ecoaccess
environmental licences and permits

Guideline

Odour Impact Assessment from Developments

Executive Summary

Noxious or offensive odours are a frequent cause for complaint by the community and may cause environmental nuisance. Nuisance odour emissions from a facility may create a poor perception of its activities in the local community, sour the facility's relations with the community and may make it unwelcome in the community. Potential odour impacts are best identified at the planning stage and addressed prior to the commencement of operations.

Proponents of new developments or modifications to existing facilities that may give rise to noxious or offensive odours need to determine the sensitivity of the receiving environment to such odours and demonstrate the use of best practice environmental management techniques to manage odours. The outcome required by the Environmental Protection Agency (EPA), and as typically set out in its concurrence conditions for development approvals, is that any release of noxious or offensive odours will not cause a nuisance at any odour sensitive place.

Accordingly proponents are advised that a well-planned proposal, which ensures compatibility with adjacent land uses, allows adequate separation distances for process upsets and adopts the principles of waste minimisation, cleaner production and best practice control technology, will minimise or eliminate the potential for odour releases. This document provides guidance to proponents, government agencies and the general public on assessing the impact of residual odorous sources from new facilities. The guideline may also be used in preparing planning schemes and applications for land development.

The guideline sets out various approaches to assess potential impacts from new development proposals. Wherever possible, the odour emission record of the facility (in the case of modifications) or industry type should be included in the assessment along with any practical experience in using odour management techniques. Tools such as odour annoyance surveys, odour diaries, complaints data and compliance history, which provide additional relevant information for assessing the impact of odour from modifications to existing facilities, are also discussed in this guideline.

Guidance is provided on the use air dispersion modelling as a tool to predict ground level odour concentrations. Comparison is made with guideline values to determine the likelihood of adverse odour impacts. Alternatively, an industry or facility-specific odour intensity approach may be used to assess the likelihood of odour impacts. A practical example of this is the approach of the Department of Primary Industries and Fisheries for piggery facilities. Guidance is also provided for circumstances where odour is due to an individual compound.

Environmental Protection Agency
www.epa.qld.gov.au **ABN 87 221 158 786**

Queensland Government
Environmental Protection Agency
Queensland Parks and Wildlife Service

Table of Contents

1. Introduction

This guideline provides proponents, government agencies and the public generally with a procedure for assessing the likelihood of odour nuisance from development proposals for new facilities, modifications of existing facilities and land developments. The information provided in the guideline can also be used in developing planning schemes.

The guideline sets out various approaches to assess potential impacts from new development proposals. Wherever possible, the odour emission record of the facility (in the case of modifications) or industry type should be included in the assessment along with any practical experience in using odour management techniques. Tools such as odour annoyance surveys, odour diaries, complaints data and compliance history, which provide additional relevant information for assessing the impact of odour from modifications to existing facilities, are also discussed in this guideline. Recognition is made in the guideline of industry specific guidelines developed by the Department of Primary Industries and Fisheries (DPI&F) as an appropriate method for assessing and managing odour impacts from such industries.

A well-planned proposal, which ensures compatibility with adjacent land uses, allows adequate separation distances for process upsets and adopts the principles of waste minimisation, cleaner production and best practice control technology, minimises or eliminates the release of odours from the site. Accordingly, it should only be necessary to assess the impact of small quantities of residual odours released from the proposed activity.

2. Legislative context

It is important to consider the legislative context when following this procedural guide. The object of the *Environmental Protection Act 1994* is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (**"ecologically sustainable development" - ESD**). The Explanatory Notes to Section 5 of the Act require "all people who are given power under this Act, to use that power to protect the Queensland environment and do so consistent with the principles of ESD".

Applications must be supported by enough information to enable the administering authority to make a decision. In making its decision, the administering authority is required to comply with Environmental Protection Policy requirements and consider the information provided, standard criteria, applicant suitability, and in some cases, public submissions and views from a conference. This procedural guide is chiefly designed to assist applicants for environmental authorities and development approvals for environmentally relevant activities, but may also be used for other activities not subject to these specific approval requirements, such as proposed land developments that may be affected by existing facilities that have odour emissions.

Under the *Environmental Protection Act 1994*, proposals are assessed to ensure they will not adversely affect environmental values including air quality, public amenity and safety. In essence, this means ensuring the proposal, if implemented, is not likely to cause environmental nuisance or environmental harm. The definition of environmental harm under the *Environmental Protection Act 1994* includes environmental nuisance. Odour impacts are a frequent and significant cause of environmental nuisance. The Act places a general environmental duty on a person carrying out an activity that causes, or is likely to cause, environmental harm to take all reasonable and practicable measures to prevent or minimise the harm.

The legislative framework for environmental management in Queensland includes:

- The *Environmental Protection Act 1994* giving general provisions and recommendations;
- The *Environmental Protection (Air) Policy 1997* specifying subordinate legislation for particular issues;

- The *Environmental Protection (Waste Management) Policy 2000* requiring consideration of relevant matters including the waste management hierarchy, polluter pays principle and emission controls;
- *Environmental Protection Regulation 1998* - Part 2A;
- Industry codes of practice stating ways of achieving compliance with the general environmental duty for an activity; and
- Environmental guidelines, not legally binding but serving to help industry improve environmental performance.

The Environmental Protection (Air) Policy 1997 which commenced in February 1998, deals with environmental management decisions involving odour assessment in a general way under Section 12, matters for consideration in granting an environmental approval. The Policy prescribed odour prevention goals in Schedule 1 for ambient concentrations of carbon disulfide, hydrogen sulphide, toluene, styrene and tetrachloroethylene. The current User's Guide to Queensland's Environmental Protection (Air) Policy 1997 gives little guidance on odour impact assessment of complex mixtures of pollutants.

The *Environmental Protection Regulation* 1998 was amended in 1999 to include Part 2A - Environmental Nuisance which provides for nuisance abatement notices to control emissions that cause unlawful environmental nuisance. These provisions are not relevant for emissions from environmentally relevant activities carried out under development approvals or environmental authorities. The nuisance provisions commenced in February 2000. The *Environmental Protection Act 1994* includes a range of mechanisms for managing odours, including environmental evaluations, environmental audits, environmental protection orders and environmental management programs. The means of determining whether odour from a release to the atmosphere could cause an unreasonable interference with a person's enjoyment of a place currently rests on special evidentiary provisions where an authorised person may form an opinion on the basis of that person's own senses.

The assessment of the risk of odour nuisance is an applicable environmental impact study, assessment or report and is therefore one of the 'standard criteria' that must be considered when developments are assessed under the *Environmental Protection Act 1994*. Other relevant criteria include the principles of ecologically sustainable development, planing frameworks, the character resilience and values of the receiving environment, best practice environmental management for the activity, financial implications as they relate to the industry or activity and the public interest. Conditions of developments must be necessary or desirable in achieving the object of the Act. They may include prescribed environmental outcomes, stated measures to minimise likelihood of environmental harm and monitoring programs.

3. Human perception of odour leading to annoyance and nuisance

Humans, like many other animals, have evolved with a sense of smell that gives them the advantage of being able to assess their environment rapidly and with a high degree of sensitivity. Humans can describe the perception of an odour stimulus in terms of its detectability, intensity, pleasantness and character. However, the human brain processes the signal from the odour stimulus in combination with information it is receiving from other environmental stimuli and with reference information that it has stored regarding previous experiences and associations. The result of this broader cognitive appraisal is what determines an individual person's unique behaviour in response to a perceived smell.

The sensory perception of odours can be characterised by four major attributes or dimensions:

1. Detectability (or odour threshold) refers to the minimum concentration of odorant stimulus necessary for detection in some specified percentage of the test population. The odour concentration of a sample can be characterised by the number of dilutions to reach this detection threshold. Odour concentration is the most common attribute used to quantify odours.

2. Intensity refers to the perceived strength or magnitude of the odour sensation. Intensity increases linearly with the *logarithm* of the odour concentration. Odour intensity is assessed on a seven-point intensity scale from no odour to extremely strong odour.
3. Hedonic tone is a judgement of the relative pleasantness or unpleasantness of an odour. It is assessed on a nine-point hedonic tone scale from very pleasant to offensive.
4. Odour quality is simply a qualitative description of what the odour smells like.

The term annoyance is used to describe the complex set of reactions that a person experiences as a result of an immediate exposure to an unpleasant odour which if continued and the person cannot avoid it, causes that person to suffer stress.

Most odours, even those that are commonly identified as pleasant, for example, coffee-roasting odours can cause annoyance when they are intermittently clearly detectable.

The term nuisance is used to describe the cumulative effect on people caused by repeated events of annoyance over an extended period of time. Nuisance results when people are affected by an odour they can perceive in their living environment, at home, at work, or during recreational activities, and

- the appraisal of the odour is negative;
- the perception occurs repeatedly;
- it is difficult to avoid perception of the odour; and
- people believe that the odour has a negative effect on their well-being.

