaerosols). Bioaerosols can be released from microbes (bacteria, viruses, protozoa, and fungi), plants and animals. Common examples of bioaerosol includes composting facilities, waste stockpiles, intensive animal farming industries, and commercial crop growing.

Bioaerosols may consist of an entire microscopic structure, such as a bacterium, virus, bacterial spore and pollen species, or as a component of an organism, such as hair and skin cells, degraded microbial cell components (β(1-3)-D-glucans and endotoxins), bacterial exotoxins and mycotoxins. In any area, bioaerosols are likely to be made of a complex mixture of various microorganisms and microbial components as well as non-microbial organic matter.

Bioaerosols have the potential to cause adverse health effects in individuals if they are inhaled, ingested, or deposited on the skin. Negative health impacts from bioaerosols may be either due to viable microorganisms capable of causing an infection, or cell components that can cause allergies and inflammation.

Radioactive substances

Radioactive substances can be discharged to air by various activities, processes, and facilities and occur in low levels naturally throughout Victoria. Under the EP Act, emitters have a responsibility to understand whether radioactive emissions from their activities can create a risk of harm to human health or the environment.

When the activity, process, or facility involves the use or production of radioactive materials (as defined in the Radiation Act 2005), the Department of Health (DH) is the principal regulatory body. However, EPA also has a role in the regulation of radioactive discharges and waste, especially when a serious risk to human health or to the environment has occurred or is likely to occur. EPA's involvement in matters relating to radioactive discharges is determined on a case-by-case basis.

3.3. Types of sources

Pollutants can be emitted into the air from a large variety of sources.

- **Domestic**: all emissions from residential dwellings, including solid fuel heating appliances.
- **Transport**: mainly vehicles using roads, but also includes off-road vehicles, ships, trains and aircraft.
- **Industrial/commercial/agricultural/mining**: including all emissions from commercial or industrial premises ranging from large manufacturing or mining operations through to small and medium enterprises.
- **Naturally occurring**: many pollutants are released from natural sources, such as particulate matter generated by wind erosion (for example sea salt spray) or bushfires.

As stated previously, even though the GED applies to all activities with a potential to cause harm, this guideline focuses primarily on emissions from commercial, industrial, agricultural, transport, mining and extractive industry sources.

The specific characteristics of different types of sources affect how they are assessed and managed. For this reason, it is useful to think of individual emission sources on a site as falling broadly within these categories:

- **Point sources**: typically stacks and vents, from very small (centimetres) to large (tens of metres).
- **Line sources**: vehicles on roads are the main example of this type of emission. It can also include any source of discharges that is spread along a line of more than 20 metres.
- **Area sources**: typically surfaces larger than 20 square metres in area. Examples include wastewater ponds, landfills, and dust from open areas.
- **Volume sources**: wind erosion from waste stockpiles and fugitive emissions from buildings can often be categorised as a volume source.
- **Fugitive emissions or diffuse sources**: these often include the combined result of many small emissions from a large number of sources that are difficult to quantify or identify. Examples include leaks and emissions through gaps and cracks in walls and containers. Fugitive emissions

can sometimes be the most significant emission source for a site. Fugitive sources are often included in dispersion models as volume sources.

Emissions cannot be definitively assigned to one category or another. Rather, the categories listed above can be used to more broadly understand and describe the types of sources present on a site.

3.4. Characterising sources of emissions

3.4.1. Identifying and describing emission sources

It is usually useful to clearly list all potential emission sources associated with an activity. Depending on the specific nature of the activity, it is better to begin by capturing the broadest possible extent of emission sources, as the scope can be narrowed at a later stage (for example, by focusing on specific sources of greatest concern). The process of identifying sources of emissions to air is site-specific and should include one or more of the following approaches:

- **Risk management documentation**: many industries are required by EPA to maintain documentation that demonstrates how they have identified site-specific risks and how they are managing them. EPA-permissioned activities in particular are required to prepare and maintain a risk management and monitoring program (RMMP, see Section 8.1 and – *Implementing the general environmental duty: a guide for licence holders* (EPA Publication 1851)). The types of documentation that may be available vary from site to site. This can be evaluated as part of a desktop assessment and can include:
    - conceptual site models and site plans
    - risk assessment documents (for example aspects and impacts register)
    - operational control procedures
    - environmental work instructions
    - monitoring/modelling results (air sampling and operational data)
    - incident reports
    - EPA licence
    - process flow diagrams (PFD)
    - permission information and performance statement (PIPS)
    - National Pollutant Inventory (NPI) reports.
- **Site inspections**: it is considered good practice to conduct one or more site inspections. These can be carried out by any parties involved in the assessment or minimisation of air pollution risks from a site. Although desktop assessments can generate useful information, site inspections allow for the identification of emission sources that may have previously gone unnoticed (such as fugitive emissions).
- **Meetings with operational staff**: depending on the scale of the assessment being carried out, it is often useful to meet with the staff involved in the day-to-day operations at a facility. They can often provide key information on how operations are really conducted, including timing of emissions, and frequency of upset conditions or other non-standard conditions at the site.
- **Expertise and professional judgement**: good knowledge of the types of operations at a site is required to reliably identify sources of emissions. Comparisons to similar sites or previous experiences can be a useful way to identify sources that are not identified by the methods listed above.

To obtain information to manage air pollution risks from a site, it is important each source is adequately characterised. This should include compiling data on:

- stack characteristics (height, diameter, mass emission rate, volume flow rate, moisture content and any stack covers that may be present, noting that EPA advises stack covers should not be used as they prevent free flow of dispersion).
- hours of operation and timing of releases (including those associated with occasional activities).
- any seasonal or temporal variation in operations that might affect the type and magnitude of emissions.
- quantities of raw material/products/by-products being generated, stored, handled or discharged.
- dimensions of volume, area or line sources.
- any external variables that might affect emission rates, such as wind speed, temperature etc
- location of the source on the site.
- details of any emission control equipment or activities associated with the source.
- emission rates of various pollutants.

3.4.2. Characterising pollutant emission types and rates

Identifying the appropriate level of assessment for different pollutants and quantifying their emission rates can be a technically complex task. It can be carried out in various ways, depending on whether the source is proposed or already exists, and the type of data available. The following sections provide an overview of some of the more common ways to estimate emission rates on a specific site (also see Case Study 1).

Continuous emissions monitoring

Continuous emission monitoring (CEM) is considered best practice for the measurement of emissions from stationary point sources. Commercially available CEM systems (CEMS) can be configured to measure a range of analytes. CEMS may have limitations in certain settings due to dependencies on the operational environment, such as installation location or their ability to measure pollutants of concern. However, when they are successfully applied, CEMS provide the advantage of generating real time data. This provides a greater understanding of point source emissions generated under standard operating conditions, as well as other operational modes, such as commissioning and process start-up/shutdowns.

CEMS produce a more complete and representative emission data set than that provided by other intermittent testing regimes, such as discrete stack testing events. This enables problems to be identified as they occur, enabling real time response to rectify any process issues. Data produced by CEMS can also facilitate improved operational/process control over time. The main limitation with CEMS is they can be expensive to install and maintain. Therefore, they are generally used only on large industrial emitters. In some industries, CEMS are specified in licence conditions, such as large emitters with higher risks of adverse effects.

Predictive emissions monitoring systems

There is a growing trend with CEM to use predictive emissions monitoring systems (PEMS). These systems do not directly measure the parameter of interest but instead measure some precursor or

indicator of the parameter. A typical example might be to monitor fuel use, oxygen intake and temperature to predict the amount of nitrogen oxides created.

PEMS are used because they employ simpler and easier-to-run monitors. However, it is important that PEMS are fully calibrated and are only used when an industrial process is well understood and stable.

In some cases, the PEMS might not need special stack emissions monitors, as the quantities and parameter needed are already tracked as part of the normal production process. In these cases, all that is needed is a special calibrated model to determine the relationship between the parameters, which is then used to calculate the emission rate of the pollutant of concern.

Stack testing and operational process monitoring

Stack testing, area source sampling, fugitive emissions quantification and other types of source sampling are carried out using well-established and validated methods and techniques. These sampling methods are often used to check emissions compliance for facilities with significant discharges. They effectively provide a 'snapshot' of the emissions at a point in time. They also provide a valid characterisation of the source for processes that are well controlled and do not vary through time.

To understand variations in emissions, particularly those that are more prone to temporal variation, it is useful to consider more frequent sampling or the use of methods other than stack testing. It is important to note a plant's operating capacity at the time of stack testing, as reduced plant capacity will lead to an under-representation of emissions.

Operational process monitoring of key operational parameters and design specifications that are critical to ensure controls and management practices are being met (for example temperature, pressure, throughput, flow rate) can be a more effective mechanism of understanding and managing emissions. Consideration should be given to using operational process monitoring in combination with verifying stack testing to manage and understand emissions.

Hazardous materials storage and handling

It is useful to list and quantify all the raw materials used in the process under consideration and assess all the ways these materials can enter the environment. This is particularly important for volatile materials, and should include all possible pathways including leaks, spills, and accidental releases. The analysis should include:

- the rates of use, including peak short-term rates and annual average discharges.
- all substances that are produced, stored or handled on the site, including the results of any chemical reactions, whether deliberate or unintended.
- the rates of production, both peak short-term and annual average discharges.

Plant specifications

Specific items of plant (such as a boiler or diesel generator) may include emission rates of key pollutants in their technical specifications documentation. These emission rates provide useful information that can be used to quantify likely emissions.

Reference sites

In some instances, a proposed development will involve similar processes to those that are carried out at other facilities that are already operational. In these cases, it can be useful to evaluate sources and quantify emissions based on these reference sites, provided they can be demonstrated to be truly representative or conservatively representative of the proposed development.

Emission factors

In some cases, it may be necessary to rely on emission factors to estimate emission rates. These could be those specified in the emission estimation technique manuals used as part of the NPI scheme or other similar schemes from overseas jurisdictions (such as the United States AP-42 air emission factors).

While the use of emission factors may sometimes be useful when characterising a source, it is important to note that they are designed to report pollution discharges, rather than assess and minimise risks from the emission points. As such, it is important to carefully consider the intrinsic uncertainties and inaccuracies in using emission factors when characterising emission rates from a source.

Published literature

Published literature can provide useful information to help characterise emissions from a source. This includes peer reviewed scientific and technical journals, industry newsletters, consumer publications or medical reports. The validity of the information obtained from these sources should be carefully evaluated, documented and referenced in any resulting assessment reports.

Consultation

Another way of assessing air emissions is to consult with neighbouring stakeholders. While these views can be subjective and difficult to quantify for regulatory or risk assessment purposes, they can be a source of information that might not be otherwise easy to obtain.

If reporters keep diaries of simple indicators, such as visible plumes or odours, this can help understand emission times, fugitive emissions and upset conditions. Even though odour impacts are not included in the scope of this guideline, a detailed odour diary may be a useful indicator of the presence of air pollutants.

Case study 1: Emissions from a chemical processing facility

A medium sized chemical processing facility undertakes various activities that involve discharges to air. These include the use of solvents, the incineration of waste, the processing of oil for energy recovery and the use of fuel oil in a smaller boiler. The operation is intermittent and none of the processes is regarded as significant enough to need ongoing emissions monitoring.

Emissions rates for all relevant pollutants are derived using a combination of methods.

- Fugitive emissions of solvents are estimated using emission factors based on the volatility of the solvents used.
- Emissions from the incinerator are quantified using stack testing carried out under different conditions, including different waste mixtures.
- Emissions from the boiler are evaluated based on the chemical composition of the oil being used and process conditions.

To continually manage their risks appropriately, the company has implemented a series of engineering and process controls to provide assurance that these emission estimations continue to remain relevant and under specified limits. These controls are undertaken by trained onsite staff, and reported on a regular basis:

- The type and quantity of all solvents used, along with an industry standard estimate of the amount of these released due to their volatility.
- When reasonably practical, an analysis of the composition of the waste incinerated, with particular regard to the amount of plastics, heavy metals and other toxic contaminants that might be present in the feedstock.
- A CEMS configured to measure contaminants of concern and compliant with Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control).
- An understanding of other waste streams coming out of processes from the site, whether channelled or fugitive emissions and their respective controls.
- Standard laboratory tests of oil batches received to determine the sulfur content and metals screening to ensure the batch is compliant to use. This also allows a calculation of the amount of sulfur dioxide and metals expected to be released.

All of these emission estimations are reported on regularly and any assessment work is updated whenever a significant change in emission rates occurs, or if it is planned to occur.

3.5. Source site description

Characterising individual emission sources extends to the context around them on the site. Effective emission source characterisation incorporates a detailed site description. This can include:

- An annotated aerial photograph or site plan showing the location of all major structures on the site, the site boundaries and source locations.
- Any structure near the emission source can affect wind flows and the dispersion of pollutants in its vicinity. These effects include altering the direction of the wind flow, the creation of downwash behind buildings and solid structures, and the channelling and concentrating of pollutants in canyons between structures. To adequately characterise potential building and structure effects on pollution dispersion, it is useful to provide a scaled site plan showing all buildings onsite and an estimate of buildings in all adjacent sites.
- A descriptive summary of all relevant activities, management practices or processes carried out on the site. Where appropriate (and especially for larger emission sources), this may involve presenting not only block flow diagrams (BFDs), but also process flow diagrams (PFDs), piping and instrumentation diagrams (P&IDs), engineering specifications, chemical inventories, or data on the volumes of feedstock or throughput of plant equipment. For smaller emission sources, this might simply involve a qualitative description of the types of activities and management practices carried out on the site and BFDs.
- Identifying the planning zone that the facility is operating in. Include any information about proposed planning zone changes if known. Local councils (as the planning authority) should be consulted to ensure that current and future zones are identified.

3.6. Reporting recommendations – emission sources

The following information about emission sources should be included in written air pollution assessment reports:

- description of the operations on the site.
- explanation of how emissions sources were identified (for example site inspection, desktop assessment, etc.).
- a site plan showing the location of all sources, key site features and any significant buildings.
- information on each emission source, such as:
    - stack height, diameter, exit velocity, flow rate and presence of any stack covers (if applicable)
    - operating hours, and timing of releases (including those associated with occasional activities)
    - any variation in operations that might affect the type and magnitude of emissions
    - quantities of raw material/products/by-products being generated, stored, handled, or discharged
    - the source area and/or volume (if applicable)
    - the dimensions of the line source (if applicable)
    - a discussion of any external variables that might affect emission rates, such as wind speed, temperature, etc.
    - details of any emission control equipment or activities associated with the source
    - emission rates of various pollutants.
- specification of how emission rates were measured or otherwise estimated, along with a description of the uncertainties around these estimates.

clear explanation of how pollutants were selected, and which pollutants were not addressed in the assessment and why.

Receiving environment

Risks posed by air pollution are related to the context of the receiving environment. For example, the same emission source may pose different health risks depending on whether it is in a remote location or in a residential setting. Therefore, to make sound decisions when managing air pollution risks, it is important to have a good understanding of the environment surrounding the emission sources. Of particular importance are local topography, meteorology, background air pollution and nearby sensitive land uses.

Topography and meteorology directly affect how pollutants disperse from the source into the receiving environment. They need to be well understood to ensure that risks are assessed appropriately and that conditions conducive to poor dispersion are not overlooked.

Many pollutants are broadly found in ambient air due to background air pollution sources or local industry sites. For example, particles from bushfires, nitrogen oxides from motor vehicles, and various air toxics from surrounding industries. Therefore, any emitter of air pollution needs to understand how their contribution adds to the cumulative risks from existing air pollution on human health and the environment.

Finally, surrounding land uses impact on the sensitivity of the receiving environment. As such, duty holders need to be aware of their potential to impact on particularly sensitive locations, such as residences, hospitals, schools or sensitive ecosystems.

4.1. Introduction to the receiving environment

This section describes how to consider the receiving environment when assessing potential sources of air pollution. It covers what characteristics of the receiving environment to consider and how these are identified and applied when evaluating the level of risk posed to human health and the environment from air emissions. Environmental values of ambient air and other elements of the environment are specified in the ERS.

4.2. Topography and landscape

The following information is required to provide a good understanding of the physical geography surrounding an emission source:

- Evaluation of whether the terrain is flat, undulating or elevated.
- Identification of any instances where the surrounding topography may be particularly conducive to poor dispersion.
- Description of land uses of the surrounding environment, with a specific focus on how they might affect surface roughness and dispersion (for example types of vegetation, built environment, surface water features, etc).

When terrain is an important feature of the receiving environment, it may be particularly useful to provide a topographic map or digital elevation model.

4.3. Meteorology

Meteorology plays a key role in the dispersion of airborne pollutants. In some cases, meteorology can also play a role in the generation of pollutants. While meteorology is explicitly and quantitatively considered in air dispersion modelling reports, it is important that it is understood and described in all air pollution reports.

Such a description could include:

- The climate of the surrounding area, including rainfall, temperature or other charts as required.
- One or more wind roses, depending on whether wind patterns vary significantly through time. For example, it may be useful to present wind roses for different seasons or times of day, depending on the site.
- A discussion on any significant interactions between meteorology and topography, such as valley winds, varying wind fields and complex terrain.
- A commentary on the potential for meteorological conditions that could impact directly on pollution dispersion, such as prevailing winds towards sensitive locations, coastal fumigation, sea breeze trapping, pollutant recirculation, low inversion layers, plumes penetrating inversion layers, highly stable conditions or calm winds.
- The location of meteorological stations used to obtain data for the assessment and justification for why the use of those stations were considered valid.

Any meteorological data used in assessments must be shown to be representative of and relevant to the case being assessed. Meteorology can, and does, vary from year-to-year and an assessment of this is included in the more detailed dispersion modelling guideline (*Guide to air pollution modelling* (EPA Publication 1957)). Potential longer-term variations due to climate change are not assessed as it is not practical or possible to determine these to the scale required at the local dispersion level.

Air pollution reports should include an appraisal of the quality of the meteorological data utilised, and adequate justification to demonstrate its relevance to the site or activity being assessed.

4.4. Background air pollution

The risks from a site's emissions must always be considered in the context of the cumulative risks posed by other air pollution sources. The consideration of background concentrations of all air pollutants is therefore always required as a critical step in understanding the overall risk to human health or environment. This includes how background concentrations vary during the year due to seasonal or other temporal trends.

Evaluating cumulative effects requires a knowledge of the existing or background concentrations of the contaminants being assessed. While in many instances there will be little or no accessible background data, this section provides a general framework to determine representative background levels.

4.4.1. Level of understanding of background air pollution

There is no clear set of rules that defines the degree to which background air pollution data is required to be included in an assessment, as this varies based on the following site-specific considerations:

- **The anticipated background air pollution of the receiving environment**: depending on the nature of the emissions being discharged, it may be appropriate to make reasonable assumptions about the potential for other sources to be present. Specifically, these assumptions relate to

whether the same pollutants generated from other sources could impact the receiving environment. With the exception of criteria air pollutants, when there are no other plausible sources of emissions affecting the surrounding air, it is reasonable to assume that background concentrations are zero. However, this assumption should always be appropriately justified and never be made by default. The following sources of information can be used to form assumptions about background air pollution:

- **EPA's air monitoring data:** continuous data for certain pollutants is collected by EPA monitoring stations and is available from EPA as well as www.data.vic.gov.au . These provide a reliable benchmark for the background levels of pollution in the surrounding area but may be less reliable in areas of lower residential and industrial density, where background concentrations are expected to be lower.
- **Pollutants with limited sources:** some pollutants are only released by specific sources or activities. In these cases, the background can be assumed to be zero if such sources would not be expected to be present. An example of this is fluoride release by brickworks, as shown in Case Study 2.
- **Local knowledge of surrounding industries:** this can provide useful information on the types and concentrations of background air pollutants.
- **NPI data and EPA licences:** the data presented in the NPI and on the EPA website on EPA licences can provide information on the types of pollutants emitted by relevant sources. In air pollution reports, it may be useful to present an aerial photograph of nearby emitters within a certain distance of the site, depending on the pollutant/s of interest. It is also recommended to list the types of pollutants released at each site. The distance may vary based on the nature of the emissions being assessed. For example, some emissions from large sources with tall stacks can be dispersed tens of kilometres from the source, while emissions from small sources become diffuse over much shorter distances. If there are no known emission sources identified for the pollutants being assessed (or if they are negligible), this would constitute a strong basis for the assumption that background concentrations are zero.

- **The nature of the discharges**: duty holders operating large or highly toxic discharges should conduct a thorough assessment of the background air pollution. Criteria pollutants are particularly significant in this context as some of them have no 'safe level' in air and often have significant background concentrations. For this reason, a greater focus on background concentrations is often required when criteria pollutants are being discharged.
- **Whether background pollution is associated with exceptional events**: when assessing PM_{10} and $PM_{2.5}$ pollution against 24-hour standards (not annual standards), it is appropriate to exclude any days where elevated background concentrations were directly associated with 'exceptional events'. These are defined in the NEPM AAQ and include bushfires, jurisdiction-authorised hazard reduction burning and continental scale windblown dust. For each excluded day, the reason why it has been excluded should be provided. Any gaps in the final background dataset should be backfilled using the most recent non-exceptional event day.
- **Sensitivity of the receiving environment**: where discharges have the potential to affect sensitive land uses, existing air pollution would be expected to be well-defined.

It is the combination of these considerations that determines the extent to which background air pollution should be addressed. For example, a qualitative statement on existing air pollution, which identifies the reasons background air pollution is anticipated to be low, would be sufficient for a small emission of a low-toxicity pollutant within a commercial/light industrial area. Conversely, a large-scale

industrial source with the potential to impact on residential suburbs might be expected to provide a detailed report, containing representative and quantitative background air pollution data.

