Separation guidelines for Queensland piggeries

ISSN 0727-6273
QI03078

Queensland Government
Department of Primary Industries

Separation guidelines for Queensland piggeries

2001

Compiled by

Eugene McGahan, Alan Skerman, Ken Casey and Tim Streeten
Department of Primary Industries, Toowoomba, Queensland

The Department of Primary Industries seeks a better quality of life for all Queenslanders - a quality of life supported by innovative world-class food and fibre industries, by responsible and ecologically sustainable use of natural resources and by capable and self-reliant rural communities.

Our business is about:

- innovative science and commercial uptake of new technology by food and fibre industries
- sustainable use of natural resources
- food safety and protection against imported pests and diseases
- market-driven and ethical food and fibre production
- capable rural communities achieving prosperity and self-reliance through successful rural businesses.

This publication has been designed to assist prospective piggery developers and their consultants in the planning of new and expanding piggery developments. The Guidelines will also assist regulatory agencies with the assessment of applications for new piggery developments or expansions of existing developments under the relevant legislation (*Environmental Protection Act 1994* and *Integrated Planning Act 1997*).

First published 2001
Reprinted 2001, 2002, 2003, 2004

Table of contents

1.0 Introduction 1
2.0 Variable separation distances - distance between piggery complex and receptors 2
2.1. S Factor formula 2
2.2. Calculation of Standard Pig Units 3
2.3. S1 – Effluent removal factor 3
2.4. S2 – Receptor type factor 4
2.5. S3 – Terrain factor 5
2.6. S4 – Surface roughness factor 6
2.7. Odour dispersion modelling – alternate method for determining required separation distances 8
3.0 Fixed separation distances - distance between piggery complex and relevant features and receptors. 10
4.0 Fixed separation distances surrounding land disposal areas 11
5.0 References 12

List of tables

Table 1. Calculation of Standard Pig Units (SPU) 3
Table 2. Values of effluent removal factor, S1 3
Table 3. Values of receptor type factor, S2 4
Table 4. Values of terrain factor, S3 6
Table 5. Values of surface roughness factor, S4 7
Table 6. Separation distances to other relevant features 10
Table 7. Separation distances surrounding land disposal areas 11

List of figures

Figure 1. Description of the 2 % falling grade line 6
Figure 2. Standard symmetrical shape piggery (5000 SPU) 9

1.0 Introduction

Piggeries should be sited, designed, constructed and operated to avoid unreasonable interference with the comfortable enjoyment of life and property, both on- and off-site (Environmental Code of Practice for Queensland Piggeries – Streeten and McGahan, 2000). To reduce the potential for adverse community amenity effects from odour, dust, noise and aesthetics, piggeries should be appropriately separated from sensitive receptors.

Odour has been identified as the principal community amenity concern in relation to piggery developments when the history of complaints made under the *Environmental Protection Act 1994* is analysed. Separation distance requirements are, thus, generally determined on the basis of limiting the potential of nuisance odours to an acceptable level. It is generally accepted that if sufficient separation distance is provided to limit the potential of odour nuisance to an acceptable level, adverse impacts due to dust and noise are more than adequately addressed. The aesthetic impact of piggeries is also addressed to some extent by providing an adequate separation distance for odour mitigation; however, this issue is best addressed on a case-by-case basis, depending on the overall landscape and community values.

These guidelines provide a method whereby piggeries can be consistently assessed in terms of their potential community amenity impact. This method is based on a combination of scientific research and practical experience. Separation distances specified in these guidelines are divided into two sections, variable and fixed. Variable separation distances from piggeries to receptors are based on the number of standard pig units, receptor type, topography, vegetation (surface roughness), and piggery design and operation. Fixed separation distances are also provided for appropriate distances between the piggery complex and relevant features such as watercourses, roads and property boundaries. It is important to note however that consideration will be given by DPI's intensive livestock environmental management officers to the implementation of site-specific practices, which would allow a reduction in the fixed separation distance (e.g. distances to watercourses may be reduced with appropriately designed vegetative buffers).