People’s perception of odour is closely tied to the way they value their environment. Attitudes towards the source, the inevitability of the exposure and the aesthetic expectations regarding their environment are some of the less tangible factors relevant to the probability of experiencing nuisance.

Prior exposure to the odorant can have two effects: (1) adaptation where the perceived odour intensity decreases on exposure and (2) sensitisation where the perceived intensity increases on repeated exposure. Once an environmental odour becomes a nuisance it is difficult to reverse the process. What used to be a faint odour becomes a signal for annoyance and the person or community affected becomes sensitised to the particular odour.

Concentrations of the chemical constituents of ambient odour are usually too low to cause direct effects on human health. However, an affected community may associate exposure to offensive odours and health impacts to the extent that health effects become real. People may experience undesirable reactions such as unease, irritation, discomfort, anger, depression, nausea, headaches or vomiting on prolonged exposure to offensive odours. Thus, it is not always possible to make a clear distinction between nuisance and health impacts. For the purposes of this guideline, odour impact is assessed only in terms of annoyance and nuisance effects.

4. Approaches to odour impact assessment

It is not yet possible to derive odour impact assessment criteria based on air dispersion modelling that take account of the large number of complex human, social and economic factors involved in odour nuisance. There is general agreement that frequency, intensity, duration, offensiveness and location (FIDOL) are factors that ought to be considered when attempting to judge the likelihood of odour nuisance. These so called FIDOL factors are not easy to quantify individually, let alone when they interact. It is therefore not possible to develop criteria that set a “pass” or “fail” benchmark for air dispersion model odour estimates, rather guidance can be derived from the estimates on likely impacts which can then be further refined through consideration of such things as the observed impacts of similar facilities, the sensitivity of the receiving community and "offensiveness" of the odours likely to be emitted. Proponents must first ensure that their proposals incorporate best practice environmental technology to manage odours.

Odour impact assessments need to reflect the levels of exposure that result in nuisance in communities affected by the odour impact. The odour impact assessment for a new facility or for modifications to an existing facility needs to be conducted for the purposes of achieving an environmental outcome, which meets a typical environmental authority condition for odour:

> "There must be no release of noxious or offensive odours or any other noxious or offensive airborne contaminants beyond the boundary of the site that causes environmental harm at any odour sensitive place."

Odour sensitive places include residences, schools, hospitals, caravan parks, national parks, shops and business premises that may be affected by odour. Noxious odours are harmful or injurious to health or physical well-being. An example is gaseous ammonia. Offensive odours are those that cause unreasonable offence, displeasure, are unreasonably disagreeable to the senses or are disgusting, nauseous or repulsive. These are typically though not universally complex mixtures. Whether an odour is unreasonable is determined subjectively taking into account the FIDOL factors mentioned above. Note that such a condition allows the licensee autonomy in how to achieve the objective.

New facilities and modifications to existing facilities

The following provides guidance to proponents of developments of existing facilities and of new facilities to assist in assessing and managing potential odour impacts.

Existing facilities

For proposed modifications to an existing facility, proponents should review its complaints data to assist in determining the likely impacts of the modifications on complaint frequency. The experience of industries with similar discharges should also be drawn upon to identify proven odour management practices. Proponents are also encouraged to consult with local community members to ascertain if there are any chronic odour impacts in the community. Techniques such as odour annoyance surveys and odour diaries may also be of assistance in determining likely impacts from the modifications. Further details are provided in Appendix A.

Atmospheric dispersion modelling may assist in predicting potential impacts from modifications to an existing facility, however community feedback on existing operations should be given greater weight than modelling estimates of the same. In particular modelling should not be used to explain away adverse community feedback. Dispersion modelling may be used to identify sources of odours at a facility and to estimate relevant contributions of the sources. This information may be used to develop cost effective odour source control strategies.

Proposed facilities

Site-specific complaint data and community response information is not available to ascertain the potential impact of a new facility. While it may be possible to draw on the past experience of similar facilities, particularly for facilities likely to have low impacts and where odour management practices are well established, odour dispersion modelling provides a framework to estimate potential odour impacts and, if required, identify opportunities for odour reduction. It is noted that odour impact assessment using dispersion modelling rarely goes beyond simply quantifying odour concentrations, estimating the duration of time for which those concentrations are exceeded over a period of a year and comparing them to impact assessment guideline written in similar format. Odour concentrations and the frequency with which they are exceeded at a particular sensitive receptor are conveniently calculated from air dispersion modelling.

Modelling and guideline approaches

Modelling is usually carried out for one-hour time steps as the meteorological data inputs are in one-hour sets. However, the human perception of odour occurs over much shorter time scales. The difference in perception and the odour dispersion modelling output may be accommodated by applying ‘peak-to-mean’ factors to the modelled odour concentrations, however, the variations in ‘peak-to-mean’ factors for different sources need to be considered when model outputs are interpreted.

Odour impact assessment guidelines are most often expressed as a modelled average odour concentration level of X ou for more than 99.5 percent of the (hourly) meteorological conditions in a year. Modelled concentrations can be scaled-up using peak-to-mean factors to estimate the short-term peak concentrations, which may be important for annoyance in humans. It should be noted that 99.5th percentile value (or 0.5 percent allowance) is a statistical parameter to filter the extreme values generated by modelling and not meant to be interpreted as allowing nuisance or failure of emission controls for 44 hours per year.

Odour impact assessment guidelines are usually set on the basis of:

- an assumed general annoyance level, which in this guideline is taken to be 5 odour units at nose response times; or
- the concentration of odour corresponding to a perceived intensity level of ‘weak’; or
- a community odour survey to measure the population annoyance.

A number of studies have been reported in European countries where odour annoyance surveys have been conducted in communities affected by odour impacts and combined with dispersion modelling of the sources of odour. The logarithm of certain percentiles of the modelled odour exposure concentration are found to be good predictors of the percentage of highly annoyed people. One recent study is that of Miedema et al. (2000) in the Netherlands who also included pleasantness of the odour as a predictor of odour annoyance. This epidemiological approach is the most appropriate tool for linking the odour emissions from a source, the dispersion characteristics of a site and the long-term effects on the population in terms of annoyance. This type of study, if more widely available, would provide a sound and less uncertain basis for setting odour impact assessment guidelines.

5. Odour impact assessment guidelines

The following guidelines are provided to assist proponents conducting odour impact assessments for new facilities and modifications to existing facilities:

5.1. Assessment for complex mixtures of odorants

For the assessment of complex mixture of odorants the following guidelines are recommended. The odour annoyance threshold or odour intensity criteria must be used for new facilities that may generate odour impacts. However, the alternative tools discussed in this section and Appendix A may also be used to assess proposals for the expansion of existing facilities.

Odour annoyance threshold (concentration) guidelines

Proponents of new facilities may undertake an impact assessment with relevant inputs of emissions and local meteorology to an air dispersion model to provide estimates of the likely odour impacts in the surrounding environment. The inputs should be as detailed as possible, reflecting any variation of emissions with time and including at least a full year of representative hourly meteorological data. The modelled odour concentrations at the “most exposed existing or likely future off-site sensitive receptors” should be compared with the following guideline values.

- 0.5 ou, 1-hour average, 99.5th percentile for tall stacks
- 2.5 ou, 1-hour average, 99.5th percentile for ground-level sources and down-washed plumes from short stacks, and
- for facilities that do not operate continuously, the 99.5th percentile must be applied to the actual hours of operation.

These guideline values are based upon application, to the default annoyance threshold of 5 ou, of conservative default peak to mean ratios 10:1 for stacks and 2:1 for ground-level or down-washed plumes from short stacks. In adopting a one hour average criteria, which simplifies dispersion modelling, it is considered necessary to distinguish essentially ground level sources and stacks. This is because the peak to mean ratios in each case and hence concentration fluctuations over the hour are expected to vary significantly and thus dual criteria are considered the fairest approach. It is noted that researchers are undertaking studies to more reliably define peak to mean ratios in a variety of scenarios. EPA will refine guidelines in the light of generally accepted research findings. Note that it is generally accepted that if a stack complies with the criteria in the USEPA Good Engineering Practice (1985) guidance (that is 2.5 times higher that any nearby building) then building downwash is unlikely to occur.

These guideline values should not be used as “pass” or “fail” test as there are a number of limitations in modelling. Sources of uncertainty include odour sources underestimated or over-looked, short-term peak emissions such as turning a compost windrow not catered for in the guideline, the guideline not being stringent enough for specific substances of greater offensiveness, variability in emission rates, models underpredicting actual concentrations and use of peak to mean ratios too low for actual dispersion. However if the modelled odour concentrations at the “most exposed existing or likely future off-site sensitive receptors” are less than the guideline values then adverse chronic odour impacts are not likely in most cases. If the processes generating odours are variable, or are likely to have “upsets”, community responses after the facility starts operations may be adverse even though modelled outputs indicate that emissions should be acceptable.

