Good Practice Guide for Assessing and Managing Odour in New Zealand

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Manatū Mō Te Taiao

Foreword

Clean air is an important part of a healthy, sustainable environment. Clean air is not just about protecting people's health from pollutants such as fine particles and carbon monoxide. It is also about protecting people from offensive smells that can affect their daily activities and wellbeing. Offensive odour is a significant cause of public complaints to councils and is typically a difficult environmental issue to assess and manage. With more people living close to industries and in agricultural areas the possibility of conflict between odorous activities and people is increasing.

There has been significant progress in dealing with odour problems in New Zealand since the introduction of the Resource Management Act 1991. I commend those industries and councils that have worked hard with local communities to resolve problems. However, better methods of odour assessment and management are needed to ensure adequate protection for all New Zealanders and to create a level playing field for activities that may need to reduce their odour emissions or install abatement equipment.

To progress this, the Ministry for the Environment has prepared this *Good Practice Guide to Assessing and Managing Odour in New Zealand*. It has been developed with the help of many practitioners, including staff from councils, industries and environmental consultancies. The guide is designed to assist those involved in odour management and the communities affected by offensive odours. It provides well-debated, expert guidance on how to determine when an odour is causing an objectionable or offensive effect, and how to reduce the potential for odour emissions to cause problems.

My thanks to those of you who contributed to the development of this guide. I hope you will find it useful.

Hon Marian Hobbs
MINISTER FOR THE ENVIRONMENT

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Contents

1 Introduction

1.1 Purpose

Objectionable and offensive odours have the potential to cause significant adverse effects on people's lives and wellbeing. Complaints about odour emissions are one of the most frequent environmental pollution incidents reported to regulatory authorities.

Typically odours are managed under the Resource Management Act 1991 (RMA), although other legislation such as the Health Act may also be relevant. Odour management is complicated by a number of factors – the range of adverse effects it can cause, and people's varying sensitivity to odours, which can cause conflict between neighbours and odour producers about the severity of the effects. Conflict needs to be resolved by assessing the effect on neighbours and deciding what action is required to remedy any unacceptable effects. It is therefore important to have a well-debated national approach to assessing and managing odour so that the methods applied are consistent.

This *Good Practice Guide for Assessing and Managing Odour in New Zealand* suggests a national approach to assessing and managing offensive odours. It contains well-debated, expert advice for those involved in managing odour, including council staff, resource consent applicants and holders, councillors, consultants, and others who may be affected by odour. The key recommendations for good practice are summarised in boxes at the end of the relevant sections.

The guide contains advice on:

- how to assess the effects of odour, including how to determine what "*no objectionable or offensive odour*" means
- how to monitor the effects of odour through community surveys, odour diaries and council investigations
- case law developed under the RMA relating to odour management in New Zealand
- when to use dispersion modelling
- how to manage odour emissions, including some basic information on suitable mitigation options.

The guide updates the Ministry for the Environment's previous odour guide, *Odour Management under the Resource Management Act*, which was published in 1995 (Ministry for the Environment, 1995).

The process for producing this guide involved the development of a background technical report (the Technical Report) entitled *Review of Odour Management in New Zealand: Technical Report* (Ministry for the Environment, 2002c). The Technical Report formed the basis of the draft version of the guide (Ministry for the Environment, 2002a), which was released for public comment in September 2002. Both the Technical Report and draft guide were reviewed and consulted on during workshops and a formal peer review process. Submissions and comments at the workshops have been taken into account in producing this final guide.

1.2 Roles and responsibilities

Regional councils, unitary authorities and territorial councils all have certain responsibilities for managing emissions that may cause offensive odours. This section provides a brief overview of these roles and responsibilities. Further details of legislative matters are discussed in section 3.

Under the RMA, regional councils are responsible for managing discharges of contaminants into the air. They must consider the potential odour effects of discharges in the planning and resource consent process. Councils are responsible for monitoring compliance with resource consent conditions applied to odour discharges, and for responding to complaints about offensive odours. Councils will often encourage or facilitate discussions between the discharger and any affected communities. However, if there is no agreement and the issue cannot be resolved, then councils should ensure that the effects are assessed using the methods discussed in section 4 and appropriate action is taken in accordance with the RMA.

Territorial local authorities have both RMA and Health Act 1956 responsibilities. Under the RMA they are responsible for controlling land use and must consider the effect of land-use decisions on amenity values when planning and making decisions on resource consents. They are also responsible for preventing nuisances under the Health Act and can monitor and take enforcement action to abate nuisances. Territorial local authorities and regional councils should aim to work together to ensure there are no gaps or unnecessary overlaps in managing discharges to air.

Public health authorities have an advocacy role, but they have no direct regulatory function with respect to air emissions. They are able to advocate on behalf of the public when there is a health issue arising from a discharge, rather than a nuisance-type odour.

People with activities that discharge to air (dischargers) must comply with the requirements of the RMA, including section 17 (general duty to avoid, remedy or mitigate adverse effects), any relevant regional plan, or resource consent conditions. Dischargers have a duty to ensure that they are not adversely affecting people in the local community. They also need to demonstrate that they are taking appropriate action to comply with any council requirements within a reasonable timeframe or as specified by the plan or consent conditions.

Communication with the community is helpful to determine the main odour concerns and to decide appropriate mitigation measures if they are needed. Prior community discussion may also avoid the need for having to undertake detailed assessments using methods discussed in section 4. Because odour is an effect on people, the community should be involved in processes to determine and resolve odour issues, such as participating in community meetings, keeping diaries or making complaints. The public need to be sure they are genuine in their complaints, and not complaining for an ulterior purpose, bearing in mind that their view of what is acceptable will be judged in terms of the 'ordinary reasonable person', as discussed in section 3.3.1. Likewise, the public has the right to expect a reasonable response from regulators and dischargers when affected by an odour issue. Members of the public may take common law action if they are not satisfied with the response from a council or an industry.

When uncertainty and conflict increase between the industry and community, usually the time and cost required to resolve issues also increases. This guide recommends that dischargers are quick to investigate or acknowledge if there is a problem and work with communities to find solutions as a priority.

1.3 Status

The recommendations in this guide are not legislative requirements under the RMA or any other legislation. However, they are based on expert advice and consultation with practitioners involved in odour assessment, and regulators charged with managing offensive odours. As such they should be given reasonable weight in decision-making processes.

It is always difficult to recommend one set of procedures or assessment criteria for application on a national basis. Environmental impacts, especially those that are largely subjective such as offensive odours, can vary significantly on a case-by-case basis and procedures that might be right for one situation will not be appropriate for another. Users of the guide should bear this in mind and use the information and guidance reasonably, taking into account the specific circumstances of each case.

When in doubt about following any of the recommendations, it is appropriate to check with your local council. They will be able to tell you what information they need to make decisions and what criteria they are likely to use to determine whether an odour is offensive and objectionable, causing significant adverse effects. They can also explain their rules and requirements for resource consents.

2 Properties and Effects of Odour

2.1 What is odour?

Odour is perceived by our brains in response to chemicals present in the air we breathe. Odour is the effect that those chemicals have upon us. Humans have a sensitive sense of smell and can detect odour even when chemicals are present in very low concentrations.

Most odours are a mixture of many chemicals that interact to produce what we detect as an odour. Odour-free air contains no odorous chemicals. Fresh air is usually perceived as being air that contains no chemicals or contaminants that could cause harm, or air that smells 'clean'. Fresh air may contain some odour, but these odours will usually be pleasant in character or below the human detection limit.

Different life experiences and natural variation in the population can result in different sensations and emotional responses by individuals to the same odorous compounds. Because the response to odour is synthesised in our brains, other senses such as sight and taste, and even our upbringing, can influence our perception of odour and whether we find it acceptable or objectionable and offensive.

2.2 Physical properties and odour perception

How an odour is perceived and its subsequent effects are not straightforward. The human perception of odour is governed by complex relationships, and its properties need to be considered when assessing potential odour effects.

The perception of the intensity of odour in relation to the odour concentration is not a linear but a logarithmic relationship. The same relationship is known to occur for other human senses such as hearing and sensitivity to light. This means that if the concentration of an odour increases 10-fold, the perceived increase in intensity will be by a much smaller amount.

Interactions between mixtures of odorous compounds can also occur. These are known as synergistic effects. An example is where one odorous compound disguises or masks the presence of other compounds. As the odour concentration reduces through dilution, the nature of the odour may change as different compounds dominate the effect; for example, mushroom-composting odour has been observed to have a distinctly different odour character at source than when diluted downwind. The odour intensity experienced by an observer is, in general, not equivalent to the sum of the intensities of the component odorous compounds. The perceived intensity may be greater or less than the components depending on the synergistic effects of the compounds present.

Exposure to an odour can result in people becoming desensitised so that they can no longer detect the odour even though the odorous chemical is constantly present in the air. This is sometimes known as 'olfactory fatigue'. For example, people working in an environment with a persistent odour are often unaware of its presence and may not be aware that the odour is having an impact on the surrounding community.

Conversely, individuals may become sensitised to olfactory stimulants through acute exposure events or as a result of repeated exposure to nuisance levels of odours.

2.3 Effects of odour

Under the RMA, the main concern with odour is its ability to cause an effect that could be considered 'objectionable or offensive'. An objectionable or offensive effect can occur either where an odorous compound is present in very low concentrations, usually far less than the concentration that could harm physical health, or when it occurs in high concentrations. Where the offensive odour is caused by high concentrations, contaminants in the odour may also be causing direct health effects such as skin, eye or nose irritation, and these should be considered in addition to any potential odour impacts. Repeated or prolonged exposure to odour can lead to a high level of annoyance, and the receiver may become particularly sensitive to the presence of the odour.

Effects that have been reported by people include nausea, headaches, retching, difficulty breathing, frustration, annoyance, depression, stress, tearfulness, reduced appetite, being woken in the night and embarrassment in front of visitors. All of these contribute to a reduced quality of life for the individuals who are exposed.

People can develop physiological effects from odour even when their exposure is much lower than that typically required to cause direct health effects. This effect is sometimes termed 'odour worry' and is due to the perception that if there is a smell it must be doing physical harm.

2.4 Factors influencing odour effects

Whether an odour has an objectionable or offensive effect will depend on the frequency, intensity, duration, offensiveness[1] (or character), and location of the odour event. These factors are collectively known as the FIDOL factors and are described in Table 2.1.

Different combinations of these factors can result in adverse effects. For example, odours may occur frequently in short bursts, or for longer, less-frequent periods, and may be defined as having 'chronic' or 'acute' effects (section 2.5).

Depending on the severity of the odour event, one single occurrence may be sufficient to deem that a significant adverse effect has occurred. However, in other situations the duration may be sufficiently low and the impact on neighbours sufficiently minor that the frequency of events would need to be higher before an adverse effect would be deemed to have occurred.

[1] In this context, offensiveness is one consideration in whether there is an 'objectionable or offensive' effect occurring as a result of exposure to odour.

Table 2.1: Description of the FIDOL factors

Frequency	How often an individual is exposed to odour
Intensity	The strength of the odour
Duration	The length of a particular odour event
Offensiveness/character	The character relates to the 'hedonic tone' of the odour, which may be pleasant, neutral or unpleasant
Location	The type of land use and nature of human activities in the vicinity of an odour source

The sensitivity of the receiving environment must be taken into account under the RMA and therefore should be considered as part of any odour assessment. The degree of sensitivity in a particular location is based on characteristics of the land use, including the time of day and the reason why people are at the particular location (e.g. for work or recreation). Different locations have different sensitivities to odour and can be classified as having high, moderate or low sensitivity.

The sensitivity that can be assigned to a range of different land uses is described in Table 2.2. This table should be considered as a guide only, and offers comment on issues that contribute to the assessment of sensitivity of the receiving environment. Reference should be made to the local regional plans, and to district/city plans where specific amenity values for various land-use zones may be defined. Regional council staff should be able to assist in working out the degree of sensitivity of the surrounding land use.

Table 2.2: Examples of sensitivity for different land uses

Land use type	Sensitivity classification			Comments and reasons for classification
	High	Mod	Low	
Residential/ living (high-density residential)	✓			People of high sensitivity to odours can be exposed. People can be present at all times of day and night, both indoors and outdoors. Visitors to the area who are unfamiliar with an odour are likely to raise awareness of a problem. In cases of mixed land uses, where the residences are present with industry, the use may be judged to have the same sensitivity as residential depending on the circumstances.
Rural residential (low-density residential, minimum property size around 1 ha)	✓		✓	Lower population density, therefore less opportunity for exposure to odour. People of high sensitivity can be exposed at all times of the day and night. Rural-type background odours may be present but are usually lower intensity than in a rural zone. Residents tend to work in cities and return home at night or weekends and may not be desensitised to rural-type odours. Can be sensitive to non-rural-type odours (e.g. rendering plant or landfill odours). Overall high or low sensitivity, depending on the circumstances of the particular area.
Rural	✓		✓	Low population density means low opportunity for exposure to odour. People living in and visiting rural areas generally have a high tolerance for rural-type odours. May be highly sensitive to non-rural type odours (e.g. rendering plant or landfill odours).

Land use type	Sensitivity classification			Comments and reasons for classification
	High	Mod	Low	
Heavy industrial			✓	A mix of odours is generally tolerated in industrial zones, as long as the intensity is not severe. People in these areas tend to be adults in good health and are more likely to tolerate some odour without finding it to be objectionable or offensive, particularly if the odour is associated with their employment (and source of income). Odours emitted from ground level sources tend to produce the greatest effects at night, when the occupancy of an industrial zone is low or nil, therefore the opportunity for exposure is low.
Light industrial		✓		Characterised by a mix of small industrial premises and commercial/retail/food industry activities. The latter are often incompatible with industrial odour effects, hence the sensitivity is described as moderate even though occupation is likely to be low at night.
Light commercial/ retail/business/ education/ institutional	✓			Similar in sensitivity to the high-density residential area, as it affects people of all ages and health status. Hospitals and schools tend to be land uses where people expect better-than-average air quality. Depending on the mix of development, human occupation may be low at night, which can moderate the sensitivity slightly, particularly if dispersion from the odour source is poorest at night.
Open space/ recreational	✓			People tend to be more aware of air quality when undertaking outdoor activities and exercise, and sensitivity is heightened. People of all ages and health status can be present. People are more likely to be present during the day but events can also be held at night. People are often visitors from other parts of the city or country who are more likely to be sensitive to odours they are not used to. Sports fields may be moderately sensitive and need to be considered on a case-by-case basis.
Tourist/ conservation/ cultural/marae	✓			Generally have high environmental or spiritual value and a low tolerance to exposure to odours.
Public roads			✓	Generally low sensitivity because people using the roads are only present for a short period of time.

Other factors that may determine whether an objectionable or offensive effect from an odour emission is likely to occur are the presence of background odours, factors influencing perception, and the mental and physical state of the affected person. Cultural issues such as the presence of marae, mahinga kai, and waahi tapu should also be considered (Ministry for the Environment, 2001c).

Odour perception is often related to the source of an odour and whether the activity causing it is considered acceptable in a particular location. An odour associated with a natural source, such as mudflats or geothermal activity, may be accepted whereas a similar odour from an industrial activity may not.

Perception and acceptability are also affected by whether people believe an odour contains harmful chemicals. In such cases a person is more likely to consider the odour to be objectionable or offensive – even dangerous – despite the likelihood that the concentration of the chemical in the odour is too low to cause direct health effects.

Perception is also an important factor where the activity generating the odour is considered offensive in nature or is culturally offensive. This can cause an adverse reaction in the people who detect odours from such activities regardless of other factors (e.g. cremation and sewage treatment).