Case study 2: Brickworks where background pollution can be assumed to be zero

A major brick works in regional Victoria is building a new expanded manufacturing plant. Brick kilns are significant sources of hydrogen fluoride, a toxic compound that can harm both human health and environmental receptors like vegetation. The assessment process involves dispersion modelling to determine the scope and nature of potential effects. Modelling is essential in this case to design appropriate controls, including the height of the stack to avoid adverse effects.

Consistent with this guideline, it is necessary to consider cumulative effects, but there is no immediately available background data on hydrogen fluoride. In this case, a simple check on potential sources around the impacted areas using the NPI database and the EPA portal shows that there are no other sources of hydrogen fluoride. Natural sources of hydrogen fluoride emissions are also
usually negligible.

Based on this, it is acceptable to assume that the background concentration of hydrogen fluoride is zero, and that all the hydrogen fluoride that might appear in the air around the plant will come from the brick kilns. EPA is satisfied that hydrogen fluoride effects are being adequately assessed, provided that:

- emissions from both stack sources and fugitive sources are considered
- appropriate assessment is made of upset conditions
- appropriate process controls and management practices are in place.

In this instance, background concentrations were assumed to be zero for the purposes of the assessment, and the assessment report provides a clear justification for this assumption.

4.4.2. Selecting suitable background air pollution data

If a quantitative assessment of background pollution concentrations is necessary, then suitable data should be obtained for all pollutants that are being discharged by the relevant, nearby emission sources. See Case Studies 3 and 4 for examples of selecting the most appropriate existing air pollution data to determine background pollution concentrations.

Background air pollution data can be sought from many sources, including:

- Existing monitoring data sets for the area of interest.
- Data from commissioned air monitoring programs specifically established for the purposes of characterising background air around the site being assessed. This is usually only relevant for very large or significant emission sources. See Case Study 4.

- Surrogate data from locations with air pollution characteristics representative of the area of interest. Even locations that are distant from the specific site may be representative if they both share a common trait/s. For example, if they are rural or near a major road.
- Air dispersion modelling to predict air pollutant concentrations from existing nearby sources. This may be the preferred approach when:
    - there is a small number of existing emission sources in the area for which reliable emission data are available.
    - the contribution to background levels from other hard-to-characterise sources (such as vehicle emissions, domestic sources, or dust from wind erosion) is negligible.
- Note for mining or extractive industries, a more prescriptive approach is provided to select suitable background data. Please refer to Table 1 in Section 5.1.3 of this guideline to classify the level of assessment required for the activity.

Guiding principles for selecting background data sources

The following guiding principles should be considered when selecting background data sources:

- **The degree to which background pollution is required to be characterised**: this varies from site to site. It is not always necessary to fully characterise background air pollution in detail and a proportionate level of effort should be taken.
- **The relevance of the data to the local environment**: data needs to be representative of likely background pollution levels in the receiving environment. An evaluation of whether data is 'relevant' requires professional judgement and should consider:
    - **The location of the monitoring site:** the site should be representative of location (ideally being within the affected airshed). The site should also be representative of land use, physical setting, and within the same airshed. If available, good quality monitoring or sampling results from the immediate surroundings should always be adopted as a first preference, provided they are relevant. See Section 4.4.2.
    - **The time of the monitoring:** data collected at the site in previous years may not be representative. This may be the case if the character of the area has changed markedly since monitoring was last undertaken. For example, historical data from a roadside monitoring site in an area that has experienced significant traffic growth would no longer be representative of current levels.
    - **Other relevant site-specific considerations:** this includes the accuracy and types of pollution monitors used, whether there are any local features that might bias the monitoring results, whether there are data gaps in the monitoring that might affect summary statistics and ensuring that the data obtained is approved for this use by its owner.
- **Whether the data is continuous or not**: the assessment of criteria pollutants with highly variable and occasionally elevated background concentrations (such as PM_{10} and $PM_{2.5}$) typically involves continuous hourly background monitoring. Where this is not the case (for example air toxics), the results of discrete (that is non-continuous) sampling may be extrapolated across longer times. When reasonable, pollutant trends should be considered. To ascertain any improvement or deterioration in background air pollution levels, it is preferable that several years of data are analysed.

- **The quality of the data**: before using existing air pollution data in an assessment, it is important that the monitoring technique and protocols are reviewed to demonstrate that the existing air pollution data is of appropriate quality.
- **The uncertainty in the data**: there will always be some degree of uncertainty in the assessment of background air pollution. Reasonably conservative assumptions should always be made and should be proportionate to the degree of uncertainty in the data. For example, conservative assumptions are required when extrapolating short-term sampling results across a longer averaging time.
- **All decisions should be appropriately documented and justified:** regardless of the approach used for characterising background air pollution, it is necessary to provide a clear rationale to support all assumptions made when characterising background air pollution. This involves a technical justification of methods, calculations and assumptions (supported by evidence).

Case study 3: Steel works assessed using pre-existing background data

A steel works plant in a major industrial precinct emits fine particles, VOCs and other toxics such as heavy metals. They have been the subject of several complaints from affected neighbours over many years. They have undergone several reviews and notices from EPA under the terms of their licence. However, according to the GED under the EP Act the steel works must now reduce their emissions so far as reasonably practicable.

The plant has engaged an air pollution consultant (practitioner) to conduct an air pollution assessment. Part of this assessment is a dispersion modelling exercise to:

- assess what sources contribute most to risk associated with the pollution.
- determine how these might be controlled and reduced.

Consistent with good practice, the consultant includes modelling and assessment of cumulative effects, which depends on reliable data on background pollution levels. However, the steel works plant is in a major industrial zone with many other potential sources, not all of which can be identified and quantified. In an ideal scenario these other sources would be included in the modelling assessment, but this is not feasible in this case.

The consultant chooses to adopt background concentrations for most pollutants of concern. This is done by taking at least five years of data from the nearby EPA monitoring site. Despite some limitations with the data (such as not having complete monitoring data for all target pollutants, which the consultant clearly documents in the report), the consultant uses EPA's monitoring data to construct a sufficiently complete picture of the existing background data and its variability over several years.

The consultant uses the collated data to present a conservative estimation of risks from cumulative effects. EPA accepts the consultant's assessment report and processes the case on the basis that background pollution was adequately accounted for in the broader air pollution assessment.

Case study 4: Extensive background monitoring required for a large mining site

A large mine site in rural Victoria is operating in accordance with a work plan approved by ERR. The mine operator wishes to increase extraction operations. When preparing the variation to their work plan, it is identified that this change could result in increased dust emissions, with the potential for increased impacts on a small rural community. Furthermore, the material extracted contains some heavy metals and respirable crystalline silica.

Such a significant variation is identified as requiring a Level 3 assessment (Refer to Table 1 in Section 5.1.4), for which a detailed assessment of background pollution needs to be carried out. The company installs monitors before the expansion works are set to start, measuring dust concentrations and collecting samples of the dust for analysis of air toxics. These monitors are located at sites representative of the three most common wind directions. These sites are also close to neighbouring residents to adequately characterise background pollution experienced by these sensitive receptors.

This detailed level of assessment combined with the modelled ground level concentrations provides a realistic indication of potential cumulative risks. Upon review, the assessment is considered to be adequate and proportionate for such a significant emission source.

4.5. Sensitive land uses

Understanding the sensitivity of the receiving environment is important to understand the potential for risks from air pollution to eventuate. Similar levels of air pollution can pose different risks, depending on the size, density and vulnerability of human populations or ecological receptors that are likely to be impacted.

4.5.1. Identifying sensitive land uses

Current land uses surrounding an emission source should be reviewed and described in any assessment of air pollution impacts. It provides a clear indication of the current sensitivity of the receiving environment to any risks from air pollution.

Potential future land uses should also be considered. The planning zoning, overlays and urban growth areas should also be reviewed, and can provide an indication of likely future uses of the land. For example, if an emission source were surrounded by vacant blocks earmarked for redevelopment as residential areas, it would not be appropriate to assess risks based on current land uses only.

Duty holders should also be aware of the issue of 'reverse amenity', where sensitive land uses encroach on less sensitive uses, such as industrial facilities. Allowing such encroachment has potentially adverse effects on the health, safety or amenity values of people. Reverse amenity can also have potentially adverse effects on the economic and safe operations of industries.

An example of reverse amenity is as follows. Where residential developments encroach on extractive resource sites, the residents may expect the extractive operator to unreasonably modify or even close down their operations. Residential land developers and local councils have an obligation to maintain adequate buffer distances between residential development sites and extractive resource sites, to prevent:

- putting the public at risk
- sterilising extractive resource sites
- creating land use conflict

This issue may be resolved for some industries by sequencing activities i.e., when the industry operator moves on to another part of their site after rehabilitating the area where the activity was undertaken, there may be opportunity for the residential development to move in, ensuring that adequate separation distances are maintained.

As part of any air pollution assessment, potentially impacted sensitive land uses should be clearly identified and presented. For the purposes of this guideline, a sensitive land use is one where it is plausible for people to be exposed over extended durations. Examples of sensitive land use include, but are not limited to, residential premises, educational and childcare facilities, nursing homes, retirement villages, hospitals. The presence of areas of ecological significance (for example national parks or other areas of ecological significance) or activities that might be vulnerable to emissions (for example certain food growing or processing facilities) should also be clearly identified.

Current and planned sensitive land uses, agricultural activities and areas of ecological significance should be clearly marked on a map or aerial photograph (including proximity distances). If dispersion modelling is required to be carried out for the site, this can be used to inform the location of discrete receptors for input into the model.

4.5.2. Size, density and vulnerability of nearby populations

In addition to the identification of sensitive land uses, which is a key input in air pollution assessments, it is useful to consider additional descriptive data to characterise potentially exposed populations. Health risks from air pollution are related to the location, size, density and vulnerability of the exposed population, as the likelihood and consequence of the health effects of air pollution are not equally distributed in the population.

There are many variables that impact on the vulnerability of a population, and it may vary between pollutants. Vulnerability could depend for example on the prevalence of existing chronic conditions in the population (for example chronic obstructive pulmonary disease), age distribution (the very young and the elderly are more susceptible to the effects of pollution) and socio-economic status. These can all be considered when conducting health risk assessments, but these are only required in limited circumstances (see Section 5.4).

For the broader objective of characterising the receiving environment, simple indicators of population size, density and vulnerability are required in assessments of air pollution to better understand impacts on the surrounding communities. These indicators can help provide context for the risks that are being assessed. Holistic consideration of this information provides a rigorous basis to support and justify the selection of risk controls.

Several indicators of population size, density, and vulnerability are available from the most recent ABS census at multiple statistical area levels. Indicator summaries at the smallest spatial scale relevant to the activity should include but not be limited to population, the index of relative socio-economic disadvantage (IRSD), population over 65 years and under 5 years of age, and population of people with long term health conditions such as lung condition, asthma, heart disease and diabetes. This forms a key input to baseline health assessments (see Appendix D).

It is noted that, while the identification of specific sensitive locations directly affects the outcomes of an air pollution assessment, population size, density and vulnerability are only considered in a more holistic manner when evaluating whether the risks are being minimised so far as reasonably practicable.

4.6. Reporting recommendations – receiving environment

Air pollution reports should include the following information about the receiving environment:

- Topography:
    - general description of the surrounding landscape.
    - comment on whether the topography is flat, elevated or complex.
    - comment on whether topography might interfere with pollution dispersion
    - include a topographic map.
- Meteorology:
    - general description of the local climate.
    - present one or more wind roses as appropriate.
    - comment on whether local meteorology is expected to create conditions that are poorly dispersive or difficult to model using dispersion models.
    - provide location of the meteorological station(s) used in the assessment, along with justification supporting their use.

- Background air pollution:
    - consider presenting a figure showing the location of nearby NPI-listed sources of the same pollutants as those being emitted by the site.
    - if data from locally relevant monitoring stations is used, present their locations on one of the figures (photos or maps).
    - if concentrations from inner urban monitors are likely greater than at the peri-urban/rural proposal location, consider a site monitoring campaign to better estimate background levels.
    - provide a clear justification for the inclusion (or exclusion) of different types of background data. Support this with evidence where possible.
- Population size, density and vulnerability:
    - provide locations and descriptions of potentially affected sensitive land uses and their distances to the pollution sources.
    - present a figure summarising all neighbourhoods and their cumulative populations in the receiving environment using ABS data.
    - summarise ABS vulnerability indicators as percentiles for all affected areas and compare with greater capital city (urban areas) or rest of state averages (rural areas).

Step 2 – Assess risks

What is the level of severity or risk based on likelihood and consequence?

Framework for the assessment of air pollution risks

The risk-based assessment of air pollution is a decision-support tool. It is intended to help duty holders prioritise and manage their risks appropriately and proportionately.

When evaluating risks from air pollution, there are three levels of assessment in order of increasing complexity.

Level 1 assessments – these screening level assessments are qualitative or semiquantitative in nature. They are used to quickly describe risks from activities that either have:

- intrinsically low risks, or
- risks that are so common and well understood they can be effectively controlled without the need for extensive assessment work.

Level 2 assessments – are the most common type of risk assessment for industry. They usually involve the use of dispersion modelling or monitoring. Predicted or measured pollutant concentrations can be benchmarked against a set of pre-defined APACs to understand the resulting risks.

Level 3 assessments – these detailed risk assessments are only used in circumstances when a simple comparison of pollutant concentrations to APACs cannot adequately describe health risks, or when emissions exceed the APAC for a given substance.

Regardless of the level of assessment, it is important for assessors to clearly describe and justify all key assumptions in all assessment reports. Guidance on EPA's minimum reporting standards for air pollution assessment reports is provided in Section 5.6.

5.1. Air pollution assessment framework

5.1.1. Objectives of air pollution assessment

Air pollution risk assessments have the following objectives:

- Understand the level of inherent or current residual risk posed by the activities at a site, to inform how these risks can be eliminated or reduced so far as reasonably practicable.
- Estimate future residual risks based on various proposed risk controls to understand the relative benefits or disbenefits of each option.
- Ensure any future residual risks remaining after reasonably practicable controls have been implemented do not pose an unacceptable risk to human health or the environment.

5.1.2. Risk-based decision-making in air pollution assessment

The risk-based assessment of air pollution is a conservative, decision-support tool. It is intended to assist duty holders to proportionately manage their risks and ensure continuous reductions in air pollution. Most risk assessments are not designed to identify or predict real impacts that will actually occur in the environment. They are intended to conservatively estimate the risks to ensure that adequate controls are implemented.

For example, a risk assessment cannot usually predict whether an individual will be affected by a specific pollution event. This is because the adopted criteria (the APACs) are not a simple threshold above which all individuals in the community will experience health effects. Rather, pollution exceeding one or more APACs indicates that the issue requires addressing through further assessment or more effective risk control measures.

To inform decision-making that is protective of human health and the environment, all assessments should be conducted in a manner that is reasonably conservative. More details on what constitute reasonably conservative assumptions are provided in Appendix A.

5.1.3. Level of assessment

The appropriate level of assessment varies depending on the degree to which the risks posed by an activity are understood. Some emission sources or activities are dealt with as a matter of routine and can be minimised with little assessment. More complex risks require detailed assessment to be understood and controlled appropriately. Three broad levels of assessment are described below and presented in Figure 5:

- **Level 1 – Qualitative assessment**. For some emission sources, it may not be necessary or useful to carry out a full quantitative assessment of pollution risks. Instead, a qualitative, or semi-quantitative screening assessment may be sufficient. This may occur when a source is very common and well understood, with risks that are known to be controllable using certain techniques or technologies. In these instances, the resulting risks are usually so low that a qualitative assessment is sufficient. This allows duty holders to proceed directly to risk control (rather than invest resources into a quantitative risk assessment). See Section 5.2 for further information.
- **Level 2 – Screening assessment**. If the Level 1 assessment indicates the need for quantitative assessment, then a Level 2 assessment should entail modelling and/or monitoring pollutant concentrations (see Section 5.3) and comparing these to the relevant APACs (see Section 6) to assess risks.
- **Level 3 – Detailed risk assessment**. In some circumstances, comparing ground level concentrations with APACs is not enough to assess risk. This is normally due to the characteristics of the emission source or receiving environment. Examples include sites emitting a complex mixture of highly toxic substances, or emissions that have the potential to deposit in soil or water and bioaccumulate in organisms or biomagnify in the food chain. A Level 3 assessment may also be warranted when emissions exceed APACs. Specific circumstances when a Level 3 assessment is suitable, and the types of tools available to conduct the assessment are provided in Section 5.4 and Table 2.

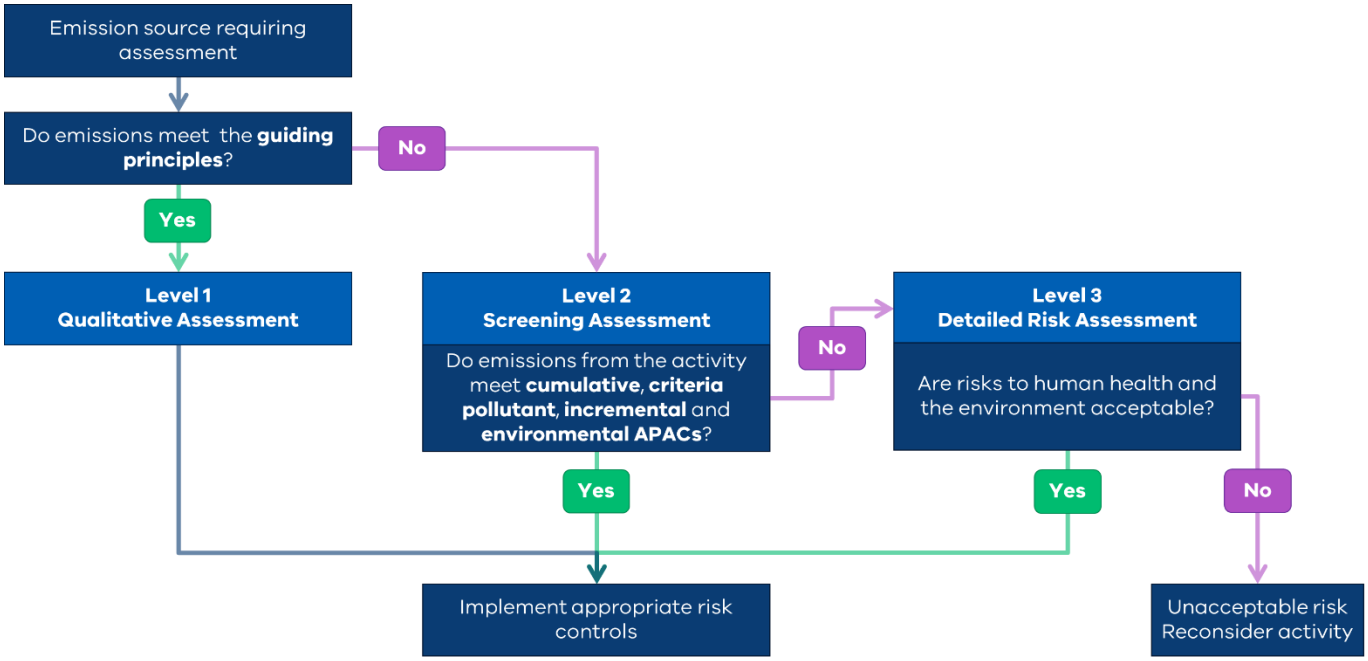

Figure 5 – Levels of assessment of air emission sources. See Section 6 (Air Pollution Assessment Criteria (APACs)) for explanation on how to apply cumulative, incremental, and environmental APACs.

5.1.4. Mining and extractive industries

For mining and extractive industries (new and/or variation) the level of assessment required is provided in Table 1. An assessment of risks associated with new or existing mining industries may be required in the following situations.

- **A new mining or extractive activity is being proposed**.
- **Existing mines**: An assessment of risks from air pollution, dust management plans, management plans and operational performance records including monitoring where required for existing mine compliance.
- **Increased production volume**: Extractive industries and mines that propose to increase the volume produced, need to undertake a level assessment in line with new production levels.
- **Increased extraction area**: It is common for mines and quarries to increase the extraction area. For this type of change with an operation, an assessment appropriate to the risks should be undertaken.

For confirmation of the level of assessment required, consult with EPA.

Table 1 – Level of assessment for mining and extractive industries

	Large mine or quarry greater than 500,000 t/yr extraction	Medium mine or quarry between 150,000 t/yr and 500,000 t/yr extraction	Small mine or quarry between 50,000 t/yr and 150,000 t/yr extraction	Mine or quarry with yearly extraction below 50,000 t/yr extraction
Urban area	Level 3	Level 3	Level 2	Level 1
Rural area close to residences (less than 500 m from the limit of work described in the work plan)	Level 3	Level 2	Level 1	Level 1
Rural area (residences more than 500 m from the limit of work described in the work plan)	Level 2	Level 1	Level 1	Level 1

Extraction refers to:

- quarries: the amount of soil and rock that is moved or extracted per year
- above-ground mines: the amount of soil, rock and ore moved on the site
- underground mines: the amount of soil, rock and ore moved above ground and brought to the surface of the mine. Any emissions from ventilation shafts of the mine must also be taken into account in the estimates of emissions where the shaft is part of the premises

5.2. Level 1 – Qualitative assessment

Risks from certain emission sources can be eliminated or reduced so far as reasonably practicable without the need for extensive quantitative assessment works. The three guiding principles listed below provide a broad understanding of when this might be the appropriate approach.