Table 6 lists minimum fixed separation distances from the piggery to receptors. These minimum fixed distances are included to account for both inaccuracies with predicting odour impact at close distances and the visual impact on the community of piggery developments. Both the variable and fixed separation distance to receptors (large towns, towns, small towns, rural residential developments and rural farm houses) must be calculated and the greater distance of the two applied.

The piggery complex is generally considered to be any land, building or other structure or any part thereof, whether temporarily or permanently used for the purpose of keeping, feeding or watering of pigs. The term includes any ponds and manure storage areas used in conjunction with the keeping of pigs, any loading or unloading facilities and carcass disposal sites, but it does not include areas that are used for land utilisation of piggery wastes. **Section 4** details separation distances from land disposal areas and relevant receptors and features, depending on the type of land disposal system employed. Land disposal areas are not included as part of the piggery complex because of the often infrequent application of wastes and the diverse spread of application areas on a farm.

These separation guidelines only apply to all new and expanding piggeries. They will assist prospective piggery developers and their consultants in the planning of new and expanding piggery developments. The Guidelines will also assist regulatory agencies with the assessment of applications for new piggery developments, or expansions of existing developments, under the relevant legislation (*Environmental Protection Act 1994* and *Integrated Planning Act 1997*).

2.0 Variable separation distances - distance between piggery complex and receptors

2.1. S Factor formula

The separation distance of the piggery complex from receptors is dependent on a number of factors, including:

- Number of standard pig units in the complex.
- Effluent removal procedures employed at the piggery complex.
- Receptor type (e.g. town, rural residence).
- Topography features (e.g. valley drainage) between the piggery and the receptor.
- Vegetation/surface roughness between the piggery complex and the receptor.

Variable separation distances are based on the dispersion of odours downwind from their source. The S factor formula was developed using measured odour emission data from both piggery buildings and effluent treatment lagoons (Smith et. al., 1997; Dalton et. al., 1997; Dalton et. al., 1998), adopted emission rates from Watts (1999) and modelling the dispersion of these odours using AUSPLUME 4.0 (Lorimer, 1997). The required separation distance was then calculated. Five different sized piggeries (500, 2000, 5000, 10000 and 25000 standard pig units) of a standard symmetrical shape were modelled with Ausplume.

Different air quality objectives have been chosen for different receptor types based on the assumption that there is a greater probability that people will be affected by odour from larger population centres and that the occupants of residences in rural areas will be more tolerant of agricultural odours.

Calculation of separation distances for each receptor type:

$$\textbf{Separation distance (D)} = N^{0.65} \times S1 \times S2 \times S3 \times S4$$

Where:

N = Number of standard pig units (SPU)
S1= Effluent removal factor
S2 = Receptor type factor
S3 = Terrain factor
S4 = Surface roughness factor

The separation distance is the distance from the closest point within the piggery complex to the receptor, (e.g. town boundary, residence, school, church or hall). The available separation distances between the piggery complex and sensitive receptors are generally the key factors limiting the number of pigs that can be accommodated on a particular site. Separation distances to all relevant receptors must be assessed to ensure that the potential for unacceptable odour nuisance is minimised.

2.2. Calculation of Standard Pig Units

The equivalent number of standard pig units (SPU) is calculated using standard multipliers for each class of pig. A SPU is based on the amount of volatile solids produced from an average size grower pig (40 kg) - 1 SPU. Multipliers are then applied to each class of pig based on their relative volatile solids production as compared to an average size grower pig. The pig mass, age and standard multipliers for each class of pig is tabulated in **Table 1.**

Table 1. **Calculation of Standard Pig Units (SPU)**

Class of Pig	Mass (kg)	Age / Period (wks)	Multiplier
Gilts	100 – 160	24 - 30	1.8
Boars	100 – 300	24 - 126	1.6
Gestating Sows	160 – 215	16.3	1.6
Lactating Sows	215 – 160	4	2.5
Sucker	1.4 – 8	0 - 4	0.1
Weaner	8 – 25	4 - 10	0.5
Grower	25 – 55	10 - 16	1.0
Finisher	55 – 100	16 - 24	1.6

2.3. S1 – Effluent removal factor

The effluent removal factor S1 relates to the odour potential of piggeries based on the design and management of the piggery buildings. Good shed management practices, including the frequency of effluent removal from buildings, is known to reduce odour emissions (Dalton et. al., 1998). **Table 2** lists effluent removal factors based on the frequency that faeces, urine and other biological material are removed from the confines of the buildings.