High levels of background odour in an area can desensitise people to a specific odour, and the addition of other similar odours may go unnoticed. Conversely the cumulative effects from additional odour may result in the odour becoming unacceptable. The likely effect depends primarily on the nature of the odours and the location in which they are occurring. If the nature of the odour is quite different to the background odour, then the background odour will probably not affect the perception of odour from a new odour source.

Sensitisation can also occur where an incident with significant adverse effects changes a person's threshold of acceptability for an odour. This can result in a high level of complaint over the long term and a general distrust within the community of those perceived as responsible for the odour. Conversely, desensitisation or adaptation is a reduction in the perceived odour intensity and/or effect following repeated exposure. This can occur on a short-term basis from olfactory fatigue. Adaptation is a long-term process that can occur when communities become increasingly tolerant of a particular source of odour, which is primarily a psychological response to the situation. For example, where odours are associated with a local industry that is considered to be important for the wellbeing of the local community and the industry maintains a good relationship with community members, then adaptation to the odour effects can occur over time.

Recommendation 1

Odour assessments should take into account:

- the frequency, intensity, duration and hedonic tone of the odour
- the sensitivity of the receiving environment
- background odours
- potential sensitisation
- perception and cultural issues.

2.5 Classification of odour effects as chronic and acute

Objectionable and offensive effects from odour can occur from low-intensity, moderately unpleasant odours occurring frequently over a long period, or from high-intensity, highly unpleasant odours occurring infrequently. These effects relate to different combinations of the FIDOL factors and can be termed 'chronic' and 'acute' effects respectively. It is useful to know what type of effect predominates, although odour effects will often result from a combination of acute and chronic odours. Knowledge of the predominant effect is useful for discussing and selecting the appropriate tools to assess and mitigate odours. Chronic and acute effects are encompassed in the definition of 'effect' under the RMA, which refers to temporary, permanent and cumulative effects (section 3.3).

The most significant effects of odour emissions from processing and manufacturing industries will typically be chronic effects. The main odour discharge in processing and manufacturing is normally a continuous or semi-continuous emission, and the main emission sources are often controlled and quantifiable, but there may be a low-level residual odour present for much of the time. Cumulatively, the low-level odour may have an adverse effect even though no single odour event considered in isolation could reasonably be assessed as objectionable or offensive. For chronic odour effects a longer-term assessment of the frequency and character of odour impacts is required.

Acute odour effects are those that can be considered objectionable or offensive on a single occasion. Acute effects typically arise from abnormal or upset conditions such as a malfunctioning biofilter, or infrequent activities such as re-opening old areas of fill at a landfill site. Acute odour impacts are usually from highly variable and/or uncontrolled discharges and are typically very difficult to quantify. The significance of an effect or a potential effect will often depend on the management practices employed.

Recommendation 2

Odour assessments should consider whether the odour discharge is likely to cause chronic effects (low-intensity odour occurring frequently over a long period), or acute effects (high-intensity odour occurring infrequently), or both.

3 Legislation and Case Law

3.1 Relevant legislation

The Resource Management Act (RMA) is the primary piece of legislation under which odour discharges are regulated in New Zealand. The Health Act contains provisions relating to nuisances (section 29) that can be enforced by city and district councils where anyone permits or causes a nuisance.

The Health Act enables territorial authorities to appoint health officers and make bylaws to secure the abatement of nuisances that are likely to be injurious to health or that are offensive. However, the fines and other enforcement provisions available under the RMA mean that this has tended to assume greater importance than the Health Act.

This section focuses on the legislative basis for odour management, key definitions, regulatory responsibility and case law that has been established under the RMA.

3.2 RMA definitions

3.2.1 Purpose of the RMA

Section 5(1) sets out the purpose of the RMA, which is "to promote the sustainable management of natural and physical resources". Section 5(2)(c) provides for this to occur while "avoiding, remedying, or mitigating any adverse effects of activities on the **environment**".

Section 2 of the Act defines 'environment' and 'amenity values' as follows:

Environment *includes –*

- *(a) ecosystems and their constituent parts, including people and communities; and*
- *(b) all natural and physical resources; and*
- *(c) amenity values; and*
- *(d) the social, economic, aesthetic, and cultural conditions which affect the matters stated in paragraphs (a) to (c) of this definition or which are affected by those matters.*

Amenity values *those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes.*

Since offensive odours can be considered to cause effects on amenity values, people and communities, they can be managed under the RMA.

3.2.2 Section 9: Use of land

Section 9 of the RMA provides that a person may use land in any manner they like provided it does not contravene a rule in a plan. If the activity contravenes a rule then a resource consent is required, except when existing use rights apply. The production of odour from a land use is not controlled by a district plan unless the plan includes restrictions on the effects of land uses that cause odour emissions.

3.2.3 Section 15: Discharge of contaminants

The compounds that cause odour effects are air contaminants, therefore their discharge is controlled under section 15 of the RMA. Under section 15(1) discharges from industrial or trade premises are only allowed if they are authorised by a rule in a regional plan, a resource consent, or regulations. If the activity is prohibited under the plan then no resource consent can be obtained.[2]

Under section 15(2) the opposite presumption applies to discharges from any other source. Unless these sources are controlled by a rule in a plan, discharges are allowed as of right and resource consent is not required.

3.2.4 Section 17 and enforcement provisions

Section 17 of the RMA imposes an overriding duty upon every person to avoid, remedy or mitigate any adverse effect on the environment. The duty can be enforced by enforcement orders or abatement notices to require a person to cease doing something that is or is likely to be noxious, dangerous, offensive or objectionable to such an extent that it has or is likely to have an adverse effect on the environment. Relevant enforcement provisions are sections 314(1)(a)(ii) and 322(1)(a)(ii).

Odour emissions are typically classed as being objectionable or offensive to the extent that they are adversely affecting the environment. Odours do not normally become directly harmful to people's health because this usually only happens when the chemicals within an odour reach very high concentrations, much higher than their odour threshold. This is not to say that odours do not cause serious effects if individual compounds within them are below their health effects thresholds. 'Avoiding objectionable and offensive effects' is often used in resource consents and regional and district plans to describe the minimum requirement for an air discharge potentially resulting in odour.

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[2] Section 418 transitional provisions of the RMA carried over the licensing schedules under the (now repealed) Clean Air Act until plans could be developed. Most regional and unitary councils have a proposed or operative plan under the RMA, so section 418 is no longer relevant for most air discharges.

3.2.5 Regulatory responsibilities for odour

Odour is produced both as a result of the use of land and from discharges to air, land or water and can therefore be covered by sections 9 and 15 of the RMA, as discussed above. Section 30 of the RMA specifies regional council functions including the control of discharges into or onto land, air or water and discharges of water into water. Section 31 covers the functions of territorial authorities, including the control of any actual or potential effects of the use, development or protection of land.

There are clearly options for integrated management between regional and district councils and the focus should be on integrating requirements in plans and joint decision-making. To ensure that there are no gaps in the management of odour or any duplication of effort, a clear protocol between territorial authorities and regional councils about their roles is recommended, and information sharing and discussions should take place regularly. Advice on dealing with conflicts and overlapping functions in rural areas can be found in *Managing Rural Amenity Conflicts* (Ministry for the Environment, 2001b).

Recommendation 3

Where potential overlapping functions exist, regional and district/city councils should establish a clear protocol outlining roles and responsibilities to avoid duplication of effort, inconsistent rules and excessive regulation.

3.3 Case law principles

This section summarises some principles that have been considered or established in case law under the RMA, and which are relevant to odour management. The principles that apply are often specific to a particular set of circumstances and no one ‘rule’ will apply to all cases. A full summary of the cases quoted can be found in Appendix 2 of the Technical Report (Ministry for the Environment, 2002c).

3.3.1 Objectionable and offensive

The legal context for the terms ‘objectionable’ and ‘offensive’ is provided in section 3.2.4, which discusses section 17 of the RMA. Cases that are relevant to the consideration of objectionable and offensive effects under the RMA are *Zdrahal,*[3] *De Coek*[4] and *Minhinnick*.[5] In these cases it was noted that whether something was noxious, dangerous, offensive or objectionable had to be linked to whether it was of such an extent that it has or is likely to have an adverse effect on the environment.

3 *Zdrahal* v *Wellington City Council* [1995] 1 NZLR 700; (1994) 2 HRNZ 196; [1995] NZRMA 289 (HC).

4 *De Coek* v *Central Otago District Council* [1995] NZRMA 324.

5 *Watercare Services Ltd* v *Minhinnick* [1998] 1 NZLR 294; (1997) 3 ELRNZ 511; [1998] NZRMA 113 (CA).

In *Zdrahal*, the test for what may be offensive or objectionable was discussed. It was *not* considered sufficient that:

- a neighbour or other person within the relevant environment considers the activity or matter to be offensive and objectionable; or
- that the Tribunal itself might think the matter was objectionable.

The then Planning Tribunal considered that the person must not be hypersensitive but that their views must be "reflective of the opinions of a significant proportion of the public". The Tribunal found that in order to decide on such a matter, it must transpose itself into the ordinary person representative of the community at large. This means that for an odour to be considered objectionable or offensive in the eyes of the Court, information on the effects of the odour must be gathered which demonstrates that the test of the ordinary reasonable person can be met. This generally means that a history of complaint information, council officer investigations and evidence from affected parties is needed for such a case.

3.3.2 Effects

'Effect' is defined in section 3 of the RMA as including:

> *a) any positive or adverse effect; and*
>
> *b) any temporary or permanent effects; and*
>
> *c) any past, present, or future effect; and*
>
> *d) any cumulative effect which arises over time or in combination with other effects –*
>
> *regardless of the scale, intensity, duration or frequency of the effect, and also includes –*
>
> *e) any potential effect of high probability; and*
>
> *f) any potential effect of low probability which has a high potential impact.*

Two cases have considered the meaning of 'effect' in relation to odour emissions, in particular, temporary odour effects of low probability (acute effects). Different outcomes have resulted depending on the circumstances. In *Te Aroha Air Quality Protection Appeal Group* v *Waikato RC*[6] the risk of objectionable odour from a proposed rendering plant, although of low probability, was considered unacceptable given the sensitivity (zoning) of the receiving environment and the non-complying status of the proposed activity in terms of the district plan. In *RC Vosper & Sons Ltd* v *New Plymouth DC*[7] the risk of an odour from a proposed cremator was not considered to be one of "high potential impact". This was because although the odour could be considered offensive by association with the activity, it would be temporary and not liable to affect a wide area.

Current case law does not include the use of the terms 'chronic' and 'acute' that are introduced in this guide. However, their meanings are reasonably consistent with the definition of 'effect' given above in subsections (e) and (f) respectively.

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6 (No 2) (1993) 2 NZRMA 574 (PT).

7 [1994] NZRMA 324 (PT).

3.3.3 Internalisation

The principle of 'internalisation' is that those who create adverse effects must confine them within their own sites rather than force society to bear the burden of dealing with them. This principle has its origins in common law associated with property rights and nuisances. Two cases under the RMA that relate to internalisation are *Hill* v *Matamata Piako DC & Waikato RC*[8] and *Winstone Aggregates Ltd* v *Papakura DC*.[9] In these cases the Court found that objectionable effects could not be contained within the site and so deferred the applications for resource consent until it could be demonstrated that odour effects could be controlled via procedures documented in a management plan.

In Hill v Matamata Piako DC & Waikato RC the Court stated:

> *We reiterate again in this decision that we are of the view that adverse effects such as objectionable odour emissions should be confined on site. People living and working in rural neighbouring properties adjacent to sites where intensive farming such as broiler chicken rearing is carried out should not be subjected to objectionable and nauseating odours. It is incumbent upon the industry as a whole and upon individual farmers to so arrange their affairs in the way of siting, management, technology and feed formulations to ensure that objectionable odours are confined on site. This may well involve extra cost to the industry generally and to particular farmers. As a general principle we are of the view that such cost should be borne by the industry in the event that the siting of operations is such that there is potential to cause adverse effects.*

The Court accepted that a condition requiring a buffer zone to disperse odours and prevent adverse effects may be reasonable in certain circumstances, but only where all reasonable measures have first been implemented to internalise the adverse effects.

3.3.4 Reverse sensitivity

The term 'reverse sensitivity' refers to the constraints that an activity may impose upon another less-sensitive activity. *Auckland RC* v *Auckland CC*[10] defines reverse sensitivity and confirms that it is appropriate in some circumstances to make provisions addressing reverse sensitivity in district plans.

In *McMillan* v *Waimakariri DC*[11] a zone change to allow for a subdivision adjacent to two pig farms was declined on the basis that the change did not meet the purpose of the RMA. This was because the plan change would not be an efficient use of land in the area and the pig farms would challenge the amenity values of the subdivision. In this case it was considered that there was adequate land available in the district for rural–residential development.

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8 (EnvC) A065/99.

9 (EnvC) A096/98.

10 (EnvC) A010/97.

11 (EnvC) C87/98.

All activities are still under an obligation to avoid, remedy or mitigate adverse effects and contain adverse effects within their own sites; the overriding duty in section 17 still applies. *Managing Rural Amenity Conflicts* (Ministry for the Environment, 2001b) provides more detail and case law on internalisation and reverse sensitivity.

3.4 Resource consent conditions

Conditions in resource consents relating to odour must be clear, reasonable and enforceable. But because odour effects are often highly subjective there are special considerations when formulating consent conditions for odour discharges. In particular, a condition relating to 'no objectionable or offensive odour' will often be supported by other types of conditions. Examples of the types of resource consent conditions that may be applicable are:

- odour emission limits (e.g. measured from a stack or over an area)
- control equipment performance requirements (e.g. odour concentration)
- control equipment requirements (e.g. specifying biofilter depth, or incinerator temperature and retention time)
- operating and management requirements.

Design specifications are sometimes used in consent conditions to ensure that control equipment meets a minimum acceptable standard. The degree of specification needed in the consent depends in part on the track record of the consent holder in applying the best practicable option (section 3.4.2), and the amount of information provided in the application. There needs to be a balance in the conditions between flexibility for the consent holder to use any technology to achieve odour reductions, and certainty for the regional council and neighbours that appropriate technology will be utilised.

Some legal principles for formulating conditions relating to odour effects are discussed below. Guidance on consent duration for odorous activities is not provided. For further information on drafting consent conditions, refer to *Effective and Enforceable Consent Conditions* (Ministry for the Environment, 2001a) and Appendix 2 of the Technical Report (Ministry for the Environment, 2002c), or contact your local council.

3.4.1 Objectionable and offensive odour

Based on the discussion in this report, the recommended consent condition for the environmental effect of an odour is that it should be of the general form:

> *There shall be no objectionable or offensive odour to the extent that it causes an adverse effect at or beyond the boundary of the site.*

It is usually insufficient for an odour to simply be detected at or beyond the boundary of a site. As discussed in section 3.3.1, the odour must be sufficient to create an adverse effect and the odour must be objectionable or offensive in the opinion of an 'ordinary reasonable person'. Further, for a breach of the condition to occur it would generally not be sufficient for one person or one council officer to find an odour objectionable in a one-off situation unless it can be demonstrated that an adverse effect has occurred in that instance. Whether there is a breach is always dependent on all of the FIDOL factors. All the recommended assessment methods are to assist in determining whether the above consent condition or minimum standard can be, or is being, complied with for an individual discharge source. Sufficient proof is required before enforcement action can be taken in relation to this condition.

> **Recommendation 4**
>
> Conditions imposed upon resource consents should be: for resource management purposes, certain, relevant to the discharge, reasonable and enforceable.
>
> The recommended condition for odorous discharges is: *"There shall be no objectionable or offensive odour to the extent that it causes an adverse effect at or beyond the boundary of the site."*
>
> The descriptors 'objectionable' or 'offensive' should always be used in conjunction with the term 'effect' rather than 'objectionable or offensive odour' *per se*.

