EPA VICTORIA

Guidance for assessing **odour**

/ Publication 1883 / June 2022

VICTORIA State Government

Authorised and published by the Victorian Government, 1 Treasury Place, Melbourne

Publication 1883 2022
Authorised and published by EPA Victoria
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Executive summary

Offensive odour interferes with people's normal enjoyment or use of the environment. It can cause people to feel revolted, disgusted, upset, or annoyed. Odour is subjective and varies in its perception from person to person.

Odour is a key environmental issue set out in the Environment Protection Act 2017 (the Act). Odour is also clearly defined as a form of pollution and offensive odour constitutes a harm in accordance with the Act. Odour is also included in the environment reference standard (ERS) under section 93 of the Act. Under the Act, the risk of harm from odour that is offensive to the senses of human beings must be reduced as far as reasonably practicable, with the overall objective of an air environment that is free from offensive odours.

Guidance for assessing odour provides information on how to assess the risk posed by odour emission sources and to understand the receiving environment where effects might occur. This guidance is focused on the assessment of odour under the provisions of the Act, including the General Environmental Duty, which requires all Victorians to take precautionary and reasonable actions to avoid hazards causing harm.

This guidance is primarily intended for government, the planning sector, practitioners and specialists, who need to understand offensive odours that are associated with a development proposal, investigation or study where an odour assessment is required. Risk assessment is related to whether the risk of harm can be easily understood through the assessment framework.

There are three levels of assessment in this guide, progression through each level of assessment will depend on the scale or complexity of the scenario. These can be performed in sequence: If the lower levels of assessment show that the activity is low risk for odour, there is no need to proceed to the higher levels of assessment.

Level 1 assessment is a "gateway assessment" and includes tests for:

- Cumulative sources consideration
- Duration of emissions
- Wind direction
- Minor odour emission sources

Level 2 assessment consists of two tools, cumulative effects test and the source-pathway receiving environment tool. The cumulative effects test takes into consideration the effects of multiple odour sources where there is different dispersed industry, different clustered industries and clusters of similar industries.

The source-pathway-receiving environment tool gives guidance on determining the level of hazard posed by the odour source, the effectiveness of the exposure pathway and the sensitivity of the receiving environment. It enables the calculation of a risk score. Depending on this score and the quality of the evidence used, further steps in the risk assessment can be identified.

Level 3 assessment provides detailed risk assessment tools for issues that are complex or where the other levels of assessment have been exhausted because there is not enough evidence to establish what the odour risk is. The value of a risk assessment is enhanced if there are multiple, independent lines of evidence that support each other.

It is not a step-by-step process and presents several different tools which may be used. The tools include:

- Comparisons with similar operations or case studies.
- Risk assessment using field odour surveillance data.
- Complaint assessment.
- Odour complaint case study.
- Community odour surveys/questionnaires and odour diaries.
- The use of dispersion modelling.

Finally, the guidance is rounded out with sections on, what to include in assessment reports and uncertainty in odour assessments. There is also a series of appendices including industrial odour source categories, odour character descriptors, and assessment templates.

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Glossary of terms

Area odour survey: Set locations are chosen as **observation points** where an **odour observation** is made for each odour survey. This is repeated to give a statistical profile of odours in an area.

Best available techniques and technologies: The best combination of eco-efficient techniques, methods, processes or technologies used in an industry sector or activity that demonstrably minimises the environmental impact of odour emissions.

Confirmed odour: When an odours character, intensity and frequency is verified by observations at an observation point.

Development: The subject of the odour assessment**,** a new or modified industrial or commercial use that may have odour emissions, or a sensitive use proposed to be located near the former.

Exposure pathway: The means by which odour is transmitted from the odour source.

Fence-line surveillance A set of observations completed in a line perpendicular to the "interface" downwind from the odour source/s. It can be expanded with a series of parallel lines to understand the distance that odour from each source persists.

General environmental duty: A person who is engaging in an activity that may give rise to risks of harm to human health or the environment from pollution or waste must minimise those risks, so far as reasonably practicable.

Innocuous character: These are odours that don't bother most people, and are ubiquitous in an urban environment, however, prolonged or frequent exposure may cause adverse reactions.

No odour: No odour or an odour not strong enough to be recognised.

Observation point: Single location where an odour observation is made.

Obvious odour: Odour is easily recognised, can be described and may be attributed to a source. The assessor can smell it without any effort.

Odour character: Objective description of what the odour smells like.

Odour context: Combination of the location and the experiences of people being exposed to the odour.

Odour duration: Length of odour exposure events.

Odour frequency: How often odour exposure events occur.

Odour intensity: The ease to which an odour can be recognised.

Odour observation: An individual assessment of an odour at a single time and location during surveillance.

Odour presence: The proportion of the time and odour is observed during a single odour observation.

Odour source hazard: Source and nature of odour emissions.

Offensiveness potential: The potential for an odour to be inherently unpleasant based on its characteristics

Plume tracing: Used to determine the length, width and area of an odour plume for a single source of odour. This has two parts, working from the odour source outwards or working from receptor towards the source.

Receiving environment: Nature and use of the environment where the odour is impacting.

Separation distance: The length of the space between an industrial land use and a sensitive land use.

Sensitive land use: Any land use or zone that requires a focus on protecting human health and wellbeing, local amenity and aesthetic enjoyment.

State of knowledge: All the information a person should reasonably know about managing risks specific to an industry sector or activity.

Subtle odour: Odour can be recognised only when focusing, such as by standing still, inhaling slowly and concentrating.

Unsafe character: These odours are likely to trigger adverse responses as they would be perceived as unsafe or toxic, they are typically odours the human sense of smell was developed to avoid. Most people would adversely react to these odour types.

Unwelcome character: these odours typically unpleasant for most people, they are not likely to be perceived as toxic or unsafe.

Acronyms and abbreviations

AS/NZS	Australian / New Zealand Standard
BATT	Best available techniques or technologies
EPA	Environment Protection Authority Victoria
ERS	Environmental Reference Standard
FIDR	Frequency, intensity, character and receiving environment to which an odour is experienced.
GED	General environmental duty
SPR	Source-pathway-receiving environment
USEPA	United States Environmental Protection Agency
ORS	Odour receiving environment score.
OSS	Odour source score
OPS	Odour pathway score

1. Introduction

Guidance for Assessing Odour presents new tools to assess risks associated with offensive odour. They are designed to provide enough evidence regarding the risk of odour impacts occurring commensurate with the scale and complexity of the scenario being examined.

1.1 Purpose of guidance

EPA is committed to working with all Victorians to help them understand how to fulfil obligations under the Act by providing guidance, advice and other support. This guidance provides a framework for the assessment of offensive odour including:

- Guidance on methods for assessing the impacts of odour pollution on human health and wellbeing, including site specific risk assessment methods and
- Recommendations on what to include in assessment reports.

1.2 Intended audience

This guidance is intended for those who need to understand offensive odours and provide evidence for odour assessments, such as the government, the planning sector, practitioners and specialists.

This guidance will also be of use to decision makers, planners, environmental managers, consultants and industry. It can be used to assess the risk of harm due to offensive odour for a development, investigation or study. It will most likely also be of interest to other stakeholders such as resource managers, legal professionals and the public.

2. Regulatory and policy context

2.1 Offensive odour

Offensive odour interferes with people's normal enjoyment or use of the environment. It can cause people to feel revolted, disgusted, upset, or annoyed. Offensive odour can also be detrimental to people's health and well-being.

Examples of Offensive Odour:

- interfere with backyard activities such as barbecues, having visitors or hanging out washing
- infiltrate into homes or preventing windows being opened
- trigger health impacts through physiological and psychological triggers such as stress, headaches, nausea, shortness of breath or aggravating asthma symptoms
- interfere with a person's capacity to work
- taint the preparation or enjoyment of food at commercial premises and restaurants.

2.2 The Environment Protection Act

Odour is a key environmental issue set out in the Act. It is included as a key definition for "environment": *"the physical factors of the surroundings of human beings including … odours"*.

Odour is also clearly defined as a form of "pollution" – *"any emission, discharge, deposit, disturbance or escape of – a solid, liquid or gas, or combination of a solid, liquid or gas, including but not limited to smoke, dust, fumes or odour"*.

Offensive odour constitutes a harm in accordance with the Act. The *Environment Protection Act 2017,* sections.4(1)(a) & (b) define harm as

- *"An adverse effect on the amenity of a place or premises that unreasonably interferes with or is likely to unreasonably interfere with enjoyment of the place or premises; or*
- *"a change to the condition of the environment to make it offensive to the senses of human beings".*

Odour is also included in the environment reference standard (ERS) under section 93 of the Act; *"an air environment that is free from offensive odours from commercial, industrial, trade and domestic activities"*. The ERS has been created for assessing and reporting on environmental conditions in Victoria. The ERS objective for odour is qualitative in nature.

Therefore, under the Act, the risk of harm from odour that is offensive to the senses of human beings must be reduced as far as reasonably practicable, with the overall objective of an air environment that is free from offensive odours.

3. Assessment of offensive odour

Odour assessment may be conducted for the following reasons:

- Application processes for EPA permissions including licences and permits.
- Planning assessments including; buffer area overlays, local council planning permit applications, precinct structure planning and rezoning applications.
- Where a separation distance is to be varied or assessed, see EPA Publication - Separation Distance Guidelines (Publication 1949)
- Evaluating the risk of harm in accordance with the ERS for odour, as part of obligations to a duty holder under the Act.
- An investigation into a specific odour source for strategic or enforcement purposes.

Agent of Change
The agent of change is the party that is proposing to change the status quo. It could be a new industrial use or an industrial use that is modified, the rezoning of land from one use to another with different sensitivity or the establishment of a new sensitive use near an industrial or commercial area.

The overall objective of an odour risk assessment (regardless of the reason for the assessment) is to determine the level of risk of harm from the odour hazard in the area(s) of interest. The persons responsible for conducting an odour assessment are usually the agent of change

3.1 Odour assessment framework

It is important to gather clear, robust evidence in support of a development and clearly understand the risk of harm caused by odours that can be offensive.

Odour assessment complexity is related to whether the risk of harm can be easily understood through the framework. There are three levels of assessment, progression through each level of assessment will depend on the scale or complexity of the scenario.

For any risk assessment you need to first identify if cumulative effects are a concern (see **section 3.2**) before proceeding to a Level 1, or Level 2 assessment. If at any stage of an assessment there is not enough evidence available to meet the criteria, you should proceed

to the next assessment level. An overview of each level of assessment is summarised in a flow diagram of the risk assessment process (Figure 1).

Level 1 assessment

This is a "gateway assessment" where there are three tests; these can be performed in sequence or parallel, depending on the scenario. If the level 1 assessment shows that the activity is low risk for odour, there is no need to proceed to a level 2 assessment.