Table 2. **Values of effluent removal factor, S1**

Effluent Removal System	Value of S1
Held for greater than 24 hours within building (e.g. static pit or pull plug)	1.00
Held for less than 24 hours within building (e.g. flushing system)	0.95
Held for less than 12 hours (e.g. flushed twice daily)	0.90
Deep litter system (no effluent treatment ponds)	0.50

Notes:

1. These guidelines call for a reasonably high standard of management at all piggeries. **Table 2** gives factors that relate to the odour potential for different building types and effluent management systems.
2. Where different building design or management practices exist within the piggery complex the effluent removal factor S1 should be weighted according to the number of SPU within each system.
3. The S1 factor could be adjusted if there is new odour reducing technology employed that can be demonstrated and quantified.
4. The S1 factor for deep litter systems ("Eco-shelters") stocked at recommended rates with good management practices (e.g. sufficient bedding equivalent to 1 kg of straw/pig/day) is 0.5. This assumes there is no liquid effluent treatment system and solid stockpiles are regularly removed.

2.4. S2 – Receptor type factor

The receptor factors presented in **Table 3** account for the variation in population density, odour sensitivity and expectations of amenity within the community. Different receptor factors have been adopted for the various receptor types for the following reasons:

- Because towns cover a wider area and have a much higher population density than rural areas, the probability of an odour plume adversely affecting a significant number of residents is significantly higher in a town/urban area than in a rural area. The greater the population of the town, the larger the residential area which could potentially be adversely affected by an odour plume.
- There is a wide variation in people's sensitivities to odours. What some people regard as offensive may not be offensive to others. The larger the population at an impact location, the greater the probability of an odour offending someone.
- It is believed that there is a greater acceptance of odour among people who live and work in an environment similar to that in which the enterprise causing the odour exists. Consequently, people working in rural occupations and/or living in rural areas may have a greater tolerance of rural odours (such as livestock smells) than urban dwellers. This characteristic was observed in a survey of people living in the vicinity of a feedlot where the rural respondents reported odours less frequently and were less frequently annoyed by odours than rural residential respondents (Walsh *et. al.*, 1995).

Regardless of the receptor type, it is the intention of these guidelines to provide a method for determining an appropriate separation distance that ensures that the frequency, intensity, duration and offensiveness of odours from piggeries remain within acceptable limits.

Table 3. **Values of receptor type factor, S2**

Receptor type	**Value of S2**
Large town > 2000 persons	17.3
Town > 100 persons	9.8
Small town > 20 persons	7.1
Rural residential development – intensive	7.1
Rural residential development – extensive	5.7
Rural farm residence	4.7
Rural school	4.7
Rural church/community centre	3.0
Public area (minimum value, see note 3)	1.5

Receptor type definitions

The following definitions apply to the receptor types outlined in **Table 3**:

Large town: Population greater than 2000 people.

Town: Population in the range from 101 to 2000 people. *(The population of towns and large towns may be obtained from local authorities or census statistics).*

Small town: Population in the range from 20 to 100 people. *(The population of small towns may be obtained from specific census or local authority records or by counting the number of dwellings and assuming three persons per dwelling).*

Rural residential developments: A situation where the subdivision of land has occurred resulting in blocks of land larger than standard residential blocks, but too small for commercial agricultural or pastoral pursuits. Residences on these subdivisions are reasonably widely spaced, but much closer than for commercial farm residences. These developments can be broadly divided into two categories:

(i) **Intensive** in which the areas of individual blocks of the subdivision are less than one hectare, and

(ii) **Extensive** in which the area of individual blocks is within the range from one hectare to ten hectares.