3.4.2 Applying the best practicable option

Section 108(1)(e) of the RMA makes provision to include a condition requiring the consent holder to adopt the best practicable option to control any adverse effects caused by a discharge. The best practicable option (BPO) in relation to the discharge of a contaminant or an emission of noise is defined in section 2 of the RMA as the best method for preventing or minimising the adverse effects on the environment, having regard to:

> *(a) the nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and*
>
> *(b) the financial implications, and the effects on the environment, of that option when compared with other options; and*
>
> *(c) the current state of technical knowledge and likelihood that the option can be successfully applied.*

The Medical Officer of Health v *Canterbury Regional Council and Ravensdown Fertiliser Co-operative Limited*[12] dealt with the BPO under section 108. The then Planning Tribunal stated that in its view the key word was 'practicable':

> *Practical effect is given to those requirements* [the provisions of section 108] *by ensuring that the contaminants discharged by the applicant are at a level which on the best scientific and technical information available constitute the best practicable option of minimising adverse effects on the environment.*

In that case, odour from the factory was said to be capable of adversely affecting the amenity values of the area. But the Planning Tribunal noted that there was nothing known to science and technology at the time of the case that meant odours from the factory could be completely eliminated. The Tribunal was satisfied that all that was practicable at the time was being done to minimise the adverse effects of the odour discharge on the environment. The Tribunal considered that its duty was to ensure that suitable conditions are imposed which require the applicant to adopt the BPO for preventing or minimising odour into the surrounding

[12] (PT) W109/94.

community. Therefore, the BPO does not necessarily mean the complete elimination of adverse environmental effects. However, if adverse effects are significant despite applying the BPO then it brings into question whether the consent should be granted.

The BPO is restricted under section 108(8) of the RMA so that the inclusion of a condition requiring the BPO must be the most efficient and effective means of preventing or minimising any actual or likely adverse effects on the environment to an "acceptable" odour effect level. When applying the test of efficiency and effectiveness, the regulatory authority needs to consider not just the efficiency from the applicant's viewpoint but also from the council's and the community's perspective.

In *Australasian Peat Limited* v *Southland Regional Council*[13] the Planning Tribunal required *certainty* in relation to a condition requiring the best practicable option for the control of dust. The Tribunal stated that the best practicable option must be specified, i.e. that the measures to control dust must be included in the consent. Therefore BPO conditions must include specific details about the equipment required and performance standards that should be monitored to ensure the ongoing effectiveness of the BPO.

Further information on odour control and best practice guidance is provided in section 5.2.

Recommendation 5

The best practicable option for minimising emissions should not be considered in isolation from the potential for adverse odour effects from the activity. Likewise, industry codes of practice should not be solely relied upon as proof that odour effects are acceptable.

The best practicable option should be clearly defined and relate to the specific methods and technologies used to minimise odour emissions. There should be some flexibility provided to enable change, provided the effects remain the same or decrease.

Performance standards relating to the best practicable option should be included in consent conditions. These can include treatment efficiency and operating specifications to ensure that engineering systems are appropriately designed.

3.4.3 Management plans

There are two different approaches to management plans:

1. the management plan may be approved by the local authority (or the Court – in the case of an appeal) and written into the conditions of the resource consent; or
2. the resource consent requires the consent holder to prepare and lodge a management plan with the local authority after the consent is granted.

[13] (PT) C44/96.

Relevant cases where the Court required the management plan to be approved and incorporated into consent conditions are *Hill* v *Matamata Piako DC*[14]and *Purnell* v *Waikato RC*.[15] In *Hill* the Court held that that the proponent of a chicken broiler operation must satisfy the Court that a proper management system would be put in place to sufficiently mitigate the effects of odour before a consent could be granted.

In *Wood* v *West Coast RC*[16] and *Walker* v *Manukau CC*[17] the Court has taken the approach of allowing a consent holder to lodge a management plan from time to time with the local authority. The Court agreed, in the case of noise, that:

> *... specific noise control limits can be laid down but the way in which these are to be complied with is for the consent holder who can be required to provide a management plan containing information about the method of compliance. However, because technology might change over time the consent holder should have the ability to change the management plan without having to go through the process of seeking a change to the conditions of consent.*

In the case of *Walker* the Court held that consent conditions requiring a management plan to be approved by an officer are invalid, stating:

> *Either there should be a management plan prepared now, approved by this Court, and written into the conditions of the land use consent, or there should be no more than a requirement that the consent holder prepares and lodges a management plan from time to time with the respondent.*

Where site management is critical to ensuring good odour performance, management-based controls should be identified at the time of the consent application. This can take the form of a management plan that, for complex activities, may need to be submitted as a draft for later approval. Specifying management techniques at the time of considering the consent provides a level of certainty that the odour effects condition can be achieved. More information on management plans can be found in sections 4.9 and 5.2.2.

Recommendation 6

Conditions relating to management plans cannot reserve the power to approve conditions outside the formal resource consent process.

Conditions must not unlawfully delegate or defer matters essential to the consent itself.

A management plan designed to mitigate objectionable or offensive odour effects should be comprehensive and made available at the time of applying for the resource consent.

14 (EnvC) A065/99.

15 (EnvC) A085/96.

16 (EnvC) C127/99.

17 (EnvC) C213/99.

4 Odour Assessment

4.1 Why assess odour discharges?

The effects of odour emissions are assessed for a wide range of reasons, including complaint investigation and resource consent applications. The amount and type of information required for an assessment depends on the circumstances of the odour discharge and the reason for undertaking the assessment. Usually the aim of the assessment is to determine whether the odour is offensive and objectionable and therefore causing adverse effects on the local community.

Odour assessments can generally be categorised as being needed for one of five reasons:

1. investigating odour complaints
2. resource consent applications or consent review to renew an existing activity
3. resource consent to modify an existing activity
4. resource consent for a proposed activity
5. monitoring compliance with resource consent conditions.

4.2 What information is required?

Odour assessments can be conducted based on a combination of approaches and information from a range of sources, including:

- the odour complaint history
- experience with the discharge and past compliance
- community consultation
- odour diaries, community surveys, and other surveying tools such as field investigations
- dynamic dilution olfactometry (DDO) measurements
- odour dispersion modelling
- site management and contingency plans, and whether the best practicable option (BPO) is being applied
- process controls and design, including records of emission control improvements undertaken or proposed and engineering risk assessment for system failures
- analysis of site-specific wind and topographical features
- experience and knowledge from other sites of a similar nature, scale and location.

Advice on each of these methods is contained in the following sections. Guidance on choosing which ones are most useful for a particular assessment is provided in the assessment decision trees in Appendix 1 and below. The types of assessments are divided into three categories:

- category 1: existing activity – a resource consent renewal, compliance monitoring or complaint response
- category 2: modifications to an existing activity
- category 3: a proposed activity.

Selecting the appropriate assessment method should include consideration of whether the effects are likely to be acute or chronic. The techniques and information sources recommended are generally applicable to either chronic or acute effects. However, the use of dynamic dilution olfactometry (DDO) measurement and dispersion modelling to investigate acute effects is not recommended in most circumstances due to its limitations (see sections 4.10 and 4.11).

Please note that the decision trees in Appendix 1 should only be considered as a guide. Assessment methods may deviate from those outlined on a case-by-case basis depending on the circumstances.

4.2.1 Category 1: existing activity

Category 1 assessments are for a consent renewal for an existing activity with no process changes, or for compliance monitoring. The primary information source for assessing category 1 odours are council experience with the site (compliance monitoring reports, etc) and community feedback, such as from complaints, community groups or consultation, and/or surveys. If significant adverse odour effects are found to be occurring, then changes will be required and the activity will fall into category 2.

Process controls and operations, including emission control improvements and documented management systems, can also be important information for consent renewals. This kind of information may also be required for monitoring and complaint investigation depending on the requirements of any consent held.

Dispersion modelling is not generally recommended as a tool for assessing whether significant adverse effects are occurring from category 1 activities.

4.2.2 Category 2: modifications to an existing activity

Where modifications are proposed to an existing activity, the existing level of odour effect should usually be assessed to provide baseline information. The baseline should be established using the methods for category 1 activities. Odour dispersion modelling should not be used to try to prove the absence of an adverse effect when community data can be collected or is already available to demonstrate the current level of effect. Where modifications such as a plant expansion or installation of odour controls are proposed, the effect of the changes on the potential for odours must be assessed. The assessment of whether the proposal is likely to create odour effects and/or whether mitigation is sufficient should be based on information from other sites, known performance and proven control technology, and/or dispersion modelling. Modelling can be useful as a tool for undertaking a comparative assessment of the significance of various odour sources, or for identifying the degree and range of community impacts so that community surveys and diaries can be designed.

4.2.3 Category 3: a proposed activity

For a new activity in a location where there is presently no activity of the type proposed, the assessment must be based on dispersion modelling results or past experience with the same activity and the proposed controls in other locations. Modelling can be difficult where odour emission-rate data are not readily available, or the use of data from another site cannot be readily transferred or easy to justify. For new activities conservative assumptions are often required in the modelling, and in some circumstances it may not be appropriate to model at all because of the lack of justifiable data for the model. In these cases the assessment should rely on experience from other sites in conjunction with site-specific considerations.

Recommendation 7

Before commencing an odour assessment:

- determine which assessment tools are the most effective for the specific discharge and situation using the categories above and the decision trees provided in Appendix 1
- determine whether the potential effects are likely to be caused by continuous/semi-continuous process emissions (chronic effects), or by infrequent emission events (acute effects).

Use the decision trees in Appendix 1 to determine appropriate assessment methods depending on the category into which the activity falls.

Only use odour dispersion modelling for new activities where the predominant odour effect is due to normal process discharges that are continuous or semi-continuous and reliable odour emissions data are available.

Do not use odour dispersion modelling to try to prove the absence of an adverse effect when community data can be collected, or are available to demonstrate the current level of effect.

Do not use dynamic dilution olfactometry (DDO) measurement and dispersion modelling to investigate potential acute effects of odour discharges.

4.3 Complaint investigation and analysis

4.3.1 General principles

Odour complaint data can be a good indicator of the effect of an odour discharge, particularly where there is a relatively dense population. But complaint records do not necessarily indicate the full degree of adverse effects because many people will not complain even if they are very annoyed, and others will give up making complaints if they feel they are not making any difference.

Sometimes complaints are made for vexatious reasons, or by people who are sensitised or have vested interests. These factors can reduce the overall usefulness of the complaint records because they may skew the complaint frequency data compared to other evidence of adverse effects.

Sometimes there is a lower complaint rate than would otherwise be expected because the population exposed to the odour is reduced when people are away from their homes while the odour effects are occurring. They may, for example, be at work.

Odour complaint data may be of less value:

- in areas with low population density
- when other sources of odour are present
- when complaint records cannot be validated with wind data.

Complaints that have been validated during an inspection by a council officer and/or cross-checked against wind direction are extremely useful, regardless of population density or other odour sources.

Councils have a duty under section 35(5)(i) of the RMA to record a summary of all written complaints received concerning alleged breaches of the RMA and the details of how the complaint was dealt with. When a complaint is received, the details should be recorded in a complaint database or log, as discussed in section 4.3.2. If a site inspection was not possible, date, time and location information can be used with the operating status of the alleged source and data on wind conditions at the time (from monitoring records) to help determine whether the complaint was valid.

Complaints should always be recorded even where the complaint cannot be investigated by a site inspection, such as when staff are unavailable outside normal working hours. Complaint incidents can be used to build up a long-term picture of odour effects and provide a measure of the cumulative effects of repeated incidents.

Recommendation 8

Odour complaint data should be given more weight in odour assessments when validated by a council officer or validated against wind direction data at the time of the complaint.

Complaint data alone should not be relied upon to assess the significance of adverse effects, particularly where:

- there are low population densities
- there are other similar sources of odour
- the complaint records cannot be validated against wind conditions and site operations at the time.

4.3.2 Investigations by council officers

Council officers will usually carry out a site investigation in response to an odour complaint. The officer must form an opinion as to whether the odour is having an objectionable or offensive effect on that specific occasion, and determine the cumulative effect of the odour. Officers should consider the legal interpretation of 'objectionable or offensive effect' to determine whether an adverse effect is occurring (section 3.4).

Consistent procedures for odour complaint investigation and reporting are needed to ensure that the data captured are as useful as possible for assessing the effect of the odour. The procedure followed is particularly important if the complaint records are likely to be used as evidence for enforcement action under the RMA.

It is difficult to validate complaints in every circumstance because odour emissions are often highly variable with time. For example, an odour's intensity may lessen or disappear by the time an officer arrives to investigate a complaint. This may be due to varying wind speed or atmospheric stability between the time the odour complaint was received and when the officer makes it to the site.

Measurements of plume width can help identify sections of the community that are likely to be affected and whether complaints could be expected from elsewhere. Plume width assessment can help determine if odour is fluctuating due to plume movement or emission variation. This helps to develop a general understanding of the nature of dispersion from the odour source, and may be used to identify whether there is odour from other sources. Plume width should be assessed by moving at right angles to the wind direction through the anticipated plume of odour.

When investigating a complaint it is important to complete all off-site investigations before going onto the site of the alleged odour source. This prevents an officer from becoming desensitised from exposure to strong odours at the source before investigating the nature of the effects in the receiving environment. The recommended complaint investigation and recording procedure is provided in Table 4.1. There will be circumstances where following each step in the procedure is unnecessary. Officers should use their judgement to decide what is appropriate to the circumstances; for example, when an odour is extremely intense, 30-minute observations may not be required to determine that an adverse effect is occurring. In such a case it is more important to go on site to determine the source of the odour, perhaps with an expectation that it may be able to be stopped. Another reason not to follow the procedure could be where it is clear that multiple complaints relate to one incident and a detailed investigation has already been undertaken.

Note that where an assessment is being carried out as part of routine monitoring and there is no objectionable or offensive odour, it is sufficient to do a traverse across the wind direction and note the direction, time and location of the inspection.

Table 4.1: Complaint investigation and recording procedure

Step	Action
Step 1: Receive the complaint	1 Record the date, time and location of complaint and the complainant's description of the alleged odour event, including strength, duration and character of the odour.
Step 2: Visit the location of the complaint for at least 30 minutes	2 Record the time of arrival. 3 Assess and record the strength/intensity, character and duration of the odour using the intensity descriptors in Table 4.2 and character descriptors in Table 4.3 (section 4.3.6). 4 Record the wind direction and strength, and weather conditions throughout the investigation and how these were determined. 5 Record the type of impact that the odour has from Table 4.4, considering the location and observations recorded from action 3 above. 6 Assess the width of the odour plume by moving at right angles to the wind direction, where possible. 7 Record the time of departure from the complainant's location.
Step 3: If there is an effect from odour and the source is identified	8 Assess the odour upwind of the suspected source. Where practicable, conduct a 360° sweep around the source to eliminate other possible sources of odour. 9 Record any observations of recognisable odour at other locations surrounding the alleged source, including times of observations at each location. 10 Visit the suspected site causing the odour and explain the findings of the investigation to site staff. 11 Confirm the site operations taking place at the time of the complaint. 12 Request an explanation for the odour discharge (if appropriate, warn that their statement may be used in evidence). 13 Record the name(s) of persons spoken to at the site and their comments. 14 Investigate whether odours are from abnormal or normal operations and record evidence to support the conclusions made.
Step 4: Make overall assessment	15 Make an overall assessment of adverse effects beyond the boundary, as illustrated in Figure 4.2.

When making any contact with site operators/owners, if a council has decided on prosecution, the officer must inform the operator that their statement may be used in evidence.

Where there is an obvious shift in wind direction it may be more appropriate to go to the current position of the plume. If the wind is fluctuating, remain at the complainant's location and carry out the 30-minute intensity assessment to obtain a picture of frequency and intensity as the complainant experiences it.