These guiding principles are general in nature and do not apply when site-specific conditions mean that risks would not be adequately understood through a Level 1 assessment.

(1) Routine activities that have controls that are known to be effective. Some activities are common and have been demonstrated over many years to be adequately managed through the implementation of specific risk controls. These include (but are not limited to):

- Concrete batching plants
- New asphalt batching plants
- New motor vehicle spray painting booths
- Natural gas boilers <20 MW

- Small gas turbines <5 MW combined heat and power plants

(2) Mass emission rates that are so low they can be considered negligible. When a source of emissions is very minor, it may be acceptable to assume these emissions are close to zero. Generally, emission sources that are not required to report to the NPI can often be considered to pose a negligible inherent risk. As such, these emissions require no further quantitative assessment, so long as adequate justification is provided.

(3) Fugitive emissions that are difficult to assess accurately. For certain fugitive emission sources, a full quantitative assessment is prone to such large uncertainties that it is often more effective to invest resources into risk controls rather than into assessment works. This is particularly true of dust emissions from diffuse sources such as:

- waste processing facilities accepting solid inert or construction and demolition wastes
- earth-moving activities
- construction activities
- sites processing organic wastes or green wastes.

If all three of the guiding principles listed above do not apply, then further quantification of risk is required. This is the case, for example, for large and/or complex projects such as waste incineration, waste to energy, chemical processing, large mining or road projects, which always require a Level 2 or 3 assessment.

If the duty holder believes that a Level 1 assessment is sufficient to inform the implementation of appropriate risk controls, they need to provide EPA with a brief report. This should include:

- a description of the emission sources and receiving environment (as outlined in Sections 3 and 4).
- all the proposed emission controls, risk controls, management practices and checks (see Sections 7 and 8).
- a concise rationale justifying proposed approach against the three principles listed above.

EPA will consider all available site-specific information when evaluating whether further evidence and/or assessment is required.

Case study 5: Concrete batching plant

A small concrete batching plant processing less than 3,000 t/yr is proposed to be constructed on a main road. Warehouses and light industrial land are present on either side of the site of the proposed development, with private residences across the road.

The developers provide EPA with a Level 1 qualitative assessment report. This includes a description of:

- site operations, throughput, associated emission sources, hours of operation.
- meteorology, topography and nearby land uses (including sensitive ones).
- demographic characteristics of the population living near the site.
- any other discharging industries near the site.
- likely background air pollution levels based on data from the nearest EPA air monitoring station.

The report also includes a description of how concrete plants are a common and well understood source. It outlines how extensive dust and odour controls are planned to be implemented consistent with the guidance in– *Reducing risk in the premixed concrete industry* (EPA Publication 1806). The report also notes that dust emissions from the plant would be difficult to assess with any confidence due to large uncertainties in the emission rates from these types of fugitive sources but emissions are likely to be minimal due to the controls in place.

EPA reviews the submitted documentation, and provided the plant is following current best practice methods, it does not ask for further modelling or monitoring assessment. This is because any residual risks remaining after best practice controls are implemented would be expected to be low. EPA will monitor compliance through its standard reporting procedures. Further mitigation actions from the concrete plant will be based on the number and nature of any pollution reports received.

5.3. Level 2 – Screening assessment

A Level 2 assessment builds on the initial Level 1 assessment by undertaking further works involving modelling and/or monitoring to further understand the risks.

5.3.1. Air pollution modelling

The ability to model the discharge, release, creation, transport and fate of pollutants in the atmosphere is essential for assessments of air pollution risks.

The advantage of modelling is that it allows:

- alternative scenarios to be tested.
- design features to be evaluated.
- effects to be identified.
- mitigation options to be explored.

Modelling can be done before a facility is built, or on a process that has commenced. Modelling does not, however, provide all the answers and it can be complicated. A key disadvantage of modelling is that it requires input data that is not always readily available, accurate or representative of emissions under different operating conditions, thereby increasing the uncertainty in the modelling predictions.

Modelling fugitive emissions and wide area sources is prone to particularly large uncertainties due to the complex nature of the emission sources and dispersion. Due to this, modelling may not always be suitable to assess an air pollution source and its associated risks. In these situations, an assessment of the management plans (air pollution and dust management) and operational performance records including monitoring should be considered.

The use of modelling should always be accompanied by an evaluation of the expected operational performance measures. The accompanying report should include a discussion of the strengths and weaknesses of the modelling conclusions, including a detailed list of the input data limitations.

Regulatory model

Dispersion modelling should be performed using EPA's preferred model in line with standard modelling methodologies directed by the United States Environmental Protection Agency (US EPA) AERMOD modelling guidance. AERMOD is the US EPA regulatory model, and as such contains comprehensive guidance and is updated regularly. The US EPA modelling guidance provides a leading framework for other environmental regulators to use. The most up-to-date US EPA model version and guidance should always be used.

From time to time, EPA publishes guidance on modelling methodologies and approaches in a Victorian context.

Alternative models

Experience with AERMOD modelling has been adequate for most situations and it provides a reasonable base case for assessing different types of projects in a consistent way. There needs to be a clear and compelling case to use alternative models for common situations where AERMOD is demonstrably suitable. Complementing AERMOD modelling with alternative modelling (that is carrying out both) will enhance the confidence in the predictions from non-AERMOD models.

In highly complex scenarios alternative fit for purpose models are acceptable. For example, when dispersion modelling around buildings should consider canyon effects, or when background concentrations are poorly represented by the nearest EPA monitor. Prior approval from EPA should be obtained before using these alternative models or prior to applying for a permission or authorisation using these alternative models. This should be documented in any accompanying assessment report.

5.3.2. Air pollution monitoring

Measuring and monitoring the concentration of pollutants is one way of assessing risks from air pollution. This is done by comparing concentrations to risk-based criteria such as the APACs in this guideline (see Section 6.3).

The fundamental objective of air pollution monitoring is to collect data that can be used to make informed decisions to best manage air emissions and improve the environment. Effective monitoring is consistent with the following four objectives:

- **Scientifically valid** – air pollution data is from a regularly calibrated monitor that is relevant to the site of interest.
- **Representative** – spatial/temporal variations and the extent of human exposure are considered when designing monitoring networks.
- **Consistent** – air pollution data is recorded, analysed, processed, reported and archived following best-practice principles.
- **Accessible** – suppliers and users of air pollution data have quick and easy access to methods, procedures and new developments.

5.4. Level 3 – Detailed risk assessment

Some complex scenarios may need a more detailed assessment of risks. This is because the risk posed by the site's emissions or receiving environment cannot be completely understood with a simple comparison of concentrations to APACs (see Section 6.3), or because modelled or measured concentrations exceed the APAC for a given substance. The term 'detailed risk assessment' is used in this guideline to represent the type of methods that can be used in these uncommon situations.

This section provides a list of detailed risk assessment methods. These are not intended to be comprehensive or prescriptive, rather they provide an indication of the type of additional assessment that might be expected under certain circumstances (see Table 2 2). The type of assessment conducted should reflect the endpoint that the APAC is derived from. For example:

- A human health risk assessment (HHRA) of non-carcinogenic risk for exceedance of a cumulative APAC based on respiratory irritation.
- A HHRA of carcinogenic risk for exceedance of an incremental APAC based on lung cancer incidence.
- An ecological risk assessment (ERA) using environmental APACs for emissions impacting an area of ecological significance.
- A microbial risk assessment for activities generating bioaerosols.

The multiple lines of evidence approach should be considered in any detailed risk assessment. This includes assessment of multiple health effects across the air pollution health pyramid (WHO 2016) for criteria pollutants.

Further explanation of the methods provided in Table 2 can be found in Appendix D. An air pollution assessment might include elements of multiple methods, which would then be detailed in one air pollution assessment report. They should not be thought of as being separate assessments or separate reports.

Table 2 – Types of detailed risk assessment methods and when they might be used. Further information on each method is provided in Appendix D.

Assessment type	Circumstances when it might be applicable
Baseline health assessment	• A development is proposed that has the potential to impact a large population • The exposed population is suspected of being particularly vulnerable • Note: this assessment is often carried out in conjunction with a human health risk assessment of criteria pollutants (described below).
Human health risk assessment (HHRA) of air toxics	• Significant amounts of multiple air toxics are likely to be released by the activity, forming a complex mixture • Pollutants of concern are air toxics (not criteria pollutants) • The activity discharges new or emerging contaminants not addressed by the APACs, meaning a toxicology review is required • Multiple exposure routes are considered (e.g. as part of a multi-pathway risk assessment), such as ingestion and dermal contact • The activity poses a significant health concern and a HHRA can help better communicate health risks than a modelling or monitoring report.
Microbial risk assessment	• The activity involves one or more bioaerosols (see Section 3.2.3) • A complete source-pathway receptor exists between the bioaerosol emissions from the site and offsite human populations.

Multi-pathway risk assessment	• Significant amounts of pollutants are emitted that are persistent, bioaccumulating; and/or bound to particles that are likely to deposit on soil or water
	• There is a plausible current or future risk associated with accumulation of substances in soil, water or up the food chain, such as:
	  ○ agricultural areas and areas used to produce food
	  ○ water reservoirs or significant water bodies
	  ○ areas of ecological or cultural significance
	• Emissions are likely to be ongoing (>10 years)
	• Other circumstances where impacts of air pollution to soil or water may be of concern (e.g. a complex terrain subject to a plume strike).

Ecological risk assessment (ERA)	• The activity has the potential to impact an area of ecological significance
	• The emissions could adversely impact nearby ecosystems, for example:
	  ○ concentrations exceed environmental APACs
	  ○ pollutants are ecotoxic, bioaccumulative or otherwise harmful to ecosystems at the concentrations likely to be present in the environment.

Nuisance dust risk assessment	• The activity has the potential to result in significant dust emissions.
Multiple lines of evidence approach	• Background levels of a criteria pollutant exceed the relevant APACs • Individual observations or analyses do not provide sufficient evidence on their own to describe the risk.

5.5. Incorporating cumulative effects in air pollution assessment

The assessment of risks from air pollution should always consider the possibility of cumulative effects from various factors contributing to the overall risk of harm. In its broadest sense, the term 'cumulative' encompasses all the factors that can contribute to a health or environmental impact. However, the degree to which cumulative effects should be accounted for in an assessment varies, depending on the complexity and specific characteristics of the issues being assessed. Assessment reports need to clearly outline which types of cumulative effects were included or excluded from the assessment and why.

Cumulative effects arise from:

- background, or pre-existing air pollution, which should be considered as described in Section 4.4.
- the size, density and vulnerability of the exposed population, which should be addressed as described in Section 4.5.

Other types of cumulative effects that are only required to be addressed in specific circumstances and include cumulative toxicology of chemical mixtures; cumulative exposures to multi-pathway pollutants; and cumulative effects of air pollution on baseline health, all of which are described in more detail in Appendix C.

5.6. Recommended reporting standards in air pollution reports

5.6.1. Report contents

Assessment reports being submitted to EPA should follow a standard methodology and format. Although the scope and size of a report will vary depending on the assessment, reports should contain the following features:

- **Executive summary**: brief statement of the key features and results. This may be the only part of the report that some people read, so it should be succinct, clear and contain the most important results and conclusions.
- **Scope**: reasons why the assessment has been conducted and what aspects of an activity were in or out of scope.
- **Introduction**: background to the issues and link to any other relevant work.
- **Legislative and policy requirements**: include details of any existing requirements and the level of compliance with these requirements, including federal, state, and local government requirements. This section should also include reference to any licences or permits required by relevant regulators and other agencies.

- **Description of the development or activity**: description of the activity being assessed and any changes to existing activities. This section should characterise air discharges (including all contaminants of concern) and their sources.
- **Description of the site and its surroundings**: area or location being assessed, including maps with all relevant features (and photos if available). Show any related sensitive locations.
- **Consultation**: summary of any consultation undertaken with stakeholders. Discuss how the outcomes of this consultation have informed the development of the proposed project or activity.
- **Methodology**: description of the processes, monitoring and models used. Include any assumptions made and statistics or analysis used.
- **Data used**: sources and validity of all input data, including emissions and process data, meteorology, existing concentrations and all assumptions made.
- **Assessment of effects and associated risks**: selection of assessment criteria (for Level 2 assessments, these will be APACs). Summary of assessment outputs (in tabular or graphic format when possible), with an emphasis on key results that can inform decision-making. Potential for cumulative effects from multiple sources or other factors should be discussed. Detailed results should be included in an appendix.
- **Risk control**: mitigation options that are available and have been considered. Justify the reasons for adopting some and not others. Explain how the current risks have been reduced to so far as reasonably practicable. This section can include an evaluation of risk controls and 'best available techniques and technologies'.
- **Discussion**: implications of the findings. An uncertainty assessment should be included clearly outlining key assumptions and the degree of uncertainty associated with them. This may involve presenting a sensitivity analysis.
- **Conclusion**: summary of the scope, method, results and implications.
- **References**: all material used should be referenced explicitly and should include web-based links where appropriate.
- **Appendices**: any detailed calculations, monitoring data or other supplementary information. This should include dispersion model control files if dispersion modelling has been used. It should also include laboratory reports and complete monitoring results.

5.6.2. Peer review and quality control

Components of the assessment and the reporting should be peer reviewed. This makes the report and its conclusions more robust and of higher quality. Peer review is a standard procedure in many organisations and can be internal or external.

In addition, information, measurements, calculations, and analysis should be provided in sufficient detail so the assessment can be replicated by another suitably qualified practitioner.

It is also of benefit to both duty holders and assessors if the reporting is complete and contained within a structured template. This allows for a more efficient and effective assessment and can reduce the time required for approvals.

Air pollution assessment criteria (APACs)

APACs are concentrations of pollutants in air that provide a benchmark to understand potential risks to human health or the environment. They are risk-based concentrations that can help identify when or if an activity is likely to pose an unacceptable risk to the receiving environment.

APACs are not intended to be concentrations one can 'pollute up to'. They are also not concentrations below which no action is required. This is because under the GED, anyone engaging in an activity that may give rise to risks of harm to human health or the environment due to discharges to air is required to minimise those risks so far as reasonably practicable.

6.1. Introduction to the APACs

APAC are risk-based levels. They apply to modelled or monitored air data, regardless of the type of source that generated the pollution. APACs are intended to serve a dual purpose:

- Help emitters understand the current inherent risks posed by their activities to inform the implementation of appropriate controls.
- Provide a benchmark against which current or future residual risks (risks remaining after proposed controls are implemented) can be compared to evaluate whether they are acceptable or not.

APACs are not intended to be concentrations one can 'pollute up to' and must not be interpreted as concentrations below which no action is required. This is because the duty holder is required under the GED to minimise risks so far as reasonably practicable.

Air pollution assessments should not be limited to the pollutants listed in this section given that all pollutants have the potential to pose a risk to human health or the environment.

There are four broad types of APACs:

- **Cumulative non-carcinogenic APACs**: these are health-based values intended to be protective of non-cancer risks to public health. Cumulative non-carcinogenic APACs apply to all sources within the airshed (including background).
- **APACs for criteria pollutants**: these are the indicators for ambient air established in the Environment Reference Standard (2021). Criteria pollutants are widely distributed across the country. They are regulated at a national level, calculated based on human and environmental effects, and apply to all sources within the airshed (including background).
- **Incremental carcinogenic APACs**: these are health-based values intended to be protective of cancer risks to public health. There is sufficient evidence that some air pollutants can cause cancer. Substances that are genotoxic carcinogens require additional consideration of their risk to human health. Incremental carcinogenic APACs apply only to the incremental concentration of air pollution emitted from the activity (excluding background).
- **Environmental APACs**: these are protective of other environmental values including ecosystems and agricultural land. Environmental APACs apply to all sources within the airshed (including background).

Odour impacts are not considered in this guideline and are addressed in *Guidance for assessing odour* (EPA Publication 1883).

6.2. The APACs

6.2.1. Health-based and environmental APACs

Lists of derived cumulative non-carcinogenic, criteria pollutant, incremental carcinogenic and environmental APACs are provided in Table 3, Table 4, Table 5 and Table 6, respectively. APACs were derived using the methods described in Appendix B.

6.2.2. Developing new APACs

If no APAC is provided for a pollutant in this document, then it is possible to derive one by:

(1) Following the same hierarchical method of adopting a suitable value from the level 1 to 5 sources that were used to derive the APACs (see Appendix B). Appropriate justification should be provided on the validity and reliability of the criteria adopted.

(2) If a suitable value is not available from Option (1), then an APAC can be derived by modifying Workplace Exposure Standards (WES) or Limits (WEL) for Airborne Contaminants by adjusting them to make them protective of receptors to the types of exposures that might occur outside of occupational settings.

- For low and moderately hazardous air pollutants, the adopted APAC (expressed as an 8-hour average) is the time-weighted average (TWA) divided by 10. This safety factor of 10 accounts for extrapolation from a healthy adult exposed over their working life to the general population potentially exposed over a lifetime. This factor ensures the protection of sensitive groups including the elderly and children.
- For highly hazardous pollutants, the adopted APAC (expressed as an 8-hour average) is the TWA divided by 20. This correction factor includes an additional safety factor of 2 due to the severity of the potential health effects arising from exposure to these pollutants.

(3) When no suitable value is provided by Option (1) or (2) for an air pollutant, then it may be necessary to undertake a detailed risk assessment following the approach outlined in Appendix D.

6.2.3. Updating APACs

APACs are intended to be reflective of current science. As such, they will evolve as various jurisdictions, particularly international jurisdictions, update their air pollution guidelines. All efforts will be made to maintain an up-to-date list of APACs. EPA plans to periodically review this guideline following the methods specified in Appendix C. It is possible for emitters to pre-empt future updates of the APACs by applying the methods to contemporary national and international guidelines at the time. In most cases, EPA would accept new APACs derived in line with the methodology specified in this guideline.

6.3. Application of APACs

6.3.1. Application of APACs to modelling outputs

EPA recommends that APACs are applied to modelled concentrations in the following way:

- Concentrations are reported for:
    - the most impacted location at or beyond the boundary of the site.
    - any sensitive land uses that have been specifically identified (see Section 4.5).
- Results are presented for each impacted location as the:
    - incremental ground level concentration of emissions from the site.

  - background concentration of the pollutant.
  - total cumulative concentration of the pollutant (activity increment and background).
- The percentiles of the data are reported as follows:
  - the 99.9th percentile for averaging times of an hour or less.
  - the 100th percentile (maximum) for all averaging times greater than an hour.
- APACs apply to a specified averaging time, which can vary across pollutants. Different averaging times are protective of different types of impacts. All relevant averaging times require consideration for each substance.
- APACs with an averaging time less than 24 hours apply at any location at or beyond the boundary of the facility. APACs with averaging times of 24 hours or greater apply at discrete sensitive locations. This is because acute exposures can plausibly occur in most locations (for example, in a park, along a shopping strip or at a place of work), while longer exposures are more likely at sensitive locations (see Section 4.5). A given pollutant may have multiple APACs with different averaging times, in which case each APAC would apply to different locations according to the rule set out above.
- APACs are not designed to evaluate risks from highly elevated single exposures of very short duration (in the order of minutes) such as might occur during an incident or emergency. In these instances, alternative assessment criteria should be considered that are designed for that purpose (for example Acute Exposure Guideline Levels (AEGLs) from the US EPA, or the emergency response planning guidelines from the American National Oceanic and Atmospheric Administration).

Exceedance of one or more APACs indicates that the activity has the potential to pose an unacceptable risk to human health or the environment. This prompts the need for a Level 3 detailed risk assessment to be conducted to assess the risk to sensitive receptors, consider if modelling assumptions are realistic (see Appendix A) and propose reasonable and proportional controls to mitigate the risk for that specific pollutant.

It is important to note that compliance with GED may necessitate further risk controls, even when predicted concentrations are below the relevant APACs.

6.3.2. Application of APACs to monitoring data

Monitored data can be directly compared to APACs, provided that the sampling time corresponds to the averaging time of each individual APAC. It may be necessary to provide additional interpretation and include conservative assumptions if the monitoring duration is not the same as the averaging time or if it only matches some of the relevant APACs.

One-hour averages can be converted into shorter averaging times[1], but the use of conversion factors between averaging times greater than 1 hour (for example Haber's Law) are generally not supported by EPA except if accompanied by valid and clear justification.

Incremental carcinogenic APACs only apply to the incremental concentration of the pollutant from that activity (excluding background and other airshed sources). Incremental carcinogenic APACs are derived

[1] Using the function $C_t = \left(\frac{60}{t}\right)^{0.2}$, where t is an averaging time (in minutes) that is shorter than 60 minutes.

for genotoxic carcinogens because these substances can cause cancer in populations even at low exposure levels. The background concentration of these chemicals may vary.

If concentrations exceed the incremental, cumulative or environmental APACs, then further risk assessment (Level 3) and controls are required to mitigate the risk.