Similarly, odorous emissions that are extremely offensive, such as some mercaptans, may also cause odour impacts with emissions lower than the guideline value. Conversely, modelled values higher than the guideline values do not necessarily mean that adverse community responses will occur. A less offensive odour or an environment that is less sensitive to the type of odour being emitted, for example an agricultural odour in a rural area, may not give rise to environmental nuisance.

Research of odour impacts of similar facilities will help provide information on impacts and reduce the uncertainties. Also, if a proponent assembles a body of data that demonstrates to the satisfaction of the Agency that different values would more accurately represent a particular situation, the following factors could be modified in developing a site-specific guideline:

- • odour annoyance threshold;
- • worst case peak-to-mean factor;
- • size of building or other wake effects; and
- • percent compliance acceptable to the receptor community.

Regardless of the modelled odour emissions, it is in the interests of the developer to plan to reduce emissions of odour to the absolute minimum and to carefully consider the likely impact of any residual odour emissions in the context of the local community. The local community may have little tolerance for odour nuisance which could lead to imposition of environmental management programs by the EPA, possible expensive retro-fitting of control equipment.

Odour intensity guideline

EPA will accept an assessment of odour impacts from the sources using an odour intensity guideline value. This approach recognises the fact that the same concentration (stimulus) of different odorants does not elicit the same perception of intensity (response) in people. This approach may be advantageous to activities that emit odorous substances that exhibit low intensity at relatively high concentration.

Odour concentrations above the detection threshold are not direct indicators of perceived odour intensity. For each odorant, its odour intensity is a non-linear function of its concentration and the perceived odour intensity can be described using a mathematical equation (Stevens Law or the Weber-Fechner Law). The Weber Fechner law can be expressed by the equation:

$$I = k_w \log (C/C_0) + \text{constant}$$

Where, **I** - is the perceived psychological intensity;

k_w – is the Weber-Fechner constant;

C – is the concentration of odorant (ou);

C_0 – is the concentration of odorant at the detection threshold (1 ou); and

Constant – is the constant calculated from the line of best fit for the odorant.

Odour intensity can be categorised according to the German Standard method VDI 3882/1, *Olfactometry - Determination of Odour Intensity, Part 1*, 1992, into odour intensity in categories described as not perceptible, very weak, weak, distinct, strong, very strong and extremely strong and assigned corresponding numerical values, 0 to 6. The seven-point intensity scale is defined as follows:

0. not detectable;
1. very weak;
2. weak;
3. distinct;
4. strong;
5. very strong;
6. extremely strong.

Solving the experimentally established Stevens Law or Weber-Fechner equations at a particular intensity level for odours characteristic of an individual facility yields the corresponding odour concentration guideline value. The approach requires a considerable amount of initial work by a proponent or industry group to establish the intensity versus concentration relationships for a particular odour type. The necessary research has been done for the intensive chicken growing industry and to a lesser extent, the intensive pig growing industry in Australia. Recently, some research work has been done to develop relationship for activities such as municipal landfill, oil extraction, wastewater treatment and alumina refinery.

This method requires an odour intensity study to determine the relationship between odour concentration and odour intensity, in order to specify the odour concentration equivalent to the intensity level of “weak”. The method used to determine odour intensity and concentration must follow the procedure and standards set in the Australian and New Zealand Standard (AS/NZS 4323.3:2001) and the German Standard VDI 3882/1 in order to be meaningfully compared with the EPA’s odour guidelines. The samples collected from the source will be analysed simultaneously in the laboratory for odour concentration and intensity, using odour panels and dynamic olfactometry equipment. By doing this, it is possible to develop a relationship between them and determine the odour concentration equivalent to the intensity level of “weak”.

As with the assessment above, the proponent should conduct computer modelling and compare the results with the following criterion:

- odour concentration equivalent to an intensity level of “weak” multiplied by the relevant default peak to mean factor, averaged over one-hour, 99.5th percentile, applicable at the “most exposed existing or likely future off-site sensitive receptors”; and
- for facilities that do not operate continuously, the 99.5th percentile must be applied to the actual hours of operation.

As discussed above, the relevant default peak factors are 0.1 for tall stacks and 0.5 for ground-level or down-washed plumes from short stacks.

EPA recognises there may be a justification to vary the design guidelines in some cases depending on the offensiveness of the odour, the surrounding land uses and the values of affected communities. It is considered that setting the annoyance threshold at weak rather than distinct or strong is an approach most likely to protect amenity. Where the odours are a normal feature of the environment or have a low offensiveness rating, this may be too conservative and thus EPA would, subject to the following issues being addressed, support using the odour concentration equivalent to an intensity level of “distinct” in such cases.

In seeking a relaxation of the design guidelines, a proponent must submit well-researched supporting evidence to the EPA. The proponent must be able to satisfy the EPA that surrounding land-uses are of low sensitivity to odour impacts or that the odour has a low offensiveness rating or that the affected community would tolerate some degree of impacts. For example, it may be reasonable to expect agricultural odours in rural areas or industrial odours within industrial estates. Community odour dose annoyance response functions, based on good experimental data for a similar industry and a similar community, may provide a good case for considering variations of the design guidelines. The aim of the EPA is that there should be no objectionable or offensive odour to the extent that it causes an adverse effect at or beyond the boundary of the site.

Alternative assessment tools for odour assessment – expansion of existing activities

Alternatively, EPA will accept an assessment of odour impacts from the sources using the tools discussed in Appendix A. These tools can be used for assessing the current status of odour impacts from existing industries that may wish to expand. Impact from an existing facility can be more realistically assessed using these tools in preference to relying solely on dispersion modelling. Once the survey is conducted to establish the current odour status of an existing facility, a site-specific odour assessment criterion can be developed for the expansion of this facility. Odour dispersion modelling should not be used to try to prove the absence of an adverse effect from an existing facility when community data, such as complaint records, are already available to demonstrate the current level of effect.

5.2. Assessments for an individual specified odorant

Odour impact assessments for individual specific odorant may be carried out in a similar way to those for complex mixtures of odorants using an air dispersion model with inputs of estimated emissions and meteorological data as described above. The odour impact assessment guidelines in this case can be similarly based on odour detection thresholds. The difficulty is that reported odour detection thresholds of individual chemical species may vary by several orders of magnitude; it may not be clear whether reported values are detection or recognition thresholds; and the methods and reliability of the determinations may be unknown. Nevertheless, odour impact assessment guidelines for individual specific odorants may be drawn from a number of sources including:

- Queensland *Environmental Protection Policy (Air)* for the odorants: hydrogen sulfide, carbon disulfide, styrene, tetrachloroethylene and toluene;
- Design criteria prescribed by the Victorian Government State Environment Protection Policy (Air Quality Management) 2001 for Class 2 (odour-based) indicators; or
- Preferably, reported odour threshold data that have been determined in recent years using dynamic dilution olfactometer techniques (Woodfield and Hall, 1994 and Nagy, 1991).

The Queensland EPP (Air) criteria for above odorants are 30-minute average concentrations. The Victorian EPA design criteria are three-minute average, 99.9th percentile concentrations. Queensland EPA adopts Victorian EPA design criteria for Class 2 (odour-based) indicators. Care must be taken in converting one average hour modelling results to three and 30-minute averages that the assumptions underlying the conversion algorithm apply in the specific case.

5.3. Step-wise procedure

Proposed development applications, whether for new or existing facilities, are assessed against the “standard criteria” of the *Environmental Protection Act 1994.* Proponents must demonstrate the use of best practice environmental management. Following the waste management hierarchy under the *Environmental Protection (Waste Management) Policy 2000*, this would include adopting the following measures, wherever reasonable and practicable, in the following order of preference:

- Using management techniques to avoid or minimise creation of odours e.g. using less odorous materials, managing anaerobic ponds to avoid malodours,
- Reusing or recycling the odours e.g. using vapour recovery technologies in refineries, using biogas as fuel
- Using best practice technologies to collect and treat odorous emissions e.g. scrubbers, afterburners, bio-filters, adsorbtion technologies, ozonation;
- As a last resort, relying on buffer zones, winds and stacks to disperse emitted odours.

Note that masking agents have not been included in the examples as they are not usually an effective management technique to control odours as opposed to technologies that chemically change the odours to make them less offensive. Once the proposed development has been designed to operate in accordance with industry codes of practice or other relevant best practices, an assessment of the impact of any residual odour emissions in the surrounding environment can be made.