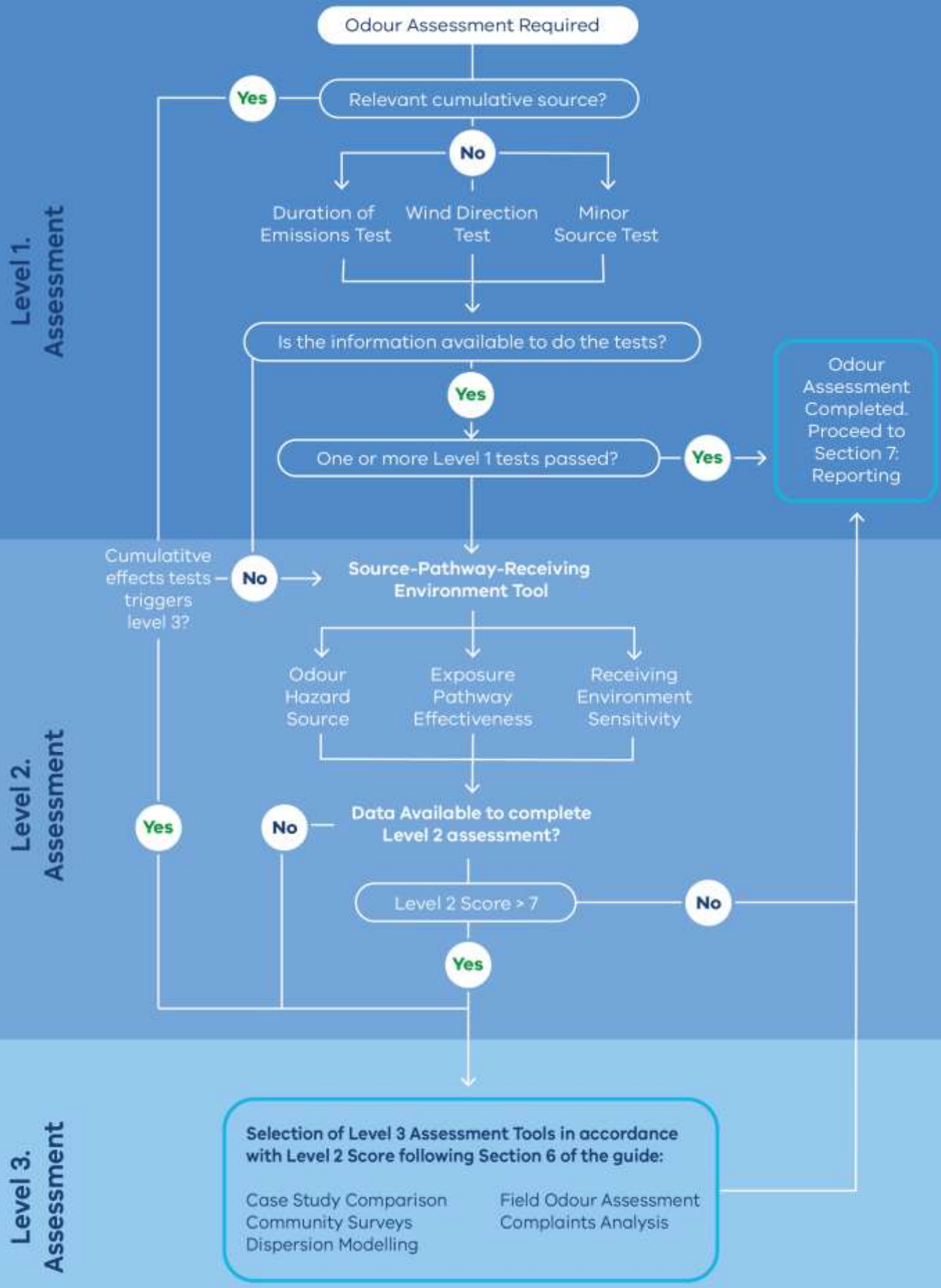
Level 2 assessment

This assessment consists of gathering information on the level of hazard of the odour source, the effectiveness of the exposure pathway and the sensitivity of the receiving environment. An interim risk score is obtained by using the Source-pathway-receiving environment tool (SPR). Depending on this score and the quality of the evidence used, the assessment either concludes or proceeds to a level 3 assessment.

Level 3 assessment

This level of assessment is usually needed for complex industries or scenarios or where there is more than one odour source under consideration. Level 3 assessment provides tools that can be used to support evidence of odour hazard risks for various industry sectors or activities. Using more tools ensures a more robust assessment, which strengthens the evidence and better supports decision making.

Figure 1: Flow diagram of odour assessment process



3.2 Cumulative effects in odour tests

Cumulative effects should be considered whenever an application involves multiple odour sources or the addition of a new odour source in an area with an existing odour source/s.

The most common meaning of the term "cumulative" is the combined effect of various sources of ground level odour impacts. These include:

- **On-site sources**: When assessing the overall risk posed by the site, reasonable efforts should be made to incorporate all significant on-site sources in the assessment.
- **Known off-site sources**: This is the contribution to odour impacts from known sources from nearby sites. This type of cumulative effect is intended to encompass all relevant neighbourhood sources of odour. It is particularly relevant to situations where similar types of odour are released by multiple sites in a defined area.

3.2.1 Threshold for level 1 assessment

A level 1 risk assessment should be used when looking at single odour sources or in cases where the new odour source is so different to existing sources it does not create a cumulative impact.

For example, this is where new or modified singular emission sources that are either near other odour sources OR if the source under consideration has a low odour potential and there are existing odour sources with a higher potential.

For example:

> If a coffee roaster is proposed and other sources nearby include a seafood processor and a stockfeed manufacturer, the new source won't make a significant difference to the overall odour exposure risk and a level 1 assessment can proceed.

Go straight to a level 1 assessment if the proposal is for a new industry and it has:

- a low odour potential (Appendix A) and,
- surrounding industries have a medium or higher odour potential.

For all other scenarios proceed to **section 3.2.2**.

3.2.2 Thresholds for level 2 and/or level 3 assessments

The next three sections provide three common scenarios that will generally apply to specific situations. They illustrate when a level 2 assessment should proceed or if it is necessary to complete a level 3 assessment. When in doubt due either to a lack of conclusive evidence or a high level of complexity, EPA recommends completing a level 3 risk assessment.

3.2.3 Different dispersed industry

Proceed to a level 3 assessment if the odour source under examination has the same or higher odour potential (Appendix A) as existing industry and industries are spread out, meaning sensitive receiving environments are downwind during multiple different wind conditions (Figure 2). Otherwise proceed to a Level 1 risk assessment.

Figure 2: Scenario 1: Multiple industry cluster/residential interfaces

3.2.4 Clustered industry

Continue with a level 2 assessment if the odour source under examination has both:

- the same or lower odour potential and,
- industries are clustered together presenting a single interface with sensitive uses (Figure 3).

Figure 3: Scenario 2: Single industry cluster/residential interface

3.2.5 Same source clusters

When a proposal is the same or has similar processes to existing industry in an area and they have overlapping separation distances (Publication 1949), it is necessary to consider the cluster of sources as a single source. This accounts for the impact of existing sources and how the separation distance may vary when adding a further odour source.

3.2.6 Cumulative Impacts Case Study

A coffee roaster processing 150 tonnes of coffee per year is 150 m from the nearest sensitive use zone. The separation distance for coffee roasters is 250 m when they produce greater than 200 tonnes per year (t/yr.). A single site like this does not require a separation distance to sensitive uses provided it has adopted the best available techniques and technologies to manage and control odours (BATT). In this scenario, a level 2 risk assessment is sufficient.

A second coffee roaster is proposed which also produces 150 t/yr. If the two roasters are closer than 250 m to each other they should be counted as a single source. This is because there is a combined 300 t/y volume, meaning the 250 m separation distance applies (Figure 4). In this scenario, as a minimum a Level 2 risk assessment applies.

Figure 4: Example of cumulative impacts

4. Level 1 odour assessment

A level 1 odour assessment consists of three basic tests. They are screening tools to determine if more detailed assessment is necessary. The tests should be completed in order, if test is passed no further assessment is required, if not proceed to the next test. If none of the tests are met proceed to a level 2 assessment.

4.1 First test: Duration of emissions

The potential for odour to be perceived as offensive is a function (in part) of its duration. You use this test to examine the total number of hours in which an odour source could be emitting odour (usually hours of operation for the process or activity).

In the case of area sources in the open air, this would be the time the source would be uncovered or exposed to the elements.

For this test, wind direction frequencies do not need to be considered. Odour emissions are also not quantified in this test. The duration of emissions assumes the worst-case scenario, in that sources will emit odour constantly at high enough concentrations during operation to cause impacts. The test questions are:

- Do odorous emissions occur for less than 200 hours per year (< 2% of the time)?
- If the activity or operation occurs for less than 200 hours per year do individual activities or operations occur for less than 8 hours at a time?

If the answer is yes to both questions, the risk of odour is low, proceed to **Section 7**: Reporting.

If the answer is no to both questions, or there is insufficient information to do the test, proceed to the second test.

4.2 Second test: Wind direction

Example calculations

The receiving environment is down wind of the emission source 30% of the time.

The process that produces odour operates 10 hours per week (6% of the time)

Probable maximum frequency of exposure = 0.3 x 0.06 = 1.8% or 157 hours.

Second test has been passed

This test is an estimation of the maximum time an odour may impact an area based on:

i) the time odour sources are emitting (test 1) and

ii) the amount of time the wind conditions are directing emissions to the receiving environment.

The test question is:

Do prevailing wind patterns direct odorous emissions towards the receiving environment less than 200 hours per year (< 2% of the time)?

If the answer is yes, the risk of odour is low, proceed to **Section 7**: Reporting.

If the answer is no or the information is not available to do the test, proceed to the third test.

4.3 Third test: Minor odour emission source

This test is used to determine the level of odour emissions from facilities with low complexity and applies to stationary odour sources with known, quantifiable emissions (either from a known similar operation or from emissions testing.

All odour sampling and analysis testing should be done according to, *Stationary Source*

Emissions Method 1: Selection of sampling positions and measurement of velocity in stacks (Australian Standard 4323.1) and Part 3: Determination of odour concentration by Dynamic Olfactometry (Australian Standard 4323.3) i.e., emission rate reported dry at 0°C and 101.325 kPa.

In the case of new odour facilities, emission rates from equivalent reference facilities with emission test results may be used.

The requirements to classify as a minor odour emission source are:

- The source is stationary with a stack height of at least 10 m.
- The source height is at least 1.7 times the relevant building height(s), meaning there aren't any obstructions within a 15 m radius that could influence stack dispersion (including building wake effects).
- The emission source is situated on level terrain (free of terrain effects).
- The distance between the emission source and the receiving environment occupied by people is ≥ 100 m.
- At the source location, average wind speeds of < 1 m/s occur less than 20 % of the year.
- For stack heights > 50 m, the minor mass flow for the stack height of 50 m applies.

The source falls under the emission rate vs stack height line in Figure 5 demonstrates optimal stack height versus odour emission rate (millions of odour units/m^3/hr – MOU/hour). It was referenced from VDI 3886 Determination and assessment of odours - Odour survey - Determination of necessity and references for preparation (Verein Deutscher Ingenieure, 2019).

If all requirements are met the source is a minor emission source, risk of odour is low, proceed to **Section 7**: Reporting.