For the purposes of these Guidelines, six (6) or more adjoining blocks, as described in either (i) or (ii), constitute a rural residential development. For an intensive rural residential subdivision, an S2 value, the same as for a small town, is suggested, whereas for an extensive rural residential development, a lower S2 value, between the value for a small town and a rural farm residence is recommended.

Rural farm residence: This is a residence of the owner or operator of a commercial rural property. It includes **any** dwelling that could be reasonably inhabited and may include dwellings that are not occupied when the assessment is undertaken. The Local Authority's records regarding the building approval status of a dwelling, may provide guidance in assessing whether a dwelling should be considered as a receptor.

Rural school: A country school that is not located within a town. In some cases, a teacher's residence may be attached to the school.

Rural church/community centre: A country church or community hall that is not located within a town.

Public area: This situation includes such places as country recreation/sports areas that are used at varying frequencies. The value provided in **Table 3** should be regarded as a minimum value, which would be applicable, if the public area is used less than once per month on average. Subject to an individual assessment, higher S2 values may be selected, depending on the sensitivity of the facility and the type and extent of usage.

Notes:

1. The separation distance is to be measured to the edge of the town, not the centre. When determining the location of the edge of the receptor, land zoning and the probability of future residential development should be taken into account. In the case of town receptors, the Local Authority should be consulted to determine the location of the town boundary. Documentation of this consultation should be included in the application.
2. A rural residence is any dwelling that could be reasonably inhabited and may include dwellings that are not occupied when the assessment is undertaken. It also includes any small rural school. Although more people would be expected at the school compared to a single residence, the use of the school during evenings when odours are most likely to be an issue is limited.
3. The value for public areas would apply to areas subject to occasional use. Larger separation distances may be appropriate for public areas used frequently or sensitive in nature and frequently used halls and recreation areas. These would be assessed individually.
4. In circumstances where the separation distance from the piggery to a receptor is within 10 % of the required separation distance, certification of the actual separation distance must be provided. The distance should be determined either by ground survey, geodetic positioning system (GPS) equipment, or other suitable method. The accuracy of GPS systems should be stated. The applicant should demonstrate that the person carrying out the distance measurement is suitably qualified in operating the equipment. Certification of the measured distance may be provided by means of statutory declaration, licensed surveyor, engineering consultant or project manager.

2.5. S3 – Terrain factor

The terrain factor, S3 varies according to the likelihood of odour impact resulting from night-time air drainage flows. Recommended values are presented in **Table 4.**

Topographical features of the selected site may adversely affect the odour impact under certain circumstances. During the early evening or night-time under low wind speed conditions, receptors located in a valley complex at a lower elevation than the piggery may be subject to higher odour concentrations. This is a result of down-valley (katabatic) wind and/or the occurrence of low-level atmospheric temperature inversions. Unless site specific information has been gathered under conditions dominated by low wind speeds, the value for the factor S3 given in **Table 4** should be applied. In the case of piggery expansions, operational experience may be used in selecting an appropriate S3 value.

Table 4. **Values of terrain factor, S3**

Description	**Value of S3**
Low relief at > 2 % from site (a)	1.2
Valley drainage zone (b)	1.2 - 2.0
Flat (c)	1.0

Notes:

(a) **Low relief** applies where a receptor is generally below the 2 % (1.15°) falling grade line from the piggery, but not in topography which would tend to confine odours. (Any intervening topographical features should be considered in the selection of the surface roughness factor S4). Refer to **Figure 1** for a description of the 2 % falling grade line.

(b) **Valley drainage zones** apply when the receptor is situated in a valley, below the 2 % (1.15°) falling grade line from the piggery. The valley must have significant confining side walls which tend to prevent the dispersion of any odours generated by the piggery. Values ranging from 1.2 to 2 may be selected depending on the degree of confinement. Factors such as the steepness of the valley and confining walls, the width of the valley and the continuity of the confining features should be considered in selecting an appropriate value.

(c) **Flat** topographic conditions apply for all cases other than low relief and valley drainage as described in (a) and (b).

