



NUISANCE CRITERIA FOR IMPACT ASSESSMENT

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EXECUTIVE SUMMARY

The development of appropriate nuisance criteria is an evolving process due to both the difficulties of defining emission rates and the lack of definitive information of what constitutes a nuisance. However, progress has been made in this area in recent years, particularly in Europe with the work on linking surveyed odour annoyance to modelled odour impact. There is currently a lack of knowledge in Australia, which has led to arbitrary impact criteria being selected and adopted by regulators in various regions.

To provide the community, regulators and industry with confidence that residents surrounding piggery developments will be protected against odour nuisance, a consistent process needs to be used that is validated against community impact surveys or complaint records.

A clear protocol needs to be documented for assessing the odour impact of piggery developments. The most appropriate model needs to be decided upon, with the appropriate input parameters, emission rates and meteorological data file.

The adopted process for assessing impact should offer protection to the community, without constraining industry development.

INTRODUCTION

Nuisance criteria for impact assessment is a developing science, primarily due to the difficulty in defining what is a nuisance and the difficulty in defining the emission and dispersion of odour. Recent advancements in developing criteria are based on modelling, combined with odour-dose response surveys, particularly in Europe.

To enable the results of community odour annoyance surveys to be applied they need to follow a clear protocol. This includes the collection of all emission data for the odour emitting source and modelling the dispersion of the odour with an accepted model (in Australia this is AUSPLUME), using validated meteorological data. The modelled impact can then be compared against the results of the community odour annoyance survey to determine the level of modelled odour that causes a nuisance. Implicit in this calculated impact criteria is that it can only be applied in situations when the same methodology is used, including the method of odour collection and determination, and the model and modelling the parameters used.

In lieu of this definitive information in Australia for various industries, regulators have developed "best-bet" impact criteria, with little knowledge of the available emission data, impact modelling, what constitutes a nuisance and indeed the industries they are regulating. It must be remembered that the primary reason for impact criteria is to protect the surrounding community against odour nuisance from a particular industry.



A “true- test” of a chosen impact criteria is appropriate is whether or not the adopted process works, despite the deficiencies that currently exist in determining if a development will cause a nuisance.

This paper explores current impact assessment criteria researched and/or applied in Australia and overseas for piggeries, other intensive animals and other odour producing industries. It also recommends steps to ensure a process is put in place for assessing piggeries that is equitable for the community, regulators and industry.

CURRENT AUSTRALIAN IMPACT ASSESSMENT CRITERIA

Standard Impact Criteria

Odour impact criteria used around Australia vary substantially – Table 1 summarises the criteria by state. All impact criteria included in this table have been reviewed in the last 3 years. It can be seen that all states, except Victoria assess odour impact at the receptor.

TABLE 1 – AUSTRALIAN STATE IMPACT CRITERIA

Impact Criteria	Percentile Occurrence	Odour Concentration	Averaging Time	Assessment Point
Victorian EPA	99.9	1 OU (CEN) – non-rural 5 OU (CEN) – rural	3 mins	Property boundary
Queensland EPA (2002 draft)	99.5	1 OU (CEN) point 5 OU (CEN) non-point Distinct (odour intensity)	3 mins	Sensitive Receptor (existing or likely future)
NSW EPA	99.0	2 OU (CEN) – pop’n 2000+ 3 OU (CEN) – pop’n 500+ 4 OU (CEN) – pop’n 125+ 5 OU (CEN) – pop’n 30+ 6 OU (CEN) – pop’n 10+ 7 OU (CEN) – pop’n ≤2	1 sec [#]	Sensitive Receptor (existing or likely future)
SA EPA	99.9	2 OU (CEN) – pop’n 2000+ 4 OU (CEN) – pop’n 350+ 6 OU (CEN) – pop’n 60+ 8 OU (CEN) – pop’n 12+ 10 OU (CEN) – pop’n <12	3 mins	Sensitive Receptor
WA DEP	99.5 99.9 99.5	2 OU (CEN) 4 OU (CEN) Distinct (odour intensity)	3 mins	Sensitive Receptor (existing or likely future)

– For area sources, a P/M60 ratio of 1.9 applies to E, F stability in the far-field (2.3 in the near-field) & 2.3 for A-D stability in the far-field (2.5 in the near-field) {near-field typically 10 * largest source dimension}. For volume sources, a P/M60 ratio of 2.3 applies. The P/M60 is applied to emissions prior to inclusion in modelling.