6.4. Air pollution assessment criteria (APAC) tables

Table 3 *– Table of cumulative non-carcinogenic APACs. Cumulative APACs apply to all sources within the airshed (incremental and background).*

CAS Number	Substance	Class[a]	Highly hazardous pollutant[b]	Hazard classification[b]	Averaging time	APACs[c] ppm	APACs[c] µg/m³	Critical effect	Basis[d]
71-55-6	1,1,1-Trichloroethane	2	-	-	1 hour	1.6	9000	Neurological effects	US EPA
					24 hours	1.1	6000	Neurological effects	US EPA
					1 year	0.9	5000	Liver histopathologic changes	US EPA
79-00-5	1,1,2-Trichloroethane	2	-	-	24 hours	0.03	160	Necrosis of the olfactory epithelium	ATSDR
					1 year	0.01	55	Irritation of the olfactory epithelium	TCEQ(int.)
540-59-0	1,2-Dichloroethylene	2	-	-	1 hour	2	7900	Central nervous system impairment, eye irritation	TCEQ(int.)
106-99-0	1,3-Butadiene	3	✓	**Carcinogen, mutagen**	1 hour	0.3	660	Developmental toxicity	OEHHA
					1 year	0.0009	2	Ovarian atrophy	US EPA
103-11-7	2-Ethylhexyl acrylate	-	-	Skin sensitisation	1 hour	0.05	380	Respiratory tract irritation	TCEQ(int.)
					1 year	0.005	38	Respiratory tract irritation	TCEQ(int.)
591-78-6	2-Hexanone	2	✓	**Highly toxic (chronic)**	1 year	0.007	30	Nervous system (motor conduction velocity)	US EPA
75-07-0	Acetaldehyde	2	✓	**Carcinogen**	1 hour	0.3	470	Respiratory system	OEHHA
					1 year	0.005	9	Degeneration of olfactory epithelium	US EPA
67-64-1	Acetone	2	-	-	24 hours	8	19000	Neurobehavioral effects	ATSDR
					1 year	6.7	16000	Neurotoxicity	TCEQ(final)
107-02-8	Acrolein	3	✓	**Highly toxic (acute)**, skin corrosion	1 hour	0.0048	11	Respiratory irritation	TCEQ(final)
					24 hours	0.003	6.9	Respiratory irritation	ATSDR
					1 year	0.0000087	0.02	Nasal lesions	US EPA
79-10-7	Acrylic acid	2	-	Skin corrosion	1 hour	2.0	6000	Nasal irritation	OEHHA
					1 year	0.0003	1	Degeneration of nasal olfactory epithelium	US EPA
107-13-1	Acrylonitrile	3	✓	**Carcinogen**	1 year	0.0009	2	Degeneration of nasal olfactory epithelium	US EPA
98-88-9 & 98-88-4	Alpha chlorinated toluenes and benzoyl chloride	3	-	Skin corrosion	1 hour	0.0049	28	Upper respiratory tract irritation, eye irritation	TCEQ(int.)
7664-41-7	Ammonia	2	-	Skin corrosion	1 hour	4.6	3200	Eye and respiratory irritation	OEHHA
					24 hours	1.7	1184	Respiratory irritation	ATSDR
					1 year	0.1	70	Respiratory irritation	ATSDR

CAS Number	Substance	Class[a]	Highly hazardous pollutant[b]	Hazard classification[b]	Averaging time	APACs[c] ppm	APACs[c] µg/m³	Critical effect	Basis[d]
62-53-3	Aniline	2	✓	**Highly toxic (chronic)**, eye damage, skin sensitisation	1 year	0.0003	1	Spleen toxicity	US EPA
7440-36-0	Antimony and antimony compounds	2	-	-	24 hours	NA	1	Squamous metaplasia of the epiglottis	ATSDR
					1 year	NA	0.3	Lung inflammation	ATSDR
7440-38-2	Arsenic and arsenic compounds	3	✓	**Carcinogen**	1 hour	NA	9.9	Respiratory irritation	TCEQ(final)
					1 year	NA	0.015	Intellectual function	OEHHA
7440-39-3	Barium and barium compounds	2	-	-	1 hour	NA	5	Eye, skin and gastrointestinal irritation, muscular stimulation	TCEQ(int.)
71-43-2	Benzene	3	✓	**Carcinogen, mutagen, highly toxic (chronic)**, aspiration hazard	1 hour	0.18	580	Haematological	TCEQ(final)
					24 hours	0.009	29	Haematological	ATSDR
					1 year	0.003	9.6	Haematological	ATSDR
7440-41-7	Beryllium and beryllium compounds	3	✓	**Carcinogen, highly toxic (chronic and acute)**, respiratory sensitisation, skin sensitisation	1 year	NA	0.001	Immunological beryllium sensitisation	ATSDR
75-25-2	Bromoform	2	-	-	1 hour	0.005	50	Liver damage, upper respiratory tract irritation, eye irritation	TCEQ(int.)
7440-43-9	Cadmium and cadmium compounds	3	✓	**Carcinogen, highly toxic (chronic)**	1 hour	NA	18	Immunotoxicity	TCEQ(final)
					24 hours	NA	0.03	Lung inflammation	ATSDR
					1 year	NA	0.005	Renal function and lung cancer	WHO
1333-86-4	Carbon black	2	-	**-**	1 hour	NA	35	No irreversible health effects	TCEQ(int.)
75-15-0	Carbon disulfide	2	✓	**Highly toxic (chronic)**	1 hour	2	6200	Developmental toxicity	OEHHA
					24 hours	0.03	100	Adverse health effects	WHO
56-23-5	Carbon tetrachloride	2	✓	**Highly toxic (chronic)**	1 hour	0.3	1900	Developmental toxicity	OEHHA
					1 year	0.02	100	Fatty change in liver	US EPA
50-32-8	Carcinogenic PAHs (as benzo(a)pyrene)[e]	3	✓	**Carcinogen, mutagen, toxic to reproduction, bioaccumulative**, skin sensitisation	1 year	0.00000019	0.002	Developmental toxicity	US EPA

CAS Number	Substance	Class[a]	Highly hazardous pollutant[b]	Hazard classification[b]	Averaging time	APACs[c] ppm	APACs[c] µg/m³	Critical effect	Basis[d]
10049-04-4	Chlorine dioxide	2	-	Skin corrosion	1 year	0.000072	0.2	Vascular congestion and peri bronchial oedema	US EPA
108-90-7	Chlorobenzene	2	-	-	1 year	0.2	1000	Renal effects	OEHHA
67-66-3	Chloroform	2	-	-	24 hours	0.1	488	Liver effects	ATSDR
					1 year	0.02	98	Liver effects	ATSDR
18540-29-9	Chromium (hexavalent)	3	✓	**Carcinogen**, skin sensitisation	1 hour	NA	1.3	Increased relative lung weight	TCEQ(final)
					1 year	0.0000023	0.005	Respiratory irritation	ATSDR
16065-83-1	Chromium (trivalent)	2	-	-	30 days	NA	0.1 (e)	Respiratory irritation	ATSDR
4170-30-3	cis-Crotonaldehyde	2	✓	**Mutagen, highly toxic (acute)**, eye damage	1 hour	0.01	29	Eye irritation	TCEQ(final)
					1 year	0.003	8.1	Mild hyperplasia of respiratory tract	TCEQ(final)
7440-50-8	Copper and copper compounds	-	-	-	1 hour	NA	10	Metal fume fever, gastrointestinal irritation	TCEQ(int.)
98-82-8	Cumene	2	✓	**Carcinogen**, aspiration hazard	1 year	0.08	400	Increased kidney weight	US EPA
110-82-7	Cyclohexane	2	-	Aspiration hazard	1 year	1.7	6000	Developmental toxicity	US EPA
75-09-2	Dichloromethane	2	-	-	1 hour	3.4	12000	Central nervous system depression	TCEQ(final)
					24 hours	0.9	3000	Carboxyhaemoglobin in blood	WHO
					7 days	0.1	450	Carboxyhaemoglobin in blood	WHO
62-73-7	Dichlorvos	2	-	Skin sensitisation	24 hours	0.002	18	Nervous system effects	ATSDR
					1 year	0.000055	0.5	Neurological effects	US EPA
109-89-7	Diethylamine	2	-	-	1 hour	0.033	99	Nasal and eye irritation	TCEQ(final)
124-40-3	Dimethylamine	2	-	-	1 hour	0.05	90	Upper respiratory tract irritation, gastrointestinal irritation	TCEQ(int.)
1746-01-6	Dioxins and furans (as TCDD equivalents)(f)	3	✓	**Carcinogen, bioaccumulative**	1 year	0.000000003	0.00004	Increased mortality and other critical effects	OEHHA
106-89-8	Epichlorohydrin	3	✓	**Carcinogen, mutagen**, skin corrosion, skin sensitisation	1 hour	0.3	1300	Respiratory irritation	OEHHA
					1 year	0.0003	1	Nasal effects	US EPA
141-78-6	Ethyl acetate	2	-	-	1 hour	4	14400	Upper respiratory tract irritation, eye irritation	TCEQ(int.)
					1 year	0.4	1440	Upper respiratory tract irritation, eye irritation	TCEQ(int.)

CAS Number	Substance	Class[a]	Highly hazardous pollutant[b]	Hazard classification[b]	Averaging time	APACs[c] ppm	APACs[c] µg/m³	Critical effect	Basis[d]
75-00-3	Ethyl chloride	2	-	-	24 hours	15	39580	Developmental toxicity	ATSDR
					1 year	3.8	10000	Developmental toxicity	US EPA
100-41-4	Ethylbenzene	2	-	Aspiration hazard	1 hour	20	86000	Ototoxicity	TCEQ(final)
					24 hours	5	21712	Auditory capacity	ATSDR
					1 year	0.06	261	Renal function	ATSDR
107-06-2	Ethylene dichloride	3	✓	**Carcinogen**	1 hour	0.55	2200	Degeneration of the olfactory epithelium	TCEQ(final)
					24 hours	0.2	700	Liver histology changes	WHO
					1 year	0.1	400	Elevated liver enzymes	OEHHA
107-21-1	Ethylene glycol	2	-	-	24 hours	0.8	2000	Respiratory irritation and systemic toxicity	ATSDR
					1 year	0.2	400	Respiratory irritation	OEHHA
75-21-8	Ethylene oxide	3	✓	**Carcinogen, mutagen, highly toxic (chronic)**, skin corrosion, skin sensitisation	1 year	0.02	30	Neurotoxicity	OEHHA
16984-48-8 & 7664-39-3	Fluorides	2	-	-	1 hour	0.73	60	Increased airway inflammation	TCEQ(final)
					24 hours	0.02	31	Respiratory irritation	ATSDR
7782-41-4	Fluorine	2	-	Skin corrosion	24 hours	0.01	16	Respiratory irritation	ATSDR
50-00-0	Formaldehyde	2	✓	**Carcinogen**, skin corrosion, skin sensitisation	30 min	0.08	100	Sensory irritation	WHO
					24 hours	0.04	49	Respiratory irritation	ATSDR
					1 year	0.008	9.8	Respiratory irritation	ATSDR
7647-01-0	Hydrogen chloride	2	-	Skin corrosion	1 hour	1.4	2100	Respiratory irritation	OEHHA
					1 year	0.01	20	Respiratory tract hyperplasia	US EPA
74-90-8	Hydrogen cyanide	3	-	-	1 hour	0.3	340	Nervous system effects	OEHHA
					1 year	0.0007	0.8	Endocrine disruption	US EPA
7783-06-4	Hydrogen sulfide	2	-	-	24 hours	0.1	150	Eye irritation	WHO
					1 year	0.001	2	Nasal lesions	US EPA

CAS Number	Substance	Class[a]	Highly hazardous pollutant[b]	Hazard classification[b]	Averaging time	APACs[c] ppm	APACs[c] µg/m³	Critical effect	Basis[d]
108-31-6	Maleic anhydride	2	-	Skin corrosion, skin sensitisation, respiratory sensitisation	1 year	0.0002	0.7	Respiratory irritation (nasal)	OEHHA
7439-96-5	Manganese and manganese compounds	2	✓	**Highly toxic (chronic)**	1 hour	NA	9.1	Respiratory tract irritation	TCEQ(final)
					1 year	NA	0.15	Neurotoxic effects	WHO
7439-97-6	Mercury and mercury compounds	2	✓	**Toxic to reproduction, highly toxic (acute and chronic), bioaccumulative**	1 year	NA	1	Objective tremor, renal tubular effects	WHO
67-56-1	Methanol	2	✓	**Highly toxic (acute)**	1 hour	21	28000	Neurological effects	OEHHA
					1 year	15	20000	Developmental toxicity	US EPA
74-83-9	Methyl bromide	2	-	-	1 hour	1	3900	Nervous system effects	OEHHA
					1 year	0.001	3.9	Nasal lesions	ATSDR
74-87-3	Methyl chloride	2	-	-	24 hours	0.5	1032	Neurological effects	ATSDR
					1 year	0.04	90	Cerebellar lesions	US EPA
78-93-3	Methyl ethyl ketone	2	-	-	1 hour	4	13000	Eye and respiratory irritation	OEHHA
					1 year	1.7	5000	Developmental toxicity	US EPA
108-10-1	Methyl isobutyl ketone	2	-	-	1 year	0.7	3000	Developmental toxicity	US EPA
80-62-6	Methyl methacrylate	2	-	Skin sensitisation	1 year	0.2	700	Degeneration of olfactory epithelium	US EPA
101-68-8 & 9016-87-9	Methylene diphenyl isocyanate and polymeric methylene diphenyl diisocyanate	3	✓	**Highly toxic (chronic)**, respiratory sensitisation, skin sensitisation	1 hour	0.001	12	Respiratory system	OEHHA
					1 year	0.000059	0.6	Nasal effects	US EPA
71-36-3	n-Butanol	2	-	Eye damage	1 hour	0.2	610	Eye and upper respiratory tract irritation	TCEQ(int.)
123-86-4	n-Butyl acetate	2	-	-	1 hour	2.3	11000	Irritation to eyes and respiratory tract	TCEQ(final)
					1 year	0.99	4700	Nervous system effects	TCEQ(final)
110-54-3	n-Hexane	2	-	Aspiration hazard	1 hour	5.4	19000	Neuro-endocrine effects	TCEQ(final)
					1 year	0.2	700	Peripheral neuropathy	US EPA

CAS Number	Substance	Class[a]	Highly hazardous pollutant[b]	Hazard classification[b]	Averaging time	APACs[c] ppm	APACs[c] µg/m³	Critical effect	Basis[d]
7440-02-0	Nickel and nickel compounds	3	✓	**Highly toxic (chronic)**, skin sensitisation	1 hour	NA	0.2	Immune system	OEHHA
					1 year	NA	0.01	Lung inflammation	ATSDR
7697-37-2	Nitric acid	2	-	Skin corrosion	1 hour	0.03	86	Reduced lung capacity	OEHHA
98-95-3	Nitrobenzene	2	✓	**Highly toxic (chronic)**	1 year	0.002	9	Respiratory tract lesions	US EPA
71-23-8	n-Propanol	2	-	Eye damage	1 hour	1	2460	Eye and upper respiratory tract irritation	TCEQ(int.)
95-50-1	o-Dichlorobenzene	2	-	-	1 hour	0.15	900	Eye and nose irritation	TCEQ(final)
87-86-5	Pentachlorophenol	3	-	-	1 hour	0.0005	5	Upper respiratory tract irritation, eye irritation, central nervous system effects	TCEQ(int.)
109-66-0	Pentane	2	-	Aspiration hazard	1 hour	68	200,000	No observed adverse effect	TCEQ(final)
					1 year	8	24000	No observed adverse effect	TCEQ(final)
108-95-2	Phenol	2	-	Skin corrosion	1 hour	1.5	5800	Respiratory irritation	OEHHA
					1 year	0.05	200	Liver and nervous system effects	OEHHA
75-44-5	Phosgene	3	-	Skin corrosion	1 hour	0.001	4	Lung histology	OEHHA
					1 year	0.000074	0.3	Fibrosis	US EPA
7803-51-2	Phosphine	2	✓	**Highly toxic (acute)**, skin corrosion	1 year	0.0002	0.3	Decreased body weight	US EPA
85-44-9	Phthalic anhydride	2	-	Eye damage, skin sensitisation, respiratory sensitisation	1 year	0.003	20	Respiratory irritation	OEHHA
107-98-2	Propylene glycol monomethyl ether	2	-	-	1 year	0.5	2000	Narcosis	US EPA
75-56-9	Propylene oxide	3	✓	**Carcinogen, mutagen**, skin corrosion	1 hour	1.3	3100	Respiratory irritation	OEHHA
					1 year	0.01	30	Nasal effects	US EPA
110-86-1	Pyridine	2	-	Skin corrosion	1 hour	0.0093	30	Skin irritation, liver and kidney damage	TCEQ(int.)
-	Radionuclides	3	-	-				See note (g)	
14808-60-7	Respirable crystalline silica	3	✓	**Carcinogen, highly toxic (chronic)**	1 year	0.001	3 (h)	Silicosis	OEHHA
7440-22-4	Silver and silver compounds	2	-	-	1 hour	NA	0.1	Skin irritation and argyria	TCEQ(int.)

CAS Number	Substance	Class[a]	Highly hazardous pollutant[b]	Hazard classification[b]	Averaging time	APACs[c] ppm	APACs[c] µg/m³	Critical effect	Basis[d]
100-42-5	Styrene	2	✓	**Highly toxic (chronic)**	1 hour	5.1	21000	Respiratory irritation	OEHHA
					7 days	0.06	260	Neurological effects	WHO
7664-93-9	Sulfuric acid	2	-	Skin corrosion	1 hour	0.03	120	Respiratory irritation	OEHHA
					1 year	0.0002	1	Respiratory irritation	OEHHA
584-84-9/ 26471-62-5	TDI (toluene-2,4 and 2,6 diisocyanate)	3	✓	**Highly toxic (acute)**, respiratory sensitisation, skin sensitisation	1 hour	0.0003	2	Asthmatic response	OEHHA
					24 hours	0.00001	0.07	Decreased lung function	ATSDR
					1 year	0.000003	0.02	Decreased lung function	ATSDR
127-18-4	Tetrachloroethylene (i)	2	-	-	1 hour	1	6800	Nervous system effects	TCEQ(final)
					1 year	0.04	250	Kidney effects	WHO
108-88-3	Toluene	2	✓	**Toxic to reproduction**, aspiration hazard	1 hour	2	7600	Neuro physical impairment	ATSDR
					7 days	0.07	260	Nervous system effects	WHO
79-01-6	Trichloroethylene	3	✓	**Carcinogen**	1 year	0.0004	2	Developmental toxicity	US EPA
75-69-4	Trichlorofluoromethane	2	-	-	1 hour	10	56000	Cardiac sensitisation	TCEQ(int.)
121-44-8	Triethylamine	2	-	Skin corrosion	1 hour	0.7	2800	Visual disturbances	OEHHA
					1 year	0.002	7	No observed adverse effect	US EPA
25551-13-7	Trimethylbenzene (mixed isomers)	2	-	-	1 year	0.01	60	Decreased pain sensitivity	US EPA
75-01-4	Vinyl chloride	3	✓	**Carcinogen, highly toxic (chronic)**	1 hour	27	68000	Mild headache, dry eyes and nose	TCEQ(final)
					24 hours	0.5	1300	Developmental toxicity	ATSDR
					1 year	0.04	100	Liver cell polymorphism	US EPA
1330-20-7	Xylenes	2	-	Aspiration hazard	1 hour	5	22000	Eye irritation	OEHHA
					24 hours	2	8685	Respiratory irritation	ATSDR
					1 year	0.02	100	Impaired motor coordination	US EPA
7440-66-6	Zinc and zinc compounds	-	-	-	1 hour	NA	20	Metal fume fever	TCEQ(int.)
					1 year	NA	2	Metal fume fever	TCEQ(int.)
7646-85-7	Zinc chloride fume	2	-	Skin corrosion	1 hour	0.007	42	Metal fume fever	TCEQ(int.)

Table 3 Notes:

(a) Substances are classified as per Schedule 4 of the Environment Protection Regulations 2021. Note that APACs were derived for 2-ethylhexyl acrylate, ozone, copper and copper compounds and zinc and zinc compounds despite them not being listed in the Regulations, and as such they do not have a class.

(b) Hazard descriptors are based on the following:

- Carcinogenic = carcinogenicity category 1A or 1B in the Hazardous Chemical Information System (HCIS).
- Mutagenic = germ cell mutagenicity category 1A or 1B in HCIS.
- Toxic to reproduction = reproductive toxicity category 1A or 1B in HCIS.
- Highly toxic (chronic) = specific target organ toxicity (repeated exposure) – category 1A or 1B in HCIS.
- Highly toxic (acute) = Acute toxicity – category 1A or 1B or Acute toxicity (inhalation) – category 1A or 1B in HCIS.
- Skin corrosion = Skin corrosion – category 1A or 1B in HCIS.
- Skin sensitisation = Skin sensitisation – category 1 in HCIS.
- Respiratory sensitisation = Respiratory sensitisation – category 1 in HCIS.
- Eye damage = Eye damage – category 1 in HCIS.
- Aspiration hazard = Aspiration hazard – category 1 in HCIS.
- Bioaccumulative = listed as a persistent bioaccumulative toxic substance in US EPA's Toxics Release Inventory Program.
- Criteria pollutant = see definition in Section 3.2.1.

"Highly hazardous pollutants" (HCIS category 1A or 1B carcinogenicity, germ cell mutagenicity, reproductive toxicity, acute toxicity, or is listed as a persistent, bioaccumulative and toxic substance in the US EPA Toxics Release Inventory Program) are indicated with a tick. The hazard that caused the substance to meet the "highly hazardous pollutant" criteria is indicated by bold text.

(c) APAC concentrations are expressed in both ppm and $\mu g/m^3$. Numbers in black text are those provided by the original source of the guideline, and numbers in purple have been converted. Conversion was done assuming a pressure of 1 atmosphere and a temperature of 25°C. Concentrations in ppm are only provided for substances that are volatile. Suspended substances such as particulate matter and non-volatile metals were only expressed in $\mu g/m^3$.