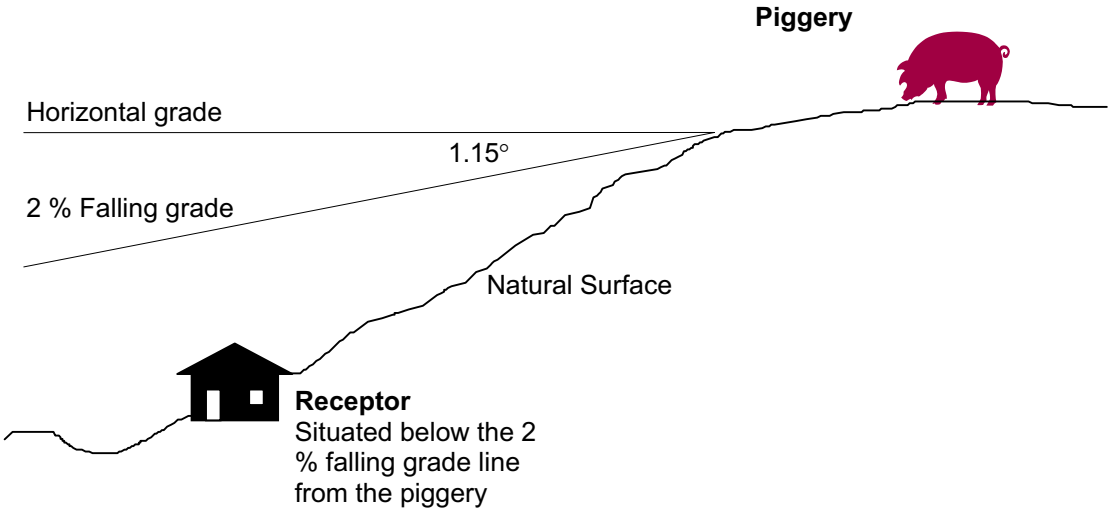

Figure 1. Description of the 2 % falling grade line

2.6. S4 – Surface roughness factor

The S4 factor varies according to the roughness of the earth's surface between the piggery and the receptor. The principle elements that determine surface roughness are vegetation density and surface topography. Recommended values of S4 are provided in **Table 5. The values presented in this Table 5 are not to be added (i.e. only the value for the single category which best represents the site conditions should be selected).**

The rate at which odour disperses after leaving a piggery is determined by wind speed, atmospheric conditions and the roughness of the surface over which the odour moves. "Rough" surfaces cause the odour to disperse more rapidly than "smooth" surfaces.

The S4 factors given in **Table 5** assume that the selected roughness is continuous between the piggery and the receptor. Where roughness is variable or non-continuous, judgement should be used in selecting an appropriate composite factor.

The values given in **Table 5** should be used with care and a number of qualifications apply to their use. For example, in most cases, no permanent concession should be allowed for tree cover not controlled by the applicant. This applies particularly where a belt of trees on a neighbouring property is the only vegetation between the piggery and the neighbouring house. However, if the vegetation is extensive across several properties and unlikely to be cleared, then a concession may be appropriate. This situation may occur where a town is several kilometres from the piggery. Although not under the control of the piggery operator, some forests such as national parks and state forests can generally be regarded as permanent.

No concession should be given for the "intention" to plant a vegetative barrier, and in the event that an operator fails to maintain a barrier taken into account in the licence assessment, then a reduction in the allowed number of standard pig units would be necessary. However, operators are encouraged to establish and maintain an upper storey and lower storey vegetative buffer zone to improve visual amenity, odour dispersion, dust reduction and noise attenuation.

The values presented in **Table 5** were generated by running the AUSPLUME model for six (6) different roughness height values (0.05, 0.1, 0.2, 0.4, 0.8 and 2.0) for a 5000 SPU piggery to investigate the effect of roughness height on odour dispersion.