Impact Criteria Specific to Rural Industries

Western Australian poultry guidelines

The WA Criteria method states that “for new poultry farms or new proposals for sensitive land uses near existing poultry farms, the 7 OU concentration 3 minute average 99.5 percentile contour should be plotted”. The impact is assessed against nearby sensitive land uses, which are described as “residential, hospitals, hotels, caravan parks, schools, aged care facilities, child care facilities, shopping centres, play grounds, recreational centres etc”. The odour impact criteria is 7 OU AS4323.3, 3 minute average, 99.5 percentile.

Victorian broiler farms

The method set out by the Victorian Code for Broiler Farms states that the “99.9 per cent of model predictions of maximum odour levels (calculated as three-minute averages) shall not exceed five odour units (that is, five times the odour detection threshold as measured with EPA Method B2) at and beyond the boundary buffer”. Previous testing has suggested that the CEN method gives results 2 times higher than the B2 method (Bardsley & Demetriou, 1997). Converting the old Victorian criteria to the AS4323.3 gives an odour impact criteria of 10 OU AS, 3 minute average, 99.9 percentile. It is believed that this criteria was recently being reviewed, with the purpose of assessing the impact relative to the Australian Standard (AS4323.3).

It is known that at least one shire in Queensland that currently has several meat chicken production units is applying these criteria for the assessment of new developments.

IMPACT ASSESSMENT CRITERIA FOR PIGGERIES IN THE UNITED STATES

An extensive air quality study for Concentrated Animal Feeding Operations in Iowa was completed in February 2002. A summary of the exposure limits related to odour is discussed below:

U.S. states can regulate air emissions without referring to a specific chemical constituent. The 1998 national survey of animal confinement policies, found thirteen states where odour standards were imposed as a matter of state policy or court decisions. Three states require that odour from intensive animal operations be held below a threshold.

In Missouri and Colorado the threshold is based on a dilution standard. The Colorado dilution standard of 7:1 means that an air sample collected at the emitter property line is diluted with seven volumes of fresh air. If odour can still be detected by using an olfactometer and panel of smellers, there is a violation.

In Missouri an instrument called a scentometer is used in the field at a dilution threshold of 5.4:1 to determine if a significant odour is present. If odour is detected a sample is sent for further examination by an olfactometry panel. If the panel detects the odour at a dilution threshold of 7:1 or greater, or an intensity greater than a reference standard of 225 ppm of n-butanol, then a violation has occurred.

North Carolina uses an arbitrary scale of 0 to 5 for panel members to evaluate odour complaints on-site. Zero is no odour detected. A five is considered a very strong odour.



Normally, two or more observers go to the complainant site to determine if an odour problem exists. This sometimes requires evaluation during night-time conditions.

No guidelines in the U.S. for assessing odour impact of piggeries with odour modelling appear to set impact criteria levels.

IMPACT CRITERIA ASSESSMENT FOR OTHER INDUSTRIES

Cudmore and Dons (1999) produced a detailed report (Environmental Standards for Industrial Odour Effects: A recommended Approach) in response to proposed methods for assessing industrial odours within the Waikato Consultative Draft Regional Plan. They state that: *"The report is primarily a technical document, the aim of which is to provide a sound basis for developing effective regulatory practices for odour management by providing some practical guidance for community surveys and the appropriate role for olfactometry/dispersion modelling assessment methods."*

This study included a review of community annoyance and complaints studies. From these studies Cudmore and Dons concluded that the 99.5-percentile odour concentration (1-hour average, detection based) values that are likely to avoid significant increases in population annoyance and that are inferred from community-based studies in Australasia include:

- 20 to 30 ou/m³ (Tasman Pulp & Paper Co Ltd);
- 30 ou/m³ (Meadow Mushrooms Ltd, Christchurch); and
- 46 ou/m³ (Penrith Sewage Treatment Station, Sydney).

From this they conclude that a 99.5-percentile odour concentration value of 20 ou/m³ (detection threshold) using European methods (NVN2820) would be an acceptable level of odour impact in many circumstances.