Council officers should always provide a copy of their report to the site management of the alleged odour source. This allows site management to check the details of the report, note the problem and make any response necessary. Complainants often want to remain confidential, so this needs to be considered when passing information to site management. Complainants should be encouraged to be identified and reassured that complaints are a means of gathering information that can help to diagnose a problem on site.

Some councils have adopted an approach of carrying out proactive investigations. This involves visiting a site at times when odours are likely to occur, and is based on previous complaint records, weather conditions and/or time of day when odour effects are more likely to occur. This may be particularly useful in situations where the officer has been having difficulty validating complaints due to response time after a complaint is logged. Usually validation problems are due to changing weather conditions or short-duration odour events. The approach is also useful for determining whether complainants may be being vexatious. Some examples of proactive monitoring are given in Case Study 1.

Case Study 1: Proactive monitoring

In one case where the council was having difficulty validating complaints, proactive monitoring gave the council confidence to go to the parties with a case that they did not consider the odour was causing an objectionable effect. A review of this case by the Parliamentary Commissioner, the local MP and the ombudsman resulted in the council's position being accepted and no further action was needed, saving resources in the long run.

In another case proactive monitoring allowed the council to quickly confirm that there was a legitimate problem and the council was able to convince the discharger to take action to resolve the problem, again saving time and resources.

Recommendation 9

Council officers should follow the complaint investigation and reporting procedure specified in Table 4.1 to investigate reported odour complaints.

Officers should complete all beyond-the-boundary observations before going on to the site of the odour source.

4.3.3 Independent assessors

In some circumstances independent assessors may be used instead of council officers to investigate complaints. An independent assessor may be used, for example, when the travel distance to the odour complaint is too far for the officer, or where council staff are not trusted, as can happen if a council officer does not agree with the position of one of the parties. In certain situations it may be appropriate for a Justice of the Peace (JP), who has the trust of both the community and company, to be used. They can also be viewed as being entirely independent of the situation, and this often brings about a resolution that is accepted by all parties involved.

4.3.4 Investigation by site workers

People who work at the odour source will often undertake investigations themselves, particularly if the council officers are unable to respond quickly or complaints come directly to site staff.

Where the site has a resource consent to discharge contaminants to air, a condition of the consent will often be to keep records, and to investigate and report any odour complaints received. In this case, the information recorded by the site workers should generally follow the same approach as outlined in Table 4.1.

Records should also be kept of complaints investigated by council officers. Site staff should consider whether an adverse effect is occurring and if so undertake a course of action to remedy the problem.

> **Recommendation 10**
>
> Consent holders should keep records of odour complaints and should follow the procedures outlined in Table 4.1.

4.3.5 Sensitivity of investigators

The variation in people's sensitivity to odour should be considered when investigating odour complaints. Dynamic dilution olfactometry (described in section 4.10) is sometimes used to assess whether a council officer undertaking an investigation is within the normal range of the population and can therefore be considered to be representative. The limitations of this method are that people vary in their sensitivity from day-to-day, the test involves only one chemical (n-butanol), and it is not necessarily representative of sensitivity to all odours in environmental situations. DDO is, however, generally accepted as being useful for screening to assess whether an officer has a highly sensitive or particularly insensitive sense of smell. But the test should not be seen as a 'calibration' of the officer according to a specific standard.

An officer who has a particularly sensitive or insensitive sense of smell can still carry out odour investigations provided they are aware of any 'bias' that may affect their conclusions regarding adverse effects. In cases of ongoing complaint or where prosecution is being considered, a number of council officers should assess the odour to account for varying sensitivity.

When assessing the significance of any off-site odour effects, site workers need to be aware that they may be desensitised to an odour and should be careful to consider the odour from the point of view of someone who does not work at the site.

> **Recommendation 11**
>
> DDO should be used to indicate to staff investigating odours whether they are normal, highly sensitive or insensitive to odour.
>
> Site staff involved in assessing odour incidents should consider whether they might be desensitised to the odour when making their assessment.

4.3.6 Field observations of intensity, character and impact

Details about the intensity, character and adverse effect rating of the odour as recommended in actions 3 and 5 of Table 4.1 should be recorded using the methods described below.

A scale for describing odour intensity during field observations is detailed in the German Standard VDI 3882 (I) (1992): *Olfactometry Determination of Odour Intensity*[18] (Table 4.2). This scale is used in Europe and Australia for grading intensity. Experience using this scale has shown that observations have a good degree of consistency between observers.

Table 4.2: German VDI 3882 odour intensity scale

Odour intensity	Intensity level
Extremely strong	A
Very strong	B
Strong	C
Distinct	D
Weak	E
Very weak	F
Not perceptive	G

The German Standard VDI 3940 *Determination of Odorants in Ambient Air by Field Inspection* procedure for logging observations in the field involves recording the odour intensity every 10 seconds over a 30-minute period in one location. The VDI scale should be used for recording odour intensity versus time information spanning a desirable period of around 30 minutes. This provides short-term information on frequency, intensity and duration factors.

The observations should be carried out for at least 30 minutes. Shorter time periods may result in the observer missing the extent of the effects.

An exception to the 'every 10 seconds for 30 minutes' rule is needed when the odour plume is strong and constant, such as in stable, drainage flow conditions. Staying permanently in the plume will result in the observer becoming desensitised to the odour, so it is appropriate in this case to drive or walk through the plume once every 5–10 minutes, then repeat over a period of at least 30 minutes.

Objective recording of FIDOL factors needs to include the *intrinsic nature* of the odour, which is often referred to as the odour character (such as fishy, sewage, bakery, etc). A suggested table of general odour character descriptions is given in Table 4.3. Councils may wish to add other descriptions to this table for field use.

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18 VDI 3882 – Part (I), Pub. Verein Deutscher Ingenieure, Dusseldorf. Available from Beuth Verlag GmbH, Berlin.

Table 4.3: Odour character descriptors

001	Fragrant	021	Like blood, raw meat
002	Perfumy	022	Rubbish
003	Sweet	023	Compost
004	Fruity	024	Silage
005	Bakery (fresh bread)	025	Sickening
006	Coffee-like	026	Musty, earthy, mouldy
007	Spicy	027	Sharp, pungent, acid
008	Meaty (cooked, good)	028	Metallic
009	Sea/marine	029	Tar-like
010	Herbal, green, cut grass	030	Oily, fatty
011	Bark-like, birch bark	031	Like gasoline, solvent
012	Woody, resinous	032	Fishy
013	Medicinal	033	Putrid, foul, decayed
014	Burnt, smoky	034	Paint-like
015	Soapy	035	Rancid
016	Garlic, onion	036	Sulphidic
017	Cooked vegetables	037	Dead animal
018	Chemical	038	Faecal (like manure)
019	Etherish, anaesthetic	039	Sewer odour
020	Sour, acrid, vinegar		

The investigator should summarise the overall impact of the odour on the complainant. An example impact scale is shown in Table 4.4. This covers a range of impacts that refer to chronic through to acute effects and should not be used at the end of the assessment.

Table 4.4: An example of a scale for rating odour impact

a) The odour can be detected but is not annoying under normal conditions.
b) The odour can be detected but is not annoying, unless it is continuous.
c) The odour is moderately strong and is annoying if it is continuous or if its occurrence is very frequent.
d) The odour is moderately strong and is annoying if it occurs for periods of more than 5 to 10 minutes. Shorter, infrequent occurrences are not annoying.
e) The odour is strong and is annoying even in periods of short duration.

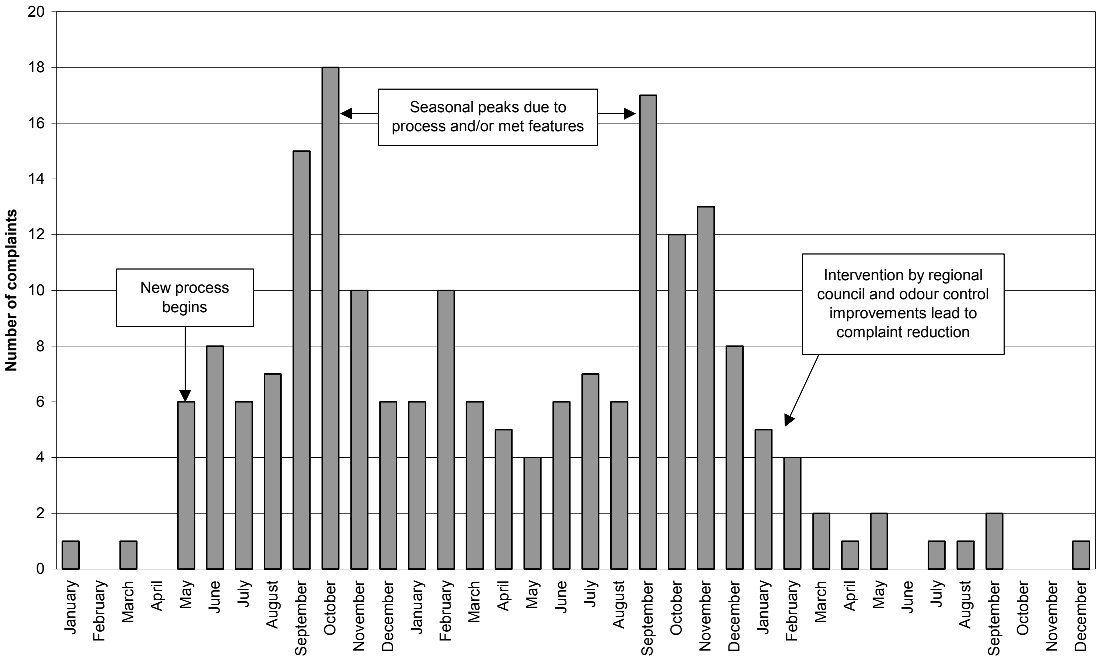
Recommendation 12

The FIDOL factors and impact rating of an odour should be recorded during investigation of an odour incident/complaint based on Tables 4.2, 4.3 and 4.4.

4.3.7 Summarising complaint data

A chronological summary of odour complaints 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 in the prevailing meteorology. An example summary of complaints received following the commencement of a new odour-producing process is shown in Figure 4.1.

Figure 4.1: Example of a complaint frequency graph



It can also be useful to plot wind direction and the frequency of complaints registered from particular locations. The analysis of weather conditions and other parameters, such as time of day and character of the odour, can be very important for identifying the odour source and validating the complaint.

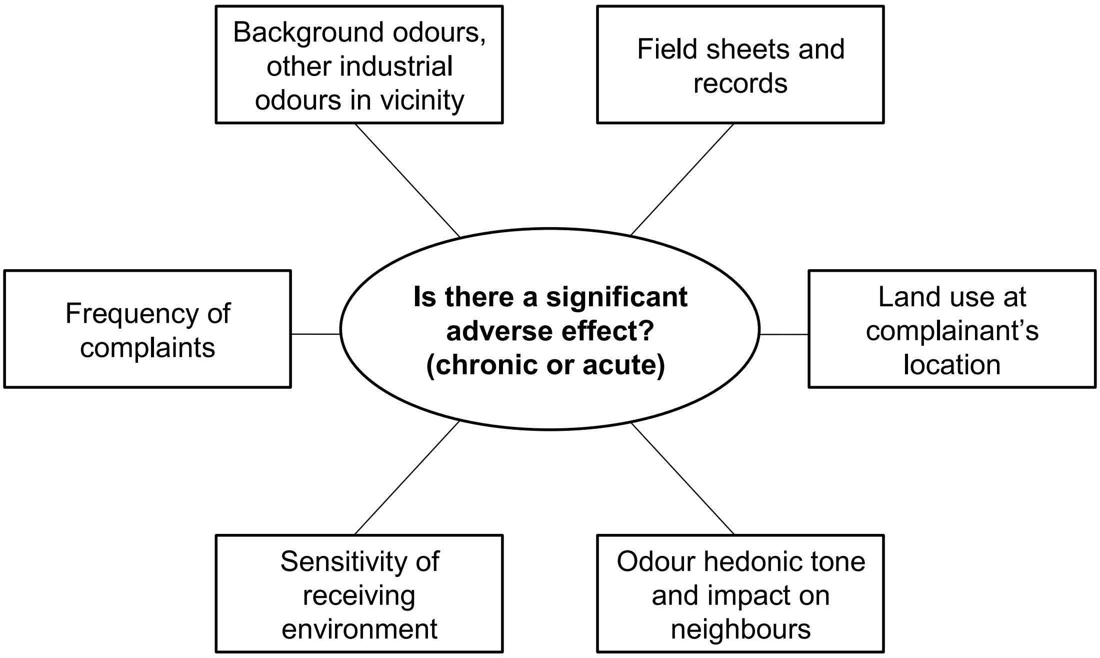
4.3.8 Determining an adverse effect based on complaint data and analysis

Following a complaint investigation or series of investigations, an officer must decide whether the odour is objectionable or offensive to the extent that it was having an adverse effect. The effect could be either chronic or acute, or possibly both. For acute odour events the opinion will be formed during observation in the field. For long-term chronic effects, an overall assessment of repeated observations is required.

Objectionable or offensive effects should be determined on a case-by-case basis by considering the FIDOL factors and other issues discussed in section 2.5. Figure 4.2 illustrates the factors that need to be taken into account when deciding whether there is an adverse effect or not. The methods described in this guide will assist investigating officers to determine the degree of effect, but it will be up to the officer and council (or ultimately the Environment Court) to evaluate each factor and draw conclusions on whether an 'ordinary reasonable person' would consider that the odour is having a significant adverse effect or not.

If decisions cannot be made about the significance of effects based on complaint response and investigations, other methods such as odour surveys and odour diaries may be useful. Some further guidance on using assessments to instigate action is contained in section 5.

Figure 4.2: Factors in considering if there is an adverse effect from odour



4.4 Odour surveys

Odour surveys typically measure 'population annoyance' due to all sources of odour. The results can be used to rank odour sources according to their contribution to the cumulative stress within a community. Odour surveys are limited in that they are only useful in areas where there is sufficient population density to achieve statistically significant results. In low population areas, odour diaries, odour-modelling assessments and complaint records are the preferred methods of assessment.

Odour surveys directly measure the extent of adverse effects resulting from repeated odour impacts in a community. A standard questionnaire for surveys in New Zealand is recommended to ensure that the results between surveys are comparable (see Appendix 2). The survey has questions about the state of the environment in general – not just odour – in order to minimise bias. The questionnaire may be modified to suit particular circumstances or objectives but the Technical Report (Ministry for the Environment, 2002c) should be referred to for further information.

Survey respondents are asked about the level of annoyance they experience from odour. Responses are classified according to the scale in Table 4.5. The key statistic used from odour surveys is the 'percent at-least annoyed' category, which is made up of the responses ranging from annoyed to extremely annoyed.

Table 4.5: Annoyance levels used in odour surveys

Definitely not annoying	
Very little annoyance	
Little annoyance	
Some annoyance	
Annoying	Percent at least annoyed
Quite annoying	
Very annoying	
Extremely annoying	

The steps when undertaking an odour survey are as follows.

1. Identify sub-areas within the community to be surveyed by reviewing historical complaint records and wind data. Within each sub-area the population should be exposed to a similar amount of odour, considering distance from the source and/or prevailing winds. If the sub-area is too large, exposure will vary too much among the group and there will be a wide range of responses that may dilute the results from the affected area with those unaffected. The survey areas should be agreed in consultation with council air-quality staff.

2. Select the population size for the survey. A minimum target of 50–70 respondents from any one sub-group of the community provides a margin of error for the survey in the order of 5–10%.