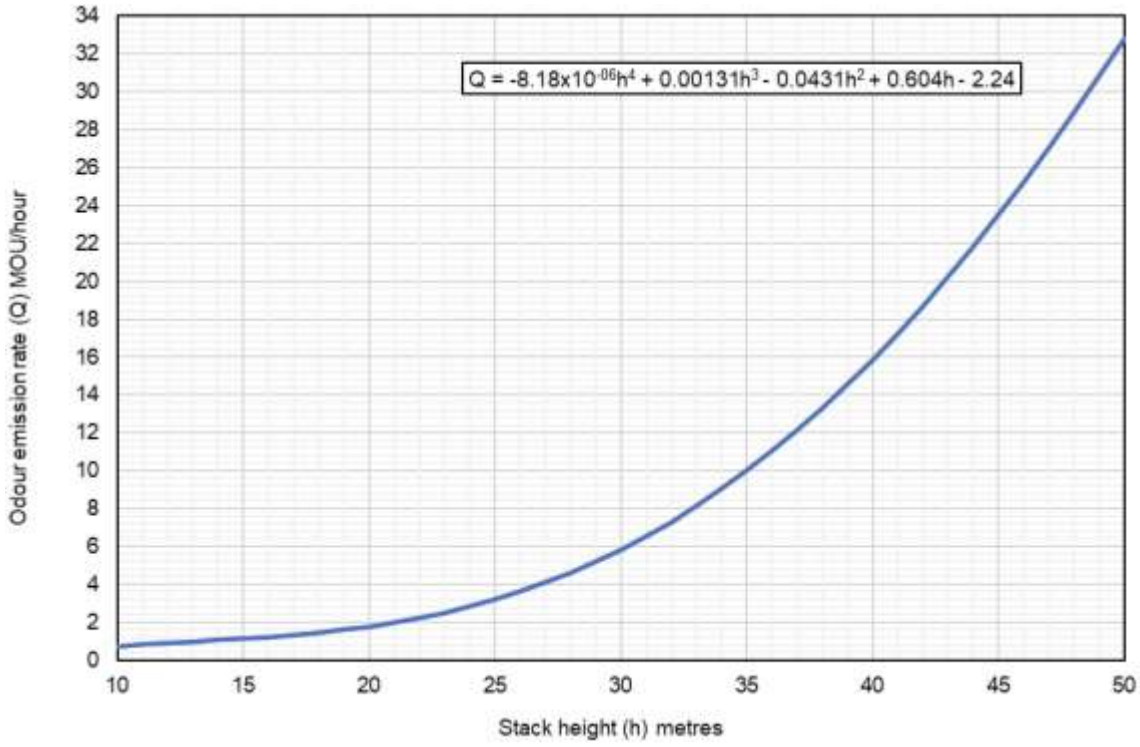


Figure 5: Odour flow rate vs stack height minor odour source classification

Example calculations for the determination of a minor odour emission source:

- Odour concentration = 1000 OU
- Flow rate = 12 m/s
- Stack diameter = 700 mm
- Odour emission rate = 250,000 OU m3/min

250,000 x 60 = 15 million OU/hr or 15 MOU/hour

15 MOU/hour would require a stack height of at least 39.5 m to be considered a minor odour source.

5. Level 2 odour assessment

5.1 Source/Pathway/Receiving environment tool.

This is primarily a qualitative tool. Assessments should demonstrate a clear understanding of the potential odour impacts of the industry under examination. If there is not enough information to complete a level 2 assessment, proceed to a level 3 assessment.

Scoring is based on three attributes:

- Hazard potential of the source (odour source score – OSS)
- Exposure pathway between the source and sensitive locations (odour pathway score – OPS)
- Sensitivity of the receiving environment (odour receiving environment score – ORS)

5.2 Level 2 risk potential score and next steps

Each attribute is broken up into categories organised into columns, a score of 1-3 is then applied to each category, except for certain high-risk odour activities (Appendix A: Table of industrial odour sources by odour potential) where the default is 4. The overall score for each attribute is the highest score for each attribute.

Weightings are also applied to

- the OSS based on the odour controls in place
- the ORS based on any relevant compliance or community history

All the attribute scores are added together to get an overall risk score which will range between 1 and 12

Based on the score, the following should apply:

1 to 7 – low risk:	the risk of odour is low, proceed to **Section 7**: Reporting.
8 or 9 – medium risk:	borderline cases – there may be one element that can influence the score and tip it into a low or high score. In these cases, this should be explored further.
10 to 11 – high risk:	A level 3 assessment is recommended to fully understand risk.
12 – very high-risk	A level 3 assessment is not likely to demonstrate risk is acceptable but may provide further illustration on the nature of the risks and/or inform on odour mitigation measures.

If there is not enough information available to score a category, proceed to a level 3 risk assessment

Examples

Calculating an attribute (OPS) attribute:

- Distance = **2**
- Meteorology = **1**
- Terrain and Built form = **1**
- Hours of Operation = **2**

OPS = **2**.

Calculating and overall risk score:

- OSS = **2**
- OPS = **2**
- ORS = **3**

Overall level 2 assessment score = **7**, meaning the risk of offensive odour is low.

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5.3 Odour source hazard potential (OSS)

To determine the odour hazard potential of a source (the potential of the site to discharge odours that are offensive to the people), use Table 1 to assign a score for each category. Note that the activity type category can score up to 4 for odour sources with very high odour potential:

1. **Activity type**, sites that by their nature are more or less likely to generate odour (Appendix A: Table of industrial odour sources by odour potential .
2. **Size of odour hazard** (based on physical size, or throughput)
3. **Offensiveness potential** of odour emission based on character (Appendix B).

A weighting (Table 2) is then made for the effectiveness of the odour controls (-1, 0 or +1).

To get an OSS, you pick the highest score from each category (1–4), with weighting given according to the effectiveness of odour controls.

Table 1: Derivation of scores for odour source hazard potential

Score	Activity type	Size of odour hazard	Offensiveness potential
1	**Low odour potential:** Column 1, Appendix A	**Small size:** Materials usage hundreds of tonnes/m^3 per year Area sources of tens of m^2.	**Innocuous** Most people would not be bothered by the odour; however, prolonged or frequent exposure may cause adverse reactions.
2	**Moderate odour potential**: Column 2, Appendix A	**Medium size:** Materials usage thousands of tonnes/m^3 per year Area sources of hundreds of m^2.	**Unwelcome** Unpleasant odour range: although not likely to be perceived as toxic or unsafe, these odours are usually unwelcomed for most people.
3	**High odour potential:** Column 3, Appendix A	**Large size:** Materials usage hundreds of thousands of tonnes/m^3 per year, or Area sources of thousands of m^2.	**Unsafe** Likely to trigger adverse responses as people are likely to perceive odour/s as unsafe or toxic. Most people would adversely react to these odour types.
4	**Very high odour potential**, Column 4 in Appendix A.		

Table 2: Odour control effectiveness weighting

	Degree of effectiveness of odour controls		
Category	**High:** • Tangible mitigation measures in place leading to little or no residual odour; releases only due to plant failure. • Fully enclosed operations with extraction and treatment equipment utilising best available technology and techniques.	**Moderate:** • Some mitigation measures in place, but significant residual odour remains. • Some areas of the site may be controlled but there are areas not addressed. • There is a lack of maintenance or monitoring of equipment.	**Ineffective:** • Open air operation with no containment • Reliance solely on management techniques requiring human intervention • Composting technology not commensurate with risk of feedstock.
Weighting	**-1**	**0**	**+1**

5.4 Odour exposure pathway effectiveness (OPS)

Use this part of the level 2 assessment to evaluate the effectiveness of the odour pathway (OPS) from the odour generating hazard to the receiving environment. This part of the assessment consists of three criteria; to get an OPS, you pick the highest score in any row (1–3) from Table 3, which consist of:

1. **Distance:** How far the receiving environment is from the source.
2. **Meteorology:** If wind patterns direct emissions towards the receiving environment more frequently, or if conditions are stable.
3. **Terrain & built form:** The presence of hills, valley drainage, urban canyons formed by tall buildings, forested areas, bare open plains, etc.
4. **Hours of operation:** Number of hours of odour emission or odour generating activity.

Table 3: Scores for odour exposure pathway effectiveness

Score	Distance	Meteorology	Terrain & Built Form	Hours Of Operation
1	**Long distance:** Receiving environment is kilometres or hundreds of metres from source	**Favourable:** Winds rarely (<10%) blow from source away from receiving environment	**Favourable:** Highly built-up intervening zone with multiple non-sensitive uses that have no emissions of their own Densely forested Source is downslope of receiving environment (or located in a valley or quarry hole).	**Low frequency:** Emissions are rare and only occur if there is a significant upset or multiple lines of failure Emissions related to specific infrequent planned (monthly or annual) activities.
2	**Medium distance:** Receiving environment is tens to hundreds of metres from source Separation distance has not been met or only just met at the threshold distances.	**Neutral:** Even distribution of winds (10–20%) from source to receiving environment	**Neutral:** Moderate vegetation, source is on same altitude as receiving environment Intervening land use zone contains other non-odorous industry or smaller businesses.	**Moderate frequency:** Emissions or operations not continuous, typically confined to business hours during the day Reasonably regular in frequency (once per day to several times per week).
3	**Short distance:** Receiving environment is adjacent to the source/site Distance well below (less than half) separation distances.	**Unfavourable:** High frequency (>20%) of winds from source to receiving environment.	**Unfavourable:** Flat cleared land Source is upslope of receiving environment, with isolated dwellings or structures in pathway Receiving environment abuts source.	**High frequency:** Emissions continually occurring 24/7 or for long periods at a time (e.g., landfills, oil refineries, sewage treatment plants, etc.)

5.5 Receiving environment sensitivity

The sensitivity of the receiving environment has two aspects: the overall land use in the receiving environment and the compliance history, social or historical context experienced by people in determining the odour receiving environment score (ORS).

Land use is based on the existing uses and/or land use terms and nesting diagrams in the Victoria Planning Provisions (VPP) land use terms and nesting groups (Clause 73.03 & 73.04) (Table 4). Assessment is based on the most sensitive land-use within (or proposed to be within) the separation distance or 2 kilometres, whichever is closest.

Historical context

+1 should be added to the ORS when:

- there are known ongoing amenity impacts.
- there is a history of odour complaints.
- there are facilities with histories of non-compliance.
- a well-known contentious issue with political or legal aspects.