Table 5. **Values of surface roughness factor, S4**

Surface roughness features		**Value of S4**
Crops only, no tree cover		1.15
Few trees, long grass	(a)	1.00
Undulating hills	(b)	0.90
Level wooded country	(c)	0.75
Heavy timber	(d)	0.65
Heavy forest (both upper and lower storey)	(e)	0.60
Significant hills and valleys	(f)	0.50

Notes:

(a) **Few trees, long grass:** Open country with a permanent covering of grass or pasture of around 1 m or more in height and with a light scattering of timber which is distributed continuously across the buffer area. Topography would be predominantly flat to slightly undulating. Isolated clumps of trees would not be sufficient to attract this concession. Land being actively cropped would not attract this concession because of the extended periods when it is bare or carrying only very low ground cover.

(b) **Undulating hills:** Situations where topography consists of continuous rolling, generally low level hills and valleys, but without sharply defined ranges, ridges or escarpments, similar to much of the eastern Darling Downs and Burnett regions. *(This category assumes minimal vegetative cover. If significant vegetative cover exists at the site, one of the categories described in (c), (d) or (e) may be more appropriate).*

(c) **Level wooded country:** Open forest country with tree density not sufficient to provide a continuous canopy, but sufficiently dense to influence air movement. There would be little or no lower storey vegetation. The density needs to be such that the vegetation can be considered as a continuous belt and isolated clumps would not attract this concession. The minimum tree height is 4 m and the minimum extent in the direction of the receptor is 400 m.

(d) **Heavy timber:** Generally tall forests with dense timber stands, providing a continuous canopy. There is limited understorey vegetation, mainly associated with regrowth. The minimum tree height is 4 m and the minimum extent in the direction of the receptor is 400 m.

(e) **Heavy forest, upper and lower storey:** Dense layers of taller timber with an interlocking canopy and extensive amounts of lower storey vegetation of various species resulting in almost complete ground cover and a dense upper canopy. Examples are uncleared brigalow areas and dense eucalypt forests where little or no clearing or harvesting has occurred. The minimum tree height is 4 m and the minimum extent in the direction of the receptor is 400 m.

(f) **Significant hills and valleys:** Situations where one or more lines of hills sufficiently large enough to influence air movement exist between the receptor and the piggery.

2.7. Odour dispersion modelling – alternate method for determining required separation distances

Under some circumstances, the use of the standard S factor formula for siting a piggery may not be an appropriate method. Such situations include:

- Proposals involving separate piggery complexes within the same general locality (e.g. multi-site production systems).
- Piggeries that vary significantly from the standard symmetrical shape assumed in the formulation of the S factor formula (Refer to **Figure 2**).
- Piggeries that have significantly different effluent treatment systems (e.g. covered lagoons).