The assessment methodology uses an air dispersion model with inputs of information on odour emissions, local terrain and local meteorology to predict ground-level concentrations of odour in the surrounding environment and compares them to odour impact assessment guidelines to indicate the likelihood of odour nuisance in the local community. The stepwise procedure closely follows that given by the New South Wales Environmental Protection Agency (2001). A flow diagram showing the main steps of the odour assessment is given in Figure 1.

If the proposed facility or expansion of an existing facility, is designed for "best practice environmental management" (Section 21, *Environmental Protection Act 1994*), the recommended buffer distances (Section 6.6 of this guidelines) are met, has no complaint history of this type of industry and the nature of the discharge or emission is insignificant, then no further assessment of odour is required. If the above guidelines are not met, the proponent needs to undertake an odour impact study in accordance with the procedure as outlined in the following sections. Proposals for sensitive land use developments near existing odour sources will also need to make an assessment of impact from the nearby source.

Air dispersion modelling is the method most widely used by consulting organisations for odour impact assessment of proposed developments. Alternative assessment tools including compliance records, complaint data, odour diaries and odour surveys are more appropriate for assessing the current level of impact of existing activities when community data are already available. Odour dispersion modelling can then be used to assess incremental impacts. The following stepwise procedure may be followed when assessing the odour impact from a proposed new facility or a modification to an existing facility.

Step 1. Identify and list all potential odour sources

Odour sources can be continuous or intermittent, point sources (for example chimneys, stacks or exhaust pipes), area sources (for example stockpiles, ponds or open-topped tanks) or volume sources (for example, a building with many openings from which odour escapes). Include all sources within the site boundary and any nearby sources beyond the boundary if it is possible they could contribute to cumulative odour impacts. It is important to include fugitive sources as these often make an important contribution to the odour impacts.

For each source:

Determine its location and elevation in metres relative to a fixed origin.

Determine its geometry and release characteristics:

- For point sources determine, stack height, stack diameter, stack temperature and exit velocity.
- For non-point area sources, determine surface area, side length and release height
- For non-point volume sources, determine release height and initial horizontal and vertical spreads.
- To account for building wake effects, determine the location and dimensions of buildings within a distance of 10*L from each source, where L is the lesser of the height or width of the building.

In the case where a facility has multiple sources with varying odour characteristics, the assessment can often be simplified by considering the sources with the predominant odour, that is, the source with the largest proportional contribution to the concentration at the receptor location in question or the source that emits odour with the steepest intensity versus concentration curve.

Step 2. Estimate odour emission rates

For new developments, where possible, estimates of odour emission rates should be based on actual odour measurements on samples taken from similar facilities, either full-scale facilities operating elsewhere, or experimental or demonstration-scale facilities. Where this is not possible, use published emission factors and/or data supplied by manufacturers of process and control equipment.

For non-point area sources, include any information on the influence of meteorological factors such as wind speed and ambient temperature on emission rates.

Where available, include information on diurnal, weekly and seasonal variations in emission rates.

Identify ‘worst case’ emissions that may occur at start-up, shutdown or during other ‘upset’ operating conditions. If these emissions are significantly higher than those for normal operations, it will be necessary to evaluate the worst-case odour impact, as a separate exercise to determine whether the planned buffer distance(s) between the facility and neighbouring sensitive receptors will be adequate.

All the emissions data and emissions factors gathered for use in the impact assessment should be traceable to the currently recommended standards for odour sampling and measurement, namely, the Australian and New Zealand Standard AS/NZS 4323.3:2001, *Stationary source emissions - Determination of odour concentration by dynamic olfactometry*, detailed in the next section. Historic odour data, based on other than AS/NZS 4323.3:2001 standard, are likely to be inconsistent with that obtained using current sampling and measurement standards. Any historical odour concentration data used by proponents in impact assessments should be supported by experimentally determined relationships between the methodology used and that of AS/NZS 4323.3:2001.

For individual odorous compounds determine mass emission rates in grams per second; for complex mixtures determine emission rates in ou.m^3/s.

In assessing the impact of a proposed facility, there will be some value in assessing impacts of alternative design scenarios, for example, by:

- varying source release parameters
- enclosing potential sources
- varying process inputs to less odorous compounds
- using aerobic systems instead of anaerobic systems
- providing backup control equipment, for example, pumps and filters
- purchasing buffer zones
- reviewing facility locations to minimise valley drainage aspects
- establishing a community consultation committee
- undertaking lifecycle assessment of process
- enclosing odorous operations and venting to control equipment
- reviewing the efficiency of control equipment
- reviewing management practices
- developing an environmental management system for the facility.

Results can be used to select the most cost-effective and environmentally effective processes and control strategies.

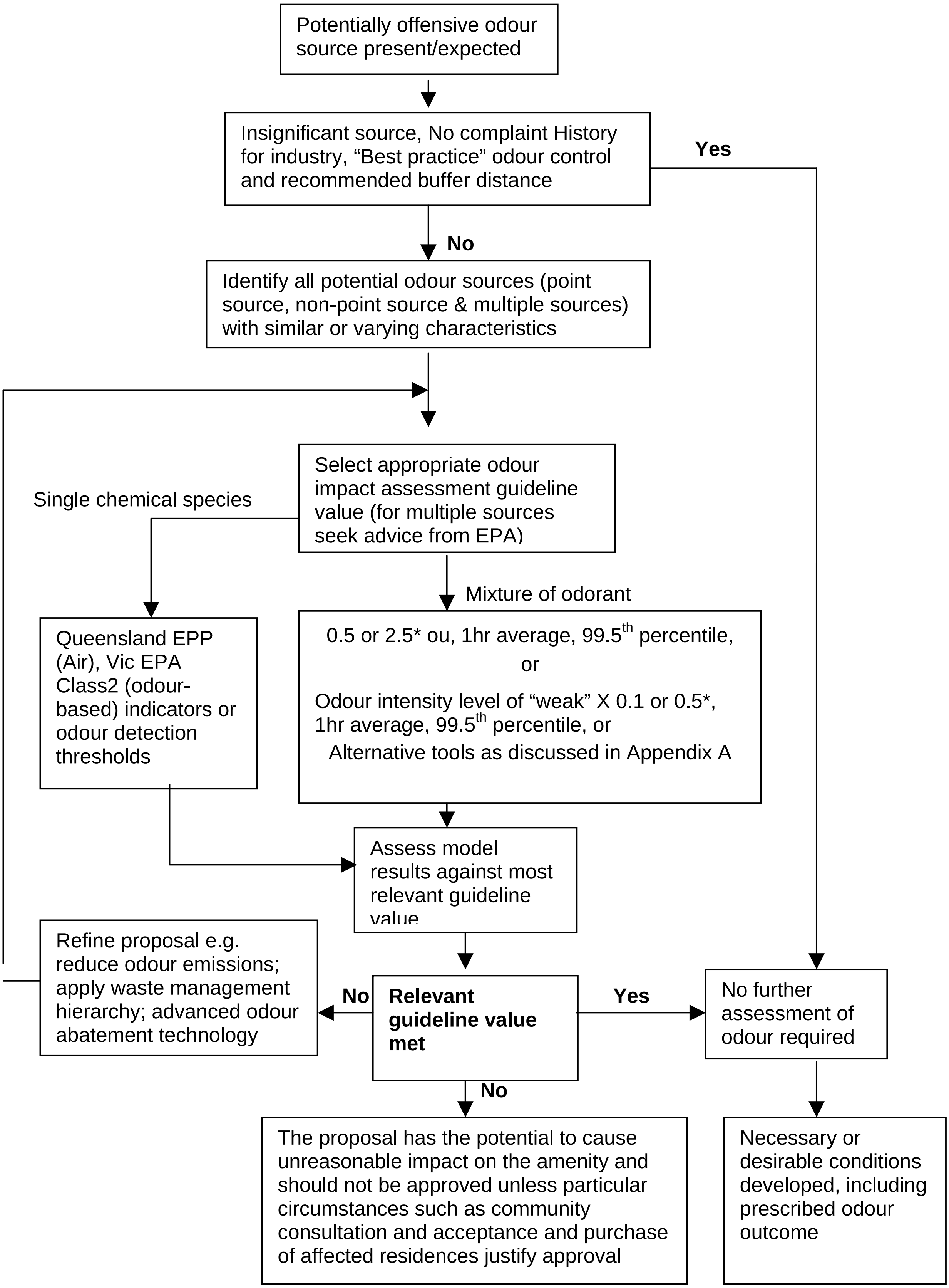

Figure 1.
Odour assessment flowchart
New Developments.
[*Note: Peak to mean factor depends on source characteristics – see text in 5.1]

Step 3. Other model inputs

Gather other information for air dispersion model inputs including:

- grided x, y and z terrain data,
- an appropriate cartesian or polar receptor grid for presenting the spatial distribution of odour concentrations, and
- the locations of any specific sensitive receptors, in consultation with local government planners, and any future sensitive receptors, such as residences, schools, hospitals.