3. Conduct the survey by a telephone interview. Randomly select phone numbers from a number listing for the area being surveyed. It is usually necessary to obtain three times the number of phone numbers as the sample size. Phone numbers can be purchased from Telecom to order, or for a small township can be obtained by scanning the white pages. If possible, conduct the survey during a two-hour period in the evening. This prevents people in the neighbourhood talking about the survey, which may skew the results.

4. Calculate the percentage of people who were 'at-least annoyed' by odour for each sub-area. Where there are multiple sources, break the survey results down according to the main source(s) identified by respondents.

5. Compare the survey results to those for a control population.

6. Calculate survey margins of error using statistical methods as described by McCullagh and Nelder (1983) or by Perry and Green (1984).

Control data should be gathered by surveying a population that is not affected by any significant odour, in parallel with the affected population. The control population should have similar demographics and culture to the affected population being surveyed and similar exposure to any background odours such as mudflats or geothermal odours.

Typical results from control surveys in New Zealand show that 5–15% of the community report being 'at least annoyed' by industrial odours, even when there are no significant odours (Aurora Environmental, 2000). Fifteen percent at least annoyed is therefore taken to be representative of a community unaffected by odour.

The guideline criterion recommended for assessing survey results is '20% at least annoyed' based on New Zealand experience from control populations.

When interpreting the results of the survey, if the control population has a level of less than 15% at least annoyed, this indicates that the survey methods were correct. If the control population returns a level of more than 15%, the control population may be subject to some odours and is not a true control group.

The 20% at least annoyed criterion allows for a small level of effect that would not be considered objectionable by reasonable people. Twenty percent is the cumulative effect from all sources. The 20% criterion should not be compared to the upper percentile value but to the mid-point of the confidence range, provided that the survey has been carried out according to the appropriate and statistically significant sampling methods.

Recommendation 13

Odour annoyance surveys should be conducted using the questionnaire from Appendix 2.

Target and control populations should be identified in consultation with council air-quality staff.

The acceptable level of cumulative odour impacts due to all sources is ≤ 20 % at-least annoyed.

4.5 Odour diaries

Odour diaries are used by people in affected communities to record their daily exposure to odour. Diaries can be useful for determining particular conditions under which people are affected by odour from a particular source or sources. An example odour diary record sheet is provided as Appendix 4.

A diary programme can be useful for collecting data on the frequency and strength of odour impacts at various locations over a given period. The resulting data can be used to calculate the percentage of time (hours/year) that people are exposed to odours from a specific source, as well as the typical strength and character of the impacts. The information recorded in a comprehensive diary programme 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
- wind direction and strength.

Diarists should be given instructions on how to record information so that it is as consistent as possible. They should also be given feedback on the programme to help maintain their enthusiasm to continue keeping the records.

A less comprehensive diary programme may be sufficient. For example, where the aim is to investigate whether an odour source is still creating some impacts in a community following some improvement in odour control, such as in Case Study 2.

Case Study 2: AFFCO NZ Ltd odour diary programme

A diary programme was used by AFFCO NZ Ltd as a monitoring tool for odour at its Imlay plant in Wanganui. Imlay is a meat-processing plant with a large rendering facility that had a history of odour problems. AFFCO undertook substantial upgrades to its extraction and odour treatment system in 1998 and wanted to establish whether the new system was effective in eliminating rendering plant odours.

AFFCO had undertaken an odour annoyance survey during 1997 to establish the extent of adverse effects on the neighbouring community. An odour diary programme was considered an appropriate tool for the second study in 1998 because a further survey could be affected by a lag between the reduced odour levels and the level of annoyance likely to be measured in the community. A diary programme was used to establish if rendering odours were still occurring as a result of AFFCO's activity, bearing in mind there were other sources of industrial and commercial odour present in the community.

Five residential properties downwind of the rendering plant were used for the programme. Diarists were selected in consultation with the community liaison group that had existed for a number of years.

Six months of diary records were used, along with plant operating status and wind records, which confirmed that the predominant rendering odours had been eliminated. The results also helped to identify other sources of odour within the community and their relative significance.

4.6 Repeat questioning

The German VDI standard 3883 (Part 2) for assessing annoyance by repeat questioning involves using selected individuals within a community to routinely record their annoyance rating from odour at a pre-specified time of the day at a given location. An annoyance index is calculated from the observations and is used to monitor the relative change in the extent of odour impacts over a period of time. There is, however, little experience of this method in New Zealand, so evaluation of the results would be difficult. This method is therefore not recommended for use without further research.

Industries or councils that wish to pursue this method are encouraged to do so in parallel with other survey methods described in this guide. Findings should be made available to other New Zealand practitioners so that the future use of this method and its ability to measure adverse effects can be evaluated.

4.7 Community meetings

Community meetings are often used to gauge the extent of any dissatisfaction due to exposure to odours. Holding an open public meeting is generally a first step and a community liaison sub-group is often established from this meeting. This group can be used as a forum to negotiate solutions and to provide direct and ongoing community input on odour issues. Membership of the liaison sub-group should be decided in a democratic and transparent manner. It must be noted that the views of the group are only indicative of those in the wider community. Other tools such as newsletters may be useful to ensure the wider community is kept informed on an ongoing basis.

In situations where there are only one or two complainants, open public meetings can be used to see whether there is a more widespread problem. This can indicate whether complainants may be vexatious or are particularly sensitive; i.e. not representative of the 'ordinary reasonable person'.

Community consultation is useful to investigate whether people consider that any odours are of an acceptable level. Sometimes concerns are raised during consultation such as at the consent renewal time, even though there have been no formal complaints made. Ongoing dialogue between odour producers and potentially affected communities is recommended to allow dischargers to deal with issues as they arise. This can prevent ill feelings building up in the community.

Community liaison groups normally include management and engineering staff from the site producing the odour, members of the local community, and council officers. Group meetings may be chaired by an independent mediator/chairperson. Normal meeting rules and standard procedures should be followed to ensure order is maintained. Minutes and matters arising from the minutes should be recorded and discussed.

Further guidance on running community consultation can be found in *Striking a Balance: A Practice Guide for Consultation and Communication for Project Advocates* (Ministry for the Environment, 1999).

Recommendation 14

Community meetings and liaison groups are strongly recommended to provide community input into odour issues.

Community liaison groups should include management and engineering staff from the site, members of the local community, and council officers.

4.8 Experience from other sites and best practice

The potential for objectionable or offensive odours can be assessed using knowledge and experience from similar sites. Assessing technology and management systems from other similar sites can indicate the effects expected from a new or upgraded activity. Assessment of this type generally requires input from an air pollution control expert, and/or a person with experience of a particular odour source.

Best practice guides or industry codes of practice recommend technology and practices for specific industry types. But be aware of the objective of the code when applying the recommendations. Codes may be designed to protect from odour, noise, health effects or safety hazards, but the recommendations will depend on the type of land use at the boundary of the site and the processes in practice when the code of practice was developed.

Site-specific considerations must be taken into account in any assessment based on experience from another site, including:

- meteorology, such as the occurrence of calm conditions and down-valley air flows (katabatic winds)
- surrounding land use and population density
- terrain and the effect on dispersion
- the degree of similarity of the processes (e.g. methods and raw materials).

If any of these factors vary significantly between the sites being compared, then the experience of impacts from a particular operation my not be readily transferable.

4.9 Management and contingency plans

Many odour emissions are strongly related to site procedures and process management. If good management is not in place then adverse effects are more likely to occur. Therefore information on management and contingency is needed to assess the potential for adverse odour effects. Management procedures should be documented in an odour management plan, which is usually submitted at the time of lodging an application for a resource consent.

A management plan should clearly describe the systems required to ensure the reliable operation of odour controls, performance monitoring, and the reporting of these.

Matters that should be included in an odour management plan are outlined in Appendix 3.

4.10 Measuring odour by olfactometry

Odour emissions can be measured in odour units (OU) using dynamic dilution olfactometry (DDO). DDO is a laboratory measurement of the concentration of an odour. The method uses a panel of observers to identify whether an odour is present through sniffing ports. The concentration of the odour is determined by using odour-free air to dilute the sample to a level where 50% of a panel of people smelling the odour can just detect it. This point is given the concentration of 1 OU and the number of dilutions required to reach 1 OU determines the original concentration of the sample. The concentration of odour in air, as measured by DDO, is expressed as the number of odour units per cubic metre (OU/m^3). These data are then used as an input into atmospheric dispersion modelling to predict downwind odour effects (see section 4.11).

The standardisation of DDO in Australasia and Europe has only occurred in the past five years. The variability in the measurement method before standardisation means that earlier data are not necessarily comparable to the current measurements. The recommended method for DDO in New Zealand is AS/NZS 4323.3:2001 *Stationary Source Emissions – Determination of Odour Concentration by Dynamic Olfactometry*, which is based on the European draft standard.

There are two methods for conducting DDO measurements: the 'yes/no' and the 'forced choice' methods. The AS/NZ standard applies to both methods, but the two current laboratories in New Zealand use the forced choice method. There are also two ways of reporting measurements: detection, and certainty or recognition odour thresholds. The detection threshold is the lowest concentration of a compound that can just be detected by a certain percentage of the population, while the certainty or recognition threshold is the lowest concentration of a compound that can be recognised with certainty as having a characteristic odour quality. In general, recognition thresholds are higher than the detection threshold.

DDO and other techniques for odour measurement are described in detail in the Technical Report (Ministry for the Environment, 2002c), along with other less commonly used techniques, such as electronic instruments and chemical measurement of odorous compounds. The use of odour thresholds in odour assessment is discussed in Appendix 6.

4.11 Odour modelling

Odour dispersion modelling predicts the concentration of an odour downwind of the source using a computer programme. Modelling inputs include the characteristics of the discharge, local terrain heights, meteorological conditions, the location of downwind receptors, and odour emission rates. Odour dispersion modelling is one of the only tools that can predict the potential effects of a new odour-emitting activity.

This section briefly covers the key issues and limitations of odour modelling methods and uses, and highlights some things to watch out for when preparing or auditing an assessment of odour effects based on dispersion modelling. Specific advice on odour modelling is contained in the Technical Report, and detailed guidance on general dispersion modelling is provided in the *Good Practice Guide for Atmospheric Dispersion Modelling* (Ministry for the Environment, 2002b,) currently under development. It is important to recognise that odour modelling is a complex technique and those intending to carry it out should be appropriately trained.

Dispersion modelling of odour emissions should only be used where the emission sources can be quantified, and where the discharge is continuous or semi-continuous. In other words, modelling should only be applied to discharges with potential chronic odour effects rather than acute odour effects, such as may occur from abnormal operations.

4.11.1 Odour emission rate measurement

Odour emission rate estimates are needed for dispersion modelling. Both the concentration and the volumetric flow of the emission must be measured to estimate the odour emission rate. For a point source, the odour emission rate is expressed as odour units per second (OU/s) and for area sources the rate is expressed per unit area per second ($OU/m^2/s$).

It is often difficult to determine odour emission rates for diffuse or fugitive sources of odour and/or where the flow rate is low, because it is hard to estimate the discharge flow rate and the limit of detection for DDO measurement is relatively high. Fugitive sources may have a very high concentration that is noticeable close to the source, but a very low flow rate so that the odour dissipates rapidly with increasing distance from the source. Subjective assessments of the significance of sources may be the only option where the emission rate cannot readily be measured.

Where only one chemical is causing the odour and the expense of DDO is not justified, it may be appropriate to measure the concentration of the particular chemical alone and compare the result to its odour threshold to estimate its concentration in odour units. The odour threshold approach is, however, limited because most odours are caused by a complex interaction between different chemicals, and the chemicals responsible are present in very low concentrations, often making interpretation difficult. It is therefore generally more appropriate to use DDO odour measurement data in dispersion modelling. Experience indicates that for an odour that contains several compounds the combined odour measurement cannot be readily related to the concentrations of specific chemical compounds.

Standards Australia has published an Australia/New Zealand standard: *Stationary Source Emissions – Determination of Odour Concentration by Dynamic Olfactometry*, code AS/NZS 4323.3:2001. The standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EV/7, *Methods for Examination of Air*. The objective of AS/NZS 4323.3:2001 is to provide a method for determining the odour concentration of a gaseous sample using DDO with a panel of human assessors as the sensor. The standard can be downloaded from the Standards Australia website (http://www.standards.com.au). AS/NZS 4323.3:2001 applies to both yes/no and forced-choice response methods.

Odour thresholds for individual chemicals and a list of recommended odour threshold references are given in Appendix 6. More detailed information and specific recommendations about odour emission measurement are available in Chapter 7 of the Technical Report (Ministry for the Environment, 2002c).

Recommendation 15

Odour emission rates should be measured using dynamic dilution olfactometry carried out in accordance with the joint Australian/New Zealand standard AS/NZS 4323.3:2001 *Stationary Source Emissions – Determination of Odour Concentration by Dynamic Olfactometry*.[19]

4.11.2 Model applicability versus community feedback

For existing operations, atmospheric dispersion modelling predictions should generally be given less weight than community feedback on odour effects. In particular, if sufficient community data are available to demonstrate that there is an odour problem, odour modelling should not be used to try to argue the contrary. Dispersion models can be used diagnostically to identify sources of odour from existing activities that are contributing to off-site effects. Models allow individual sources of odour to be 'switched off' to investigate the contribution of the remaining sources to the overall odour impact, and help to identify which sources should be controlled and to what level.

4.11.3 Multiple sources and background odour

For dispersion model scenarios with one or two sources, the maximum measured emission rate from each source is typically used for dispersion calculations. For multiple sources, however, this may result in overly conservative and unrealistic results. To prevent this, assessors should consider whether or not the different sources are likely to be additive, or if one is likely to mask others when more than one is present. Average emission rates are sometimes preferred for multiple sources when not all the sources discharge at the peak rate at the same time. The assessors must understand the emission characteristics of the processes they are modelling, and if peak emissions are likely to coincide, these scenarios should be accounted for in the model set-up.

The effect of background odours and multiple sources should be considered on a case-by-case basis. If the odour being modelled is quite different to, or much stronger than, any background odour (e.g. a strong odour from a chemical manufacturing plant in a rural area), then background odour should probably not be included in the model but considered subjectively in terms of its potential influence.

4.11.4 Odour-modelling guideline values

Dispersion model outputs in odour units per cubic metre (OU/m^3) can be compared to odour-modelling guideline values to determine whether objectionable or offensive effects are likely to occur. The comparison should take into account the sensitivity of the proposed receiving environment, as described in Table 2.2.

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19 The standard can be downloaded (for a fee) from the Standards Australia website, http://www.standards.com.au.

The recommended odour-modelling guideline values are summarised in Table 4.6. Other values can be used on a case-by-case basis where they are justified for specific odour sources and the work has been adequately peer reviewed.

Table 4.6: Recommended odour-modelling guideline values

Sensitivity of the receiving environment (refer to Table 2.2)	Concentration	Percentile
High (worst-case impacts during unstable to semi-unstable conditions)	1 OU/m^3	0.1% and 0.5%
High (worst-case impacts during neutral to stable conditions)	2 OU/m^3	0.1% and 0.5%
Moderate (all conditions)	5 OU/m^3	0.1% and 0.5%
Low (all conditions)	5–10 OU/m^3	0.5%

Note that:

- atmospheric stability has been accounted for in high-sensitivity receiving environments (stability refers to the degree of mixing that occurs)
- the percentile allows for a small level of exceedance of the predictions, to account for worst-case meteorological conditions, at which objectionable odours are unlikely because the conditions occur infrequently
- the 'baseline' percentile is 0.5%, although 0.1% will also be used to assist in the evaluation of model results depending on the type of source and consistency of emission data; further discussion of percentile selection is given in the Technical Report (Ministry for the Environment, 2002c)
- the concentration components in the table already include the peak-to-mean ratio adjustment for all source types, and should be used as design ground-level concentrations for one-hour modelling averages.