Cudmore and Dons (1999) also reported on work by Pacific Air and Environment, Brisbane where they advised that studies on wastewater treatment, landfill and industrial facilities in Queensland all indicate that the threshold for complaint appears to be in the range 15-40 ou/m³ (detection), expressed as a 99.5-percentile, 1-hour average concentration.

IMPACT CRITERIA FOR THE QUEENSLAND PIG INDUSTRY

The basis of the selection of the most appropriate impact criteria in developing the Separation Guidelines for Queensland Piggeries (McGahan *et al.*, 2000) were predominantly based on three factors:

- The conclusions of the Cudmore and Dons (1999) review.
- The use of variable impact criteria based on population size (As per the Queensland feedlot separation guidelines).
- Assessment of the developed guidelines against DPI complaint history for piggeries in Queensland.

The chosen odour impact criteria used in the development of the separation guidelines for piggeries in Queensland range from 5 to 25 ou/m³ (NVN 2820 standard), with the 25 ou/m³ criteria being for individual rural residences and 5 ou/m³ being for large towns (> 2000 people). This is because towns cover a wider area and have a much higher population



density than rural areas. The greater the population of the town, the larger the residential area which could potentially be adversely affected by an odour plume. There is also a wide variation in people's sensitivities to odours. An odour that is regarded as offensive by some people may not be offensive to others. As a result, areas with a larger population have a greater probability of odour impact.

The developed guidelines were validated by assessing collated odour complaint data for piggeries in Queensland. All piggeries that had received validated odour complaints failed the variable separation distance formula. There were no validated odour complaints from piggeries that met the variable separation distance formula.

When performing a detailed odour modelling impact assessment study for a piggery development, the DPI adopts the following impact criteria:

Large town > 2000 people - 5 ou/m³.

Town 100 - 2000 people - 10 ou/m³.

Small town 20 - 100 people - 15 ou/m³.

Rural residential development - 20 ou/m³.

Rural residence - 25 ou/m³.

All impact criteria are calculated on a 1-hour average, 99.5-percentile odour concentration, measured to the NVN2820 standard

ODOUR SURVEYS FOR DEVELOPING IMPACT ASSESSMENT CRITERIA FOR PIGGERIES

Odour Impact and Odour Emission Control Measures for Intensive Agriculture (Irish Environmental Protection Agency, 2001)

This report was commissioned by the Environmental Protection Agency (EPA), Ireland and was produced by OdourNet UK Ltd. The report provides an overview of odour issues for piggeries, based on a literature review, a limited programme of measurements and experience gained from regulatory practices in other countries. The information was developed to allow the EPA in Ireland to formulate its approach for processing licence applications and in achieving transparent and uniform decision-making on related odour issues.

The report states that *"the mechanism that leads from the production of pig odours via release and dispersion in the atmosphere to causing odour nuisance in a specific population is complex.... Odour nuisance is a result of long-term, intermittent exposure to an environmental stressor, in a complex context of physical, physiological, social and psychological factors that determine the behavioural response of the individual. Odour nuisance is not a linear push-button response to a particular intensity of exposure at any moment by a particular smell."* The report suggests that the most appropriate approach to study the relationship between an odour source, the dispersion characteristics of a site and the long-term effects on the population in terms of annoyance is an epidemiological study.

Once this relationship is established, odour impact can be assessed using source emission measurements combined with dispersion modelling. The results can be assessed using the epidemiological dose-effect relationship, or exposure criteria derived from such a relationship.



Assessment of odours is typically undertaken by measurement of emission rates at the source, followed by emission modelling. Assessment in the field is more difficult, because of the large variations in momentary concentration caused by atmospheric dilution; other background odours and the practical problems of measuring very low odour concentrations (< 20 ou/m³ – CEN TC264).

CEN TC264 is equivalent to the new Australian and New Zealand Standard – Determination of odour concentration by dynamic olfactometry (AS/NZS 4323.3).

The odour impact criteria proposed in this report are based on a large-scale epidemiological study conducted in the Netherlands to establish the dose-effect relationship between percentages of population annoyed and calculated odour exposure. The study used approximately 2,300 standardised telephone questionnaires collected from households living in the vicinity of pig production units.