Reference all locations to the same fixed origin as used for the source locations.

For assessments, generate a site-specific meteorological data file using methods detailed under the section headed ‘Meteorological input data’. The data file should include at least one year of hourly average values for the minimum set of parameters required for regulatory models, namely:

- wind speed
- wind direction
- ambient temperature and
- atmospheric stability class and mixing height.

Advanced models will require additional inputs such as spatially varying land-surface type data and three-dimensional meteorological fields.

Step 4. Choose appropriate odour impact assessment guidelines

If the odour release is a single chemical species, select the appropriate criterion from the sources including Queensland *Environmental Protection Policy (Air),* Victorian Government State Environment Protection Policy (Air Quality Management) for Class 2 (odour-based) indicators and published odour threshold data determined using dynamic dilution olfactometry, as mentioned in Section 5.2.

If the odour release is a complex mixture of chemical species and the odour is offensive and surrounding land-use is sensitive regarding odour impact, then select any one of the guidelines:

- odour impact assessment guidelines based on odour threshold (odour concentration) method, or
- assessment guidelines based on odour intensity level of “weak”, or
- other tools such as odour annoyance surveys, odour diaries, complaints data and compliance history, which provide additional relevant information for assessing the impact of odour from expansions of, or modifications to existing facilities, or
- other appropriate guidelines, for example, agricultural activities in rural areas can adopt Department of Primary Industries and Fisheries guidelines as they are industry specific.

Step 5. Air dispersion model

Select and run an air dispersion model and present outputs in accordance with recommendations listed under the section headed ‘Modelling’. This guideline does not recommend the use of any particular model. Gaussian models such as AUSPLUME are still the most popular regulatory models. The appropriate model should be selected based on the requirements of each particular case.

Step 6. Present dispersion model results

Tabulate the odour predictions at each of the existing and likely future sensitive receptors and at the most exposed off-site receptor.

Use model output options to generate grided concentration data for various percentiles (for example 99.5^{th}) or grided frequencies with which various chosen levels (for example 1 ou) are exceeded. Export the grided output files to a suitable graphics software package to create contour plots. Use the graphical outputs to define potential affected zones.

Step 7. Compare the predictions with odour impact assessment guidelines chosen at step 4.

The uncertainty in predicting odour impacts is such that it may not be possible to make a clear cut, pass or fail, decision on a proposal when the predicted impacts are at a level similar to the assessment guidelines. In these cases, the decision-making authority may need to seek further information on the likely odour impacts and base its final decision on the local context and the licensing authority's environmental management policies of the local area.

Step 8. Odour impact assessment report

The dispersion modelling and impact assessment report must contain the information requirements specified below:

5.4. Site plan

Provide a scale location plan, which shows:

- layout of the site clearly showing all unit operations,
- all emissions sources clearly identified,
- facility's boundary,
- most exposed existing or likely future off-site sensitive receptors,
- topography.

5.5. Description of the activities carried out on the site

Provide an accurate description of the activity and the surrounding environment. This must include:

- process flow diagram clearly showing all unit operations to be carried out on the premises,
- detailed discussion of all unit operations, including all possible operational variability,
- detailed lists of all process inputs and outputs,
- plans, process flow diagrams and descriptions which clearly identify, and explain all pollution control equipment and pollution control techniques for all processes on the premises,
- a description of all aspects of the air emission control system, with particular regard to any fugitive emission capture (e.g. hooding, ducting), treatment (for example, scrubbers, bag filters) and discharge systems (for example, stacks),
- operational parameters of all potential emission sources, including all operational variability, that is, location, release type (for example, stack, volume or area) and release parameters(for example, stack height, stack diameter, exhaust velocity, temperature, emission rate) and process type (for example, batch or continuous)).

5.6. Emission inventory

Provide the emission inventory data that is used in modelling, including:

- detailed discussion of the methodology used to calculate the expected odour emission rates for each source with references to the source of the information and the methodologies used for sampling and measurement,
- a table showing all stack and fugitive source release parameters (for example, temperature, exit velocity, stack dimensions and emission rates).

An odour emission rate model should take into account the following factors, or any other factors that are unique to a particular industry:

- the hours of operation of the facility,
- whether the process or activity is batch or continuous in nature,
- whether emissions vary as a function of:
  - process conditions (for example, temperature, pressure etc.)
  - production rate,
  - hour of the day, week, month or season,
  - meteorological variables (for example, wind speed, ambient temperature, humidity, atmospheric stability class and rainfall),
  - feedstock, and
  - animal age or feed type.

This is not intended to be an exhaustive list and the key parameters will be specific to the industry in question.

5.7. Description of meteorological data

Describe the meteorological data used in the study including:

- selection and preparation of meteorological data,
- detailed discussion of the prevailing dispersion meteorology at the proposed site. The report should typically include wind rose diagrams and an analysis of wind speed, wind direction, stability class, ambient temperature and joint frequency distributions of the various meteorological parameters,
- description of the techniques used to prepare the meteorological data into a format for use in the dispersion modelling,
- a description of the results of quality assurance and quality control checks on the meteorological data used in the dispersion modelling.

6. Supporting guidance

6.1. Measurement

The odour concentration of unknown mixtures of compounds is measured using a technique called dynamic olfactometry. A dynamic olfactometer is a dilution apparatus, which mixes streams of odorant sample and dilution air (odour-free) in selected ratios. One or more sets of sniffing ports are attached to the olfactometer, through which either reference air (odour-free) or the diluted odorant can flow out. The human nose is used to detect odour sensation at the sniffing port. Using this technique, the odour concentration of a sample is measured in odour units (ou), which is simply the number of times the sample must be diluted to reach the detection threshold of the panel of humans using their noses as odour detectors.

Recently, in Europe, considerable effort has gone into the standardisation of dynamic olfactometry methods to achieve reliable and consistent measurement of odour concentrations using dynamic olfactometry. The CEN working group produced the European Draft Standard (1999), which defines the method for the objective determination of the odour concentration of a gaseous sample using a dynamic olfactometer with human assessors. The standard is performance-based rather than being a prescription for the use of specific equipment and is, therefore, applicable to yes/no and forced-choice methods, and to single panellist and multi-panellist machines.

The Australian and New Zealand Standard AS/NZS 4323.3:2001, *Stationary source emissions - Determination of odour concentration by dynamic olfactometry* is based on the draft European CEN standard. Queensland EPA adopts AS/NZS 4232.3:2001 as the basis of all odour measurements used in accordance with this guideline for evaluation of odour impact.

The unit of measurement in AS/NZS 4323.3:2001 is the odour unit (ou). The odour concentration at the detection threshold is by definition 1 ou. The AS/NZ standard uses 1-butanol as reference odorant and sets132 µg as the Reference Odour Mass (ROM). For all odorant(s), one ou is that concentration of odorant(s) at standard conditions that elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one ROM evaporated in one cubic metre of neutral gas at standard conditions. These definitions effectively express odour concentrations in terms of ‘n-butanol concentration equivalents’.

Adoption of AS/NZS4323.3:2001 by odour measuring laboratories throughout Australia will help to ensure that measurements from different odour laboratories are comparable. The dynamic olfactometry methods that were in use prior to AS/NZS 4323.3:2001 often had little control over accuracy, instrument calibration, inter-laboratory reproducibility and intra-laboratory repeatability. EPA no longer supports the Department of Environment and Heritage (DEH) laboratory method No.6. Odour emissions estimates based on methods in use prior to the development of AS/NZS 4323.3:2001 will not be acceptable by EPA for odour impact assessments unless the proponent can support conversions based on experimentally-determined relationships.

Panellists are selected using n-butanol as the chosen reference material. Only people with a consistent personal threshold for n-butanol of between 20 ppb and 80 ppb during 10 measurements over a 3-day period with a log standard deviation less than 2.3 are acceptable.

There are two quality guidelines specified in the standard, accuracy and precision (repeatability). The standard specifies how these two quality guidelines are calculated. The requirement for accuracy means that the laboratory must, at worst, produce a value for the threshold concentration of the reference material, n-butanol, of between 31 and 51 ppb. The criterion for repeatability requires that consecutive single measurements, performed on the same test material in one laboratory shall not differ by more than a factor of 3.0 in 95% of cases or expressed another way, a 95% confidence interval would range from 46% to 218% of a single measured value.