(d) The following abbreviations were used to indicate the source of each APAC:

- ATSDR: United States Agency for Toxic Substances and Disease Registry inhalation minimal risk level (MRL).
- OEHHA: Californian Office of Environmental Health Hazard Assessment reference exposure levels (REL).
- $TCEQ_{(final)}$: Texas Commission on Environmental Quality final air monitoring comparison values (AMCVs).
- $TCEQ_{(int.)}$: Texas Commission on Environmental Quality interim air monitoring comparison values (AMCVs).
- US EPA: United States Environmental Protection Agency Integrated Risk Information System Reference Concentration (RfC).
- WHO: Air quality guidelines published by the World Health Organization.

(e) APAC applies to soluble particulates. For insoluble particulates, the APAC is 5 $\mu g/m^3$.

(f) Calculated using the toxic equivalency factors provided in Appendix C.

(g) Please refer to Section 3.2.3 regarding the role of EPA and DH in the regulation of radioactive environmental hazards.

(h) EPA recommends assessment of RCS in the PM_{10} fraction as a precautionary approach to ensure protection of ambient air and to reflect the weight of evidence on health effects associated with respirable particles in occupational health and safety assessments.

(i) The ATSDR minimal risk level (MRL) for tetrachloroethylene of 0.006 ppm, based on the critical effect of decreased colour vision, may be more relevant to activities producing continuous emissions of tetrachloroethylene. Under the GED, duty holders should seek to continually improve practices and minimise emissions of tetrachloroethylene as far as reasonably practicable.

***Table 4** – Table of APACs for criteria pollutants listed in the Environment Reference Standard (2021). Cumulative APACs apply to all sources within the airshed (incremental and background).*

CAS Number	Substance	Class[a]	Highly hazardous pollutant[b]	Hazard classification[b]	Averaging time	APACs[c] ppm	APACs[c] µg/m³	Basis[d]
630-08-0	Carbon monoxide	1	✓	**Toxic to reproduction, highly toxic (chronic), criteria pollutant**	8 hours	9.0	10300	ERS (e)
7439-92-1	Lead and lead compounds	1	✓	**Toxic to reproduction, bioaccumulative**	1 year	NA	0.50	ERS (e)
10102-44-0	Nitrogen dioxide	1	-	Criteria pollutant, skin corrosion	1 hour	0.08	150	ERS (e)
					1 year	0.015	30	ERS (e)
-	Particles as PM_{10} (f)	1	-	Criteria pollutant	24 hours	NA	50	ERS (e)
					1 year	NA	20	ERS (e)
-	Particles as $PM_{2.5}$ (f)	2	-	Criteria pollutant	24 hours	NA	25	ERS (e)
					1 year	NA	8	ERS (e)
10028-15-6	Photochemical oxidants (as ozone)	1	-	Criteria pollutant	8 hours	0.06	120	ERS (e)
7446-09-5	Sulfur dioxide	1	-	Criteria pollutant, skin corrosion	1 hour	0.075	200	ERS (e)
					1 day	0.02	50	ERS (e)

Table 4 Notes:

(a) to (d) as detailed in Table 3 Notes.

(e) For criteria pollutants, the relevant objectives specified in the ERS should always be adopted as APACs. Should the ERS be updated at any point in time (for example to implement a variation to the NEPM AAQ), then this updated ERS objective will apply as the APAC objective.

(f) As noted in Section 4.4.2, assessment of 24-hour PM_{10} and $PM_{2.5}$ is done against cumulative concentrations excluding 'exceptional events'.

Table 5 *– Table of incremental carcinogenic APACs. Incremental APACs apply only to the incremental emissions from the facility (excluding background).*

CAS Number	Substance	Class[a]	Highly hazardous pollutant[b]	Hazard classification[b]	Averaging time	APACs[c] ppm	APACs[c] µg/m³	Critical effect	Basis[d]
106-99-0	1,3-Butadiene	3	✓	**Carcinogen, mutagen**	1 year	0.0002	0.3	Leukemia mortality	US EPA
75-07-0	Acetaldehyde	2	✓	**Carcinogen**	1 year	0.003	5	Nasal squamous cell carcinoma or adenocarcinoma	US EPA
7440-38-2	Arsenic and arsenic compounds	3	✓	**Carcinogen**	1 year	NA	0.007	Lung cancer mortality	WHO
132207-32-0	Asbestos	3	✓	**Carcinogen, highly toxic (chronic)**	1 year	0.0001 F/mL(f)		Mesothelioma	WHO
71-43-2	Benzene	3	✓	**Carcinogen, mutagen, highly toxic (chronic)**, aspiration hazard	1 year	0.0005	1.7	Leukemia	WHO
50-32-8	Carcinogenic PAHs (as benzo(a)pyrene) (e)	3	✓	**Carcinogen, mutagen, toxic to reproduction, bioaccumulative**, skin sensitisation	1 year	0.00000001	0.0001	Lung cancer	WHO
107-06-2	Ethylene dichloride	3	✓	**Carcinogen**	1 year	0.0001	0.4	Hemangiosarcoma	US EPA
75-21-8	Ethylene oxide	3	✓	**Carcinogen, mutagen, highly toxic (chronic), skin corrosion, skin sensitisation**	1 year	0.000002	0.003	Lymphoid cancer and breast cancer incidence	US EPA
75-56-9	Propylene oxide	3	✓	**Carcinogen, mutagen**, skin corrosion	1 year	0.001	2	Nasal cavity hemangioma or hemangiosarcoma	US EPA
75-01-4	Vinyl chloride	3	✓	**Carcinogen, highly toxic (chronic)**	1 year	0.004	10	Hemangiosarcoma	WHO

Table 5 Notes:

(a) to (e) as detailed in Table 3 Notes.

(f) An incremental carcinogenic APAC is provided for asbestos despite it not having a genotoxic mode of action. This was done to ensure consistency with the approach used by the World Health Organization to derive the guideline, which is based on an acceptable incremental lifetime cancer risk (ILCR). The incremental carcinogenic APAC for asbestos is reported in fibres per millilitre (F/mL).

Table 6 *– Table of environmental APACs. Environmental APACs apply to all sources within the airshed (incremental and background).*

CAS Number	Substance	Endpoint[a]	Averaging time	APAC[b] ppm	APAC[b] µg/m³	Basis[c]
7664-41-7	Ammonia	Natural or urban vegetation	1 year	0.01	8	NZ AAQG
7440-43-9	Cadmium and cadmium compounds	Food chain effects from accumulation in agricultural soil	1 year	n/a	0.005	WHO
7664-39-3	Fluorides (as HF)	Urban vegetation	24 hours	-	2.9	ANZEC
			7 days	-	1.7	
			30 days	-	0.84	
			90 days	-	0.5	
		Commercially valuable plants that are highly sensitive to fluoride, including but not limited to grape vines and stone fruit.	24 hours	-	1.5	
			7 days	-	0.8	
			30 days	-	0.4	
			90 days	-	0.25	
		Natural vegetation	90 days	-	0.1	
		Fluoride accumulation in unwashed samples of forage, hay or silage grown in area	40 µg/kg$_{(DW)}$ 12 month running average			
			60 µg/kg$_{(DW)}$ 2 consecutive month average			
			80 µg/kg$_{(DW)}$ monthly sample (one exceedance per year allowed)			
10102-44-0	Nitrogen dioxide	Terrestrial vegetation	1 year	0.02	30	WHO
75-07-0	Ozone	Agricultural crops	5 days	0.2 AOT40 (ppm-hr) (d)		WHO
			90 days	3 AOT40 (ppm-hr) (d)		
		Urban vegetation	90 days	3 AOT40 (ppm-hr) (d)		
		Natural vegetation	180 days	10 AOT40 (ppm-hr) (d)		
7446-09-5	Sulfur dioxide	Agricultural crops	1 year	0.01	30	WHO
		Natural vegetation	1 year	0.008	20	

Table 6 Notes:

(a) The endpoint represents the receptor or issue that the APAC is protective of, if the endpoint is not relevant to a site, then the APAC does not apply.

(b) Except where otherwise specified, APAC concentrations are expressed in both ppm and µg/m^3. Numbers in black text are those provided by the original source of the guideline, and numbers in purple have been converted assuming a pressure of 1 atm and a temperature of 25°C.

(c) The following abbreviations were used to indicate the source of each APAC:

  a. ANZEC: Australian and New Zealand Environment Council 1990 – *National goals for fluoride in ambient air and forage*.

  b. NZ AAQG: New Zealand Ministry for the Environment 2016 - *Good practice guide for assessing discharges to air from industry*.

  c. WHO: Air quality guidelines published by the World Health Organization.

(d) AOT40 is the sum of the differences between hourly ozone concentration and 40 ppm for each hour when the concentration exceeds 40 ppb during an averaging time.

Step 3 – Implement controls

What measures are suitable and available to the business to eliminate or reduce a risk?

Risk minimisation under the GED

Under the GED, persons who engage in activities that involve air emissions are required to eliminate risks of harm to human health and the environment from those emissions so far as reasonably practicable. Where it is not reasonably practicable to eliminate such risks, they are required to reduce them so far as reasonably practicable. Options for controlling such risks should be prioritised from the highest level of effectiveness to the lowest.

Pollution to air can also be considered an emission of waste to air. As such, emitters of pollution should consider the waste management hierarchy when evaluating control measures. The risk management and waste management hierarchies can assist with prioritising control measures to be implemented to ensure that risks are minimised so far as reasonably practicable.

Duty holders should clearly document how the existing or proposed risk controls meet the requirement to minimise risks so far as reasonably practicable.

Risk controls can be preventative or mitigative. Preventative controls prevent harmful events from happening, whereas mitigating controls limit the consequence or damage from a harmful event if it were to occur. Where risk cannot be eliminated, a combination of preventative and mitigative controls should be implemented.

7.1. Risk management hierarchy

EPA has developed guidance (*Assessing and controlling risk: a guide for business* (EPA Publication 1695)) provides businesses with a risk management framework. This can be applied to help prevent harm to human health and the environment. The framework is based on principles that can be applied to any business, irrespective of size or level of risk. EPA Publication 1695 includes a hierarchy of risk controls that is consistent with the principles of the EP Act (see Figure 6).

Figure 6 – Risk management hierarchy (EPA Publication 1695)

Application of the risk hierarchy and assessment of risk controls is a dynamic process. It should be undertaken regularly to identify whether risk reduction measures are effective and can be improved, so far as reasonably practicable. To evaluate the effectiveness of risk controls both a formal review of risks and a review of the effectiveness of risk controls and the availability of alternative controls should be conducted and documented. There should also be mechanisms for managing change to ensure that risks are not increased by changes to process or chemicals used in activities on the site.

A key consideration in the review of risks is whether current risk control(s) can be improved by adopting other control(s) that are 'higher' on the risk hierarchy. This means consideration should be given to prioritising substitution (often achieved by engineering controls) over administrative controls and considering what hazards can be eliminated altogether.

Some parallels exist between the hierarchy of risk controls and the waste management hierarchy. Therefore, the following sections will draw upon the commonalities and differences between the two. The waste management hierarchy is a key principle of the EP Act (see Section 1), which recommends the following order of waste management approaches:

1. avoidance
2. reuse
3. recycling
4. recovery of energy
5. containment
6. waste disposal.

7.1.1. Risk elimination and avoidance

Risk elimination is mirrored in the waste management hierarchy by the principle of waste avoidance. As the highest level of risk control, duty holders are expected to demonstrate how elimination of risks was considered in their decision-making, and if it was not implemented, why was it not reasonably practicable to do so.

Risk elimination may require an assessment of the physico-chemical properties of the materials used. For example, avoiding the use of diesel as a fuel and replacing it with natural gas to reduce diesel exhaust emissions. An assessment of physico-chemical properties may include assessing the risk from feedstock(s), catalysts, intermediate products, by-products and/or solvents, particularly for volatile materials and/or gases under high pressure. Risk elimination can also consider alternative process design, such as closed systems to eliminate gaseous discharges.

7.1.2. Risk substitution/engineering controls

Risk substitution occurs when a hazard is replaced with less hazardous materials or processes. This can include process changes of fuels, changing the types of solvents used (see case study 6), using more secure storage and transport methods, or upgrading hazard response tools such as spill kits. A risk substitution is preferred over engineering controls where possible.

Examples of engineering controls include: low nitrous oxide burners, scrubbers, baghouses, and thermal oxidisers. A subset of these controls includes maintaining process conditions, temperature, pressure, levels and flow. Examples of mitigative engineering controls also include emergency relief systems (safety control) such as interlocks that prevent processing under abnormal conditions. Another example is the use of control systems that provide for automatic shutdown of the process to minimise or mitigate excessive emissions.

Consistent with the waste management hierarchy, a preference exists for controls that capture emissions and treat them at the source. Based on this, approaches that focus on dispersion from a stack are the least preferred options.

When considering the use of engineering controls to reduce risks, due regard should be given to best available techniques and technologies. These must be taken into account as part of assessing controls to identify the most reasonably practicable measures to minimise risk.

7.1.3. Administrative controls/personal protective equipment (PPE)

Administrative controls generally include the implementation of appropriate procedures and manual operations on a site. In the context of air emissions, administrative controls may include any of the following:

- Adequate preventative work practice controls, such as equipment maintenance and improved housekeeping.
- Procurement procedures to ensure that equipment meets performance criteria.
- The development and implementation of contingency procedures that result in reduced risks from air pollution, such as avoiding or reducing emissions during unfavourable meteorological conditions.
- Adequate training procedures, policy, supervision or shift design that reduces risks, such as induction processes, permitting systems and competency training, and responding to process upsets.

- Community consultation, including the various ways a duty holder can inform potentially affected individuals about the nature of the hazard and any steps they can take to reduce exposures, thereby minimising resulting risks.
- Emergency planning should exceedances in emissions occur, with the aim of mitigating the impacts of those emissions on human health and the environment. For example, this could include communication protocols with local community to advise residents to remain indoors and close windows during an incident to reduce exposures.

PPE is the lowest order of control. PPE should be used only as a last line of defence if individuals could be directly exposed to air pollution (for example, P2 and dust masks, or respirators).

In deciding and weighing up which controls are best implemented to reduce risk so far as reasonably practicable, duty holders are ultimately exercising their GED (refer to Section 1.6.1).

Case study 6: Risk management hierarchy applied to a formaldehyde emitter

A large plant produces a building material by: mulching cut timbers, adding a forming resin and baking the mix. This is then dried, cut to size and shipped.

The whole process produces various waste products which are discharged to air, including dust and air pollutants. The most hazardous of these is formaldehyde, which is the solvent used in the resin. The plant uses thousands of litres of solvent a year and formaldehyde is vented through several carbon filtered stacks. The plant also has various fugitive sources around its large process building.

The company considers multiple alternative options to reduce the risks posed by its formaldehyde emissions:

- Changing the resin used in the process to one that does not have formaldehyde in it.
- Reducing fugitive emissions by sealing the main building and using fans to create negative pressure. This forces the discharges through the existing carbon filter vents.
- Installing a catalytic oxidisation system to replace the need for carbon filters.
- Increasing the stack height to increase the dispersion of the plume.

The analysis of these options shows that eliminating formaldehyde emissions by changing the resin is the most viable. It involves a relatively minor investment to upgrade the resin handling facilities. This decision is consistent with the risk management hierarchy, which favours the elimination of risks whenever possible.

The company also decides to minimise fugitive emissions of other VOCs by sealing the building and creating negative pressure, as this is found to be very cost-effective. The last two options are not considered further as they are not practicable or consistent with the risk and waste management hierarchies.

7.2. Minimising risk of harm to human health and the environment

As described in Section 2.2.2, duty holders must have regard for six key considerations when making decisions on whether a proposed risk control is going to eliminate or minimise risk so far as reasonably practical. Duty holders must address each of these six components listed in Table 7 in their decision-making process. Evaluating risk controls is a dynamic process. Regular evaluation helps to identify whether risk reduction measures are still appropriate and determine if they can be improved upon.

Table also provides an indication of the matters EPA will be considering when evaluating proposals such as development licences, exemptions, compliance assessment or licence monitoring. For example, EPA might consider more stringent controls when a large population is exposed, or when a failure of the system would pose potentially irreversible impacts.

As part of any proposal that has the potential to impact air pollution, it is expected that an evaluation of multiple risk control options will be presented. These need to highlight the relative benefits, costs and disadvantages of each option, and include a rationale for the selection of the preferred option.

Duty holders should document the various risk controls they have considered and address the risk by comparing them, taking into account the matters listed in Table . This will demonstrate to EPA that the duty holder:

- has considered the alternatives.
- has decided on the most appropriate control measures at that time.
- is complying with the GED, so far as reasonably practicable.

Having a documented control measure option analysis will also be beneficial for the duty holder when reviewing control measures in the future. For example, a control measure which is not practicable at this point in time, may become feasible for implementation in the future.

Information addressing the questions listed in Table will inform evaluations of whether the proposed risk controls are reasonably practicable.

Table 7 – Key matters to consider when implementing the GED

Matters to consider in the context of air emissions	
Eliminate	• What can be done to eliminate the risk of air pollution? This should be done first.
Likelihood	• What is the likelihood of harmful emissions eventuating from normal (expected) operating conditions? • What is the likelihood of harmful emissions eventuating from abnormal or unexpected (upset) conditions? • How frequent will intermittent or fugitive emissions occur (e.g. during maintenance etc)? • How likely is it that people will be exposed to emissions for the duration required for impacts to occur (acute or chronic)? • Where are the sensitive receptors in relation to the activity?

Degree of harm	• Does the activity release highly hazardous pollutants or Class 3 indicators (see Tables 3 – 6)? • Is the receiving environment already impacted by elevated background pollution levels? • Is the exposed population particularly vulnerable? What is the reported SEIFA index of the surrounding area? How large is the potentially exposed population? • What would the consequence be of a catastrophic failure in the proposed risk controls? • What are the short- and long-term exposure risks? • What is the size and density of the exposed population?
State of knowledge about the risks	• How well are the potential risks understood (based on state of knowledge)? • How well have risks from the site activities been characterised? • What works were carried out to evaluate the risks and develop adequate risk controls? • If a risk has eventuated, was it reasonably foreseeable? • What is the industry approach in eliminating or reducing those risks? • What information exists in the public domain on this matter? • What guidance or compliance advice has been provided by EPA? • What is known about historical incidents and lessons learnt?
Availability and suitability	• What technologies, processes and equipment are available to control the risk • Is the proposed approach consistent with best available techniques and technologies?
Cost	• What is the cost of installing and operating the various techniques and technologies that have been considered?

7.3. Risk controls for specific hazards

Class 3 substances

Class 3 substances are those substances listed in Schedule 4 of the Environment Protection Regulations 2021. These substances are included in Tables 3 – 6.

Regulation 112 of the Environment Protection Regulations 2021 applies to a person who is the holder of an EPA operating licence where an activity has either one or more sources, generates or results in the generation of Class 3 substances. This Regulation outlines how to comply with the GED in the generation, emission and management of Class 3 substances.

> *A person whom this Regulation applies must, so far as reasonably practical eliminate the generation of Class 3 substance, and If it is not reasonably practical to eliminate the generation of a Class 3 substance, reduce the generation of the Class 3 substance so far as reasonably practical.*

When it comes to determining what is reasonably practicable for development licence and operating licence applications, EPA will place more weight on the highly hazardous nature of Class 3 substances

(see case study 7). The amount spent on risk control measures needs to be proportionate to the risk of harm: the higher the risk of harm, the higher the investment expected.

Case study 7: Small medical waste incinerator emitting dioxins and furans

A waste incinerator is set up to accept medical wastes. It is a viable option because the products are potentially infectious and contaminated, and the local authorities wish to minimise potential risks from transport, so it is desirable to dispose of the waste quickly and close to the source, if practicable.

However, this waste incineration has the likely potential to generate toxic emissions, especially dioxins and furans. A level 3 assessment is required, prompting the site operator to consider additional means of eliminating or reducing these emissions. The company investigates multiple options and clearly documents the alternatives against the Commission Implementing Decision (EU) 2019/2010 of 12 Nov 2019 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for waste incinerations. The business includes in their criteria: documentation, associated costs and benefits and shows these options from the Directive:

- Optimisation of the incineration process
- Control of the waste feed
- On-line and off-line boiler cleaning,
- Rapid flue-gas cooling

and, one or a combination of techniques given below as in the BAT:

- Dry sorbent injection
- Fixed-or moving-bed adsorption
- SCR (selective catalytic reduction)
- Catalytic filter bags
- Carbon sorbent in a wet scrubber

The company selects a carbon sorbent in a wet scrubber, in addition to, temperature control and interlocks to prevent abnormal flue-gas cooling. The associated minimum stack monitoring frequency for dioxins and furans is performed once every six months, while for other contaminants of concern, the facility will follow best available techniques as per EU Directive and indicates that will use a continuous emissions monitoring system (CEMS) to report emissions standardised at 11% oxygen. These risk minimization measures, along with the rationale for how they were selected, are provided to EPA, who deems the duty holder has reduced their risks so far as reasonably practicable.

Nuisance dust

In the specific case of activities with a potential to create a visible dust issue, it is useful to consider the implementation of dust management plans.

Prevention of dust impacts can be achieved through application of best available technologies and techniques to control dust emissions at the source. As a minimum the aim of dust prevention is to prevent visible dust emissions. The definition of 'best available technologies and techniques' is dependent on the type of industry, size of operations and potential for offsite impacts.