Two approaches were used to develop the modelling guideline values for New Zealand: the annoyance threshold method and the dose–response method. The former is more theoretically based whereas the latter is empirically based using odour surveys. More detailed information on how surveys can be used to define guideline values and the rationale behind the recommended guideline values is provided in Chapter 9 of the Technical Report (Ministry for the Environment, 2002c).

The Ministry for the Environment will update the modelling guideline values as necessary when more empirical research of the effects of odours on communities emerges from odour dose–response studies (discussed in section 4.4).

Recommendation 16

The guideline values in Table 4.6 should be used along with Table 2.2 to assess modelling results and to determine whether the odour is likely to cause an adverse effect.

The guidelines already include the peak-to-mean ratio adjustment for all source types and should be treated as design ground-level concentrations for one-hour modelling averages.

4.11.5 Model interpretation and limitations

Odour-modelling guideline values should not be interpreted as a 'pass or fail' test. The evaluation of the potential for objectionable or offensive effects must be on the basis of probability. The conservatism in the model predictions should be considered. Factors influencing the level of conservatism include the odour emission rate data, land use and activities where guideline exceedances are predicted to occur, the model assumptions, and the meteorological data file used.

There are a number of limitations inherent in the modelling approach. Depending on the level of conservatism, predicted guideline value breaches do not necessarily mean that adverse odour effects will occur. Likewise, being within the guideline value does not mean there will be no adverse effects. Any calculated breach occurs for a whole hour according to the model, which predicts hourly averages, but in practice peaks will only occur for short periods. The model assumes that the wind direction remains constant throughout the hour, but wind directions can fluctuate within an hour. The model also assumes that the rate of odour emission from each source is constant from hour-to-hour, but the emission rate will vary over time. Factors called peak-to-mean ratios are applied to models to help account for the short-term peaks versus the hourly average model outputs, but the science is uncertain. Using annoyance surveys (odour dose–response studies) to calibrate the model accounts for many of the limitations inherent in the theoretical approach to developing guidelines.

Odour modelling may be limited in its application due to:

- the variability in odour emission rates, which may not be adequately characterised by 'one-off' odour measurements
- lack of a meteorological data set representing local conditions
- the fact that odours are not simply additive in their effect – there are complex masking and synergistic effects that vary for each mixture of odorants
- the fact that intensity of odour does not vary linearly with concentration.

Model results should therefore be just one of the indicators of the potential for adverse effects, and other tools should be used in conjunction with modelling when assessing potential effects.

Recommendation 17

Modelling should be given less weighting in situations where reliable community assessment data are available.

Modelling is best applied to situations where the odour emission rate can be measured and where the odour emissions are reasonably constant, causing potential chronic effects.

5 Odour Management and Control

5.1 Management options for regulators

5.1.1 Regulation

Regulators manage odour emissions through policies and rules in regional and district plans. The rules typically specify those discharges that are permitted (usually subject to certain conditions) and those that require a resource consent. Monitoring and responses to odour complaints also play a significant role in managing potential odour impacts of existing activities. The options available to regulators are largely provided under the RMA, as discussed in section 3.1. Resource consents may be granted subject to conditions, as discussed in section 3.4.

District councils can manage odour effects through controls on land use. Separation distances can be considered in line with the principles of internalisation and reverse sensitivity discussed in section 3.3. Buffer zones can work both ways; for example, protecting existing residential activities from a new pig farm moving in, as well as stopping residential subdivision and development from occurring around an existing pig farm.

Further guidance on establishing buffer zones for different activities can be found in VEPA (1990) and ARC (2002).

Guidance on writing air provisions in plans is provided on the quality planning website at: www.qualityplanning.org.nz.

5.1.2 Monitoring and enforcement

Local authorities are required to monitor, respond to and keep records of complaints to effectively carry out their functions. Guidance on methods for monitoring to assess compliance and for responding to complaints is provided in section 4.

For existing sites, where complaints have been received a decision must be made about whether there is an adverse effect occurring from offensive and objectionable odour. In these cases, assessments recommended for category 1 activities in section 4.2.1 should be undertaken to determine any adverse effect of odour (see Appendix 1 for the relevant decision tree).

It can be difficult to decide when to take action for non-compliance with an odour effect condition. Complaint response can be a drawn-out process, particularly where there is uncertainty and complaints cannot be validated. Other assessment tools may be needed to gather more information.

Community assessment techniques (complaints, diaries, surveys and meetings, as described in section 4) are the highest priority for assessing existing odour sources. These should be used as the primary information source in decisions about what action to take. Tools typically used to determine potential adverse effects such as modelling and the existence of management procedures should not be a consideration, although modelling can be used to interpret complaint and survey data.

Odour complaint response generally tells an officer on a particular occasion whether he or she observed an odour that could be considered to have an impact (such as the ratings in Table 4.4). Diaries, surveys and complaint history can give an indication of the cumulative impact over time (chronic effects).

The ultimate action a council takes will depend on the policy of the individual council, the history of the site, the degree of adverse effect and how much co-operation there is from the discharger.

Enforcement action is usually the last resort and it is most often supported by complaint data. Such cases can be lengthy and leave the community dissatisfied, particularly for chronic effects. Some councils have been quick to take enforcement action on the basis of relatively few complaints. This is generally easier for acute effects or where the discharger has clearly been negligent. In other cases, it is more appropriate to provide a warning and allow the discharger time to rectify problems.

Figure 5.1 summarises the information and actions that should be considered when an adverse effect from odour has been confirmed.

Figure 5.1: Information and actions considered for odour response

Information

- Individual complaint intensity and duration
- Complaint history and frequency
- Odour diaries
- Odour surveys
- Community meeting outcomes
- Level of co-operation from discharger

Action

- Ongoing complaint response and recording (evidence gathering)
- Proactive monitoring (evidence gathering)
- Ongoing community liaison and communication
- Monitoring charges on a time and expense basis
- Infringement notice
- Abatement notice
- Enforcement order

Methods for analysing complaint data, history and frequency are discussed in section 4.3.6. If there are repeated valid complaints and non-co-operation, a council should embark on evidence gathering to take enforcement action. Complaint records and odour diaries demonstrating the adverse effect of the odour are useful in court, particularly those validated by officers.

Councils need to consider the admissibility of evidence when deciding to take enforcement action. In the sentencing notes from *ARC* v *Nuplex*,[20] the judge commented on the issue of whether the sentencing can take into account a continuing offence. In this case, the company had pleaded guilty to two charges of odour on isolated occasions, and the charges for a continuing offence had been withdrawn. The judge considered the extent to which he could take account of the evidence of ongoing effects, since they were unproven in this case, and whether the incidents had to be assumed to have occurred in a vacuum as an isolated incident. The case suggests that one-off incidents where there is an adverse effect confirmed by a council officer may be easier to prove in court, compared to ongoing complaint records and community information.

[20] *Auckland Regional Council* v *Nuplex Industries Limited*, Auckland District Court, 13 November 1998. CRN Nos 7004021704; 7004021706.

Ongoing monitoring may require considerable council resources and/or be drawn out over many months. This can make the process frustrating for all concerned. Response times will often mean that an officer is unable to get to the site in time to validate the complaint. Proactive monitoring, which involves visiting a site frequently over a short period of time, at times when odour is expected to occur (e.g. early morning) is recommended. This has the effect of building up a better picture over a shorter timeframe and provides the ability to take appropriate action more quickly than would otherwise be possible. Sometimes the action may be to do nothing, because the council has not substantiated any odour problems and more resources are not justified.

Where a problem is acknowledged by a discharger, community liaison can be useful to work through a solution and negotiate timeframes that are realistic for all parties. If timeframes are not met, councils should consider enforcement action.

Where a community is not satisfied with the actions of the council and/or the discharger, common law actions are available (as discussed in section 1.2).

5.2 Process management and controls

This section outlines mitigation options for avoiding, reducing and managing odours at a specific site. The mitigation method that is appropriate depends on site and process requirements. Reducing odour or the potential for odour effects can be achieved using one or a combination of approaches. The appropriate solution depends on the nature of the odour, the contaminants present, the characteristics of the source and the control efficiency required. Assessment of the controls needed must consider both normal and abnormal conditions. In many cases a high level of specialist engineering input is required to develop the most appropriate solution.

5.2.1 Site design

Site planning is the key consideration for all odour sources, particularly those that are diffuse and difficult to capture and control, such as intensive agricultural activities and waste management activities. The following issues should be considered:

- the designated land use of the site and the surrounding land under the district plan
- the location of activities within the site and their orientation in relation to prevailing winds and sensitivity of the downwind receptors
- the presence of buffer distances to the site boundary and to sensitive land uses
- the need for screening, such as by earth bunds, shelter belts or natural topography.

5.2.2 Process design and management

Good design and operating procedures can prevent and minimise odour problems. They avoid or reduce the need for 'end-of-pipe' controls in some cases. The design should consider raw materials, waste handling, processing plant, instrumentation and control, and plant buildings. Process monitoring allows action to be taken to prevent system failure. It is essential to:

- select or change raw materials to reduce the potential for odours (e.g. for low VOC paints, or improving raw material quality for rendering)
- ensure odour sources are adequately enclosed and that equipment is accessible for cleaning
- incorporate and monitor process operating conditions such as temperatures and pressures that will minimise odour, and monitor parameters that are important for good performance (e.g. dissolved oxygen in oxidation ponds, pressure drop and gas temperature in a biofilter, and chemical concentration for a chemical scrubber)
- implement a preventative maintenance programme to minimise equipment failure and unplanned downtime
- educate staff about the importance of regulatory compliance and good management for achieving compliance
- have a regime of good housekeeping
- conduct odorous operations during weather conditions that are most favourable for dispersion where no other mitigation option is available (e.g. avoid early morning and evenings, consider wind direction in relation to sensitive areas, avoid hot humid weather).

Procedures and controls should be documented in a management plan. An example outline of a management plan is provided as Appendix 3.

Recommendation 18

Management plans should document process operating conditions, controls, monitoring and maintenance, and be structured using the example in Appendix 3.

5.2.3 Community consultation and negotiated solutions

As discussed in section 4.7, communicating with the local community is important for building a good relationship and trust, which are a useful foundation for times when odour problems do occur. It is important to bring the community on side as part of the problem-solving process, both to help identify where problems lie and to negotiate solutions, including timeframes for implementation.

Abnormal odour events can occur without warning or may be from planned maintenance. Letting people surrounding the site know about such events as early as possible helps reduce annoyance in the community. The discharger should also inform people about what is being done to remedy the problem and to prevent its recurrence, and how long the problem will take to fix. The level of annoyance may reduce if people see that the discharger is genuinely addressing adverse effects in a proactive manner.

Methods for communication include public meetings, community working parties, mail drops and a phone line for complaints and enquiries.

If the site is well operated and having very little impact, it may be difficult to get people to attend a community meeting. In these cases a less formal approach, such as an annual barbecue, can provide a useful opportunity for community feedback.

5.2.4 Control technologies

Odour sources that require treatment need to be captured and ducted to control equipment. Some gas streams require pre-treatment steps, including particulate removal and cooling or condensation to remove moisture and reduce temperature, depending on the final control option. Condensation reduces the volume of gas to be treated and therefore reduces the control equipment sizing requirements, but condensation creates a liquid waste stream. Pre-treatment may also involve humidification (e.g. prior to a biofilter). Installation of control technologies can be staged over a number of years, with gradual improvements being made as technology advances (see Case Study 3).

Case Study 3: Odour control at the Christchurch wastewater treatment plant

The Christchurch Wastewater Treatment Plant (CWTP) illustrates the complexity and length of time that can be involved in developing an odour control solution. Odour sources from the CWTP include uncovered tanks and channels, sludge treatment facilities and buildings, biogas leaks and the oxidation ponds.

Wastewater treatment has taken place at the site since 1900. The modern CWTP first operated in 1962 and since then several major changes have taken place. The following is a chronology of the works and odour control techniques applied.

- 1985–86: trickling filter covers and a biological soil filter were installed to extract and treat the odorous air given off by the trickling filters, which were the major source of odour from the plant.
- 1993: a cover was constructed to capture odour generated by turbulence as the effluent flows into ponds 1 and 2 and air was diverted into a small soil filter.
- 1997/98: the inlet structure, screening room and grit washing area and pre-aeration tanks (1999/2000) were enclosed and also ventilated to the trickling filters and then to the biofilter. Trickling-filter extraction was upgraded, increasing negative pressure to minimise fugitive emissions from the covers.
- 1997/98 the biogas engine stacks were changed from a horizontal to a vertical discharge point to assist dilution and dispersion.

Further odour mitigation works are planned over the next few years as the current plant upgrade continues, including:

- the demand on the oxidation ponds is being reduced through an upgrade of the trickling filters, new solids contact process and new clarifiers (this upgrade serves to reduce the risk of objectionable odours from the ponds due to overload when one or more major elements of the plant are out of service for any reason)
- sludge lagoons are to be covered or replaced.

Further mitigation options will be considered if adverse odour effects continue.

Odour control equipment is generally limited to a small range of technologies that have been used for many years. Most technologies are well understood and have proven performance. The available technologies are summarised below. More information on the systems and their application is provided in Appendix 5.

Dilution and dispersion

Dilution and dispersion are usually achieved via emission through a tall stack. A stack will be appropriate for very low-intensity or non-offensive odours, discharged at low rates and as a final step following treatment of an odorous gas stream. The stack should be appropriately designed to ensure it is an adequate height above buildings in the vicinity, and this may require dispersion modelling. Efflux velocity is an important consideration and there should be an unrestricted final vertical discharge (i.e. hooked vents or rain caps that restrict flow should be avoided). Dispersion has a moderate capital cost but low running costs.

Masking compounds and neutralising agents

Masking compounds and neutralising agents are products available for treating fugitive odours such as from landfill working faces, felmongeries, intensive farming of animals, and wastewater treatment plants.

The compounds are inexpensive in terms of capital cost but not many agents are well proven. They can also be expensive in the long term and certain agents should not be used for specific activities, such as certain chemicals in poultry sheds that may lead to residue issues. The amount of compound required may also make the method cost prohibitive.

The products available can be classified as follows.

- *Masking agents* are mixtures of aromatic oils that cover up an objectionable odour with a more desirable one. Care needs to be taken with the use of masking agents because the combination of chemicals may result in an odour that is even more objectionable or offensive.
- *Chemical counteractants* are mixtures of aromatic oils that cancel or neutralise odour and reduce the intensity.
- *Digestive deodorants* contain bacteria or enzymes that eliminate odour through biochemical digestive processes. These are usually added to wastewater treatment systems to promote biological activity and to prevent the release of the odorous compounds into air (i.e. a preventative treatment as compared to the above, which are air sprays that modify or remove the odorant once it is in the air).

Masking agents are generally only suitable for assisting in the control of odours from large-area sources, such as landfills. Even in these cases they should not be relied upon for odour control, but should act as a 'last line of defence' after stringent management practices and adequate buffer distances. Agents are often more suited to process failure or abnormal emissions than routine control. In these cases they should be seen as a temporary rather than a permanent solution.

Volatilisation of the active ingredients and contact with the odorous molecules are key to the success of air sprays. More research is required to establish the effectiveness of many of the products available, but subjectively it appears that some compounds have worked in some circumstances.

Incineration

Incineration is the destruction of odorous pollutants by thermal oxidation into carbon dioxide and water. Incineration is best applied to carbon- and hydrogen-containing odorants, such as volatile organic compounds (VOCs) and landfill gas. There are several types of incinerator or thermal oxidiser equipment design: thermal, recuperative, catalytic, regenerative and flares. Incineration has high capital and operating costs, but generally high treatment efficiencies can be achieved.