Instrument calibration is required in order to check whether the olfactometer makes dilutions in an accurate and repeatable way. A certified reference gas and a measuring instrument should be used. The calibration gas should not be adsorbed in the measuring instrument or the olfactometer. The measuring instrument should give a linear response over at least 4 orders of magnitude (eg. 0 to 10, 10 to 100, 100 to 1000, 1000 to 10000 dilutions). If this is not possible, the reference gas should be used in different concentrations. These measurements can be used to determine the repeatability by calculating the standard deviation of the dilutions over the entire dilution range of the olfactometer. At least 5 repeats should be made per setting. For each repeat, the olfactometer settings should be altered and reset again. The resultant data should be used to test for the repeatability and the accuracy. The olfactometer should be calibrated at least once a year.

6.2. Sampling

AS/NZS4323.3:2001 includes methods for sampling odours. The sampling technique can be applied to all sources emitting odours, whether point or non-point, provided the odour emissions can be channelled for sampling. Essentially, the standard covers the method for collecting and transferring a sample of odorous gas to a container.

Samples of odours for olfactometric analysis are usually collected in a sample bag and transported to the odour laboratory for analysis. Equipment used in the sampling process must be chosen to minimise the likelihood of adsorption, chemical transformation or diffusion both in the sample train and in the sample container.

The number of odour samples required will depend upon the nature of the source of the purpose of the measurement. Sufficient samples should be taken to ensure that the odour stream is properly quantified. Replicate samples will enable the calculation of some basic statistics of measurement. The number of replicate analyses required to achieve a definite precision is discussed in AS/NZS 4323.3:2001.

The most commonly used method of static sample collection uses the ‘lung principle’. Here the sample bag is placed in a rigid container, the air is removed from the container using a vacuum pump and the reduced pressure in the container causes the bag to fill. The period during which the sample bag is filled will depend upon the fluctuation, with time, of the odour emission. If the odour stream is considered to be constant, then point samples will be adequate. The period during which the sample is taken shall be determined taking into account the fluctuation of the odour emissions with time. Taking the sample over a period of a few minutes averages short-term fluctuations. Taking point samples at appropriate times during the emission cycle averages longer-term fluctuations.

Where the gaseous flow is hot or humid, such that condensation within the bag is possible, in-situ pre-dilution is recommended. This can be done statically, by pre-filling the sample bag with a known volume of neutral gas and then adding a known volume of sample, or better, by dynamically mixing known volumes of sample and neutral gas in a pre-dilution device. The pre-dilution device should be regularly calibrated so that the dilution factor is known.

AS/NZS4323.3:2001 describes sampling equipment for sampling from a point source, for example, ventilation outlets, but does not cover sampling area sources where there is little or no outward flow. There is still some debate over methods for taking samples of odour from surfaces such as ponds, landfills, or feedlot manure pads. The two preferred sampling devices; the isolation flux chamber and the wind tunnel differ in the airflow rate and the airflow dynamics, which are established inside the device. In general, the two methods do not give equivalent results for odour emission rates.

6.3. Air dispersion modelling

Air dispersion modelling provides a means of assessing the impacts of odour emissions in the environment surrounding proposed facilities. Using appropriate emissions and meteorological inputs, a model predicts ground-level concentrations of odour, which can be compared to odour impact assessment guidelines to evaluate the risk of nuisance to the surrounding community

The most widely used regulatory air dispersion model in Australia is AUSPLUME, a Gaussian plume model that was originally developed by Victorian Environment Protection Authority as the approved plume calculation procedure under Schedule E of State Environment Protection Policy (Air Quality Management) in 1985. It is designed to predict ground-level concentrations or dry deposition of pollutants emitted from one or more sources, which may be stacks, area sources, volume sources, or any combination of these. The most recent version of AUSPLUME, version 5, was released in 2001. Common applications of the AUSPLUME model include:

- existing air pollution problems,
- new source assessment,
- emission control strategy evaluation, and
- in the determination of stack heights.

AUSPLUME and other similar steady-state Gaussian models such as ISCST3, have limitations imposed idealised assumptions such as constant meteorological conditions over long distances, idealized plume geometry, and uniform flat terrain. Recent advances in the development of air dispersion models and the computational power of desktop computers have made more accurate modelling more generally accessible. EPA accepts the use of AUSPLUME as an appropriate model for most near-field assessments of odour sources located in relatively flat terrain and as an initial screening model to determine whether a more advanced model might be required for a particular situation. Proponents may consider alternatives to the steady-state Guassian models when assessments require predictions of odour concentrations far from the source of release, in complex terrain or at locations where light winds, convective conditions and sea-breeze circulations occur frequently. In some cases, it may be necessary to weigh up the convenience and limitations of the steady-state Gaussian models against the complexity and additional demands of advanced models and seek advice from the EPA before embarking on the assessment.

Advanced models currently available include:

AERMOD - American Meteorological Society,

ADMS - Cambridge Environmental Research Consultants, and

CALPUFF - Earth Tech Inc., California,

TAPM – CSIRO, Australia.

These recent models can be expected to provide more accurate odour impact assessments than steady-state Guassian plume models in the exceptional circumstances described above.

EPA cannot prescribe any one model that suits all situations and leaves the choice open to proponents on a case-by-case basis. EPA takes this position in order to allow scientific and technical advances to be introduced without regulatory delays. However, EPA reserves the right to reject a proposed model or application thereof, if it considers it to be inadequate, inappropriate or unproven. The proponent should justify the selection of model based on the merits of the particular case. Wherever practicable, the model that is expected to most accurately estimate concentrations for the application of interest should be selected. Early discussion with the EPA officers is recommended, especially if a model other than those mentioned above is selected. Agreement on the data base to be used, modelling techniques to be applied and the overall technical approach, prior to the actual analyses, helps avoid misunderstandings, concerning the final results and may reduce the later need for additional analyses.

Current air dispersion models work from hourly meteorological inputs and thus are only able to predict hourly-average odour concentrations. Humans can sense concentrations of odorous substances that last only for a few seconds. Within each modelled hour, the odour concentration will fluctuate above and below the predicted average concentration as a result of atmospheric turbulence. Theoretical ‘peak to mean’ factors of been derived to estimate the magnitude and probability of occurrence of peak odour concentrations within an hour (NSW EPA, 2001). EPA has decided not to incorporate these factors in its impact assessment guidelines until there is better understanding of how these theoretical peak concentrations might relate to adverse impact in a community. Odour impact assessment guidelines for odour mixtures in this guideline therefore apply to modelled concentrations averaged over 1-hour.

For single chemical species, the question arises as to what is the most appropriate method of conversion of 1-hour average concentrations to shorter-term averages for assessment against air quality goals. For tall stacks a conservative approach should be adopted, with conversion utilising the Turner Power Law. This equates to use of conservative coefficient in the equation. Hibberd (1998) has recommended a value 0.38 for tall stacks. For other techniques, the key is that assumptions underlying the conversion apply in the specific case.

Another option is to use field measurements. The technique used in (Hibberd 1998) which utilised analysis of field measurements of relevant short-term and one hour ambient concentrations to derive conversion factors is acceptable.

The EPA will be developing comprehensive modelling guidelines as resources permit. Meanwhile, the proponent can consult the appropriate administering authority or the EPA for advice on the model selection.

Results of odour dispersion modelling may be presented as concentration contour plots and frequency contour plots. The former shows the spatial distribution of odour concentrations at a given percentile level (for example, 99.5%) around a source and are useful in showing where worst-case impacts occur. The latter shows the spatial distribution of frequencies with which a given level of odour, (for example, 1 ou), is exceeded. These are useful for looking at effects at specific places. Most dispersion models have such facilities for exporting model output data to graphics software packages such as SURFER for plotting contours.

6.4. Meteorological input data

The basic meteorological parameters required for air dispersion modelling are ambient temperature, wind speed, direction, thickness of the boundary layer and atmospheric stability determined using a simple Pasquill Gifford classification. The Monin-Obukhov length is a more fundamental descriptor of atmospheric stability and is used in more advanced modelling. It is derived from additional meteorological observations including friction velocity and heat flux.

The assessment in this guideline require the use of at least one year of hourly meteorological data which are representative of local conditions. EPA has available, AUSPLUME meteorological input files derived from historic 3-hourly Bureau of Meteorology surface data for 22 locations in Queensland. These may suffice if predicted impacts are well below assessment guidelines but in other cases, proponents will have to gather or generate their site-specific data for modelling.

The CSIRO’s air quality model TAPM can be used to generate hourly one-year meteorological data required for the dispersion models. This is a prognostic meteorological model, which eliminates the need to have site-specific meteorological observations. The model can predict airflow important to local scale air pollution such as sea breezes and terrain induced flows. For sites where observed meteorological data is not available and the site is subject to the sea and land breeze effects, it is preferable to use TAPM model for the generation of meteorological data.