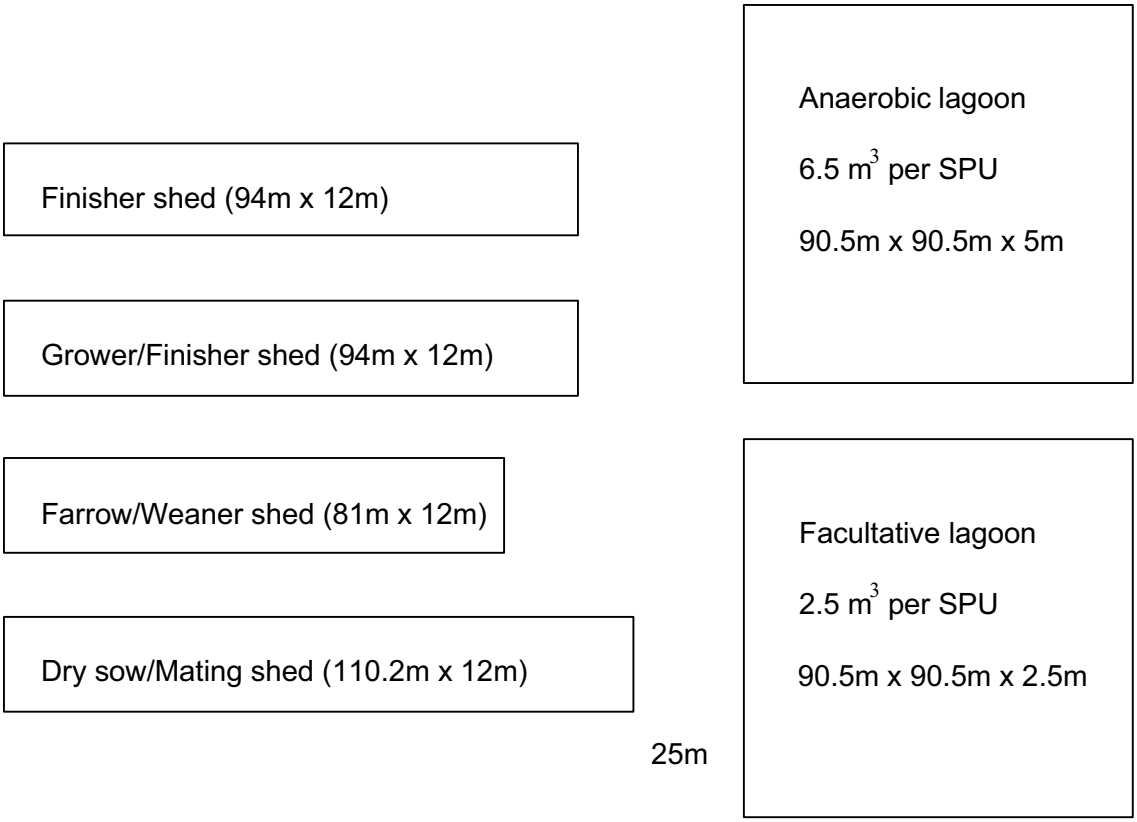

Figure 2. Standard symmetrical shape (5000 SPU piggery)

Applicants may choose to submit a comprehensive odour dispersion model to support an application for a new or expanding piggery. This will generally require the employment of a specialised consultant. DPI's intensive livestock environmental management officers should be consulted to establish the required modelling method and parameters before commencing the modelling exercise.

The modelling approach attempts to give quantitative predictions of odour levels at receptors. It employs "real-time' climatic data to attempt to quantify the frequency and duration of odour nuisance.

3.0 Fixed separation distances - distance between piggery complex and relevant features and receptors.

Table 6. **Separation distances to other relevant features**

Feature	Distance (m)
Public road – carrying > 50 vehicles per day	200
Public road – carrying < 50 vehicles per day	100
Major water supply storage	800
Watercourse	100
Groundwater bores	100
Large town (> 2000 persons)	*1000
Town (> 100 persons)	*750
Town (> 20 persons)	*500
Rural residential development	*400
Rural farm residence	*250
Property boundary	20
Neighbouring piggery	2000

*** This is a minimum fixed separation distance. The variable separation distance must also be calculated and the greater distance of the two applied.**

No piggery is to be sited within a declared catchment area or a declared groundwater area as prescribed under the Water Resources Act, unless special consent is granted from the Department of Natural Resources and Mines

For major storages owned by Water Boards or Local Authorities, restrictions may apply in their catchment areas.

Notes:

1. The measuring point for a **public road** shall be the surveyed boundaries of the road on the same side of the road as the piggery unit operation.
2. **Traffic volume** excludes vehicles associated with the piggery operation.
3. **Major water supply storage** means any public water supply storage, lake, lagoon, marsh or swamp.
4. **Watercourse** means a river, creek or stream in which water flows permanently or intermittently, which could receive runoff from the piggery.
5. The **measuring point** for a watercourse shall be the maximum level to which the water surface of a watercourse may reach before overtopping of a bank begins (bank-full discharge level).
6. No open effluent channel shall be within 50 m of the **property boundary**.
7. A **neighbouring piggery** is defined as a piggery or a combination of piggeries (with a total capacity of 1000 SPU).
8. The fixed separation distances between the piggery complex and relevant features and receptors are to be used as a guide. Dispensation may be obtained for these distances following site-specific assessment from DPI's intensive livestock environmental management officers.

4.0 Fixed separation distances surrounding land disposal areas

Separation distances shall be established between land disposal areas and residential or other nominated features. They are in addition to separation zones for the piggery complex and are determined separately. When all effluent material (liquids, solids or slurry) is transported or conveyed across a property boundary or along public roads, it shall be contained in a closed vessel or pipe. The following categories describe the disposal method employed, with the specified distances for each category listed in **Table 7**.