Table 4: Scores receiving environment sensitivity

Score	Sensitivity	VPP Land use term or nesting group (number in bold)	Existing Uses
1	Low	• **73.04-3** animal production • **73.04-2** agriculture • **73.04-10** Recreational boat facility • **73.04-15** Warehouse • **73.04-5** Industry • **73.04-7** Earth and energy resources • **73.04-13** Transport terminal • **73.04-14** Utility installation • **73.04-16** Renewable energy • Car Park • Saleyard • Tramway • Natural systems • Freeway service centre/service stations	• Industrial use or equivalent rural use (in the case of agricultural odours). No population nearby or uses are transient (e.g., state parks etc.). • Exposure to odours can easily be avoided.
2	Medium	• **73.04-8** Office • **73.04-6** Leisure and recreation • **73.04-9** Place of assembly • **73.04-11** Retail premises • **73.04-12** Retail Premises (shop) • **73.04-4** Education centre • Research centre • Winery • Cemetery or Crematorium • Emergency services facility • Brothel • Art and craft centre	• Business areas: exposure can typically be controlled by mitigation at the receptor (incorporated health ventilation and air conditioning systems etc.). • Receptors that are single dwelling or isolated rural dwellings receptor is business/commercial. • Enjoyment of the outdoors: recreational activities, playing sport, populations can move on or plan around exposure.
3	High	• **73.04-1** Accommodation • Rural living zones • Hotels/motels • Hospital • Prison • Mixed use zones with residential apartments at ground level. • Residential areas	• Built up area, towns, many dwellings with backyards and outdoor living areas. • Rural residential, schools, childcare or apartments. • Permanent populations where avoiding exposure is not possible.

6. Level 3 assessment

A level 3 assessment is a detailed risk assessment for issues that are complex or where the other levels of assessment have been exhausted because there is not enough evidence to establish what the odour risk is.

Applications or proposals for new developments where there may be potentially significant odour impacts should include multiple tools in the risk assessment. This should include the use of site-specific data where possible. The level of detail provided in the detailed assessment should be commensurate with the potential for odour impacts.

The value of individual risk assessment results is enhanced if there are multiple, independent lines of evidence that support each other. Some of these lines of evidence should utilise empirical data rather than relying on data from literature or other sources. For example, the value of information in the form of odour complaints is significantly improved if odour field assessments independently confirm the presence of odour in the same area.

Level 3 risk assessment tools are provided in Table 5, with more detail provided in **Sections 6.1 to 6.9**. An odour assessment report should include elements of multiple methods, which are considered as one single comprehensive report, rather than a collection of separate assessments or reports.

The methods used in an odour assessment report are a representative sample of the tools that should be available to an odour specialist when assessing risks from odour. Tools are selected based on availability, accessibility of data and agent of change principles. The higher the risk rating SPR (pathway receiving environment) score, the more tools that need to be used to assess risk.

Table 5: Level 3 assessment tools and applicable scenarios

Level 3 assessment	Description	When the tool is applicable
Comparison with similar operations	Analysis of data from facilities of similar size, throughput, operational conditions, technology, processes, topography, meteorology and emission sources. This should incorporate assessments from a literature review.	• A new facility is proposed. • Best used in conjunction with odour field assessment.
Risk assessment using field odour surveillance data	Survey of odour levels in the field provide an indication of odour frequency, intensity and character (FIC) from: • existing premises • odour surveillance of a reference facility • surveillance that includes other odour generating premises or sources in the area.	• For most scenarios where there are existing odour sources. • Rezoning or precinct structure planning. • Characterising odour sources impacting a community. • Assessment of a reference facility or scenario that has similar attributes to the development proposal in question.
Complaint data analysis	Analysis of odour complaint histories to provide an indication of odour frequency, intensity and character (FIC) from: • existing premises • other odour generating premises or sources in the area • complaint histories from a reference site.	• Sensitive use proposals around existing facilities where there are already sensitive uses. • Assessment of odour reports around similar industries in the absence of the above.
Community surveys	Survey of community members to identify current or past odour issues related to the existing premises and other premises/sources in the area.	• A proposed sensitive use in an area where there is existing industry. • To aid in verifying complaints data. • To compliment surveillance data.
Dispersion modelling	Computer modelling to compare different emissions scenarios through the analysis of the relative variations in predicted ground level odour concentrations. Odour modelling should not be used as the only evidence of an assessment and modelled results need to be validated against field assessment results.	• A proposed change or upgrade to premises to look at expected. change in emission pattern. • To understand the relative contribution of multiple sources to a subject site. • To understand the dispersion pattern of a proposed industry based on a reference site. • This approach uses field surveillance data (where available) to verify modelling at the reference site.

6.1 Comparison with similar operations

This tool allows for the performance of similar facilities to be used in support of a new proposal or development. It involves gathering information on the extent of odour impacts and source characteristics of a similar operation. The outputs of this tool may be incorporated into other more detailed analysis tools, such as assessing separation distances and applying results derived from level 1 and 2 assessments. Points for consideration when comparing odour studies or experiences of similar operations include:

- size and throughput
- similarity of the surrounding topography
- similarity of the local meteorology
- common emission sources and odour control technology
- seasonal or other common temporal factors that affect odour emissions.
- odour risk assessment information
- odour surveillance data (**Section 6.1**)
- complaints history (**Section 6.2**).

Case study

Company A wants to construct a cattle-sale yard in Gippsland. They have identified sensitive uses within the recommended separation distance of 500 m. The sensitive uses are isolated rural dwellings that are dispersed over a large area.

As part of the application process, Company A should demonstrate that the proposed sale yard poses a low risk of harm to sensitive uses.

As part of the risk assessment, Company A develops a case study on a similar sale yard operating in western Victoria. This case study site is a suitable reference site because it:

- has the same throughput of cattle.
- has the same type of animal housing arrangements.
- is operated by the same company.
- was assessed to be operating in accordance with BATT, with odour emissions being minimised as far as reasonably practicable.
- both facilities are in open flat countryside with similar prevailing winds and temperature profiles.
- both facilities have very similar operating practices.

The assessment (apart from the above information) included:

- assessment of the western Victoria site's operations, odour sources and layout.
- field odour surveillance results to establish frequency of downwind emissions.
- application of the field odour surveillance results to the new site in Gippsland, considering local meteorology.

Maximum distance that odour plumes were observed from the reference site were 300 m and on average they were 20–30 m wide and 100 m from the facility.

Prevailing winds for the new site in Gippsland show that any sensitive use is downwind from the site less than 25% of the time are further away than 400 m from the site.

As plumes were not predicted to extend to sensitive uses, it was concluded that odour risk was low.

6.2 Risk assessment using field odour surveillance data.

Odour annoyance is related to frequency, intensity, odour character and type of receptor.

EPA recommends that odour observation data is gathered using robust field odour surveillance methods.

EPA recommends the following field odour assessment methods:

- EPA Publication 1881, Guidance for Field Odour Surveillance", May 2021
- I.S. EN 16841-1:2016 "*Ambient air – Determination of Odour in Ambient air by Using Field Inspection Part 1: Grid Method"*, 23 November 2016.
- I.S. EN 16841-2:2016 "*Ambient air – Determination of Odour in Ambient air by Using Field Inspection Part 2: Plume Method",* 23 November 2016.

Odour surveillance programs can be discussed with EPA to help determine application and scope. EPA recommends using a comprehensive field odour assessment for high profile or complex applications.

In determining whether odour is likely to be offensive and pose a risk of harm, the frequency, intensity, character and receiving environment (FICR) needs to be established. Most odour surveillance work will not be able to effectively determine duration of odour events, so duration is considered separately.

Sections 6.3 and 6.4 outline ways using data gathered from area surveillance and plume tracing to determine the risk of offensive odour in a location or area based on the risk of odour exposure and the receiving environment sensitivity.

6.2.1 Odour intensity and confirmation of the presence of an odour

Odour Intensity

Odour intensity is based on how easy it is to recognise an odour and further details are provided in EPA Publication – Guidance for Field Odour Surveillance (publication 1881) It is objective and includes a 3-point scale where the odour is classified as either obvious, subtle, or no recognisable odour (no odour). Data relating to odour intensity should be gathered via odour surveillance.

There are many scales of odour intensity used throughout the world. EPA recommends using a simple objective scale (Table 6). These criteria are based on an odour being recognised when character can be assigned to the odour.

If using the European Standards (EN 18841-1 and EN 18841-2) or VDI standards (VDI 3940-3) to gather data, we recommend translating the data to EPA Victoria Guidance (this publication) by adopting the EPA intensity scale and following this guidance when analysing the data (Table 6).

Table 6: Odour intensity

Descriptor	Description	Equivalent VD level
Obvious (O)	Odour is easily recognised, can be described and may be attributed to a source. The assessor can smell it without any effort or focus on it.	3-6
Subtle (S)	Odour can be recognised only when focusing. For example, by standing still, inhaling slowly and concentrating.	1-2
No Odour (N)	No odour, or odour is not strong enough to be recognised.	0

Odour Presence (odour confirmation).

Odour presence is the proportion of time during a single odour observation that the odour is recognised. When making observations of odour intensity, it is likely the odour intensity can vary. Publication 1881 gives guidance on determining odour presence, such as using the proportion of time an odour was observed during an odour observation (Table 7). An odour should be present at a minimum of 10% of the period of an odour observation.

Note: Odour presence is only used for area odour surveillance to confirm whether an odour is verified at a single observation point. It doesn't apply to plume tracing or transect methods where the objective is to actively seek out an odour.

Table 7: Odour presence descriptors

Descriptor	Rating	Description of odour presence
Constant	C	Can smell it constantly or almost constantly (> 80% of the time).
Frequent/Repetitive	F	On and off extended periods with recognised odour (10–80% of the time).
Transient	T	On and off with significant periods with no odour or no recognised odour (< 10% of the time).

6.2.2 Odour character

EPA Publication 1881 gives guidance on determining odour character and gives examples of odour wheels from the literature and EPA's odour wheel (epa.vic.gov.au/report-pollution/report-odour/describe-odour). Other odour wheels and tables may also be used, but it is recommended that assessors use consistent language when describing odour character and avoid subjective or vague terminology.

Some odours have characteristics that are more likely than others to stimulate a negative reaction from the average person. In this context, some odours are intrinsically more unpleasant than others (often referred to as hedonic tone).

Appendix B and **Section 5** gives guidance on how to determine the inherent unpleasantness of the odour (i.e., its offensiveness potential). Odours are grouped into three basic types in decreasing order of risk: unsafe, unwelcome and innocuous.

6.2.3 Odour frequency

Odour frequency is how often recognisable odour would be present in a location or area, simply put, it is the percentage of observations where an odour is confirmed divided by the number of observations made over a series of odour surveys.

Odour frequency is determined differently depending on the odour surveillance method used（**Sections 6.3 and 6.4**) examples are given in determining odour frequency and the overall risk of offensive odour following two methods selected from Publication 1881

6.2.4 Odour duration

It is not possible to determine odour duration using odour surveys as odour duration is specific for individual odour "events" and is primarily used in the context of enforcement of odour offences.

Odour duration may be used in discussion of assessment results when they are put into context in a qualitative sense. For example, survey results could be compared with community reports and may help verify the details regarding the duration of odour events provided by the community.