The study recommended a 98-percentile exceedence value for new production units of 3 ou/m³ using 1-hour average odour concentrations (based on the new European standard – CEN TC264). The limit for new pig production units provides a level of protection against odour annoyance which aims to limit the percentage of those experiencing some form of odour induced annoyance to 10% or less of the general public, assuming some degree of acceptance of the rural nature of their living environment.

The limit value is complied with when, for all locations of odour sensitive receptors, the calculated odour exposure is less than an hourly average odour concentration of 3 ou/m³ in 98% of all hours in an average meteorological year.

The study also recommended a 98-percentile exceedence value for existing pig production units of 6 ou/m³ using 1-hour average odour concentrations (based on the new European standard – CEN TC264). The limit for existing pig production units provides a level of protection against odour annoyance which aims to limit the percentage of those experiencing some form of odour induced annoyance to 10% or less in the most tolerant tolerance section (agricultural/rural) of the population.

The limit value is complied with when, for all locations of odour sensitive receptors, the calculated odour exposure is less than an hourly average odour concentration of 6 ou/m³ in 98% of all hours in an average meteorological year.

The dose-effect relationship study in the Netherlands concluded that “*for the general public exposed to pig odours, 10% of respondents are annoyed at an exposure level of 1.3 ou/m³ (CEN), 98-percentile, 1-hour average odour concentration. However, for those respondents that are directly involved in agriculture it was found they are the most ‘pig odour tolerant’ selection of the population. For this group the 10% annoyance level was reached at an exposure of 13 ou/m³ (CEN), 98-percentile, 1-hour average odour concentration*”. When a conversion factor of 3 is used this equates to about 40 ou/m³, 98-percentile, 1-hour average (NVN 2820 standard). Converting the 98-percentile odour concentrations to 99.5-percentile odour concentrations for three different meteorological files (Darling Downs, SE Queensland), the range is from 60 – 100 ou/m³ (NVN 2820 standard).

Miedema *et al.* (2000)

Miedema *et al.* (2000) recently reanalysed the data collected from previous studies conducted in the Netherlands to establish relationships between odour annoyance and odour exposure concentrations caused by (bio) industrial odours in the community. The



percentage of highly annoyed persons was found to have a relationship with the logarithm of the 98-percentile of the odour exposure concentrations. One of the studies reanalysed in this report was a piggery with four operating sheds.

Odour Impact Criteria for the Australian Pig Industry – APL Project 1818 - 2002

Australian Pork Limited (APL) recently funded a study to propose odour impact criteria for the pig industry based on Australian piggery emissions data and Australian community response data. The report concluded that pig odour impact criteria were recommended to be hourly averaged 4 ou/m^3 99.5-percentile at the receptor.

Feedlot Services Australia (FSA) reviewed the final report of this project. The FSA review concluded that the report was deficient in a number of areas and the conclusions derived from it may not be valid and thus cannot be applied to practical situations. The main outcomes of the review are summarised below.

- The particulars of the main site (Farm A) are very poorly described. There are no detailed site plans, aerial photographs, shed layouts, etc. For example, the main anaerobic pond at the site has a very heavy surface crust that is atypical of most piggeries. The shed design is also atypical of current modern piggeries in Australia.
- There are no details of operational procedures during the survey period (e.g. when and where was effluent irrigated). A major problem is that two effluent treatment existed ponds on the eastern side of the property and were not included in the modelling or assessment of impacts. These ponds could well explain some of the anomalies in the annoyance survey data.
- Annoyance events have been discarded when the wind was not blowing from the piggery (odour source) to the receptor. However, given that the two eastern ponds were not accounted for, legitimate events due to these ponds may have been rejected.
- There is inadequate presentation of the annoyance results. The annoyance results are not presented as a “contour of annoyance” that could be compared to the “contour of odour impact” from the dispersion modelling.
- Pond emissions only appear to have been measured from one of the four ponds on site. Methods for estimating pond emissions used by other researchers, regulators and consultants have not been evaluated and thus comparisons with currently-accepted methodologies do not appear.

The site chosen for this impact assessment was a piggery that would not be considered to be representative of a modern piggery in Australia today. The majority of the pigs are housed under one large roof structure. The anaerobic pond is poorly designed and grossly overloaded. The difficulty in conducting this type of study in Australia is that it would be almost impossible to find a modern piggery development where there are sufficient neighbours surrounding the piggery to record any impact, because of current setback distance requirements.