Scrubbing and adsorption systems

Wet-gas scrubbing, gas-to-gas oxidation or solid-phase systems can remove or change the chemical composition of odorous contaminants.

Wet-gas scrubbing or absorption contacts the gas with a liquid phase. The contaminant either reacts with or dissolves in the liquid and is removed in the liquid phase. The most common types of wet-gas scrubbers are packed tower or plate absorbers. Careful selection of scrubber liquors is needed, and usually involves trials. Scrubbers require regular maintenance and daily tests of active agents, and pH control in some cases. There is also a liquid waste to dispose of.

Oxidation is the most common reaction in both liquid and gas treatment methods. Oxidising agents include hypochlorite, chlorine gas, permanganate and ozone. Generally accepted practice is multi-stage chemical scrubbing or catalysed chemical scrubbing. In some applications chemical scrubbing also employs an activated carbon or adsorption stage. Gas-to-gas oxidation systems, including ozonation, are no longer widely used.

With adsorption systems, contaminants attach or condense onto the surface of an adsorbent which is a porous solid. Carbon, zeolite, bentonite and polymer adsorbents have been used to adsorb VOCs and other pollutants from relatively dilute discharge concentrations. Other adsorbents used include alumina, activated clay, silica gel and molecular sieves. Some adsorbents can be regenerated by desorption and the media used again. The compounds emitted can sometimes be recovered and reused.

Chemical additives

A range of techniques can be applied to reduce odour potential at source, including the use of certain chemical additives or stabilising agents. For wastewater treatment systems and sewers, a range of chemicals can be added to the effluent to control odour or reduce odour potential. Chemicals such as hydrogen peroxide and potassium permanganate can be directly added to oxygenate wastewaters. This technique can be useful to stabilise systems that have become anaerobic. Ferric salts and magnesium hydroxide have reportedly been added to wastewater to make the sulphur unavailable for forming odorous compounds. The techniques would typically form part of an odour control regime and would rarely be adequate on their own.

Biofilters and bioreactors

Biofiltration is where organic contaminants in a gas stream pass through a bed of material and adsorb onto the surface, where they are broken down by micro-organisms (see Case Study 4). Volatile compounds break down to carbon dioxide, water, mineral salts and other harmless products. The bed material may be soil, bark, compost or any mixture of these components. Synthetic bed materials are also used.

Case Study 4: Fish by-product rendering plant

A fish by-product rendering plant caused significant odour problems soon after it was installed, due to a combination of the process, odour control methods and plant location. The plant consisted of a low-temperature fish-rendering process followed by meal-drying in a direct fired drier. Odour control consisted of a hood over the render vessel and direct ventilation of the meal drier to a rudimentary hypochlorite scrubber.

A comprehensive option for reducing odour was proposed, involving a process change to replace the existing drier with a steam-heated indirect drier, improvements to ventilation of the rendering area, and replacing the scrubber with a biological filter. A staged upgrade was agreed to with ongoing odour monitoring in the form of community surveys.

While the upgrade cost a substantial amount of money, the new indirect drier provided a benefit to the company by allowing production to increase and improving product quality, thereby increasing company returns. The upgrade has also benefited the community by reducing annoyance and complaints.

Bed material is contained in a structure or in a depression in the ground and the gas stream is distributed through slotted pipes or hollow pre-cast concrete blocks placed under the filter bed. Destruction efficiencies for the removal of odour can be difficult to set and monitor, because of the difficulty of measuring odours at low concentrations using olfactometry. In addition, odour of a different (non-offensive) nature can be present in the discharge from a biofilter (e.g. an earthy smell that does not relate to the compounds that were removed in the filter), but olfactometry cannot distinguish between the two in terms of odour units measured.

Bioreactors operate in a similar way to biofilters but use an inert support medium such as plastic rings, scoria or pumice. Micro-organisms are cultured as a biofilm on the surface of support media, where volatile compounds are absorbed and broken down.

Biological filtration and bioreactors are often the least-costly option for large gas volumes, and have been successful for rendering plants, wastewater treatment plants and for some VOC control. Design and operation of residence time, temperature, moisture content and nutrient balance are critical to ensure good operation of biofilters.

Appendix 1: Odour Assessment Decision Trees

Flow chart outlining the process for selecting odour assessment tools for preparing or evaluating resource consents for an existing industrial or trade activity

(1) Existing activities

Determine presence or absence of chronic effects

Assessment Tool	Priority	Comments
Complaint records	High	Complaints should be classified as validated by a council officer, or from wind-direction records, or as simply registered but not confirmed.
Industry/council experience	High	Experiences of the industry or regional council with the discharge.
Community consultation	High	Periodic meetings with community representatives from community associations. Look for anecdotal evidence of community feeling about odour effects.
Odour annoyance survey	High	Urban and semi-urban areas. Assess against percent at-least annoyed criterion.
Meteorology and terrain assessment	Moderate to high	Use to assess potential for downwind adverse effects as a result of poor dispersion around terrain features or in particular meteorological conditions.
Odour diaries and weather monitoring	Moderate	Isolated areas with low population densities. Assess the frequency, duration, and strength of odour impact events and associated experiences over six months, or a longer time period if necessary, to encompass a specific season.
Review of emission control system(s)	Moderate	Look for compliance with best practicable option (BPO), or industry codes of practice.
Olfactometry and modelling of odour sources	Moderate to low	Generally this tool is not recommended for existing activities unless for assessing the potential effect of proposed plant changes, confirming actual emission rate changes following new procedures and/or new plant commissioning etc, or distinguishing the activity in question from other similar activities in the region.

Are there any significant chronic effects?

Yes → Becomes a category (2) activity

No ↓

Determine acute adverse effects, either already present on occasion, or with the potential to occur

Assessment Tool	Priority	Comments
Complaint records	High	Have any complaints been attributed to acute events?
Industry/council experience and records	High	As for chronic effects.
Community consultation	High	As for chronic effects.
Review of odour management plan and contingency procedures	High	What is the level of acceptable risk for uncontrolled odour discharges? Consider high-probability/low-impact events, and low-probability/high-impact events. Is BPO being utilised?
Odour annoyance survey	Low	If the acute effects are infrequent, surveys may not reflect the impact of the effect on the surrounding environment.
Odour diaries and weather monitoring	Low	If the acute effects are infrequent, diaries may not reflect the impact of the effect on the surrounding environment.
Olfactometry and dispersion modelling of odour sources	Low	Not recommended as an assessment tool for occasional or periodic releases of odour.

Are the acute effects adequately protected against?

No → Becomes a category (2) activity

Yes ↓

Evaluation completed

Flow chart outlining the process for selecting odour assessment tools for preparing or evaluating resource consents for proposed modifications to an existing industrial or trade activity

(2) Proposed modifications to existing activities

Determine presence or absence of chronic effects

Assessment Tool	Priority	Comments
Complaint records	High	Complaints should be classified as validated by a council officer, or from wind-direction records, or as simply registered but not confirmed. Assess how proposed changes will reduce level of complaint.
Industry/council experience	High	Experiences of the industry or regional council with this or other similar discharges.
Community consultation	High	Periodic meetings with community representatives from community associations. Look for anecdotal evidence of community feeling about odour effects.
Olfactometry and modelling of odour sources	High	Use results of complaints analysis, community consultation, and any surveys or diaries to identify the scale of problem, then use modelling to assess the effect of proposed plant changes.
Odour annoyance survey	High	Urban and semi-urban areas. Assess against percent at-least annoyed criterion. Assess how the proposed changes will reduce level of annoyance.
Meteorology and terrain assessment	Moderate to High	Use to assess the potential for downwind adverse effects as a result of poor dispersion around terrain features or in particular meteorological conditions.
Odour diaries	Moderate	Isolated areas with low population densities. Assess the frequency, duration, and strength of odour impact events and associated experiences over six months, or a longer time period if necessary, to encompass a specific season. Assess how the proposed changes will reduce level of annoyance.
Review of emission control system(s)	Moderate	Look for compliance with best practicable option (BPO), or industry codes of practice.

Are there any chronic effects?

Yes → Consider further mitigation and alternative options

No

Determine acute adverse effects, either already present on occasion, or with the potential to occur

Assessment Tool	Priority	Comments
Complaint records	High	Have any complaints been attributed to acute events? Assess how proposed changes will affect plant performance.
Industry/council experience and records	High	As for chronic effects.
Community consultation	High	As for chronic effects. Assess how the proposed changes will affect plant performance.
Review of odour management plan and contingency procedures	High	What is the level of acceptable risk for uncontrolled odour discharges? Consider high-probability/low-impact events, and low-probability/high-impact events. Is BPO being utilised? Assess how the proposed changes will affect plant performance.
Olfactometry and dispersion modelling of odour sources	Low	Not recommended as an assessment tool for occasional or periodic releases of odour.

Are the acute effects adequately protected against?

No → Consider further mitigation and alternative options

Yes

Evaluation completed

Flow chart outlining the process for selecting odour assessment tools for preparing or evaluating resource consents for a new industrial or trade activity

(3) New activities

Determine presence or absence of chronic effects

Assessment Tool	Priority	Comments
Community consultation	High	Meet with community to discuss proposal. Gauge community receptiveness and likely sensitivity to odour effects.
Industry/council experience and records	High	Experiences of the industry or regional council with other similar discharges. Typical buffer distances and nature of emissions including variability and character. Also assess the applicability of assumed buffer distances based on comparison of the key wind conditions that have the potential to cause odour impacts.
Meteorology and terrain assessment	High	Establish the prevalent seasonal wind patterns, topographical features and likely cold air drainage patterns at the site. Rank different areas in terms of 'relative' potential for odour impacts to occur i.e. *highest*, *medium*, and *lowest*.
Olfactometry and modelling of odour sources	High	Use an odour-modelling guideline from a similar installation if applicable, or standard guidelines for new activities. Consider offensiveness of odour and sensitivity of the receiving environment.
Review of process emission control system(s)	Low	Look for compliance with best practicable option (BPO), or industry codes of practice.

Are there any chronic effects?

Yes → Consider further mitigation and alternative options

No ↓

Determine acute adverse effects, either already present on occasion, or with the potential to occur

Assessment Tool	Priority	Comments
Community consultation	High	As for chronic effects.
Review of odour management plan and contingency procedures	High	What is the level of acceptable risk for uncontrolled odour discharges? Consider high-probability/low-impact events, and low-probability/high-impact events. Is BPO being utilised?
Industry/council experience and records	High	As for chronic effects.
Olfactometry and dispersion modelling of odour sources	Low	Not recommended as an assessment tool for occasional or periodic releases of odour.

Are the acute effects adequately protected against?

No → Consider further mitigation and alternative options

Yes ↓

Evaluation completed

Appendix 2: Sample Survey Questionnaire

Telephone questionnaire for environmental survey

Please note that for most of the questions you only enter the codes.

Introduction

READ "Good evening, my name is <name> from <company>, an independent environmental research company. We are currently carrying out research looking at environmental issues in your local community. Could I please speak to a person in your household who is over 18 years old, and whose birthday it is next?"

Once contact is established reintroduce self if necessary and READ:
"The survey only takes five minutes to complete and all your responses will remain totally confidential. Would now be a convenient time, or may I call back later?"

If yes, continue.
If no, make time to call back, and note on summary sheet.
If refused, thank and close, and note on summary sheet.

If asked who the survey is for, READ:
"We need to keep the research as objective as possible, so I can't tell you that straight away. However, I promise that I will tell you at the end of the questionnaire."

If refused, thank and close, and note on summary sheet.
If agree, continue (note on summary sheet). READ:

1a "What do you consider to be the main environmental issues facing your local community at present, if any? By environmental issues I mean things that affect the physical environment like water quality and pollution." **Do not read list. Code all mentions.**

- Air pollution
- Noise
- Water pollution
- Drinking-water quality
- Sprays/pesticides/herbicides, etc.
- Motor vehicle emissions
- Other (specify)
- Don't know **Go to Q2**
- None **Go to Q2**

1b "Of the issues you have mentioned, which do you feel is the most important to your community?" **Do not read list. Code one only. Note responses in priority order.**

- Air pollution (general)
- Air pollution from industry
- Noise (general)
- Noise from industry
- Water pollution (general)
- Water pollution from industry
- Drinking-water quality
- Sprays/pesticides/herbicides, etc.
- Motor vehicle emissions
- Other (specify)

2a "During spring, do you suffer any effects from plant pollen such as hayfever or allergies?"

- Yes **Continue**
- No **Go to Q3**
- Refused **Go to Q3**

2b "How much of a problem is this for you?" **READ OUT all three and rotate order in which they are read out.**

- Not very serious
- Somewhat serious
- Very serious

2c "Does this problem require you to take any forms of medication?"

- Yes
- No
- Sometimes

3a "How often do you notice noise from any local industries?" **READ and rotate order.**

- All the time **Continue**
- Often
- Sometimes
- Seldom
- Never **Go to Q4**

3b "To what degree does this noise annoy you? You might want to write this scale down. Do you find this noise ..." **READ scale and rotate order.**

- Definitely not annoying
- Very little annoyance
- Little annoyance
- Some annoyance
- Annoying
- Quite annoying
- Very annoying
- Extremely annoying

3c "What is the most common source of this noise?" **Do not read out.**

- Industry
- Parties
- Traffic
- Other (specify)

4a “How often do you notice an odour or smell from industry in or around your home?” **READ and rotate order.**

- All the time **Continue**
- Often
- Sometimes
- Seldom
- Never **Go to Q5**

4b “To what degree does this odour annoy you? Do you find this odour is ...” **READ scale and rotate order.**

- Definitely not annoying
- Very little annoyance
- Little annoyance
- Some annoyance
- Annoying
- Quite annoying
- Very annoying
- Extremely annoying

4c “What do you think is the most common cause of this odour?” **Do not read out. Add appropriate causes, e.g.**

- Fertiliser factory
- Sewer line
- Traffic
- Asphalt
- Wool scour
- Fish processing
- Other **(Please write it down____)**

4d “Can you describe this odour?” **Do not read out. Add appropriate descriptors, e.g.**

- Do not know
- Chemical/acidic
- Sulphur/rotten eggs
- Fertiliser
- Oily
- Fishy
- Coal fire
- Sewer
- Other **(Please write it down____)**

4e “Can you specify the activity that causes this odour?” **Do not read out. List relevant local industries:**

- Do not know
-
-
-
- Other **(Please write it down____)**

5 “Finally, just a few short questions to finish. What is your occupation?”

- Agriculture/fishery
- Clerical
- Elementary (unskilled)Sales/service
- Homemaker
- Legislation, administration, management
- Plant/machine operators
- Professional
- Technical
- Trade
- Retired
- Study
- Unemployed

6 How old are you?

- 18–19
- 20–24
- 25–29
- 30–34
- 35–39
- 40–44
- 45–49
- 50–54
- 55–59
- 60–64
- 65–69
- 70–74
- 75–79
- 80–84
- 85+

7 “Do you live on the <east> side of <relevant road or local landmark> or on the <west> side of <relevant road or local landmark>.” **Please write response.**

If respondent refuses, assure them that their personal details will not be divulged.

8 **Code gender:**

- Male
- Female

“Thank you for your time. This research has been conducted on behalf of <client>. If you have any queries you can contact <contact>, collect on <phone>. My name is <name>.

Appendix 3: Odour Management Plans

This appendix outlines the issues that should be included in a management plan designed to address odour.

Title and purpose of the plan

- Define the environmental effect being managed by the plan and the objective in relation to that effect.
- Identify the company and the site location, and briefly describe the company's activities.

Key personnel and contact addresses/numbers

- Company general manager
- Site manager
- Environmental manager
- Staff responsible for implementing the management system.