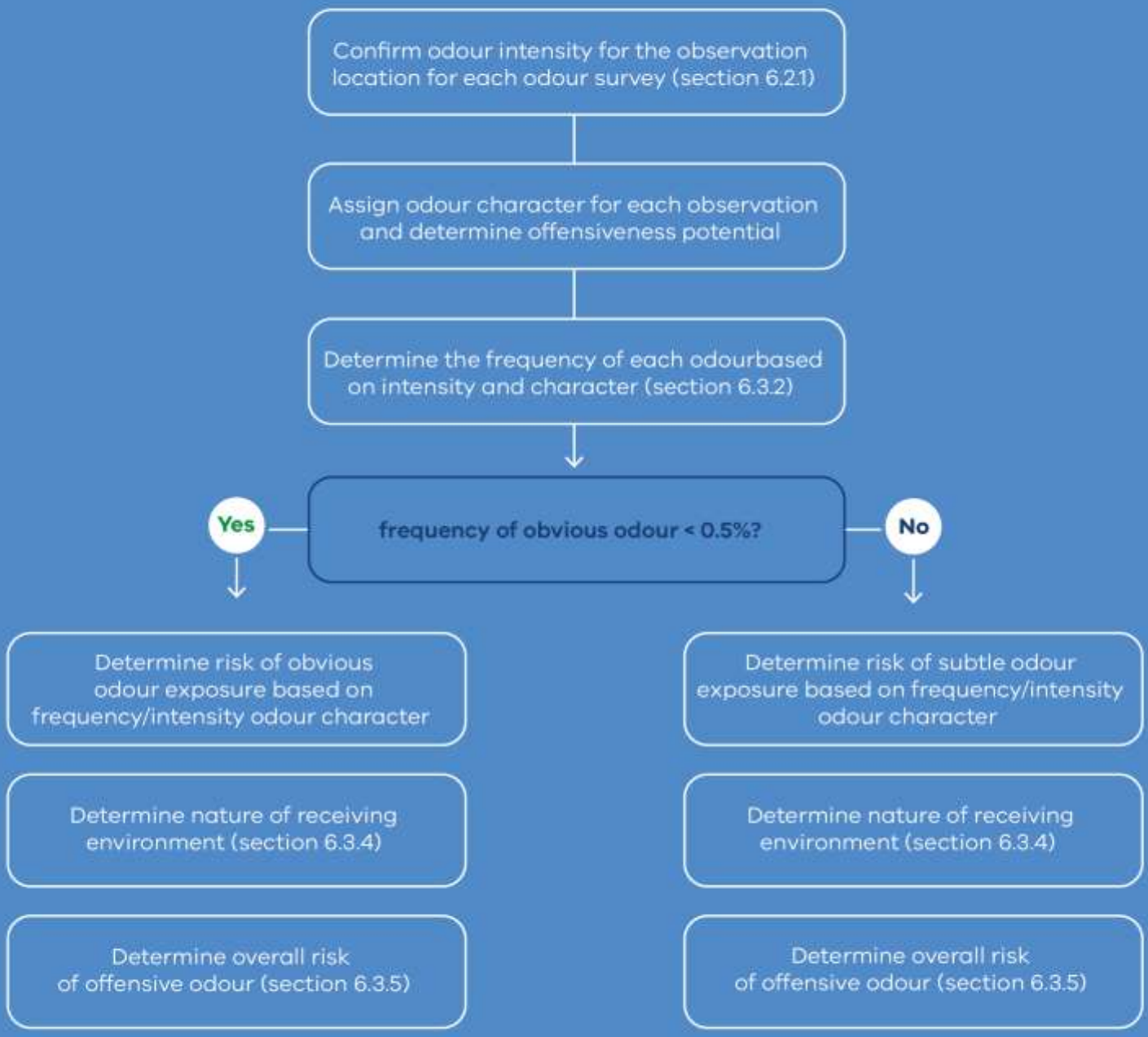
It may also be possible to forecast or retrospectively assign the duration of events based on the past or predicted weather patterns. Say an emission source is constantly emitting odour and the odour frequency is 25% and the source is upwind from the receptors when there is a southerly, the duration of odour events would coincide with the duration of southerly winds in each period.

6.3 Risk of Offensive Odour – Area Surveillance Method

Determining the risk of offensive odour using data gathered from Area Surveillance involves the following steps (illustrated in Figure) (note risk of offensive odour is described for a single observation location for illustrative purposes):

1. Determining when source odours have been confirmed
2. Determining the frequency at which source odours were confirmed for each odour character and its associated offensiveness potential
3. Combining odour frequency with odour character and intensity to determine the likelihood of odour exposure at a given point or series of points (for example in a suburb or a block).
4. Combining the likelihood of odour exposure with the sensitivity of the receiving environment to determine the overall risk that there will be offensive odour impacts.

Figure 6: Flowchart- Determination of risk of offensive odour from area surveillance



It is recommended for area odour surveillance; observations of odour would be collected at set locations for at least 13 surveys over several months with the objective of gathering data that is representative of a broad range of meteorological conditions.

6.3.1 Confirming odour

The objective of odour observation is to determine during the observation if:

- an odour was recognised.
- there were single or multiple odours.
- odours were obvious or subtle.

From Section 1.6 of Publication 1881, odours should be recorded as follows:

1. For each identified odour i.e., "A," "B," "C" etc.
2. Assign an odour character (including offensiveness potential), intensity and presence descriptor.
3. Determine the confirmed odour presence for each odour type for each odour A, B then C – (Figure 7).

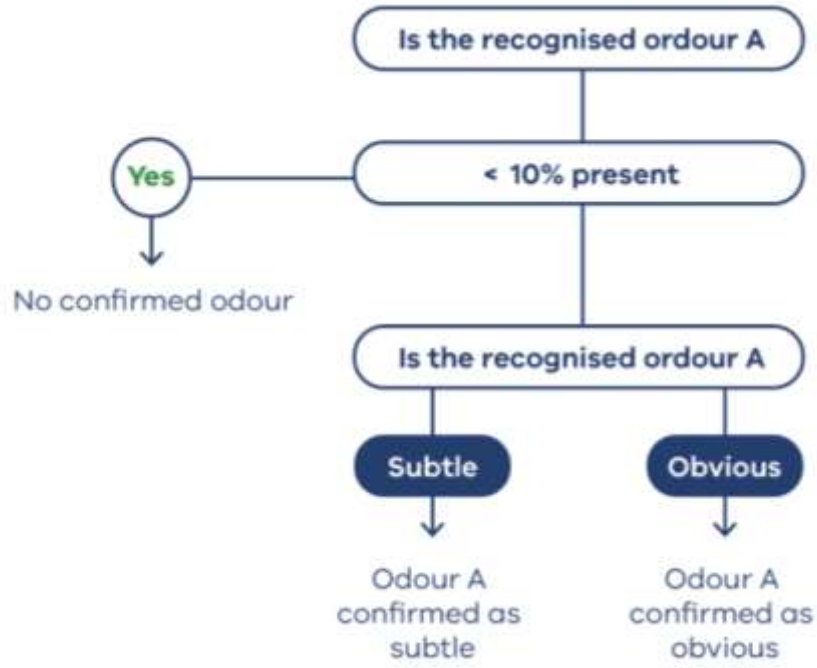


Figure 7: Odour confirmation flowchart

For example, for three odour observations during an area surveillance round the following information was recorded for character, intensity, and presence (Table 8).

Table 8: Extract from an odour surveillance field sheet (meteorological observations for each observation not included)

Start time	Stop time	Observation point	Odour character		Odour intensity (O/S)		Odour presence (C/F/T)	
			A	B	A	B	A	B
12:10	12:15	R1, Pine St	rotten compost	rendering	O	O	C	C
12:20	12:25	R2, Cone Ave	fresh compost	fresh compost	O	S	T	F
12:30	12:35	R3, Jones Park	manure	urine	O	S	C	F

The confirmed odour should then be tabulated as per Table 9

Table 9: Odour confirmation table

Site ID	Confirmed odour A	Confirmed odour B
R1	Rotten compost, obvious	Rendering, obvious
R2	Fresh compost, subtle	N/A
R3	Manure, obvious	Urine, subtle

6.3.2 Determine odour frequency at each observation point.

Odour frequency is determined separately for each odour character but may be combined if odours of a different character have a common source.

Example

An area odour survey was carried out 24 times. So, at location R3, 24 individual odour observations were made

Odours were confirmed as per (Table 10), with 15 observations of no odour, and 9 observations where odour was confirmed and assigned odour character and intensity.

The frequencies of each odour type can then be determined by diving the number of observations for each character type (and intensity) by the total number of observations.

Table 10: Odour area surveillance frequency determination

Odour character	No of observations	Odour frequency at R3
No odour	15 observations	54% No odour
Burnt waste:	2 obvious, 2 subtle	8% obvious 8% subtle
Chemical:	2 obvious	8%
Manure:	2 obvious	8%
Oily/grains:	1 obvious	4%

Assuming that area surveillance was conducted regardless of wind direction, at point R3, it is predicted to encounter any odour at a frequency of 36% and not from any single source more than 16% of the time.

Note when determining overall risk of exposure where odours of the same offensiveness potential based on their character are observed their odour frequencies can be added.

6.3.3 Combined assessment of frequency, intensity and character

Finally, the underlying risk of odour exposure is to be determined by combining odour character, intensity and frequency. For simplicities sake an example is provided where the risk of odour exposure is determined for a single observation point (Table 12 & Table 13).

Note: Subtle odour exposure only needs to be considered if obvious odour is observed less than 0.5 % of the time.

Table 11: Risk of odour exposure potential – colour key

	Negligible exposure	Almost no chance of odour exposure
	Low exposure	Odour exposure unlikely
	Moderate exposure	Likely chance of odour exposure
	High exposure	Highly likely to have odour exposure
	Very high exposure	Odour exposure near certain

Table 12: Risk of odour based on character, obvious odour intensity and frequency of predicted odour.

Frequency	**Hours per year (indicative)**	**Obvious odour character**		
		unsafe	unwelcome	innocuous
0.5 - 2.0%	< 200			
2.1% - 6.0%	200 to 525.			
6.1% - 10%	526 to 875			
> 10%	(> 875 hrs/yr.)			

Table 13: Risk of odour based on character, subtle odour intensity and frequency of predicted odour.

Frequency	**Hours per year (indicative)**	**Subtle odour character (Obvious odour is < 2%)**		
		unsafe	unwelcome	innocuous
0 - 2.0%	< 200			
2.1% - 6.0%	200 to 525.			
6.1% - 10%	526 to 875			
> 10%	(> 875 hrs/yr.)			

Note – Typically with odour risk assessments the main concern is obvious recognised odours with a clear source. However, there may be occasions where only subtle odour is occurring or obvious odour is rare (i.e., < 0.5 % of the time), in these cases we can assess the risk of odour exposure using subtle odours as in Table 13

6.3.4 Receiving environment assessment

The next stage of the assessment is based on land use of the site where odour is observed and the associated beneficial uses, this will vary from odour to odour and location to location. Receiving environments can be classified either by sensitive activities (what activity is impeded and impacted by odour) and uses (what is the overall land use) they would usually have been determined in Section 5.3, Level 2 assessment – Receiving environment evaluation.