Industry specific guidance, including separation distance recommendations and publications from EPA, local and international authorities may be used to guide duty holders on applicable measures. Examples of such publications include:

- *Reducing risk in the premixed concrete industry* (EPA Publication 1806)
- *Agriculture - guide to preventing harm to people and the environment* (EPA Publication 1819.1)
- *Construction - guide to preventing harm to people and the environment* (EPA Publication 1820.1)
- *Mining and quarrying - guide to preventing harm to people and the environment* (EPA Publication 1823.1)
- *Waste and recycling - guide to preventing harm to people and the environment* (EPA Publication 1825.1)
- *Erosion, sediment and dust: treatment train* (EPA Publication 1893)
- *Managing soil disturbance* (EPA Publication 1894)
- *Managing stockpiles* (EPA Publication 1895)
- *Working within or adjacent to waterways* (EPA Publication 1896)
- *Managing truck and other vehicle movement* (EPA Publication 1897)
- *Guidance for assessing nuisance dust* (EPA Publication 1943)
- *Separation distance guidelines* (EPA Publication 1949)
- *Landfill buffer guidelines* (EPA Publication 1950)
- Extractive Industry Work Plan Guideline (published by ERR)

In many cases, using the best available prevention controls will be informed by a risk-based dust management plan. The purpose of this plan is to assess the risk of potential and existing dust sources, and implement site-specific, best practice design controls and management practices to minimise dust. It involves the following steps:

- **Source identification**: identify all the sources and activities which generate dust onsite. Consider active processes like bulldozing and passive sources like windblown dust from stockpiles or exposed surfaces. Also consider the particle material and size, emission type, particle characteristics, controls and frequency.
- **Pathway analysis**: review the pathway between the source and receptor. Consider location (direction and distances to receptors), topography, meteorology. What constitutes a reasonably practicable level of control may depend on separation distance between the source and any receptors.
- **Receptor identification**: review the area beyond the site boundary. Identify sensitive locations such as schools, hospitals and nearby residents. Determine the relative vulnerability of the affected community using SEIFA and other environmental justice indicators. Identify ecological receptors such as agricultural activities, surface water bodies or sensitive habitats.

- **Risk assessment**: assess the risk of site generated dust impacting receptors beyond the site boundary for each source. Consider typical operating conditions and upset conditions. The level of risk assessment will be dependent on the industry and size of operations. For example, a qualitative risk assessment is sufficient for small, low risk activities. Large scale projects with high-risk activities may include a plume dispersion modelling assessment as a quantitative tool in the risk assessment process (see Section 13.8 for more details).
- **Implement controls**: controls are the combination of technology and practices to minimise dust emissions. Application of controls should be based on the level of risk for each identified source. For example, high risk sources warrant a larger investment in control technologies and practices to reduce the risk. Mitigation activities must represent the best available technologies and techniques for the activity. This could include proactive and reactive dust mitigation measures such as:
    - Early identification and action on high-risk days, such as when there are high winds, elevated background dust day, long periods of dry weather and bushfires.
    - Surveillance monitoring including visual or video inspections around source areas onsite and outside the premises. For example, surveillance at the site shows visible dust, which triggers corrective actions.
    - Targeted or continuous air monitoring with a trigger criterion for corrective actions. For example, indicative air monitoring of PM_{10} at 80 µg/m^3 over 1 hour gives an indication that the daily standard of 50 µg/m^3 will not be met, which would trigger timely corrective actions.
    - Community engagement and public reporting processes. For example, company hot lines for community members to report dust impacts, which will trigger investigations and timely corrective actions onsite.
- **Monitoring and review:** The final element of the dust management plan is a monitoring and review process. This process should ensure that controls are implemented and working as expected. The monitoring and review process will also identify new issues to include in the dust plan. The review should incorporate outcomes from corrective actions and be conducted with the aim of achieving continuous improvement.

Facilities treating waste with emission thermal treatment

Facilities that treat wastes via any thermal treatment (thermal, combustion, incineration, pyrolysis, smelting) need to prevent and minimize emissions at the source. As a minimum the objective is to apply the following EU Directive guidance or other equivalent international authorities with relevant requirements and protocols.

- Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control).
- Commission Implementing Decision (EU) 2019/2010 of 12 November 2019 establishing the best available techniques (BAT) conclusions, under Directive 2010/75/EU of the European Parliament and of the Council, for waste incineration (notified under document C (2019) 7987).
- Best Available Techniques (BAT) Reference Document for Waste Incineration: Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control).
- Best Available Techniques (BAT) Reference Document for Waste treatment Industrial Emissions Directive 2010/75/EU (Integrated Pollution Prevention and Control).

Step 4 – Check controls

Review controls to ensure they are effective

Maintaining effective risk controls and management

The development of risk controls is not intended to be the end of the risk management process. Ongoing performance evaluation through monitoring and continuous improvement is required under the GED to ensure ongoing compliance.

To evaluate performance, a duty holder needs to have clear objectives. Based on these, the duty holder sets goals and criteria to assess and evaluate environmental performance. Risk control performance measures should be clearly defined and measurable. This is to enable evaluation at an operational level, which will result in site-based or organisational environmental performance objectives.

8.1. Risk management and monitoring program (RMMP)

To gain a better understanding and assist with risk management, risk controls, and performance measurement and monitoring, duty holders should refer to *Implementing the general environmental duty: a guide for licence holders* (EPA Publication 1851). This publication presents an RMMP framework to help duty holders comply with the GED.

Duty holders, irrespective of whether they hold a permission (such as a licence, permit or registration), can apply the information in EPA Publication 1851 to support their implementation of the GED. Duty holders who are not EPA permission holders should also consider adopting the RMMP framework. These duty holders can use this framework to demonstrate how they have implemented the GED by scaling it to the level of complexity and risk presented by their activities.

A RMMP should be structured in a form that is easily followed, so that anyone looking at it can understand the process used to prepare it and find the information they are looking for. It should reflect the range and complexity of the activities at your site and the risks to human health and the environment that they present.

A RMMP would be supported by, but not limited to, associated documents such as risk assessment records, environmental performance indicators, operational control procedures, work instructions, monitoring schedules, and monitoring records. These would, in turn, be based on risk assessment records such as tables of your environmental aspects, risk consequence and likelihood tables, and risk ranking. The RMMP must be signed by a duly authorised officer of your company and must be made available to the regulator on request.

A RMMP may include, but not be limited to the items listed below. Depending on the nature of the activity and its level of complexity, a RMMP may be significantly simplified to include only the portion of these items that is considered to be relevant (please refer to case study 8):

- name of company and address of activity site
- author or other reference
- date of preparation and revision
- date for review
- description of activities (processes, raw materials, products, wastes, discharges, etc)
- description of environmental setting
- description of the expectations of interested parties (internal and external)
- conceptual site model
- risk assessment
    - environmental aspects table
    - compliance obligations
    - risks and opportunities
    - list of human health and environmental hazards
    - tables of likelihood and consequence
    - risk rating table (including identification of emergency events)
    - risk controls and mitigation measures
    - inherent and residual risk following the application of control and mitigation measures
- environmental performance objectives and indicators
- operational control procedures (or list of operational controls provided in separate documents)
- roles and responsibilities
- document management requirements
- monitoring program
- performance evaluation and review
- incident and emergency response
- training
- communications and reporting.

The following documents can be used for guidance

- For extractive industry proposals, comprehensive guidance, including templates and information on suitable dust minimisation measures, can be found in the Extractive Industry Work Plan Guideline published by ERR mentioned above, for drafting RMMPs.

- Best Available Techniques (BAT) Reference document for the Non-Ferrous Metals Industries published by the European Commission.
- Guidance on best available techniques and best environmental practices: Smelting and roasting processes used in the production of non-ferrous metals (lead, zinc, copper, and industrial gold as specified in Annex D to the Convention) from the United Nations Environment Programme (UNEP) website.
- Consolidated text: Directive 2010/75/EU of the European Parliament and of the Council of 24 November 2010 on industrial emissions (integrated pollution prevention and control) published by the EU Parliament.

Case study 8: RRMP for a small powder coating business

A powder coating business uses low-VOC products to powder coat various metallic items like fencing and bannisters. They have installed a charcoal filter trap in the ventilation stack to serve the coating booth. This is a small business that has the potential to emit small volumes of VOCs. This means that while the business does have to comply with the GED, it is not required to maintain extensive documentation in its RMMP.

In this case, the company sets up a scaled down version of the RMMP described in EPA publication 1851. It keeps records of the following:

- a concise hazard and risk register compiled in accordance with EPA publication 1695
- a brief description of the activities on the site, along with environmental performance objectives
- all relevant safety data sheets for chemicals used and stored onsite
- equipment specification documentation the coating booth and associated discharge stack
- maintenance reports of any onsite equipment
- a record of any incidents, spills, complaints, or correspondence with EPA
- a record of any relevant training carried out by staff working at the site.

This simplified RMMP is easy to implement and ensures that all the required information is readily available in the event of an inspection by an environment protection officer.

8.2. Environmental performance objectives

Environmental performance objectives are a key component of an RMMP. These objectives relate to the performance monitoring and ensure the duty holder measures the effectiveness of:

- the controls they have employed
- the outcomes of their risk-reduction measures.

Performance measurement can inform the reporting of the monitoring program. This will facilitate a clear and transparent flow of information within the duty holder's organisation and can be used as the basis for environmental reporting requirements.

Performance objectives may be business-wide or site specific and are derived and reviewed by the duty holder and their stakeholders (for example regulators and public). The objectives should clearly state what the duty holder is trying to achieve through its air pollution management system.

Performance objectives should be meaningful and measurable so they can be used to demonstrate continual improvement in environmental management. They should go beyond base level performance against all statutory and licence requirements and can be time dependent. For example, reduce nitrous oxide emissions by 20% in next 12 months or eliminate benzene emissions in 5 years. The duty holder can communicate these environmental performance objectives through its environmental policy and or documented in its RMMP. For example:

- zero incidents.
- zero pollution reports (for example, against odour or dust).
- measurable reduction in air emission contaminants.
- improvement in the community perception of air pollution (for example duty holder engagement with local community).
- increased environmental training and awareness (for example, training attendance).
- 100% reliability of critical emission control equipment (built in redundancy).
- prioritise breakdown maintenance and servicing of air emission control equipment (for example, spare parts in stock/repaired within 4 hours).
- percentage of reduction in leaks and losses from air polluting substances.

8.3. Risk control performance measures

Risk controls should be designed and implemented to drive performance towards the objectives. Risk control performance measures are specific to the activity and operations. These performance measures underpin the duty holder's overall environmental performance objectives. These controls could be preventative or mitigative. They could include measures such as:

- critical emission control equipment availability and reliability.
- emission control equipment performance standards.
- training and competency of key staff.
- inspection and maintenance of critical air monitoring equipment.

- completion of environmental audits and audit actions.
- raw/input materials quality checks.

8.4. Performance evaluation and checking controls

Performance evaluation can be quantitative or qualitative. It can take the form of measurement, data analysis or compliance audits. For example:

- air monitoring results against licence limits or other adopted APACs (see Section 6).
- trending of those results against set reduction limits.
- assessment of air pollution incidents, duration, frequency and impacts during a reporting period, such as number of significant, minor or reportable incidents.
- assessment of reliability and functionality of controls, such as temperature management of thermal oxidiser).
- process and critical equipment reliability and efficiencies, such as scrubbers, cyclones, electrostatic precipitators.
- environmental procedure compliance through regular system audits.
- supplier audits.
- competency assessments and training.
- maintenance records of emission control equipment. A regular inspection schedule ensures inspections are carried out regularly, rather than just when a piece of equipment fails. For example, does the emission control equipment perform to a required standard?
- consultant reports, site inspections, walk-throughs or others regular checks
- incident records and near misses.
- complaints, community reports or any other type of feedback from affected communities/stakeholders.
- correspondence with external parties. For example, WorkSafe Victoria, EPA, local council.

A RMMP can be an effective way of documenting performance evaluation. It shows what the company knows about the risks posed by the activities on the site and which controls are in place to manage those risks. This provides EPA's assessors with a complete set of documents so they can quickly understand:

- any risks associated with the activities onsite.
- how the risks are to be minimised.
- the practicability of further risk reductions in the future.

8.5. Continual improvement and review

What constitutes a reasonably practicable risk control varies through time as new knowledge emerges, and new techniques and technologies are developed. The risk assessment processes described in Section 5 should be reviewed as new information is developed. The controls used to minimise risk should also be reviewed regularly to remain up to date with current information and available technology.

The ultimate objective of continual improvement and review of risk control measures is to eliminate the risks of harm to human health and the environment so far as reasonably practicable.

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Appendix A – Selection of reasonably conservative assumptions

When making decisions in the presence of uncertainty, it is necessary to make explicit or implicit assumptions. Examples of this include determining the concentration of pollutants in exhaust fumes, selecting a representative location for a monitoring station, or choosing inputs for a dispersion model.

Whenever assumptions are made, they need to be 'reasonably conservative'. This is to account for uncertainty in the assessment.

Ten key guiding principles are provided below to assist in the selection of reasonably conservative assumptions.

- **Refining assumptions is valid as long as they remain reasonably conservative**
  It is good practice for assessments to start off with highly conservative assumptions that are gradually refined when and if it is useful and reasonable to do so or when more definitive input data becomes available.

  When conducted in a considered way, the iterative process of refining assumptions is protective of human health and the environment. However, when this process is done poorly, it can underestimate risks and erode stakeholder confidence in the assessment process.
- **Selecting evidence-based assumptions that are clearly documented**
  The selection of assumptions should be a deliberate and reasoned process based on robust, site-specific information. Even in the presence of uncertainty, it is usually possible to gather sufficient evidence to develop and support conservative assumptions.

  It is best practice to clearly list all key assumptions in modelling, monitoring or risk assessment reports, along with adequate justification for each assumption.
- **'Reasonably conservative' assumptions**
  Reasonably conservative assumptions represent situations that could plausibly occur over timeframes that are relevant to the hazard. Unlike 'worst case', which can consider implausibly unlikely events or conditions, 'reasonably conservative' takes likelihood into account.
- **Adequately justified assumptions**
  Supporting evidence and justifications should accompany all listed assumptions in any air assessment report.
  - Defaults/conventions: when default assumptions are adopted, clearly state what other guidance exists that adopted these defaults and why they apply in this case.
  - Technical references: factual, evidence-based assumptions should be supported with appropriate scientific referencing.
  - Site-specific characteristics: there will often be input assumptions related to site-specific features, such as the height or diameter of a stack. In these cases, it can be appropriate to refer to technical reports or clearly state how the input was measured or estimated. It may also be useful to include photos or site plans.
  - Professional judgement: it may be appropriate to base some assumptions on professional judgement and expertise. This is usually the least preferred justification for an assumption, and adequate explanation and justification should always be provided.

- **Refining assumptions is a cross-disciplinary process**
  It is common for air pollution monitoring, modelling and risk assessment work to be prepared by different teams of people. This work is often reported separately. This can sometimes result in assumptions being refined only at the very end of the process. This can result in a final risk assessment that relies on assumptions that are unreasonably conservative.

  For this reason, the risk assessment should incorporate dialogue, revision and refinement between members of the different teams throughout the process.
- **Refining assumptions rather than using correction factors**
  It is considered best practice to ensure assessment inputs are reasonably conservative rather than resorting to arbitrary adjustments or 'correction' factors. Likewise, it is generally not appropriate to include over-conservative assumptions in one input and use them to justify under-conservatism in another one. In instances when adjustment factors are required, they should always be scientifically robust and adequately justified.
- **Relating the degree of conservatism to the level of uncertainty**
  The process of making conservative assumptions should be proportionate to the level of uncertainty around each input. If a variable is well understood and there is little uncertainty around it, there is little need to incorporate conservative assumptions. If there is genuine uncertainty around an input, a higher level of conservatism should be incorporated.
- **Relating the degree of conservatism to the characteristics of the hazard**
  The selection of reasonably conservative assumptions can be affected by complex situation-specific circumstances. This principle is best explained with an example:

  An emission source is continuously emitting a substance at a varying and unpredictable rate over time. An assessor could conservatively evaluate impact by assuming the worst measured emission rate is constantly occurring. While this approach might be reasonably conservative for an acutely toxic substance, it would likely be overly conservative for chronically toxic substances, as it would significantly overestimate long-term exposures. In this case, the same assumption has different levels of conservatism for two different substances.
- **Assumptions must not contradict legal, regulatory or other requirements**
  In the process of refining assumptions, it is possible to accidentally lose sight of other requirements, including occupational health and safety requirements. Care should be taken to ensure that assumptions are never representative of a situation that is not allowed to occur for legal or other reasons.
- **Unreasonably conservative assumptions can sometimes be detrimental**
  In most circumstances, more conservative assumptions result in an outcome that is more protective of human health and the environment. In some specific situations, however, it is possible for overly conservative assumptions to be detrimental to the assessment process. Care must be taken to ensure conservative assumptions are adequate. Assessors can avoid this, by considering these factors:
  - Risk transfer: the process of managing one risk can create another one. For example, people may lose their livelihood due to their business being inappropriately shut down due to overestimated risks.
  - Alarmism: a situation when an overestimated risk causes a high level of concern in an affected community, leading to undue stress. These outcomes can significantly impact people's wellbeing.

- Warning fatigue: is the opposite of alarmism. It occurs when risks are perceived to have been overstated so often that they no longer trigger a response or action by affected stakeholders or decision-makers. This can delay important actions to reduce the risk.
- Compensating for over-conservatism: when decision-makers (for example the managers in an industrial plant) consider an assessment to be overly conservative, they may find themselves knowingly or unknowingly compensating for this conservativeness, effectively making decisions that are less protective.

Appendix B – Derivation of air pollution assessment criteria

11.1. Derivation of health-based APACs

APACs are intended to inform risk-based decisions that are protective of human health impacts from air pollution. They are not intended for use when assessing exposures in an occupational setting, as these are governed by occupational health and safety requirements.

For criteria air pollutants, the derivation of APACs is generally based on national standard-setting processes, while air toxics APACs are based on toxicity reference values (TRVs). They are ranked in a hierarchical manner from national and international standard-setting organisations. The hierarchy of TRV sources has five priority levels. These are intended to reflect the level of scientific rigour, consultation, peer-review and relevance to the Australian context.

Health-based APACs may be either be:

- **Cumulative non-carcinogenic APACs**, based on non-carcinogenic TRVs (e.g., reference concentration for respiratory irritation) and applied to all sources within an airshed (including background).
- **Incremental carcinogenic APACs**, based on cancer TRVs (e.g., inhalation unit risk for leukemia incidence) and applied only to emissions from the proposed or monitored activity (excluding background).

11.1.1. Hierarchy of sources of health-based guidelines

Sources of health-based TRVs have been prioritised into five priority levels, listed below.

Priority 1 – Victorian Environment Reference Standard

In Victoria, the indicators, objectives, averaging times and maximum exceedances specified in the ERS will be adopted as the APACs. Objectives specified in the ERS are intended to "enable an understanding of the current condition of the environment and a basis for assessing actual and potential risks to environmental values" as described in *Guide to the Environment Reference Standard* (EPA Publication 1992).

This intent is consistent with that of the APACs. The objective, averaging period and maximum exceedances for many of the indicators in the ERS are the standards in the NEPM AAQ, with some modifications.

Priority 2 – World Health Organization

The World Health Organization (WHO) sets Air Quality Guidelines (AQGs) for a number of key pollutants. The enHealth 2012 Environmental Health Risk Assessment Guidelines includes the AQGs in the highest level of toxicological data, meaning that they are recognised as a reputable and reliable source of criteria. Unlike most other standard setting organisations, WHO carefully selects averaging times for each pollutant. These are directly related to the real time over which health impacts are expected to take place. Based on the reliability of WHO guidelines, EPA has used WHO's AQGs as a priority 2 source for calculating cumulative non-carcinogenic APACs.

For carcinogenic substances, WHO provides 'unit risks', which can be used to calculate the cancer risk due to exposures to a toxicant, averaged over a lifetime of 70 years. WHO unit risks were one source used to derive incremental carcinogenic APACs for genotoxic carcinogens.

Priority 3 – United States national guidelines (ATSDR and US EPA)

There are two key standard-setting authorities in the United States that publish national environmental air pollution standards: the Agency for Toxic Substances and Disease Research (ATSDR) and the US EPA. Both these sources are included in the highest level of toxicology data sources in enHealth (2012).

The ATSDR provide Minimal Risk Levels (MRLs), defined as "an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure." MRLs are intended to serve as a screening tool to help public health professionals decide where to look more closely. They are not intended to define clean up or action levels. Importantly, the ATSDR MRLS only address non-cancer health effects. This means that all carcinogenic effects are completely and deliberately ignored. ATSDR acute MRLs have an averaging time that is expressed as a range of 1 to 14 days. For the purposes of deriving TRVs, they were all assumed to have an averaging time of 24 hours. ATSDR MRLs are a priority 3 source used to derive cumulative non-carcinogenic APACs.

US EPA guidelines are available to the public via the online integrated risk information system (IRIS). Unlike the ATSDR, the IRIS database provides guideline values that are relevant to both carcinogenic and non-carcinogenic substances. For non-carcinogens, the IRIS database provides 'reference concentration' (RfC), which is an estimate of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime (for non-cancer effects). The US EPA RfC is a priority 3 source used to derive cumulative non-carcinogenic APACs.

For carcinogens, the IRIS database provides 'inhalation unit risk' (IUR), which is an estimate of the increased cancer risk from inhalation exposure to a concentration of 1 $\mu g/m^3$ for a lifetime (70 years). The US EPA IUR was one source used to derive incremental carcinogenic APACs.