Category 1

- Effluent is discharged or projected to a height in excess of 2 metres above ground level.
- Effluent where water remains ponded on the soil surface for periods in excess of 1 hour.
- Separated solids or sludge that remain on the soil surface for more than 24 hours (i.e. are not immediately ploughed in).

Category 2

- Mechanical spreaders (in combination with "ploughing in" type equipment) and downward discharge nozzles. The discharged material shall not be projected to a height in excess of 2 metres above ground level.

Category 3

- Discharge by injection directly into the soil (to a depth of not greater than 0.4m) and at a rate not exceeding either the hydraulic or NPK limits determined for the local soil type(s).

Category 4

- Effluent from a tertiary treatment system.
- Treatment units producing effluent of a tertiary quality (that meet and maintain the manufacturer's specifications).

Where more than one category of disposal to land is used the more (or most) stringent category controls will apply.

When waste is to be spread or discharged, account should be taken of actual and forecast wind conditions so as to prevent any waste being carried by the wind into the buffer distance, or the creation of an odour nuisance to neighbouring properties.

Table 7. **Separation distances surrounding land disposal areas**

	Distances (m)			
Category No.	**1**	**2**	**3**	**4**
Large Town (greater than 2000 persons)	2000	1500	500	
Town (greater than 100 persons)	1500	1000	250	
Small Town (greater than 20 persons)	1000	750	200	
Rural Residential Development	750	500	150	
Rural Farm Residence	300	200	100	See
Public Area	200	100	50	Note
Public road – carrying > 50 vehicles per day	100	50	0	1
Public road – carrying < 50 vehicles per day	50	25	0	
Major water supply storage	800	800	800	
Watercourse (See Note 3)	100	100	25	
Groundwater bores	100	100	25	
Property boundary	20	20	0	

Notes:

1. Distances in Category 4 are subject to determination by DPI's intensive livestock environmental management officers.
2. Distances shall be measured from the perimeter of the area used for handling or disposal of effluent.
3. The fixed separation distances surrounding land disposal areas are to be used as a guide. Dispensation may be obtained for these distances following site specific assessment from DPI's intensive livestock environmental management officers (e.g. appropriate vegetative buffers will be considered in reducing the required distance to watercourses).

5.0 References

Streeten, T.A. and E.J. McGahan. (Eds). 2000. Environmental Code of Practice for Queensland Piggeries. Department of Primary Industries (the State of Queensland) and Queensland Pork Producers Incorporated.

Dalton, P.A., T.R. Harris, R.J. Smith and N.H. Hancock. (1997). Odour Emissions from Piggery Buildings. National Workshop on Odour Standardisation. University of NSW, Sydney..

Dalton, P.A., T.R. Harris, and R.J. Smith. (1998). Effect of management Practices on Odour Emissions from Piggery Buildings. 1998 International Conference on Engineering in Agriculture. University of Western Australia, Perth

Lorimer, G. (1997). The AUSPLUME Gaussian Plume Dispersion Model, Version 4.0. Environment Protection Authority and the Centre for Applied Mathematical Modelling, Monash University, Melbourne, Victoria.

Queensland Department of Primary Industries (Co-ordinator of preparation and publication). (1989). Queensland Government Guidelines for Establishment and Operation of Cattle Feedlots, DPI.

Smith, R.J., P.A. Dalton, T.R. Harris, and N.H. Hancock. (1997). Environmental Odours from Piggeries. Manipulating Pig Production VI. Canberra, ACT.

Walsh, P. A., C.M. Lunney, and K.D. Casey. (1995). The Impact of Odours on Feedlot Neighbours, Proc. Feedlot Waste Management Conference, Royal Pines Resort, Gold Coast, Qld, June 1995, QDPI Publication.

Watts, P.J. (1999). Development of a Pig Effluent Emissions Database and Analysis of Promising Control Strategies – Draft Report. Project No. FSE 1/1503, Pig Research and Development Corporation, Canberra, Australian Capital Territory.