6.3.5 Overall risk of offensive odour

In this part of the assessment, the land uses set out in **Section 5.5** are cross combined with the risk of odour exposure from **Section 6.3.3**. This gives an overall risk that the area being assessed will experience offensive odour (Table 14 & 15)

Table 14: Risk of offensive odour key

Rating	Likelihood of offensive odour
Very high	Almost certain
High	Highly likely
Moderate	Likely
Low	Unlikely but still possible

Table 15: Risk of offensive odour

	Receiving environment sensitivity		
Risk of odour exposure	High	Medium	Low
Very high exposure	Very high	High	Moderate
High exposure	High	High	Moderate
Moderate exposure	High	Moderate	Low
Low exposure	Moderate	Moderate	Low
Negligible exposure	Low	Low	Low

6.4 Risk of Offensive Odour – Plume Tracing Method

To determine odour frequency using the plume trace method (from publication 1881), at least 10 plume traces should be completed. From the 10 plume traces you will have gathered data on:

- The distance to which an odour plume extends from a source.
- The intensity profile of the plume (i.e., where the plume transitions from obvious to subtle).
- This information can be used to determine odour frequency utilising meteorological data.

For example, there is an application for a new residential subdivision 1 km to the south of a major municipal landfill that receives household putrescible waste.

Plume tracing was conducted ten times. Table 16 shows 10 plume traces conducted under varying wind speeds and directions downwind from a landfill. The distance to which obvious odour followed by subtle odour was observed. Annual wind roses for the area show that north winds occur 15.15% of the time (Figure 8)

Table 16: Plume tracing raw data

Date	WS (m/s)	WD	Plume Distance (m)	
			Obvious	Subtle
6/3/20	0	Calm	1202	1610
12/3/20	1	310	1250	1570
18/3/20	2	310	1300	1648
24/3/20	1	185	1399	1600
30/3/20	2	185	1195	1399
5/4/20	3	15	1100	1000
11/4/20	3	80 - 110	1300	1750
17/4/20	4	270 -320	900	1300
23/4/20	4	180 - 200	500	600
29/4/20	7	320	1100	1200

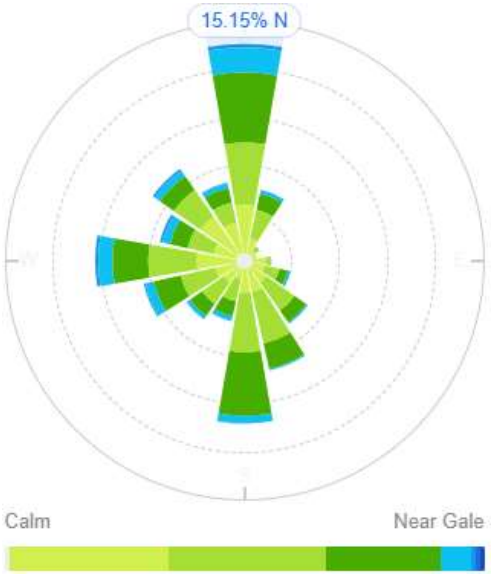


Figure 8: Wind rose example © Willy Weather 2021.

Dealing with calm winds

Calm winds (i.e., directionless) - as defined by the Bureau of Meteorology (BOM) are slower than 0.5 m/s

However, when making observations in the field wind direction can be measured at lower wind speeds (usually down to 0.1 m/s)

It is recommended when using BoM data to determine odour frequency, that this is taken into consideration and more sophisticated meteorological modelling may be required if the BoM station is > 10 km from the site under examination.

Assessment:

- the plume extends downwind from the landfill to a distance of at least 1000 m 80% of the time
- the winds are from the north 15.15% of the time
- frequency of obvious odour at the proposed residential area would be 12.5%
- landfill odour is classified as "unwelcome" (Appendix B: Odour character table grouped by offensiveness potential)
- risk of odour exposure is very high (Table 12) receiving environment is residential, so risk of offensive odour is very high or almost certain (Table 14 & 15).

To get a more detailed understanding of plume frequency, emission rates can be calculated by reverse modelling of the odour plume results. Appendix G of European Standard 16841-2 gives an example of how this may be approached. For further guidance on modelling, see Regulatory Air Modelling Guidance (EPA Publication 1957) and **Section 6.9** of this document.

6.5 Risk of Offensive Odour using monitoring data from case studies/literature

There may be case studies or literature references where odour monitoring data is available. These will be useful where the proposed use is an industrial use where odour monitoring can't occur.

Figure 10 is taken from a paper published in J. Waste Management (Bydder & Demetriou 2019). It shows the distance to which the odour plume travels for five sources.

We can examine the frequency to which odours extend to specific distances for the various sources and, using wind information, we can predict the exposure at specific distances and locations downwind.

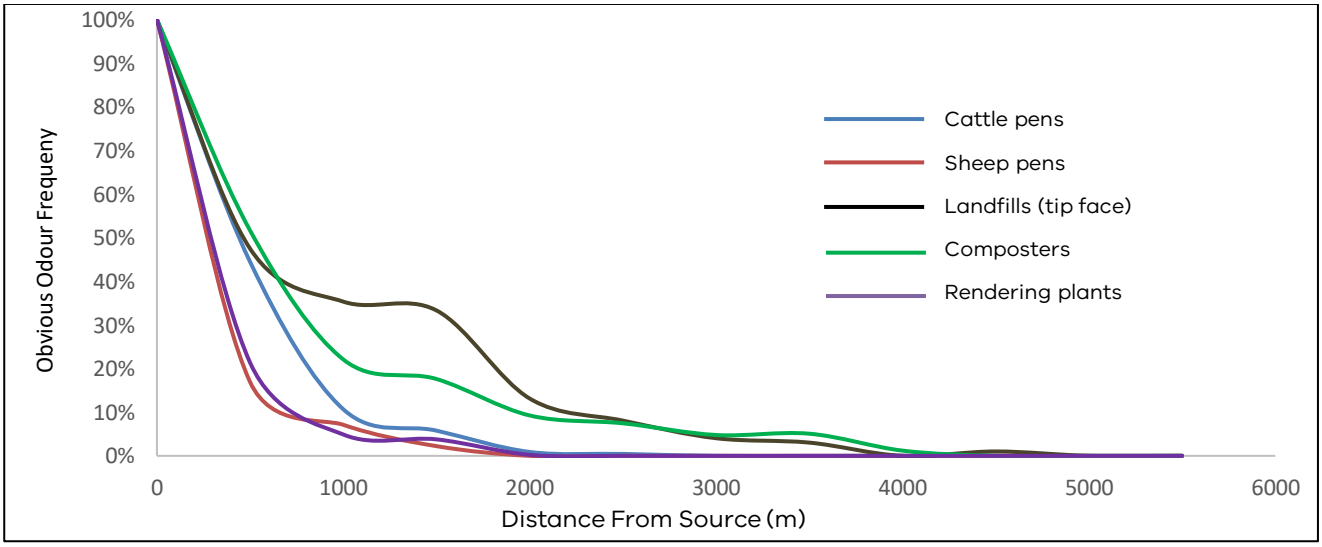


Figure 9: Plume profiles for different sources

Example: Odour complaints near a landfill

A landfill has received complaints regarding odour. Figure 10 shows a wind rose giving the distribution of winds in the area where the landfill is located. It shows that most prevailing winds come from the north, followed by winds from the south.

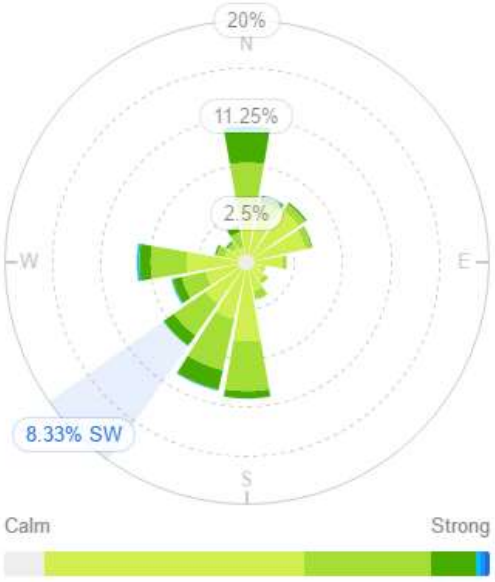


Figure 10 : Wind rose near subject landfill © Willy Weather 2021.

Most odour reports (and the closest residents to) for the landfill are in two locations "A" to the north and "B" to the south.

Predicted impact on location A

- There is a cluster of reports to the north approximately 2 km from the tip face.
- Location A is downwind from the landfill approximately 8% of the time (Figure 11).
- Odour from municipal landfills of this type extend to 2000m 13% of the time (Figure 10)
- Therefore, odour is likely to impact on the residents to the north 0.4% of the time (or 40 minutes per week).

Predicted impact on location B

- There is a cluster of reports to the south approximately 1.5 km from the tip face.
- Location B is downwind from the landfill approximately 11.25% of the time (Figure 11).
- Odour from municipal landfills of this type extend to 1500 m 33% of the time (Figure 10).
- Therefore, odour is likely to impact on the residents to the south 3.7% of the time (or 12 hours per week).

6.6 Assessment of odour complaints

Assessment of odour complaints made in the vicinity of a new or existing operation can help identify likely odour sources in the area, odour characteristics and level of impact. Such analysis can also be used as a benchmark to track the compliance progress of a new or existing operation. Complaint data can be sourced from local government, EPA and from operators themselves.

Where reliable complaints exist, a relationship between odour frequency (determined by field odour surveillance) and complaint numbers can be determined.

Complaint assessment is examining odour complaints from similar industries or scenarios to determine the likelihood of odour complaints. This enables us to predict the locations of potential odour complaints in relation to sources, when there is a known odour emission profile and pollution complaint data, along with the location of complainants.

Example

An applicant wants to build a chicken farm with eight sheds and 500,000 birds. By examining the complaint history of other farms with 8 sheds in areas with similar climate and topography, a prediction can be made as to what distance from the farm the risk of odour impacts becomes high.

In the case of existing operations, the number and details of odour complaints received were relevant to the operation under assessment. The actions taken by the occupier of the premises in response to those complaints, should be considered in complaints analysis.

Reporting of complaints data analyses should include:

- details of how the data were obtained.
- a data summary showing the number of complainants, the total number of complaints and the dates and times complaints were made.
- verification of the source of the odour where possible – this is usually an investigation or assessment based on complaint description and weather conditions at the time.
- actions taken in response to complaints (if known)
- description of the odour characteristics reported and likely odour sources.
- the meteorological conditions at the time of complaints.
- map(s) showing the location of odour complaints and potential sources in the area.

6.7 Odour complaint case study

This section presents a case study using odour complaints and surveillance data from a site in Melbourne's west during 2008 to 2019 (Table 17). The case study demonstrates how complaint data **may** be interpreted and provides commentary on how odour may be impacting the community.

Surveillance during this time included 12 surveys with between 17-21 individual observations at 4 fixed locations in one suburb. Odour frequency was determined by calculating the frequency of obvious odour encountered at each location first. Then these frequencies were used to calculate the average odour frequency for the suburb for each survey.

The odour frequency calculated for each of the 12 surveys was compared to the daily average odour complaints received during the same time that the survey was conducted (Figure 11).