VALIDATION OF IMPACT CRITERIA

One primary test to the validity of modelled impact criteria is to check it against complaints data. The DPI Queensland methodology for assessing new and expanding piggery developments has been in existence since 1999. Since the introduction of these guidelines it



is believed that no new or expanding piggery development approved using the separation distance formula or site-specific odour modelling using the DPI impact criteria and "standard" emission rates have received odour complaints.

Another method for validating or determining impact assessment criteria are the dose-response surveys that use the modelling of emission data against surveyed odour annoyance assessment. This has been more extensively studied in Europe and has been found useful for determining impact criteria, there is however, a lack of this information specifically for Australian condition, where the climate, and the piggery design and management is vastly different. The other variants to be considered for the Australian situation are the sparse rural population and less intensive agriculture.

DISCUSSION AND RECOMMENDATIONS

Many states currently use a high percentile exceedence (99.9) for determining nuisance. A percentile occurrence of 99.9% equates to 9 hours per year. Such a high exceedence criteria produces a modelling outcome that is very sensitive to outliers in the meteorological data file. That is, if the meteorological data file contains a few errors or abnormally high readings, the modelling may fail based on weather conditions that may never occur in reality at the site.

To assess whether the odour impact criteria for a sensitive receptor should apply at the property boundary or at the individual's residence needs to be assessed in terms of likely exposure. Odour impact (annoyance) occurs from the cumulative exposure to an odour that is perceived as unpleasant, not one-off occurrences. People will spend the majority of their time at their residence, not at the property boundary. If an odour impact objective is to be applied at the property boundary it needs to be reflected in the design impact objective.

As odour impact is a function of frequency of exposure, odour guidelines seek to prevent repeated odour exposure rather than seeking to preclude any off-site odour exposure. Thus, in situations where a receptor is infrequently present in sections of their property, the same protection from odour impact can be achieved with different criteria than for a situation where a receptor has a small area of land and frequently uses most areas on that land.

Odour impact criteria are based on the risk of exposure because odour concentrations at any given point are dependent on meteorological conditions. For situations where odours are predicted to move off-site for 100 hours per year, this is equivalent to 1.14% of the total hours in that year. Given that the times of worst dispersion is during the evening and early morning, a significant proportion of that 1.14% of hours is likely to occur at night when most people are asleep. For the remainder of predicted hours of off-site odour, an impact will only occur if the receptor happens to be on the particular part of the property where the odour is present. The cumulative effect of these factors is a low risk of impact.

Modelled odour exceedence values at receptors are a function of the meteorological and land use factors specific to a site, as well as the odour emission rates selected for the different sources at the site. Hence, conversion factors between different percentile exceedences (e.g. 98% to 99.5%) will vary from site to site.

A defined method needs to be determined for assessing the odour impact of piggery developments. This includes:



- The most appropriate model needs to be selected (This should currently be AUSPLUME, but the possibility of other more appropriate models being used in the future when there is confidence in their results and model inputs are easily obtained)
- The correct input parameters to the model. The most important of these being emission rates and meteorological data.
- All odour measurements need to be conducted to and reported in the AS4323.3 standard, with the sampling equipment and methodology reported. For modelling purposes these measurements need to be reported as an emission rate, with the method for calculating emission rate clearly defined.
- All meteorological data used needs to be to an agreed standard (i.e. Is TAPM generated data sufficient?).
- The amount of meteorological data required for modelling needs to be determined and the length of the data file needs to be linked to the percentile occurrence chosen (i.e if the 98-percentile occurrence is to be used are three years of data required - as per the OdourNet recommendation for the Irish EPA).

Further odour annoyance surveys that are related to modelled odour impact are required. However, to enable the results of community odour annoyance surveys to be applied they need to follow a clear protocol. For example, emission data collected using one method, cannot be applied to nuisance criteria that was developed using a different method for collecting emission data. While there is a lack of scientifically validated knowledge of nuisance criteria for the pig industry in Australia, existing developments approved using selected criteria can be assessed against validated complaint records.

The results of numerous studies to determine nuisance criteria demonstrate that odour impact criteria are specific for different industries and communities. In Australia, the factors affecting these criteria have not been well defined.