6.5. Source type and emission rates

One of the drawbacks of dispersion modelling with multiple sources of odour is that the model assumes that the odours are additive. While this is correct for single chemical contaminants, it is not correct for odour units because the actual downwind odour concentration will depend on the various concentrations of the chemical constituents in the odour mixture. If the two sources were of quite different make-up, then the combined, diluted mixture of these two odour sources can have quite a different cumulative impact on the receiving environment. In some cases the effects may be additive and in other cases it may be positively or negatively synergistic. The modelling of multiple odour sources is quite complex and a little is currently understood about the cumulative impacts of multiple odour sources. It is reasonable to expect multiple sources of the same type of odorant (eg. multiple sheds on a poultry farm) to be additive in nature. An example of different type of odorant would be the rendering plant cooking odour via a chimney and the diffuse source odour from a wastewater treatment system. Facilities with multiple odour sources should determine the odour intensity concentration relationship for each source and use the concentration, which relates to the strongest odour (highest intensity) for comparison with designated guidelines. A weak odour (low intensity) in multiple sources with high emission rate should be modelled separately and compared with its designated criterion. All sources should comply with the relevant guidelines.

Of the input data required, emission rates are the most problematical, particularly for area sources. Assumptions about new processes cannot rely completely on data for existing processes unless there is confidence about the odour characteristics. Information on the way emission rates vary with time is needed for modelling but is seldom available. Only the meteorology is treated as time dependent. Sometimes the emission rate from area sources depends on the wind speed as well.

Source information compiled for modelling should include all sources of odour from the proposed development and other nearby facilities. However, odour impact assessment differs from that of other air pollutants in that odour concentrations at receptors are rarely additive. As a general guideline, emissions from like sources may be combined but for odours with different characteristics, the one with the steepest intensity curve versus concentration curve is likely to make the dominant contribution to odour impact. In some cases, odours can be masked by other odours. Each case should be considered on its own merits, and expert advice sought in complicated situations.

Background odour concentrations should be considered but, because humans can discriminate odours quite well, the odour impact of a new source may be noticeable even when the background odour concentrations are relatively high.

Separate modelling runs with sources under the maximum emission rates or “upset conditions” may also be needed to demonstrate the sensitivity of the activity to variations in the magnitude of odour emissions.

6.6. Buffer distances

Proper land use planning avoids allowing incompatible land uses in close proximity and is one of the most important tools in odour management. Many odour problems can be avoided by appropriate siting of new facilities.

For the purposes of this guideline, EPA adopts the current Victorian EPA philosophy on buffer distances and that is, separation distances are provided as a risk management tool to manage unexpected or accidental emissions from an facility. They are provided to cater for non-routine emissions that may arise from upsets in normal operations of a premise. Separation distances provide an additional level of protection by allowing more distance and space in which emissions may dissipate without adversely affecting sensitive receptors.

EPA adopts the Victorian EPA, *Recommended Buffer Distances for Residual Air Emissions, Publication No. AQ 2/86,* as an interim guideline on buffer distances. The publication is currently under review by the Victorian EPA and will require an evaluation of its suitability for situations in Queensland.

Planning and other responsible authorities will be required to apply the guidelines in assessing the suitability of proposed development locations and the potential impacts of development. These guidelines assume a good standard of odour management is carried out on site. Separation distances will thus not be offered or used as a substitute for the effective management of emissions at source.

6.7. Likely conditions of approval for odorous industries

The objectives of preventing an environmental nuisance or harm due to release of noxious or offensive odour would generally be a condition considered necessary and desirable in all instances where the EPA authorise an activity with material risk of odours. In addition, for higher risk situations, conditions may require taking of stated measures to minimise likelihood of environmental harm may be considered necessary or desirable. It is also possible to use odour impact assessment guidelines in reverse, that is, fix the ambient concentrations at a sensitive receptor and use a dispersion model to calculate the emission rates and release conditions (for example, stack height), necessary to achieve compliance with the assessment guidelines. Subject to confidence in modelling techniques, the method can be used to provide a guide to acceptable odour emission rates and release parameters. Relevant emission conditions upon which the model conclusions were based must be referenced by specifying release parameters such as mass emission rate, gas flow rate, minimum temperature and stack height. In the event that the emission rates calculated by modelling proved inadequate or much too stringent, there are ultimately provisions in the *Environmental Protection Act*, which allow for amendments by the holder and the EPA based on relevant information.

7. Definitions and abbreviations

99.5^{th} Percentile	The modelled odour concentration at a selected point that is exceeded in a given hour with a probability less than or equal to (1.0 – 0.995). This statistical definition is often interpreted (for better or for worse) as percentage compliance, namely, the odour concentration that is exceeded for no more than 0.5% of the meteorological conditions in the length of the meteorological input file (rounded to 44 hours for one year of hourly meteorological inputs).
99.9^{th} Percentile	The modelled odour concentration at a selected point that is exceeded in a given hour with a probability less than or equal to (1.0 – 0.999). As above, this equates to the odour concentration that is exceeded for no more than 0.1% of the meteorological conditions in the length of the meteorological input file.
AS/NZS-4323.3:2001	Australian and New Zealand Standard, Stationary source emissions - Determination of odour concentration by dynamic olfactometry
Commercial place	A place used as an office or for business, industry or commercial purposes.
CEN	Committe Europeen de Normalisation.
Detection threshold	The highest dilution factor at which the sample has a probability of 0.5 of eliciting with certainty, the correct perception that an odour is present. This dilution factor will be too high for the sample to be recognized.
Dwelling	Dwelling means any of the following structures or vehicles that is principally used as a residence: (a) a house, unit, motel, nursing home or other building or part of a building; (b) a caravan, mobile home or other vehicle or structure on land; and (c) a watercraft in a marina.
Dynamic olfactometer	A dynamic olfactometer delivers a flow of mixtures of odorous and neutral gas with known dilution factors in a common outlet.
Dynamic olfactometry	Olfactometry using a dynamic olfactometer.

EPA	Queensland Environmental Protection Agency
FIDOL factors	The factors, which ought to be considered when assessing the impact of odours in the environment are: • the **frequency (F)** of the occurrence; • the **intensity (I)** of the odour; • the **duration (D)** of exposure to the odour; • the **offensiveness (O)** of the odour; and • the **location (L)**
Non-point source	Means any release other than point source.
Noxious	Means harmful or injurious to health or physical well-being.
Odorant	A substance which stimulates a human olfactory system so that an odour is perceived.
Odour	Organoleptic attribute perceptible by the olfactory organ on sniffing certain volatile substances.
Odour concentration	The number of odour units.
Odour intensity	The intensity of an odour sensation which is triggered by an odour stimulus. The perceived strength of the odour sensation increases with increasing concentration, as a logarithmic or power function.
Odour unit (ou)	One odour unit (ou) is that concentration of odorant(s) at standard conditions that elicits a physiological response from a panel (detection threshold) equivalent to that elicited by one Reference Odour Mass (ROM), evaporated in one cubic metre of neutral gas at standard conditions.
Offensive	Means causing unreasonable offence or displeasure; is unreasonably disagreeable to the sense; disgusting, nauseous or repulsive.
Peak-to-mean ratio	A conversion factor that adjusts mean dispersion model predictions to the peak concentrations perceived by the human nose. Default ratios are used in this policy in the absence of site-specific research that should be realistic in generalised circumstances.
Point source	Means any stack, chimney, vent, infrastructure, or device which is designed to cause or allow the release of contaminants to the atmosphere.
Protected area	Protected area means: (a) a protected area under the Nature Conservation Act 1992; or (b) a marine park under the Marine Parks Act 1982; or (c) a World Heritage Area.
Reference odour mass	The acceptable reference value for the odour unit, equal to a

(ROM)	defined mass of a certified reference material. One ROM is equivalent to 132 µg n-butanol which evaporated in 1 cubic metre of neutral gas at standard conditions produces a concentration of 40 ppb (µmol/mol).
Sensitive receptor	Sensitive Receptor means: (a) a dwelling, mobile home or caravan park, residential marina or other residential premises; or (b) a motel, hotel or hostel; or (c) a kindergarten, school, university or other educational institution; or (d) a medical centre or hospital; or (e) a protected area; or (f) a public park or gardens; or (g) a commercial place or part of the place potentially affected. It includes the curtilage of such any place and any place known or likely to become a sensitive place in the future.
Tall stack	2.5 times higher than any nearby building.

8. Reference Materials

American Industrial hygiene Association (1989) *Odor thresholds for Chemicals with established Occupational Health Standards.*

Aurora Environmental (2000) *Environmental Standards for Industrial Odour Effects, A028-01,June.*

Committee European de Normalisation (CEN) (1999) Odour concentration measurement by dynamic olfactometry.

Devos M, Patte F, Rouault J, Laffort P and Van Gemert L J (1990) *Standardised Human Olfactory Thresholds*, IRL Press Oxford University Press.