Priority 4 – United States and Canadian guidelines by state regulators (OEHHA and TCEQ)

While numerous international standard-setting bodies exist that publish air pollution guidelines, there are two that have been identified as being regularly updated, comprehensive and toxicity based. These are: Californian Office of Environmental Health Hazard Assessment (OEHHA), and the Texas Commission on Environmental Quality (TCEQ).

Much like the US EPA, OEHHA provides guideline values for both carcinogenic (inhalation unit risks) and non-carcinogenic substances (reference exposure levels – REL). RELs are concentrations of a chemical at or below a level at which adverse noncancer health effects are not anticipated to occur for a specified exposure duration. These are usually provided for 1 hour, 8 hour and 1-year averaging times.

TCEQ provide 'air monitoring comparison values' (AMCVs) that are chemical-specific air concentrations used to evaluate air monitoring data and are set to protect human health and welfare. Short-term AMCVs are based on data concerning acute health effects, odour potential, and acute vegetation effects. Long-term AMCVs are based on data concerning chronic health or vegetation effects.

The OEHHA RELs and TCEQ final AMCVs are priority 4 TRVs for the calculation of cumulative non-carcinogenic APACs.

Priority 5 – TCEQ interim AMCVs and ESLs

Interim AMCVs were only adopted if no other priority 4 TRVs were available. The TCEQ Effects Screening Levels (ESLs) are derived from modification of workplace exposure standards in the absence of specifically derived toxicity values. The TCEQ ESLs were treated as priority 5 TRVs for the calculation of cumulative non-carcinogenic APACs.

11.1.2. Derivation of cumulative non-carcinogenic APACs

Many air toxics have a total concentration in air (including background) below which no adverse health effects are expected to take place. This is referred to as a 'threshold' TRV, which is used as the basis for deriving cumulative health-based APACs. Threshold TRVs are usually based on critical doses from toxicological studies, adjusted using multiple correction factors to be protective of the general population, including sensitive populations.

In some cases, multiple APACs may exist for the same indicator for different averaging times. For example, a single indicator may have an annual and a 1-hour APAC. These are intended to be protective of the different types of health impacts that occur as a result of exposures of different durations.

The following method was adopted for selecting potential cumulative APACs:

- Cumulative non-carcinogenic APACs are always based on threshold TRVs.
- The process of selecting TRVs is based on a series of hierarchies that are followed in order:
    1. First, TRVs are sequentially considered for adoption as APACs, from priority 1 sources through to priority 5.
    2. Then TRVs are considered in order from the shortest averaging time to the longest one, within the constraints of the rules set out in the bullet points below.
- The following approach was adopted when selecting averaging times:
    - TRVs for any averaging time were considered for adoption as APACs if they are from priority 1 or 2 sources
    - TRVs for 1 hour, 24 hours and 1 year were considered from priority 3 sources
    - only 1 hour and 1 year TRVs were considered from priority 4 or 5 sources.
- APACs for shorter averaging times were selected to always have a higher numerical value than those for a longer averaging time. When the differences between TRVs are only minor (for example, they would round up or down to the same value), then they were treated as being the same.
- When multiple applicable TRVs are available from multiple sources, then the minimum TRV that meets this criterion is adopted.

Assumptions and exceptions in the selection of TRVs

The following specific assumptions or exceptions were made when selecting TRVs:

- Acute MRLs published by the ATSDR are usually intended to be applied to averaging times of 1–14 days. For the purposes of setting APACs, they were conservatively applied at the shortest period within this range, which is 24 hours.

- The only exception to the rule above occurs for some pollutants that are assessed on a 7-day averaging time by a priority 1 or 2 source (dichloromethane, styrene and toluene). For these pollutants, any available ATSDR acute MRL was applied as a 7-day TRV.
- 24-hour TRVs from priority 4 or 5 sources were adopted as APACs when no TRV for any averaging time could be sourced. For example, for alpha chlorinated toluenes, benzoyl chloride, barium, bromoform, carbon black, n-butanol, n-propanol, pentachlorophenol, pyridine and silver.
- In the case of chromium (trivalent), the ATSDR intermediate MRL was adopted as the TRV in the absence of an annual TRV and applied to an averaging time of 30 days.

11.1.3. Derivation of incremental carcinogenic APACs

Some substances are genotoxic carcinogens (they have the ability to directly damage DNA), meaning that they follow a non-threshold, linear dose-response function. This means that any exposure, however small, contributes to a proportionally increased risk of developing cancer over a lifetime. Additional consideration of cancer health effects is necessary for these substances.

For these substances, the TRV is a 'unit risk', which when multiplied by the exposure concentration provides an estimate of the increased chances of developing cancer. The incremental carcinogenic APAC derived for these substances is intended to represent the contribution to the overall cancer risk from the activity for sensitive receptors in the exposed population. This risk should be low, approaching zero or a level that would not be measurable in the population.

The following method was adopted for deriving incremental carcinogenic APACs:

- Incremental carcinogenic APACs were only derived for substances that are genotoxic carcinogens. These were defined as substances that are listed in the Australian Hazardous Chemical Information System (HCIS) on Safe Work Australia's website as having a hazard category of 'germ cell mutagenicity' (category 1 or 2) AND of 'carcinogenic' (category 1A and 1B). Based on this, 14 genotoxic carcinogens were identified[2].
- In all cases, the averaging time for incremental health-based APACs is 1 year.
- Incremental APACs are calculated using the following formula:

$$Health\ based\ APAC\ (Incremental) = \frac{Acceptable\ Risk \times Lifetime\ Duration}{Unit\ Risk \times Exposure\ Duration}$$

The following assumptions were adopted when deriving the incremental carcinogenic APACs:

- The Commonwealth standard for setting air pollution guidelines specifically reference an acceptable cancer risk of 1 in 100,000 (NEPC 2011).
- The lifetime duration is 70 years, consistent with enHealth (2012) and standard industry practice when carrying out non-threshold risk assessments.
- The unit risk was selected in a hierarchical manner from WHO (Priority 2), US EPA (Priority 3) or OEHHA (Priority 4). It is in units of $(\mu g/m^3)^{-1}$.

[2] Acetaldehyde, aniline, arsenic and arsenic compounds, benzene, benzo(a)pyrene, 1,3-butadiene, cadmium and cadmium compounds, epichlorohydrin, ethylene dichloride, ethylene oxide, lead and lead compounds, propylene oxide, trichloroethylene, vinyl chloride. No incremental APAC is provided for aniline, cadmium, lead or trichloroethene because the calculated incremental APACs for these substances were greater than their cumulative ones. No incremental APAC is provided for dinitrotoluene because no non-threshold TRV was identified from a priority 1, 2, 3, 4 or 5 source.

- An exposure duration of 70 years was adopted as an upper bound of a residence time. This assumption is conservative and assumes continuous exposures over a lifetime.
- All incremental APACs were initially calculated in units of µg/m^3, which was then converted into ppm (assuming 1 atmosphere and 25°C).
- Although asbestos is not a genotoxic substance, it was included as an incremental APAC as the guideline from the WHO is based on an acceptable incremental cancer risk of 1 in 100,000.

11.2. Derivation of environmental APACs

Unlike health-based APACs, there are only a very limited number of environmental APACs that are available from national and international standard-setting authorities. The selection of environmental APACs was informed by a review of the available standards and did not require a formalised selection methodology.

Appendix C – Toxic equivalency calculations

In the case of carcinogenic polycyclic aromatic hydrocarbons (PAHs) and of dioxin-like compounds, a single APAC is provided for the combined concentrations of multiple compounds. These are expressed as the toxic equivalency (TEQ) of benzo(a)pyrene (BaP) and 2,3,7,8-tetrachlorodibenzodioxin (TCDD), respectively. This is done because multiple PAHs or dioxin-like compounds are commonly emitted simultaneously from a single source and have the same toxic mode of action. This means their impacts on human health are additive, even though some compounds are more potent than others. They are expressed as BaP TEQ or TCDD TEQ as these are one of the most toxic substances in each of the two groups
of chemicals.

The calculation of the concentration of carcinogenic PAHs or dioxin-like compounds involves first multiplying each compounds concentration by its toxic equivalency factor (presented in 8 and Table) and then adding all the resulting concentrations together. The factors presented in Table 8 and Table 9 are from the NEPM ASC and Van den Berg et al. (2006), respectively. Should more appropriate and current toxic equivalency factors be published, then they should be adopted instead, along with an appropriate justification in the air assessment report.

Table 8 – Toxicity equivalency factors for PAHs

Compound	**Toxic equivalency factor (as BaP equivalents)**
Benzo(a)pyrene (BaP)	1
Dibenz(a,h)anthracene	1
Benzo(a)anthracene	0.1
Benzo(b+j)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Indeno(1,2,3-cd)pyrene	0.1
Chrysene	0.01
Benzo(g,h,i)perylene	0.01

Table 9 – Toxicity equivalency factors for dioxin-like compounds

Compound	Toxic equivalency factor (as TCDD equivalents)
Chlorinated dibenzo-p-dioxins	
2,3,7,8-Tetrachlorodibenzodioxin (TCDD)	1
1,2,3,7,8-Pentachlorodibenzodioxin	1
1,2,3,4,7,8-Hexachlorodibenzodioxin	0.1
1,2,3,6,7,8-Hexachlorodibenzodioxin	0.1
1,2,3,7,8,9-Hexachlorodibenzodioxin	0.1
1,2,3,5,6,7,8-Heptachlorodibenzodioxin	0.01
Octachlorodibenzodioxin	0.0003
Chlorinated dibenzofurans	
2,3,7,8-Tetrachlorodibenzofuran	0.1
1,2,3,7,8-Pentachlorodibenzofuran	0.03
2,3,4,7,8-Pentachlorodibenzofuran	0.3
1,2,3,4,7,8-Hexachlorodibenzofuran	0.1
1,2,3,6,7,8-Hexachlorodibenzofuran	0.1
1,2,3,7,8,9-Hexachlorodibenzofuran	0.1
2,3,4,6,7,8-Hexachlorodibenzofuran	0.1
1,2,3,4,6,7,8-Heptachlorodibenzofuran	0.01
1,2,3,4,7,8,9-Heptachlorodibenzofuran	0.01
Octachlorodibenzofuran	0.003

Non ortho-substituted polychlorinated biphenyls	
PCB 77	0.0001
PCB 81	0.0003
PCB 126	0.1
PCB 169	0.03
Mono-ortho–substituted polychlorinated biphenyls	
PCB 105	0.00003
PCB 114	0.00003
PCB 118	0.00003
PCB 123	0.00003
PCB 156	0.00003
PCB 157	0.00003
PCB 167	0.00003
PCB 189	0.00003

Appendix D – Detailed risk assessment methodologies

The following sections provide more detail on the methods that can be used to carry out the different types of detailed risk assessments listed in Table 2.

Most of the methods listed in this appendix require specialised expertise that often falls outside the traditional domain of air pollution specialists. Therefore, these methods should be carried out by a professional in the relevant area, such as a toxicologist, epidemiologist, microbiologist, risk assessor, ecologist or other specialist.

13.1. Baseline health assessment

A baseline health assessment provides information on the population statistics and health of a community. It provides a critical reference point for assessing changes and impact, as it establishes a basis for comparing the situation before and after a development. Baseline assessment may form part of the EES and is usually conducted to complement the health risk assessment for criteria air pollutant(s).

Baseline data on population statistics are available from the ABS. Health information on population scale are usually available from various state and Australian government agencies. This includes the Department of Health, the Australian Institute of Health and Welfare and the Australian Commission on Safety and Quality in Health Care.

13.2. Human health risk assessment of air toxics

The Environmental Health Standing Committee (enHealth) is a standing committee to the Australian Health Protection Principal Committee that provides leadership at a national level on issues relating to human health from environmental hazards. The framework for carrying out HHRAs in Australia is specified by the enHealth (2012) *Environmental health risk assessment guidelines*. These provide a national approach for the preparation, review and interpretation of HHRAs, including those specific to health risks from exposures to air toxics.

In this section, the term HHRA is used to describe the assessment of health risks from air toxics. The HHRA framework involves the following key stages:

- **Issues identification**: identify issues that are amenable to risk assessment and understand the context around them.
- **Hazard identification**: identify chemicals of potential concern (CoPCs) and their physico-chemical characteristics.
- **Dose-response assessment**: understand the toxic mode of action of the CoPCs and their dose-response relationships to derive a valid TRV.
- **Exposure assessment**: describe reasonably conservative exposure scenarios and characterise the levels of exposure that would occur.
- **Risk characterisation**: combine the TRV with exposure information to obtain an estimate of risk.

13.2.1. Selecting chemicals of potential concern

Early in the HHRA process, it is necessary for the assessor to identify all relevant CoPCs. It can sometimes be challenging to identify all relevant CoPCs due to an incomplete understanding of the emission sources.

As a guiding principle, assessors should be careful to not exclude any relevant CoPC too early in the process. A general approach to the identification of CoPCs is provided in Section 3.4.

13.2.2. Threshold and non-threshold health risk assessment

There are two primary models that are used to describe the dose-response relationship between an exposure to a pollutant and its health response, respectively referred to as a 'threshold' or 'non-threshold' response. Cumulative non-carcinogenic APACs follow a 'threshold' calculation. Incremental carcinogenic APACs follow a 'non-threshold' calculation. The basic methods used to calculate risks for these two responses are summarised below. More detailed methods are provided in enHealth documentation, which should be used as the basis for guiding the preparation of HHRAs.

Pollutants with a threshold response have a critical level (threshold) below which they do not trigger a measurable or detectable health response. In practice, this means that these substances can be present in air at concentrations that are low enough to not pose any foreseeable risk to human health. For substances with a threshold mode of action, risks are expressed as a hazard quotient (HQ), calculated as shown in Equation 1.

$$HQ_j = \frac{EC_j}{TRV(threshold)_j}$$ *Equation 1*

HQ_j	Hazard quotient for chemical j (no unit)
EC_j	Exposure concentration for chemical j (µg/m^3)
$TRV(threshold)_j$	Threshold toxicity reference value for chemical j (µg/m^3)

Pollutants with a non-threshold toxic mode of action are genotoxic carcinogens that contribute in a linear way to the probability of an individual developing cancer. Any exposure greater than zero is considered to contribute to a proportional increase in the resulting probability of developing cancer over a lifetime. This is referred to as the incremental lifetime cancer risk (ILCR). For substances with a non-threshold toxic mode of action, the ILCR is calculated as shown in Equation 2.

$$ILCR_j = EC_j \times TRV(non\text{-}threshold)_j$$ *Equation 2*

$ILCR_j$	Incremental lifetime cancer risk for chemical (no unit)
EC_j	Exposure concentration for chemical j (µg/m^3)
$TRV(non\text{-}threshold)_j$	Non-threshold toxicity reference value for chemical j (µg/m^3)$^{-1}$

As presented in Section 11.1.3, a specific definition of 'genotoxic carcinogen' was adopted for the purposes of deriving APACs. This approach was selected to provide a rapid, objective and consistent classification across all pollutants. While this approach may be used in an HHRA, it would be expected that a more detailed critical review of the current literature would help inform whether a pollutant is genotoxic or not.

APACs for criteria pollutants are from the Environment Reference Standard (2021), which are derived using a combination of threshold and non-threshold methods.

13.2.3. Selection of toxicity reference values

The selection of TRVs for use in an HHRA should be carried out by a suitably qualified and experienced toxicologist or risk assessor and should be in line with the approach described in relevant enHealth

guidance documents. When assessing health impacts from airborne pollutants, it is important to account for both chronic and acute risks. It is generally not acceptable to focus solely on one or the other as that might ignore important health impacts that might be experienced in the community.

A conservative approach for selecting TRVs is outlined in Appendix B was specifically developed for the purposes of deriving APACs. An HHRA is not bound by the TRVs used to derive APACs. Therefore, an individual TRV could be selected using a more detailed review of the scientific evidence for the specific pollutants in question. The selection of TRVs in a HHRA report should always be accompanied by a brief review of the relevant toxicological information, and adequate justification to support the selection of each TRV when multiple options were available.

13.2.4. Selection of exposure assumptions

The selection of plausible exposure scenarios in a HHRA should consider both the present sensitive populations and potential future ones. For example, nearby land may be zoned residential even though dwellings have not been erected on it yet.

As a default rule, it is expected that risks from genotoxic substances would be assessed using continuous exposures for 24 hours a day over 70 years. These exposure assumptions are identical to those adopted in the APACs and are broadly protective of residential and other land uses.

In some circumstances, these default assumptions may not be relevant due to site-specific considerations, and it may be appropriate to consider other exposure durations or frequencies, provided that adequate justification is provided. When exposure assumptions are modified from the default ones, it is required that HHRA reports present ILCR estimates for both exposure scenarios to provide reviewers with greater context around cancer risk estimates.

13.2.5. Risk assessment of chemical mixtures

Emissions to air may involve complex mixtures of numerous pollutants. The assessment of risks from chemical mixtures can be very challenging and usually requires the expertise of a suitably qualified toxicologist. Several methods are provided in enHealth guidance to assist assessors with this task, summarised below.

- **Assessment of representative mixtures**: in a small number of cases, toxicity data may exist for a specific chemical mixture (for example, diesel particulates).
- **Toxic equivalency**: some groups of substances include multiple chemicals with the same toxic mode of action, albeit with different levels of potency (for example, carcinogenic PAHs and dioxin-like compounds). In these cases, a toxic equivalency approach can be used as has been described in Appendix C.
- **Summation of risk estimates**: this is one of the most common approaches and involves simply adding the risk estimates for each CoPC in the mixture as shown in Equation 3 and Equation 4. While this approach may be useful as an initial screening approach, in many cases it is likely to overestimate the overall risk. As is described in enHealth guidance material, it is possible for a skilled professional to modify these equations, provided there is adequate evidence to support doing so.

$$HI = \sum_{j=1}^{n} HQ_j$$ *Equation 3*

$$ILCR = \sum_{j=1}^{n} ILCR_j$$ *Equation 4*

HI	Hazard index (unitless)
$ILCR$	Incremental lifetime cancer risk (unitless)

- **Component elimination or simplification**: when a common mode of action or other determinant of risk additivity is demonstrably absent, it may be appropriate to assume that the toxicity of a substance in a mixture is independent of the toxicity of the other substances. Adequate levels of evidence would need to be provided to justify this assumption.

13.2.6. Interpretation of 'acceptable' risk in HHRAs for air toxics

As is explained in detail in enHealth (2012), a HI (or a HQ, for pollutants being assessed individually) smaller than 1 indicates exposures are below the relevant TRVs and that therefore risks are acceptable. The lower the HI, the greater the margin of safety.

When a HI is greater than one, it does not automatically mean there is an unacceptable risk. This is due to the inherent conservatism in the TRVs (often in the order of 100–10,000). However, a HI greater than 1 does suggest some erosion of these conservative assumptions. Once a HI is high enough to outweigh the conservatism inherent in the TRV, then it becomes suggestive of a potential realised health effect.

In a practical sense, it is common practice to further assess or redefine a risk assessment whenever the HI or individual HQs exceed or approaches 1. This point effectively becomes the threshold for 'acceptable risk'. A HI greater than 1 could still be considered acceptable, provided it is supported by adequate justification and evidence. This needs to demonstrate that the conservative assumptions intrinsic in the assessment provide a margin of safety that would easily account for the exceedance.

In the case of non-threshold risks, the commonly adopted acceptable ILCR is 1 in 100,000. This upper limit has been adopted by many jurisdictions and is defined by NEPC (2011) as a 'ceiling limit'. This has been derived from extensive community consultation and is specifically relevant in the context of risks from air pollution to the Australian public.

As with HIs, the interpretation of non-threshold risks is not a simple 'pass or fail' test and requires careful interpretation. Estimates of cancer risks are expressed as a probability of developing cancer, such as 3 x 10^{-6} (or 3 in one million). While these estimates might appear to be predictive of actual cancer incidence rates in the community, in reality they are upper bounds that take into account a large amount of uncertainty by incorporating conservative assumptions.

An acceptable ILCR of 1 in 100,000 should therefore not be thought of as an acceptable number of cancers in the community. Rather, it represents an estimate of cancer risk that is so small that its effects wouldn't be distinguishable from baseline cancer rates. At these very low estimates of risk the actual increase in cancer incidence rate might approach zero or be undistinguishable from zero due to the uncertainties associated with mechanisms of carcinogenesis (WHO, 2017).

Overall, HHRAs (and other risk-based methods) are decision-making tools rather than diagnostic tools that are predictive of real health impacts experienced by an individual. While there is a relationship between HIs, ILCRs and health impacts in a community, this is not linear. Therefore, care should be taken to not over-extend the meaning of these metrics.

13.3. EnHealth terms of reference for health impact assessment

Health impact assessment (HIA) is a predictive tool that considers both positive and negative impacts on health of new developments or upgrades to existing developments.

HIAs rely on a range of data sources and analytical methods. They also rely on input from stakeholders to determine the potential health effects of a proposed policy, plan, program, or project on a population, and the distribution of those effects within the population. The main steps in an HIA process include (enHealth, 2017):

- screening: determines if a HIA is needed.
- scoping: identify which health effects to consider and set boundaries.
- profiling: current status of population and environment.
- assessment: assess and compare the importance of impacts.
- management: consider management options.
- decision making: recommendations, approval and implementation.
- monitoring: monitor project conditions and health outcomes.
- evaluation: evaluate the project conditions and health.

Guidance for conducting a HIA is provided in enHealth (2017) *Health impact assessment guidelines*.