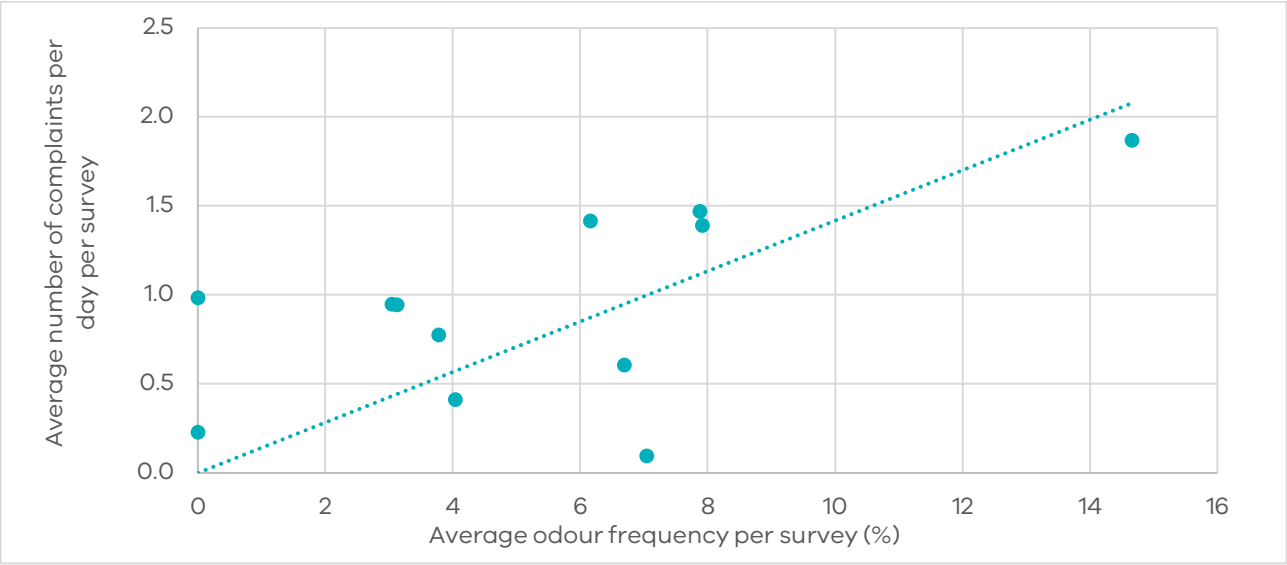


Figure 11:Frequency of obvious odours vs daily average complaints for a suburb in west Melbourne during 2008 to 2019.

Odours identified by the surveys and complaints were typically unsafe or unwelcome in character (dead animals, burning waste, chemicals, rotting meat, compost, rubbish etc).

Table 17 shows gives examples of the impact of odour on amenity, health and well-being based on the data from this case study.

Table 17: Odour complaints based and observed obvious odour frequency.

Complaint frequency	Frequency of obvious odour	Comments
1 or 2 per week	Rare < 2%	Fairly typical of most urban environments
Up to one per day	2 to 6%	Enough complaints to identify sources requiring some intervention
Up to 1 to 2 per day	7 -9%	Regular odour events, with amenity impacts occurring, intervention required.
Up to Multiple times per day	10% and above	Frequent long lasting odour events, health and well-being impacts regularly occurring. Significant distress in the community, intervention required urgently.

6.8 Community odour surveys/questionnaires and odour diaries

Community telephone or door-to-door surveys and diary studies can provide valuable information about odour impacts from existing sources. This information may be applicable to proposed changes in land use where:

- new sensitive uses are proposed near a site with a known complaint history
- comparison of a new operation with surveys of the community relating to an existing site that operates under similar circumstances (as per **Section 6.1**).

Surveys and diary studies:

- may show whether odours at a site have altered over time
- can be used to gauge the level of community dissatisfaction with previous odour incidents
- can predict the possible community response for proposed new sensitive uses, based on distance from the investigation site, topography and meteorology
- can capture information regarding odour episodes where residents did not lodge complaints.

The design, execution and analysis of surveys requires specialised knowledge and should be undertaken by those with expertise in this field.

Caution should be applied in designing survey questionnaires and interpreting results, as responses that rely on memory recall may result in some important information being omitted or conversely, exaggeration of events. In general, it is easier for community members to record odour incidents when they occur.

Surveys should:

- have a clearly defined purpose.
- be undertaken over a short timespan to limit opportunities for community members to share their responses, as this may bias the survey results.
- guarantee anonymity of respondents. This is an important principle to encourage participation in the survey.

Reporting of community survey and diary study analyses should include:

- qualifications and experience of the person(s) designing, conducting and reporting on the survey or diary study.
- details of the survey or diary study plan, including purpose, methods, target population and timeframes.
- a copy of the survey questionnaire or instructions provided to survey participants.
- a copy of the raw survey / diary data.
- interpretation of the survey / diary results.
- conclusions reached.

An example of a community odour diary sheet (EPA Publication F1019: Odour Diary) published by EPA is available on the EPA website.

6.9 Dispersion modelling

EPA has received many odour assessments supporting applications for planning, permissions, precinct structure planning and rezoning. Many of these assessments relied solely on modelling to demonstrate that odour impacts would not likely occur.

There are risks in only relying on odour modelling alone to accurately predict odour impacts and support decision making. This is especially the case for odour sources with no active flow (passive sources) such as landfills, stockyards and composting operations.

This section is to support assessors of applications in the recommended way to use odour modelling in odour assessment.

Modelling of area sources can have a high uncertainty and other data derived from other methods should be to verify or support conclusions formed through modelling. This can include from field assessments, community surveys, comparison to case studies and complaints.

6.9.1 When to use modelling

EPA does not support using modelling alone to predict odour concentrations at ground level. However, it can be a useful tool provided the limitations of modelling are understood. Modelling results can enhance and be enhanced by other assessment tools outlined in **Sections 6.1 to 6.4**. It may, however, to utilise quantitative modelling (in Odour Units) in support of an assessment if it can be supported by other evidence.

6.9.2 Relative dispersion modelling

This type of modelling tool can be used to compare different emission scenarios through the analysis of the relative variations in predicted ground level odour concentrations. For example, this tool can compare variations in emissions or changes in the number, configuration, or pollution control of sources)

This is achieved by assigning and then modelling an odour emission rate (or a nominal emission rate) in a scenario. The scenario can then be varied to determine relative contributions of sources, which can be used to assess changes made to configurations of plant and equipment or to determine cumulative impacts.

6.9.3 Meteorological modelling

These modelling tools are useful in understanding dispersion patterns from sources, such as the shape of emission contours, when assessing frequency of odour exposure. These tools may be applied using the minimum separation distance as an input to determine its shape by keeping the total area contained by the separation distance constant. These techniques are also known as determination of directional buffers as the buffer would expand or contract in accordance with the local weather patterns.

6.9.4 Modelling combined with field surveillance

EPA recommends using data from field odour surveillance to verify modelling outputs. For example, results of odour surveillance can be directly compared with odour concentration contours derived by models. Also, odour emission rates may be calculated by reverse odour dispersion modelling to determine emission rates from odour sources. For example, using back-calculation to determine landfill tipping face odour emission rates and modelling these results.

For example, the raw result of a dynamic plume measurement is the extent of the odour plume (i.e., the distance to the plume boundary). This result can be used to estimate the total odour emission rate using reverse dispersion modelling, in effect working out the emission rate where the base unit is a nominated value that is equivalent to where a recognised odour transitions from subtle to obvious (in some jurisdictions this is known as a sniffing unit (su/m^3). The odour emission rate is calculated based on the recorded plume extent, the source characteristics and the local meteorological conditions during the plume measurement.

European Standard, I.S. EN 16841-2:2016, gives examples on how emission rates may be estimated using dynamic and static plume assessment data.

These above approaches enhance odour assessments as it allows the assessor to predict odour impacts for a broader range of scenarios. In this way, i.e., modelling can be used to fill the gaps in an odour assessment.

It is recommended to seek further advice from EPA before using modelling to come up with an agreed approach and strategy in odour risk assessment. EPA recommends using the recommended modelling and meteorological tools in *Publication 1957*.

7. Reporting

Reporting recommendations in assessments

It is recommended to develop a standard reporting methodology and format to ensure all relevant information is included in a risk assessment. Although each assessment will have specific requirements, and will vary with the scope and size of the assessment, any report should contain the following features:

- **Executive summary:** One-page statement in plain English of the basic assessment outcome. This may be the only part of the report that some users read, so it should be succinct and clear.
- **Scope:** Reasons why this assessment has been undertaken including the intended outcomes.
- **Introduction:** Background to the issues and relevance of any existing or previous work.
- **Site description:** Area or location being assessed, including maps with all relevant features (and photos if available). Show any sensitive locations (such as hospitals and schools) in relation to the proposal.
- **Proposed development or activity:** Description of the activity being assessed and any changes to existing activities. This section should include adequate information to characterise the air discharges and their sources.
- **Legislative and policy requirements:** Include details of any existing requirements and the level of compliance with these requirements. This should include federal, state and local government requirements. This section should also include reference to any licences or permits required by EPA or any other agencies.
- **Receiving environment:** Description of the receiving environment potentially affected.
- **Cumulative effects:** Include information on which types of cumulative effects have been included or excluded from the assessment and why.
- **Consultation:** Summary of any consultation undertaken, either with neighbours, local councils or other affected parties. Discuss how the outcomes of this consultation have informed the development of the proposed project or activity.
- **Methodology:** Description of the processes and models used, assumptions made, any statistics or analysis used and reasons behind the selection of assessment and modelling tools
- **Data used:** Sources and validity of all input data, including emissions and process data, meteorology, existing concentrations and all assumptions made.
- **Assessment of effects:** Outcomes of the assessment and all options assessed, in as much detail as possible. This can be in summary tabular and graphic form. The emphasis should be on key results that can inform decision-making. Detailed results should be given in an appendix.
- **Risk assessment:** Description of the risk assessment undertaken, with any conservative assumptions made and the results.
- **Mitigation**: Address any mitigation options available and considered, the feasibility of these measures and justification on what measures were adopted. This section can include an analysis of the best available technology and techniques.

- **Discussion:** Implications, uncertainties (see Section 8) and reliance on assumptions. Include discussion of possible mitigation options and associated emissions reduction. This section can include cost-benefit analyses and sensitivity analyses if required.
- **Conclusion:** Whether the objectives of the assessment have been met, overall findings and what the ramifications/next steps/recommendations are.
- **References:** All material used should be referenced explicitly and should include web-based links where appropriate.
- **Appendices:** Any detailed calculations or results that are used should go into the appendices. This section should include dispersion model control files if dispersion modelling has been used.

The size and nature of each of these sections will depend on the size of the project, the activity and the associated risks, for some lower risk applications not all the above sections may be required.

When reviewing an assessment report to determine risk, EPA may consider a range of additional factors such as complaints recorded by EPA, compliance history and annual monitoring results reported to EPA. EPA may also require additional analysis to be undertaken.

8. Uncertainty in odour assessments

When making decisions in the presence of uncertainty, it is necessary to make explicit or implicit assumptions. For example, assumptions about how a certain type of feedstock is being used in a process, or how a certain type of odour will be perceived by human beings.