EPA (Ireland) (2001) Odour Impacts and Odour Emission Control Measures for Intensive Agriculture, R&D Report Series No. 14.

Hibberd M F (1998). Peak-to-mean ratios for isolated tall stacks (for averaging times from minutes to hours). *14th International Clean Air and Environment Conference 1998*.

Miedema H M E, Walpot J I and Steunenberg C F (2000) Exposure-annoyance relationships for odours from stationary sources, *Atmospheric Environment* 34, 2927-2936.

Nagy G Z, 1991. The Odour Impact Model. *Journal of the Air and waste management Association,* 41 (10) 1360-1362.

New Zealand Ministry for the Environment (2003) Good Practice Guide for Assessing and Managing Odour in New Zealand.

NSW EPA (2001) Approved Methods and Guidance for the Modelling and Assessment of Air Pollutants in NSW.

NSW EPA (2001) Draft Policy: Assessment and Management of Odour from Stationary Sources in NSW.

Standards Australia, Standards New Zealand (2001) Australian/New Zealand Standard 4323.3 – Stationary Source Emissions Part 3: Determination of odour concentration by dynamic olfactometry. AS/NZS.

United States EPA. 1985. Good Engineering Practice Stack Height.

Van Harreveld (2001) Report on feasibility of annoyance potential.

Valentin F H H and North A A, (eds.) (1980) Odour Control – A concise guide, Warren Spring Laboratory, UK.

Verein Deutscher Ingeneure 3882 Part 1 (1992) Olfactometry – determination of odour intensity.

Verein Deutscher Ingeneure 3882 Part 2 (1994) Olfactometry – determination of hedonic odour tone.

Vic EPA (2001) State Environment Protection Policy (Air Quality Management).

Vic EPA (1999) AUSPLUME Gaussian Plume Dispersion Model Publication.

Vic EPA (1990) Recommended Buffer Distances for Industrial Residual Air Emissions.

WA EPA (2002) Guidance for the Assessment of Environmental Factors, Assessment of Odour Impacts from New Proposals, Guidance No. 47.

Woodfield M and Hall D (editors) (1994), *Odour measurement and control – An update*, AEA Technology, National Environmental Technology Centre, Abingdon Oxfordshire.

Approved by

SIGNED	20 July 2004
Signature	Date

Mark Williamson

Executive Director, Environmental Operations

Enviromental Protection Agency

Enquiries:
Ecoaccess Customer Service Unit
Ph. **1300 368 326**
Fax. (07) 3115 9600

APPENDIX A – ALTERNATIVE TOOLS FOR ODOUR ASSESSMENT

Community odour surveys

In order to assess the current status of odour impacts from existing industries as perceived by the local community, odour surveys can be conducted to measure the "population annoyance". A standard procedure for conducting odour surveys is discussed in the New Zealand Good Practice Guide for Odour Management. The information given in this guideline should be adopted when conducting an odour survey in Queensland. It is recommended that odour surveys should be used as an alternative tool in areas where sufficient population density is available to achieve statistically significant results. In low population areas, odour modelling and complaint records are preferred method of assessment.

The odour survey is designed as a set of standard questions about the state of the environment to minimise the potential for biased responses from participants. Respondents from a selected community are asked about the level of annoyance that they experience from odour and the responses are classified according to the following degree of annoyance:

0. Definitely not annoying
1. Very little annoyance
2. Some annoyance
3. Annoying
4. Quite annoying
5. Very annoying
6. Extremely annoying

The criterion used from the odour survey is the "percent at-least annoyed" category, which is made up of the responses ranging from annoying (3) to extremely annoying (6).

The main steps recommended in conducting odour surveys are:

1. Identify community areas to be included in the survey. Review historical complaint data and prevailing wind conditions to select the boundaries for the survey areas.
2. Select the population size of the survey areas. A minimum target of 50-70 respondents from any one sub-group should be selected. This size of the community provides a margin of error in the order of 5-10 percent.
3. Prepare the questionnaire for environmental survey including questions about the state of the environment (not just odour) to minimise the potential for biased responses from participants. A standard odour survey questionnaire is given in Appendix 2 of the New Zealand Good Practice Guide for Odour Management.
4. Conduct the survey by telephone interview. Select phone numbers (usually three times the sample size) from a listing of the local areas. Try to conduct the survey quickly during a 2-hour period in the evening.
5. Conduct personal interviews in industrial and commercial areas, because a phone call may be less appropriate for such areas.
6. Calculate the percentage of people who detected odours and were "at-least annoyed" by the odour, representing each community or sub-area.

7. Compare the survey results with the nearby control population, or the results of other control studies. Control data can be developed by following the above steps (1 to 6) and conducting the survey for communities that are not subject to the odour from industries. In New Zealand, 5-15% of the community typically reported as being "at least annoyed" by industrial odours (Aurora Environmental, 2000).
8. Calculate the margins of error using standard statistical methods and specify in the report.
9. Develop an odour assessment criterion based on the survey conducted in the control communities. Select an X "at-least annoyed" criterion based on some degree of effect that would still be considered minor by reasonable population where X is the cumulative effect from all industries.

Odour diaries

Odour diaries provide a method of obtaining information from a community regarding the zone of impact from an odour source and the associated characteristics of the odour exposure pattern. This information should be sought from a subgroup of the community, rather than passively received by the administering authority (i.e. from complainants).

The aim of the diaries are to verify complaints and collect information on the frequency and intensity of odour exposures, at various locations, over a defined period of time, in order that action may be taken (if necessary). The information provided by odour diaries needs to be validated by checking the wind-direction and site emission status during the time of each recorded odour event. This can assist in identifying the specific processes that may be contributing to the odour impact. The longer the monitoring period, the more accurate the results, however the time period should be limited as the impacted people will usually not accept the odour nuisance for extended periods and fatigue with the process will occur. Odour diaries are a good option when it is important to monitor the impacts from a specific source within a defined time frame.

The use of odour diaries is a relatively simple and effective way for administering authorities to actively involve the community in the investigation process and obtain meaningful information on which an investigation process can be progressed. Odour diaries should be used in preference to odour annoyance surveys where there are low population densities. The information recorded in a comprehensive diary program includes:

- Date and time of day;
- Duration of the event;
- Continuity of the odour during the event;
- Character and strength of odour;
- Likely source of odour; and
- Wind direction and strength.

Diarists should be given instruction on recording information so that it is consistent and the information can be analysed objectively.

Odour complaints

An odour related nuisance complaint can be made to the administering authority either in writing or orally, and must include the following:

- the complainants name and residential address; and
- a telephone number at which the complainant can be contacted; and

- enough details of the emission to allow the authority to investigate whether the emission is causing an unlawful environmental nuisance.

If at any time after a nuisance complaint has been made, the administering authority believes, on reasonable grounds, that the complaint is frivolous, vexatious or based on a mistaken belief, the authority may reject the complaint without further investigation. Similarly, should a complainant fail to provide sufficient detail to allow an effective investigation to be undertaken, the authority may decide not to investigate the complaint.

A sequential summary of odour complaints data can be used to indicate changes in long-term odour exposure. Trends can illustrate seasonal changes in complaint frequency, which may be due to changes in plant production or changes in the prevailing meteorological conditions.

This information can be used in determining the history of an existing plant. If the industry type of the proposed facility has no complaint history, there may be no further assessment of odour is required. If the above guidelines are not met, the proponent needs to undertake an odour impact study in accordance with the procedure outlined in the following sections. Proposals for sensitive land use developments near existing odour sources will also need to make some assessment of impact from the nearby source.

Field observations of odour intensity, character and offensiveness

Useful information to determine the odour's offensiveness can be obtained by field investigations of combined records of odour intensity, character and offensiveness.

A useful scale for describing odour intensity during field observations is detailed in German Standard VDI 3882 (I) 1992: "Olfactometry Determination of Odour Intensity". The German Standard VDI 3940: "Determination of Odorants in Ambient Air by Field Inspection" also has a procedure for logging observations in the field which involves noting the odour intensity every 10 second over a 30-minute period in one location. Objective analysis of FIDOL factors must include the intrinsic nature of the odour that is often referred to as the odour character. The New Zealand Ministry for the Environment has developed a table of odour character descriptions. These can be used to identify the odour character. Deciding whether a specific odour event is "offensive or objectionable" can then be done using a scale for rating odour impact as described by New Zealand guidelines.

Compliance history

If an existing facility has a current environmental authority then it is subject to the requirements of the licence conditions, *the Environmental Protection Act 1994*, *the Environmental Protection (Air) Policy 1997* and *the Environmental Protection Regulation 1998*. The regulatory agency may consider the compliance history of existing facilities when processing the application for an extension of the project.