13.4. Use of concentration response functions for assessment of large populations exposed to criteria pollutants

Under specific circumstances, concentration response functions (CRFs) could be used as one line of evidence to assess risk to large populations exposed to criteria pollutants. When a large population is likely to be exposed to criteria pollutants emitted from an activity, further assessment may be appropriate to estimate activity-attributable changes in the incidence of health outcomes such as mortality or hospital admissions for respiratory illness.

This assessment uses CRFs to quantify the health impact per concentration unit of an air pollutant. CRFs are derived from large epidemiological studies and meta-analyses. Interpretations of results should consider the extent to which the CRF is applicable to the scenario of interest, and whether the exposed population is well represented by the populations from which the CRF was derived.

This assessment applies for criteria pollutants at city-wide and national scales where the exposed population is greater than 25,000 people. It should not be applied to small populations or individuals. Multiple lines of evidence should accompany this assessment.

Further guidance is provided in World Health Organization (2016) *Health risk assessment of air pollution: general principles*, summarised in Figure 7.

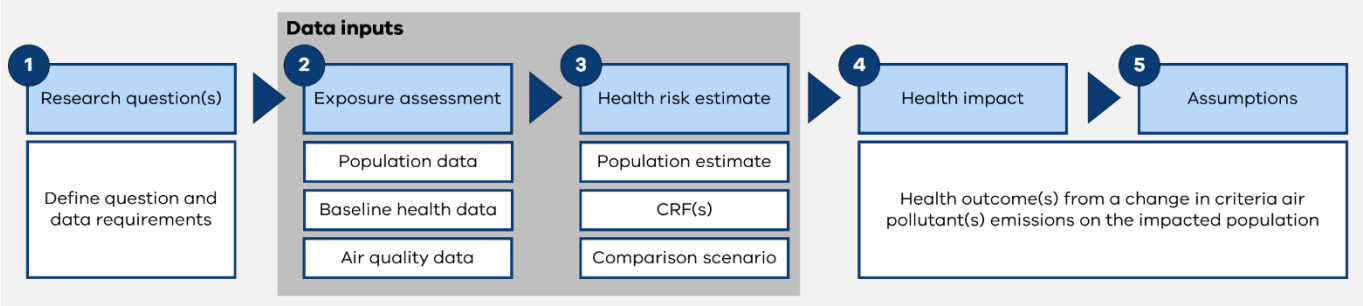

Figure 7 – Overview of the process for conducting risk assessment of criteria air pollutants exposure to large populations (adapted from WHO 2016)

13.5. Microbial risk assessment

The use of microbial risk assessment is a developing field and there are still many unknowns and uncertainties. Nevertheless, these assessments can be useful in assessing the risk to the community from microbial exposure.

Microbial risk assessments can vary greatly in their level of complexity, so that qualitative microbial risk assessments are generally quite simple, while quantitative microbial risk assessments (QMRAs) may require significant resources and expertise in microbial risk assessment. They can be increasingly complex, from a deterministic QMRA, which is based on data in the literature only, to probabilistic QMRAs, which requires pathogen monitoring and mathematical modelling.

In the following sections, a broad overview of the microbial risk assessment process is provided. More detailed guidance should be sought from suitably qualified and experienced experts.

13.5.1. Approach to assessing microbial risks

Microbial risk assessments follow the key risk assessment stages presented in Section 13.5. These assessments may be quantitative, qualitative or a combination of the two (semi-quantitative). Detailed QMRAs can only be conducted for activities that emit pathogens for which dose-response models exist.

In many ways, microbial risk assessments are similar to chemical risk assessments. However, there are some notable differences with microorganisms to consider, including:

- Host immunity plays a large part in whether an infection occurs. The same dose of a pathogen may result in a range of health endpoints, from asymptomatic carriage to death, based on characteristics of the host and method of exposure.
- Microorganisms can evolve quickly. It means that one strain of the same species may be harmless while another strain may cause severe illness.
- Some microbial infections can be transmitted between individuals after initial infection from an environmental source.
- Detection methods are not always sensitive enough to detect pathogens but these pathogens may still be present and able to cause illness.

Issues identification

The microbial risk associated with an activity will vary depending on the type of bioaerosol(s) generated, the sensitive populations nearby, and the pathways between the source of bioaerosols and the impacted populations. As part of a risk assessment each factor should be identified. A conceptual model

as in Figure that identifies the source, pathways, and receptors may be useful in determining the risks associated with an activity.

A key first step in the microbial risk assessment process is to identify complete exposure pathways. If none are identified, then the risks can be considered to be low and no further investigation is required.

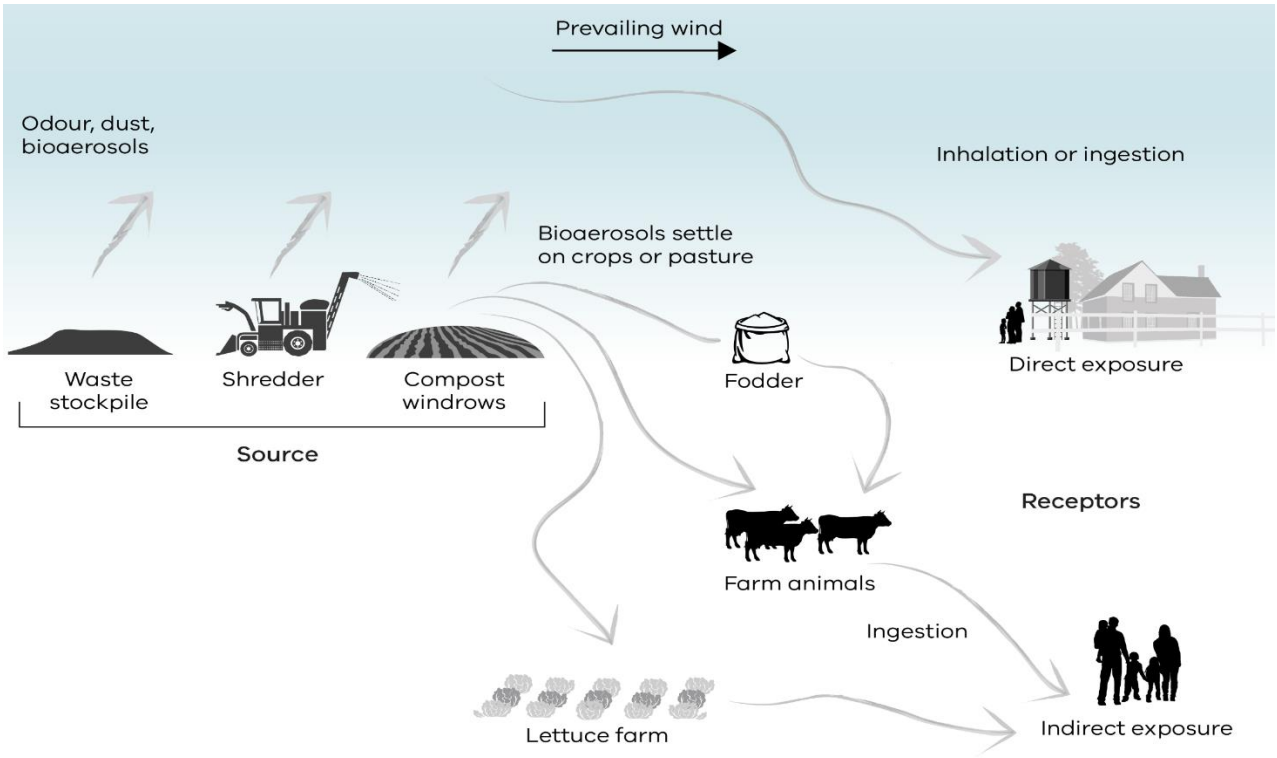

Figure 9 – Example of conceptual site model for a bioaerosol generating facility

Hazard identification

The duty holder should determine what type of bioaerosols are likely to be present and pose the greatest risk. Available literature, and epidemiological studies specific to each type of activity should be used when considering:

- which bioaerosols may pose a risk to the community.
- what sort of infections or illnesses may occur.

Assessments should be as specific as possible to the investigated activity, as differences in the original source (for example, swine versus cow manure) will affect which pathogenic microorganisms may pose the greatest risk.

Dose-response assessment

Dose-response models are only described in the literature for specific enteric pathogens (such as *Salmonella*, *E. coli* O157:H7, *Campylobacter* and rotavirus) causing gastrointestinal illnesses, and adenovirus and *Legionella* which can cause gastrointestinal and/or respiratory infections. The use of

these models to estimate the risk of bioaerosol exposure also remains a developing field. As such, use these models conservatively and in conjunction with epidemiological data. When evaluating risks from bioaerosols with no published dose-response data, alternative assessment approaches may be required.

Exposure assessment

An exposure assessment should consider:

- bioaerosols thought to be released.
- under what conditions a person might become exposed to bioaerosols.
- who might be exposed.
- the concentration of bioaerosols in the air.
- the duration and frequency of the exposure.

Sensitive populations near to the source of emissions should be considered when carrying out an exposure assessment. This includes any groups in the community that may be more vulnerable to infections, such as the very young, elderly, immunocompromised and those with underlying medical conditions.

Assessments should clearly highlight conditions in which bioaerosol concentrations may be at their highest. For example:

- when manure is being sprayed onto a field.
- when compost windrows are being turned.
- as a result of seasonal weather changes.
- when strong prevailing winds are present.

Identifying activities that generate higher concentrations of bioaerosols may also assist in their mitigation by altering practices to reduce these occurrences. This may vary from installing barriers or biofilters to trap dust and bioaerosols, to ceasing outdoor work on high wind days.

Microbial concentrations decline rapidly as distance increases away from a source due to dispersion, deposition and microbial decay. However, microorganisms associated with bioaerosol generating sites have often been reported in the literature at low concentrations as far as 1,000 m downwind. It is not generally feasible to test for specific pathogens.

If monitoring is carried out of airborne bioaerosols, take measurements at the source, near the closest sensitive population and at a site upwind to determine background concentrations. Workers at respective sites should not be used as sentinels for illness as they are not representative of the wider community and their exposure conditions will differ in concentration, duration, and frequency.

Risk characterisation

The final step of a microbial risk assessment is to collate the information collected in the previous steps to determine the risk of illness. If a QMRA has been carried out, the endpoint should be expressed in µDALY. A health-based target of one µDALY per person per year can be used as a threshold for 'acceptable risk'.

QMRAs often involve significant uncertainties, normally due to a lack of information about the fate of specific bioaerosols during transport and the use of dose response models for many microorganisms. Similarly, the effect of combined exposures to multiple microorganisms and microbial components on the likelihood of infection or immunological reaction are often poorly known. Any limitations, uncertainties and assumptions should be stated in any assessment report.

13.5.2. Characterising microbial risks when no dose-response data is available

For bioaerosols with no dose-response data, it may be necessary to adopt a conservative approach by assuming that any dose is potentially hazardous. This means focusing on assessing the likelihood of exposure as a surrogate measure of risk.

For facilities generating bioaerosols, the separation distances in Table 10 can be used to provide an understanding of the likelihood of exposure and probability of harm in exposed populations. The type of facility (Type 1 – 3) is determined by measuring and monitoring bioaerosols (total bacteria and/or *Aspergillus fumigatus*) in air at the operational facility.

This risk assessment only considers the direct risk for neighbouring communities via inhalation. A more extensive risk assessment process should be followed if an indirect risk through the ingestion of contaminated produce is identified.

Table 10 – Evaluating the risk from bioaerosols when no dose-response data is available by using separation distances as an indicator of risk

Probability of harm	**Distance (m)**		
	Type 1 facility	**Type 2 facility**	**Type 3 facility**
High	0 - 100	0 - 100	0 - 250
Medium	101 - 250	101 - 250	251 - D
Low	251 - 1,000	251 - 1,000	D - 1,000
Very low	>1,000	>1,000	>1,000

Notes:

Type 1 facility: facility generating bioaerosols other than bacterial/fungal pathogens

Type 2 facility: facility generating bacterial/fungal pathogens if <1,000 total bacteria/m^3 and/or < 500 *A. fumigatus*/m^3 at 250 m

Type 3 facility: facility generating bacterial/fungal pathogens if >1,000 total bacteria/m^3 and/or > 500 *A. fumigatus*/m^3 at 250 m

D is the distance at which these recommended levels (<1,000 total bacteria/m^3 and/or < 500 *A. fumigatus*/m^3) are achieved

Please note: the need, if any, for monitoring of total bacteria and/or *A. fumigatus* should be identified during the issues identification step of the risk assessment.

13.6. Multi-pathway risk assessment

Multi-pathway risk assessments involve the evaluation of airborne emissions depositing onto other environmental media like soil or water. It is a complex and highly site-specific approach that should only be considered when the available evidence suggests that multi-pathway risks warrant further analysis (see Table 2).

The multi-pathway risk assessment approach involves estimating deposition rates through modelling or monitoring to assess resulting pollutant concentrations accumulating in soil, water, biota and other environmental media. The exact methods used to make these estimations are not provided here as this is an area of continuing research. However, various international jurisdictions have developed detailed methodologies (for example, OEHHA 2015). It is up to the assessor to ensure that the assessment work being carried out is in line with good practice methodologies.

A multi-pathway risk assessment will often include exposure routes other than inhalation (for example, via ingestion of soil, food and water, and skin contact with soil and water). In these cases, the multi-pathway risk assessment would be paired with a traditional HHRA (see Section 13.2) to allow for the combined toxic effects from multiple exposure routes to be adequately assessed.

13.7. Ecological risk assessment

The ecological risk assessment (ERA) is a site-specific task that is relevant when there are reasonable grounds for suspecting that an area of ecological significance could be adversely impacted by air pollution.

The exact selection of methods for an ERA is expected to vary greatly based on the nature of the emissions and the surrounding environment. However, it is recommended that any approach adopted be generally consistent with the principles in Schedule B5a of the National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013) (NEPM ASC). While these principles are described in the context of the assessment of contaminated land, they are broadly applicable to other environmental media, including air.

13.8. Nuisance dust risk assessment

A nuisance dust risk assessment involves estimating the likelihood and consequence of dust impacts from an activity and in turn inform what reasonably practicable measures or actions would be required to comply with the GED. It includes both the formation of visible airborne dust plumes, and deposition of dust onto surfaces resulting in soiling.

The steps involved in characterising the sources and receiving environment impacted by nuisance dust risks are effectively the same as those described in Sections 3 and 4 of this guideline. Once nuisance dust hazards are adequately characterised, an initial screening-level assessment can be carried out in accordance with the methods in *Guidance for Assessing Nuisance Dust* (EPA Publication 1943). This can be used to provide an initial understanding of the likely degree of risk controls.

Dust surveillance

For premises or activities that already exist, ongoing visual dust inspection during operation and targeted inspections on high risk days of high dust emissions (e.g. hot, dry and/or windy days) can be an effective way of identifying and describing dust risks. These inspections can help identify key dust sources and ways in which these emissions can be eliminated or minimised.

Deposited dust modelling and monitoring

Dispersion modelling and monitoring (for example dust deposition gauges) can be useful and more affordable for smaller operators. Such information can help:

- characterise temporal or spatial trends.
- identify key problematic sources, or groups of sources on larger more complex sites.
- identify where dust sensitivities may occur.
- test the effectiveness of dust minimisation, control and management measures.

However, caution needs to be applied in using dust dispersion modelling and depositional monitoring results because they present some significant challenges due to uncertainty in emission source estimations, and the difficulties in setting acceptable threshold levels for nuisance dust risks.

Historically, threshold figures of 4 g/m^2/month (no more than 2 g/m^2/month above background), as a monthly average, taken at the boundary of an industrial premises, have been used. These figures can be continued to be used as a *rule of thumb* level for requiring further investigation and addressing dust issues, but not as a level up to which industry is allowed to pollute up to. This monitoring only partially contributes to meeting the GED, because the focus and emphasis needs to be on reviewing operation controls and management practices to prevent and minimise dust nuisance as far as reasonably practicable.

Comparison of upwind and downwind data can help understand dust emission sources. Furthermore, monthly depositional dust data taken over a period of one year can help understand seasonal trends, and where and when the focus should be on minimising dust during various parts of the year. Depositional dust monitoring programs should include control sites to provide background levels, to which measured levels can be compared.

Other sources surrounding the premises and their cumulative effects need to be considered in assessing dust impacts. Where there are multiple sources of dust at a given location, it is advantageous to have a combined dust monitoring program that also incorporates continuous monitoring, noting that this requires cooperation amongst companies likely to be one of these dust sources.

Further information is provided in *Guidance for Assessing Nuisance Dust* (EPA Publication 1943).

Operational dust monitoring for adaptive management

On established premises engaged in dust-generating activities, operational dust monitoring can provide real-time data to support adaptive management of dust emissions.

Real-time airborne dust monitoring, for example, can be used in adaptive management of nuisance dust at a premises using short term trigger levels to implement timely controls and mitigation measures to reduce and prevent emissions. Monitoring of PM_{10} is frequently used as an indicator of nuisance dust, with trigger levels set at 80 $\mu g/m^3$ (1-hour average), 120 $\mu g/m^3$ (30-minute average), 150 $\mu g/m^3$ (15-minute average) or 165 $\mu g/m^3$ (10-minute average).

Real-time monitoring is more effective when paired with the concurrent use of CCTV (Figure 10) to identify the sources of dust corresponding to monitored peaks in airborne dust concentrations. CCTV

footage needs to be securely stored and saved for at least one month and should be retrievable and made available to authorised officers upon their request.

Figure 10 – CCTV at a dusty premises

13.9. Multiple lines of evidence approach

Some air pollution issues, or types of pollutants (e.g., criteria pollutants) have no single assessment method that will clearly provide a black or white answer on the associated risks. In these cases, it is common to adopt a 'multiple lines of evidence' approach.

The 'multiple lines of evidence' approach is a conceptual approach to include many types of evidence that ultimately helps inform a risk-based decision. This approach "involves reaching a conclusion based on reasoning and expert judgement, by using all available information and keeping in mind that absolute certainty about the causal relationship is elusive" (NEPC 2011). The advantage of using multiple lines of evidence is that it can holistically draw upon types of information that are usually not sufficient on their own. The responsibility lies with the assessor to incorporate all relevant information into the decision-making process. Some examples include:

- **Comparison of predicted concentrations to background pollution**. In circumstances when background air concentrations exceed relevant APACs, it can be useful to provide an indication of:
    - the total predicted number of exceedances of the relevant APAC.
    - whether exceedances were attributable to background pollution or were associated with the emissions from the proposed/current activity.
- **Contribution from the activity to ground level concentrations**. In some assessments, particularly for criteria pollutants, it is useful to consider whether the contribution from the activity is a significant addition to what currently occurs in the environment (background). As a general rule, if the contribution from the activity is less than 4% of the cumulative APAC at the most impacted sensitive location, the activity contribution could be considered so small that it is unlikely to

result in measurable impact in the population[3], with appropriate justification. This rule is not applicable to incremental APACs, as background pollution is not considered when screening against incremental APACs.

- **Observational data**. The assessment of air pollution risks can sometimes benefit from observations, such as visual cues, odour, or visible signs of impact. On their own, these lines of evidence are seldom enough to draw meaningful conclusions, but alongside other data they can be very useful.
- **Reports from the public**. Community complaints, complaints databases, dust diaries or other types of community-recorded observations can provide an indication of the nature of observable impacts through time. As with all indicative data, they need to be interpreted with care. However, in some cases they can be invaluable as they can identify long-term trends of observed impacts in exposed communities.
- **Comparison to reference sites**. Relying on knowledge from other sites with comparable activities and/or exposed populations can sometimes provide a strong reference point when assessing risks. For example, published air monitoring or epidemiological data may exist for areas near a similar type of facility that might help understand likely impacts.
- **Monitoring data from indicative instruments**. Sampling carried out with instruments not meeting regulatory quality requirements can, in some cases and with adequate justification, be included in a broader discussion of risks as indicative results. In these instances, care should be always taken to clearly outline the limitations or errors (if known) of the approach in order to avoid inadvertently misrepresenting the accuracy or precision of the results.
- **Outputs of other detailed risk assessment methods**. Some of the methods described elsewhere in this guideline are not enough on their own to provide clarity on the risks from air pollution. For example, HHRA and burden of disease assessment (Sections 13.1 and 13.3) are seldom enough on their own to inform a risk-based decision on air pollution. However, they can become more useful when accompanied by other types of evidence.

When presenting an assessment based on multiple lines of evidence, it is useful to consider the following principles:

- The strengths and limitations of each line of evidence should both be clearly described in an objective, transparent way. Failing to describe the limitations of a line of evidence could reduce confidence in the assessment by creating a perception of the conclusions being biased.
- The weight of each line of evidence should be described. When multiple lines of evidence are present, some will inevitably be more compelling than others. It is worthwhile ensuring the reader is given all the information required to understand how much reliance could be placed on each line of evidence.
- If a line of evidence approach is used, it is important to holistically include all relevant types of evidence. Exclusion of key types of evidence could be interpreted as 'cherry picking' and might devalue the overall assessment.
- Sometimes, different lines of evidence may support contradictory conclusions. Reports should assist the reader in resolving these apparent conflicts by discussing them in detail.

[3] The increment of 4% was derived as the percentage of the 24-hour $PM_{2.5}$ APAC that just meets the resolution requirements of a beta attenuation monitor (that is 1 µg/m^3 over 24 hours, AS/NZS 3580.9.11:2008). This is conservatively consistent with approaches adopted overseas (for example APPLE 2007, US EPA 2014)

Accessibility

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