Whenever assumptions are made, they need to be reasonably conservative, indirectly accounting for uncertainty in the assessment. The more detailed the assessment, the lower the conservatism through the collection and use of more site-specific data. In all instances, assumptions should be "reasonably conservative" as far as possible.

Seven key guiding principles are provided below to assist in the selection of reasonably conservative assumptions. The principles described here apply equally across all aspects of the assessment process.

1. Refining assumptions is valid if they stay reasonably conservative.

- It is good practice for odour assessments to start off with highly conservative assumptions that are gradually refined when and if it is useful and reasonable to do so.
- When conducted in a considered way, the iterative process of refining assumptions is not only protective of human health and the environment but is also the most cost-effective.
- When, however, this process is done in a poorly planned or unscrupulous manner, it can underestimate risks and erode stakeholder confidence in the assessment process.

2. Assumptions should be clearly stated, and evidence based.

- 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 enough evidence to select appropriately conservative assumptions.
- It is best practice to clearly list all key assumptions in all risk assessment reports, along with adequate justification for each assumption. The information provided should be enough to provide a reader with confidence that the selected assumptions are conservatively representative of reality.

3. Assumptions should be reasonably conservative.

- Reasonably conservative assumptions represent situations that could plausibly occur over timeframes that are relevant to the potential odour impacts. 'Reasonably conservative' differs from the often-used term 'worst case' in that the former takes likelihood into account while the latter does not.
- It is often not necessary, useful or even possible to assess 'worst case' scenarios such as one-off plant upsets, illegal activities, power failures or other rare adverse weather events, unless they specifically fall within the scope of the risk assessment.

Example 1:

A French fry processor has received many complaints of odour from its premises. Odour surveys have found that there is an off-site odour that smells of French fries and the assessors thought it was pleasant.

It would be incorrect to assume that based on this the odour is not offensive. Knowing that continuous or frequent exposure to an odour can cause a negative response from people and there are complaints in this instance, it is a reasonably conservative assumption that the fried odour could be construed as offensive.

4. Assumptions should be adequately justified.

Supporting evidence or justification should accompany all listed assumptions.

- **Defaults:** It is common practice in risk assessment to adopt default assumptions and while some of them are relatively fixed conventions, others can be modified if the available evidence supports it. When defaults are adopted, it is useful to clearly state what other guidance exists that adopted these defaults.
- **Technical references:** Especially in the case of assumptions related to broad scientific, engineering, or other technical matters, it is best practice to support any adopted assumptions with appropriate scientific referencing.
- **Site-specific characteristics:** In most odour assessments, at least some assumptions will be related to site-specific features (such as the tipping area of a landfill being relatively consistent and at the size permitted). In these cases, it is often appropriate to refer to technical reports that provide this information, or clearly state how the input was measured or estimated.
- **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.

5. The degree of conservatism should relate to the level of uncertainty.

- The process of making conservative assumptions should be well thought out and 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 (or sometimes no) need to incorporate conservative assumptions.
- If there is genuine uncertainty around an input, that should be a prompt for incorporating a higher level of conservatism around it, this is a core condition for conducting an assessment, if we do not know we rate the risk higher.

6. The degree of conservatism should relate to the qualities of the odour

- The selection of reasonably conservative assumptions can be affected by complex situation-specific circumstances, which is why their adoption should always be carefully considered.
- This principle is best explained by means of a hypothetical example: if an odour source was continuously emitting odour at a rate that varies greatly and unpredictably through time, an assessor might conservatively evaluate impact by assuming the worst measured emission rate is constantly occurring.

- While this approach might be reasonably conservative for highly odorous emissions such as rendering or petroleum odours, it would be extremely conservative for other more innocuous odours such as those generated from food preparation.
- In this case, the same assumption was shown to be differently conservative for two different odours, exemplifying how conservatism is a function of the characteristics of the hazard.

7. 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. For this reason, most decision-making that is driven by environment protection will favour more conservative assumptions. In some specific situations, however, it is possible for overly conservative assumptions to be detrimental to the assessment process. Risk assessors should take these considerations into account in their assessments:

- **Risk transfer**: the process of managing one risk can create another one and this effect is exacerbated when the benefit of mitigating a risk is blindly pursued without due considerations for the actions that might be required to control the risk. For example, people may lose their livelihood due to their business being inappropriately shut down due to overestimated risks.
- **Alarmism**: a situation when a risk that has been overestimated (or perhaps overstated) results in a level of concern in the affected community that is disproportionate to the risk itself and ends up creating a risk of its own.
- **Warning fatigue**: the opposite of alarmism, warning fatigue is the term used to describe situations where risks are perceived to have been overstated so often that they no longer trigger a response or action by affected stakeholders (such as the community) or decision-makers (such as the owner of the risk). This situation can occur when multiple risk assessments are carried out for the same hazard (perhaps at different points in time).
- **Compensating for over-conservatism**: when a risk-based process is consistently or repeatedly shown to yield over-conservative results, the decision-makers (such as site owners) may find themselves knowingly or unknowingly compensating for this conservativeness, effectively making decisions that are less protective.

Example

Methyl methacrylate is a highly odorous substance that is stored in large drums at a resin manufacturing plant. If one is pierced or spilled, it is predicted that the odour produced would be very strong up to two kilometers away.

The resin plant has never had a spill of this type in 20 years of operation. It would be unreasonably conservative to apply a high-risk buffer out to two kilometers in this case as such a spill of a whole drum is only likely to occur under very rare set of circumstances.

References

AS/NZS 4323.1:2021 *Stationary Source Emissions Method 1: Selection of sampling positions and measurement of velocity in stacks*, 13 September 2021

AS/NZS 4323.3 -2001 "*Stationary source emissions. Part 3: Determination of odour concentration by dynamic olfactometry*", 12 September 2001

EPA Publication 1666.1, *"Determination of odour concentration by dynamic olfactometry",* 17 October 2018

EPA Publication 1881, *"Odour Surveillance", May 2021*

EPA Publication 1949 *"Separation Distance Guidelines" 2022*.

EPA Publication F1019," Odour *diary"*, June 2021

I.S. EN 16841-1:2016 "*Ambient air - Determination of Odour in Ambient air by Using Field Inspection Part 1: Grid Method"*, 23 November 2016.

I.S. EN 16841-2:2016 "*Ambient air - Determination of Odour in Ambient air by Using Field Inspection Part 2: Plume Method",* 23 November 2016.

VDI 3886 / Part 1 *"Determination and assessment of odours Odour survey Determination of necessity and references for preparation",* September 2019.

VDI 3940-3.2010, Measurement of odour impact by field inspection - Determination of odour intensity and hedonic odour tone.

Appendix A: Table of industrial odour sources by odour potential

1: Low odour potential	2: Moderate odour potential	3: High odour potential	4: Very high odour potential
Brewery, winery.	Advanced resource recovery technology facility.	Composting using technology commensurate with waste type (See EPA Publication 1588.1)	Intensive farming (e.g., pigs, sheep, chickens).
Chemical blending, mixing and storage.	Brick, tile, pipe, ceramics and refractory manufacturing.	Mushroom farms.	Feedlots and saleyards, cattle lagoon cleanout.
Food preparation, spice packaging.	Grain and stock feed mill (using meat products).	Gas and oil extraction.	Paper and paper pulp manufacture by the Kraft process, sulphur containing materials or paper mill black liquor.
Coffee roasting.	Hydrocarbon and coal derivatives storage. Gasoline, diesel fuel retail.	Aluminium by electrolysis	Petroleum refinery, gasworks.
Grain and stock feed mill and handling facility (no meat products).	Paint and ink production.	Cement manufacturing.	Chemical or waste oil recycling (mineral oils or grease trap/tallow).
Malt works.	Permanent contaminated soil treatment facility.	Coke, coal briquette production.	Rendering plants, tanneries.
Paper and paper pulp recycling.	Flexographic printing.	Chemical production.	Landfills (> 500 m^2 tipping face)
Sawmill.	Plastics or paper recycling.	Abattoirs (with live animals).	High and Medium risk waste composting not utilising commensurate technology (Pub 1588.1)
Fish farming (aquaculture).	Asphalt plant.	Biocide production.	Sewerage treatment plants with open air lagoon systems and sludge drying
Seafood production.	Hot dip galvanising.	Biosolids application areas.	
Bakery.	Surface coating, spray painting.	Transfer station with organics	
Cosmetics and toiletries, perfume.	Rubber or latex production.	Fertiliser production.	
Milk products.	Dyeing or finishing of textiles.	Oilseed processing.	
Waste to energy plants.	Metal casting and production.	Prescribed industrial waste treatment facility.	
Bulk storage of chemicals.	Manufacture of wood - fibre or wood-chip board.	Waste burning, incineration.	
Industrial gas production.	Container, tanker/drum washing/reconditioning.	Manufacture of products using fibreglass and resin.	
	Production of artificial fibres & textiles,	Pet food.	
	Timber preserving works.	Wool scouring or carbonising.	
	Storage of wet-salted hides.		

Appendix B: Odour character table grouped by offensiveness potential

Unsafe character	Unwelcome character	Innocuous character
Rotting compost	Fresh compost/mulch	Malt, yeast, beer, wine
Dead animals	Urine/ Manure	Coffee
Fish/amines	Animals (livestock)	Bread/bakery/grain
Chemicals	Chicken (sheds)	Woody/resinous
Rotten eggs	Dynamic lifter	Cosmetics/perfume
Sewage/septic	Burnt Coffee	Milk/Cheese
Rancid (dairy/milk)	Alcohol/medicinal	Cooked meat
Gas/mercaptan	Rubber/latex (burnt)	Fried/roasted foods
Sewerage	Burnt plastic	Sweet (confectionary)
Rotten cabbage	Paints/inks	Paper/cardboard
Chemicals/solvents	Pet food	Mulch/eucalyptus
Gas/petrol fumes	Asphalt/bitumen	Seaweed
Burnt waste	Plastic	Woodsmoke
Biocides	Paper pulp	Musty, earthy
Landfill gas	Sweet (chemical)	
Metallic/foundry	Sour/acidic	
	Garbage/rubbish/landfill	
	Garlic/onion	

Appendix C: Level 2 Odour assessment template

Environment Protection Authority Victoria	**Template**
Application type	
Type of source (or premises)	
Address	
Assessor	
Reference no:	

Description of proposal

Relevant matters to consideration of odour impacts	
Site location and area {Insert map}	
Zoning	
Zoning and land use {Insert map}	
Nearest sensitive uses {Insert map}	

Scoring

Level 2 assessment	Criteria	Comment	Score
Hazard potential of the source	Activity type		
	Size of odour hazard		
	Character of odour emission		
	Level of control		
(Odour source score, OSS)			
Exposure pathway between the source and sensitive locations	Distance		
	Meteorology		
	Terrain and built form		
	Hours of operation		
(Odour pathway score, OPS)			
Sensitivity of the receiving environment			
(Odour receiving environment score, ORS)			
Total score			
Recommendation			
Comment –			