Process description and method of operation

- A general description of the activities – describe the main potential sources of odour emission.

Methods of mitigation and operating procedures

- Fully describe the odour mitigation system.
- Identify relevant operating procedures and parameters that need to be controlled to minimise emissions.
- Keep an inventory of mitigation equipment and materials.
- Prepare and update reports on equipment maintenance programmes.
- Prepare a report outlining contingency procedures and ensure staff know how to follow it.

Monitoring

- Identify records to be kept, including documentation of maintenance and control parameters.
- Identify weather monitoring records to be kept.
- Identify the odour complaint recording and investigation procedure.

Staff training

- Methods
- Frequency
- Training records.

System review and reporting procedures

- The process for reviewing the overall system performance – frequency of reports to council regarding complaint frequencies, site upgrades, etc.
- External audits and ISO certification (optional).

Appendix 4: Example Odour Diary Record Sheet

Name:	Location of observations:
Month:	

Date	Time	Odour event duration (hours)	Continuity of the odour for this event (tick one)				Character of odour	Likely source of odour	Strength of odour	Description of effect odour has on you	Wind direction	Wind strength
			Continuous	Most of the time	<50% of the time	Intermittent						

Appendix 5: Odour Control Systems

1 Incineration of gaseous contaminants

Thermal incinerators

Thermal incinerators, referred to as 'afterburners' in some industrial applications, combust odorous materials to form mainly water and carbon dioxide. A straight thermal incinerator has a combustion chamber and does not include any heat recovery of exhaust air. The destruction efficiency of the contaminants depends on design criteria, including:

- chamber temperature
- residence time
- inlet contaminant concentration
- compound type
- degree of mixing.

Typical thermal incinerator design efficiencies range from 98–99.99% and above. Typical design conditions needed to meet more than 98% control are an 870°C combustion temperature, 0.75 second residence time, and flow velocities of at least 6–12 metres/second to ensure proper mixing (Buonicore and Davis, 1992).

Resource consent conditions typically require temperatures ranging from 750 to 850°C with a 0.5 second residence time, depending on the application. Sometimes a minimum oxygen concentration is specified. The lower range of temperatures is suitable for easily combustible odorous compounds, while the higher temperatures are necessary for less reactive pollutants and when very high destruction efficiencies are required.

For vent streams with low contaminant concentrations (typically below about 2000 ppmv for VOCs), reaction rates decrease and the maximum destruction efficiency achievable decreases. High destruction efficiencies may also be difficult to measure with low inlet concentrations because of the detection limits of measurement instruments. In these cases performance criteria may be better expressed as a maximum emission concentration (e.g. less than 20 ppmv for VOCs).

Recuperative incinerators

Recuperative incinerator systems use heat exchangers to preheat the waste-gas stream prior to combustion, and may recover heat to generate steam or hot water or to provide process heating. Shell-and-tube and plate-heat exchangers may be used. Shell-and-tube units are more common and have advantages when temperatures exceed 540°C.

Recuperative incinerators have similar destruction efficiencies to thermal incinerators, but they can be limited by the need to operate the heat exchanger at lower temperatures to prevent damage. These incinerators are usually more economical to operate than straight thermal incinerators because they can recover 40–70% of the waste heat from the exhaust gases, but they do have higher maintenance costs.

Suitable design and performance criteria for recuperative incinerators are similar to those for simple thermal incinerators (see above).

Catalytic incinerators

With catalytic incinerators gas passes through the flame area and then to a catalyst bed. The catalyst increases the oxidation reaction rate and enables conversion at lower reaction temperatures than in thermal incinerator units. Catalysts typically used for VOC incineration include platinum and palladium. Other formulations include metal oxides, which are used for gas streams containing chlorinated compounds (USEPA, 1998).

Several different types of catalytic incinerators are available, which are largely distinguished by the method of contacting the contaminated gas stream with the catalyst. Both fixed-bed and fluid-bed systems are used.

Contaminant destruction efficiency is dependent on the composition of the gas, operating temperature, oxygen concentration, catalyst type and space velocity. Temperature and space velocities are particularly important. High temperatures and low space velocities produce increasing destruction efficiencies. Performance criteria of 95–99% destruction could be required for inlet gases with high contaminant concentrations, or a minimum outlet concentration specified for treatment of low-concentration waste streams.

Regenerative incinerators

Regenerative thermal incinerators use direct contact with a high-density medium such as a ceramic-packed bed for heat recovery and to preheat the waste gas. Preheated and partially oxidised gases enter the combustion chamber, where final destruction takes place. Cleaned gases are then directed to one or more packed beds to heat the bed, and the gas flow is periodically reversed.

Regenerative incinerators can use a catalyst rather than ceramic material in the packed bed, which allows for destruction at a lower temperatures. Contaminant destruction efficiencies of thermal regenerative incinerators typically range from 95 to 99%, while catalytic units range from 90 to 99%. Catalytic units have the advantage of being able to remove carbon monoxide from VOC-laden air.

Regenerative incinerators are expensive and difficult to install, are large and heavy, and have a high maintenance demand for moving parts. Advantages include their low fuel requirements, an ability to operate at higher temperatures than recuperative incinerators, and their are suitability for high-flow, low-concentration waste streams.

Flares

Flares are primarily safety devices, which deal with flows of short duration such as an upset condition or an accidental release from a process, rather than a control device that treats a continuous waste stream.

Flares are generally categorised by the:

- height of the flare tip – ground or elevated
- method of enhancing mixing at the flare tip – steam-assisted, air-assisted, pressure-assisted or non-assisted
- candle type or enclosed flare.

Elevating the flare can prevent potentially dangerous conditions at ground level, and also allows the products of combustion to be dispersed. Flares can be used to control almost any VOC stream, and can typically handle large fluctuations in concentration, flow rate, and other characteristics. The primary application of flares is in the petroleum and petrochemical industries, but flares are also common for landfill gas treatment, and biogas from anaerobic digestion of sludge at wastewater treatment plants. Pilot flames can run continuously or by auto-ignition. It is important to monitor the flare to ensure that the flame does not go out in strong winds. Monitoring may be by regular inspection or automatic monitoring and an alarm.

2 Scrubbing and adsorption systems

Scrubbing systems

Scrubbing systems can vary from a simple spray tower to multiple counter-flow packed towers. Packed scrubbers are generally in the form of a tower, with the gas inlet at the base and outlet at the top. The scrubbing liquid flows counter-current to the gas stream. The tower is filled with packing material, which increases the surface area for absorption. Packing materials may be symmetrical in shape (e.g. saddles or rings), or random (e.g. coke, plastic scrap and scoria).

Plate scrubbers operate in a similar way to the packed tower. The scrubbing liquid contacts the gas stream in a series of stages. The liquid enters the top stage, flows across the plate and discharges through holes to the next plate. The gas stream rises through the same holes or openings, creating bubbles or froth where removal of the contaminant takes place.

The scrubbing liquid may be water or a chemical solution. Other solvents may be used to remove substances with a low solubility in water. The scrubbing liquid should have high gas solubility (or reaction), low volatility, be chemically stable and non-corrosive, and preferably have a low toxicity. Scrubbing liquor could include acid solutions, alkaline solutions, hypochlorite, or catalysed systems. Multi-stage systems with different scrubbing solutions are sometimes needed.

Scrubbing systems can be bought 'off the shelf' and can often be trialled for particular applications at particular sites.

Purpose-built scrubbing towers designed for a specific duty may reach efficiencies of 99.99% for certain contaminants. Common efficiencies are in the 90–99% range. The effectiveness depends on inlet concentrations, and whether equilibrium is approached between the gas and the liquid. A disadvantage of scrubbing systems is the production of a liquid waste that requires treatment for reuse or disposal.

Adsorption systems

With adsorption, contaminants attach or condense onto the surface of a porous solid (adsorbent). Carbon, zeolite and polymer adsorbents have been used to adsorb VOCs and other pollutants from relatively low-concentration gas streams. Other adsorbents used industrially include alumina, activated clay, silica gel and molecular sieves. A large surface area is key because this increases the amount of adsorption that can be achieved per unit of adsorbent.

Adsorbents eventually become exhausted when all the surface area is taken up by the contaminant and 'breakthrough' is reached. Monitoring for breakthrough is important. Adsorbents can be regenerated by incineration, or desorption with another gas or liquid, and the contaminant may be either recovered or destroyed.

The most common adsorption systems used in New Zealand use activated carbon. Systems range in size and complexity from small systems designed to remove odours from cooking operations, to complex solvent-recovery systems for the surface-coating and pharmaceutical industries. They have also been used successfully to control odours from asphalt manufacture.

Well-designed adsorption equipment can achieve control efficiencies of 95–98% for VOC inlet concentrations in the range 500–2000 ppm, independent of the recovery or disposal process. If incineration at, for example, 98% efficiency is used for regeneration, total removal efficiencies may be 93–96% (USEPA CATC, 1998). Lower efficiencies are achieved where regeneration is less effective.

3 Biofilters and bioreactors

Biofiltration is where vapour-phase organic contaminants are passed through a bed of material and adsorb to the substrate surface, where they are degraded by micro-organisms. The bed material may be soil, bark, compost or any mixture of these components. Synthetic bed materials are also used. Bed material is either contained in a structure or in a depression in the ground, and the gas stream is distributed through pipes placed under the bed. More information on biofiltration can be found in the appendices of the *Manual for Wastewater Odour Management* (New Zealand Water and Waste Association, 1999).

Bioreactors are a development of the biofilter and operate in a similar way, but use an inert support medium such as plastic rings, scoria or pumice. The support medium used can vary widely depending on the application. The micro-organisms are cultured as a biofilm on the surface of the support medium, which is supported by recirculating water.

Biofiltration is dependent on the biodegradability of the contaminants. Under proper conditions, biofilters can remove virtually all selected contaminants. Biofiltration is used primarily to treat hydrogen sulphide, organosulphides, organonitrogen compounds and non-halogenated hydrocarbons. Halogenated hydrocarbons can also be treated, but the process may be less effective because the compounds can inhibit biological activity.

Inlet concentrations of contaminants in the gas stream may range from fractions of a part per million (ppm) up to 1000 ppm, or higher. The efficiency of removal is dependent on the system and contaminant. General odour removal (measured by olfactometry) from wastewater treatment plants is expected to be at least 90%. Removal efficiencies for hydrogen sulphide and methyl mercaptan are greater than 99% and 95% respectively (Brenman et al, 1996). Biofiltration efficiency is limited by the inlet odour concentration, because it is difficult to achieve high efficiencies with a low-concentration effluent gas due to residual odour in the outlet from the filter medium itself.

Biofilter design is based on the required gas residence time in the bed. Typical gas-volume to bed-area ratios to ensure adequate residence time range from 50 to 100 $m^3/m^2/hr$, with bed depths typically 0.8–1.2 m. The principal disadvantage of biofilters is the large space required. This can be overcome by using stacked systems with synthetic media, or bioreactors, which have less demanding requirements on residence time.

To maintain maximum efficiency, moisture levels must be maintained at higher than 60% and temperature in the 20–35°C range. Control of pH is less critical but should be within the range 4–8. Bed moisture content is very important and humidity of the gas stream should be maintained at near to 100% to prevent drying of the underside of the bed. Overhead watering systems are also common. The filter bed should be maintained in an aerobic condition. A humidifier may be necessary before the effluent gas is passed to the biofilter to ensure that the bed moisture is maintained.

Biofilters have advantages over conventional adsorbers: bio-regeneration keeps the maximum adsorption capacity available constantly, and contaminants are destroyed – not just separated, as with adsorption systems. In biofilters the bed material will need replacing from time to time depending on the media used. Experience shows that bark and compost filters start to break down over time, increasing back pressure, which can cause problems in the process. In any case the bed media should be completely replaced on about a five-yearly basis, but this will depend on the conditions under which the biofilter is required to operate. Monitoring back pressure is one indicator of when the filter will require turning or replacement. Biofilters may be designed in two cells so that one can be isolated while maintenance is carried out on the other.

Bioreactors using an inert bed material normally require the biofilm to be seeded with the most appropriate bacteria and a liquor circulated to provide nutrients for microbial activity.

Biofilters and bioreactors are suitable for many applications, and the variety of processes using them is growing. In New Zealand biofilters are used in wastewater treatment, composting, and the food and animal products industries. They may be applicable for the treatment of VOCs and other contaminants from the surface coating, printing and petrochemical industries, but their success has not been well proven in these areas.

Appendix 6: Odour Thresholds for Individual Chemicals

The odour threshold is the concentration of an odorous compound at which it is noticeable to the human nose. Odour threshold data are useful in assessing effects for odour emissions, particularly in situations where one compound is known to predominate the odour effect (i.e. there are no synergystic effects with other compounds). Using odour threshold data has the advantage over odour unit measurements because chemical concentration measurements can usually be more readily carried out or can be calculated by mass balance. In some situations the expense of olfactometry may not be justified, and using odour threshold data for individual compounds may be the only option.

Both detection and certainty or recognition odour thresholds for compounds are reported in the literature. The detection threshold is the lowest concentration of a compound that can just be detected by a certain percentage of the population, while the certainty or recognition threshold is the lowest concentration of a compound that can be recognised with certainty as having a characteristic odour quality. In general, recognition thresholds are approximately three to five times the detection threshold. When using odour threshold data it is important to be clear about which type of threshold is being reported.

Odour threshold data should be used with caution because many different methods have been used and there is a wide variation reported in the literature, often by four orders of magnitude. As an example, when using dilution dynamic olfactometry methods the odour threshold is usually taken as the value at which 50 percent of the panel are able to detect or recognise the odour, but some historical data are based on a range of different percentages. Most odour threshold reference data available appear to have been developed before dilution dynamic olfactometry was standardised, so the data may not be directly applicable to assessments where odour guidelines have been developed based on the standard olfactometry techniques.

Some useful references for odour threshold data are discussed below.

- Nagy (1991) undertook work sponsored by the Air Resources Board of the Ontario Ministry for the Environment. Forced-choice dynamic olfactometry was used to determine the 50% detection levels for 86 pure compounds as $\mu g/m^3$ using a nine-member panel.
- The American Industrial Hygiene Association (AIHA) published odour thresholds for 102 compounds in 1989. The AHIA reference does not incorporate any odour threshold data that are more recent than the 1980s, even though it was last published in 1997, and a lot of the data they rely on are much older. The review is, however, a critical one. Of 191 primary sources, 155 references were excluded as unacceptable, and this remains one of the preferred sources of odour threshold data.
- Van Gemert (1999) is a compilation reference based on literature values of odour threshold concentrations incorporating studies since 1977. The most recent study incorporated prior to this review was Devos et al (1990). This latest reference is essentially an update of the earlier compilations. No attempt is made to critically evaluate the data, but data are given chronologically for each compound with the original data source identified. More than 1100 compounds with one or more odour threshold references are reported.

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About the Ministry

The Ministry for the Environment works with others to identify New Zealand's environmental problems and get action on solutions. Our focus is on the effects people's everyday activities have on the environment, so our work programmes cover both the natural world and the places where people live and work.

We advise the Government on New Zealand's environmental laws, policies, standards and guidelines, monitor how they are working in practice, and take any action needed to improve them. Through reporting on the state of our environment, we help raise community awareness and provide the information needed by decision makers. We also play our part in international action on global environmental issues.

On behalf of the Minister for the Environment, who has duties under various laws, we report on local government performance on environmental matters and on the work of the Environmental Risk Management Authority and the Energy Efficiency and Conservation Authority.

Besides the Environment Act 1986 under which it was set up, the Ministry is responsible for administering the Soil Conservation and Rivers Control act 1941, the Resource Management Act 1991, the Ozone Layer Protection Act 1996, and the Hazardous Substances and New Organisms Act 1996.

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