CONCLUSIONS

It is important that nuisance criteria are developed using a consistent approach in measuring emissions and conducting the modelling. The emissions need to be measured using 'typical' design and management. For piggeries in Australia, this means the sheds are typically narrow (10 – 15m wide) and are either naturally or mechanically ventilated or are deep litter (straw or sawdust) grow-out facilities. Effluent treatment generally involves at least an anaerobic, but often a three pond system, with the anaerobic pond designed to the rational design standard. When calculating emissions from area sources the method of measurement also need to be consistent. If the impact criteria are developed using specific equipment (e.g. wind tunnels versus flux hoods), then this needs to be stated.

Applying odour impact criteria from other industries and even from the pig industry in other countries, where the handling, treatment and reuse of effluent are vastly different is unlikely to be correct. Work in the early 1990's by Misselbrook *et al.* (1993) showed that the increase in perceived intensity for pig slurry is less steep than for broiler house odours, which are more pungent because of their high ammonia content. Thus applying an odour impact objective from even another intensive animal industry, such as broiler farms may be incorrect. More recently ranking of environmental odours in terms of annoyance potential has been undertaken in Europe (reported in EPA, Ireland, 2001). The study found that



odours from livestock enterprises are ranked in the more unpleasant end of the list, but not at the extreme end of dislike.

The modelling of odour emissions from piggery developments to provide protection against odour nuisance to the community via odour impact criteria is still an inexact science and is likely to remain so. Provided a consistent process is used and the system is validated against odour complaint records it will give regulators and the community confidence that residents surrounding piggery developments will be protected against odour nuisance. The process needs to offer protection to the community without constraining industry development.

A clear protocol needs to be documented for assessing the odour impact of piggery developments. The most appropriate model needs to be decided upon, with the appropriate input parameters, emission rates and meteorological file. A methodology for a three-tiered assessment process is presented in a paper at this workshop (Nicholas *et al.*, 2002)

It needs to be clearly defined where there is a lack of quality emission data. This will not only improve odour impact assessment but will be beneficial for identifying changes in design and management that reduce emissions from piggeries.

Further odour annoyance surveys that are related to modelled odour impact are required. The approach in achieving this is to collect emission data for a site and model the impact using a dispersion model and then compare the results against a community odour annoyance survey to determine the level of modelled odour that causes a nuisance. However, the difficulty in achieving this for a modern pig production enterprise in Australia is acknowledged. In lieu of this lack of data current impact criteria can be assessed against recent piggery developments where there are validated odour complaint records.

REFERENCES

Bardsley, T and Demetriou, J. 1997. Odour measurements that don't stink. Proceedings of the National Workshop on Odour Measurement Standardization, ed. J. Jiang, University of N.S.W., Sydney, Australia, 20-22 August, pp 46-52.

Cudmore, R.S. and Dons, A. 1999. Environmental Standards for Industrial Odour Effects: A Recommended Approach for New Zealand. Aurora Environmental Limited. Report No. A028-01.

Irish Environmental Protection Agency. 2001. "Odour impacts and emission control measures for intensive agriculture". R&D Report Series No. 14.

Iowa State University and the University of Iowa Study Group. 2002. "Iowa concentrated animal feeding operations air quality study", February 2002.

Jiang, J. 2002. Development of Odour Impact Criteria for the Australian Pig Industry – Final report for Australian Pork Limited. APL Project 1471.

McGahan, E.J., Skerman, A.S., Casey, K.D., and Nicholas, P.J.. 2000. "Separation Guidelines for Queensland Piggeries". Intensive Livestock Environmental Management AserVICES, Department of Primary Industries, Queensland, Internal Publication.



Miedema, H.M.E., Walpot, J.I., Vou, H. and Steunenberg, C.F. 2000. "Exposure – annoyance relationships for odour from industrial sources". *Atmospheric Environment* 34: 2927-2936.

Misselbrook, T.H., Clarkson, C.R. and Pain, B.F. 1993. "Relationship between concentration and intensity of odours for pig slurry and broiler houses". *Journal of Agricultural Engineering Research* 55: 163-169.

Nicholas, P.J., McGahan, E.J. and Watts, P.J. 2002. "Application of Emission Data in Modelling and Assessment". National Workshop on Odour Assessment for Piggeries. Australian Pork Limited, Sydney, 13-14 April 200.