Planning and environment guideline for establishing meat chicken farms

Guide 1
Assessment guide

by Eugene McGahan and Stephen Wiedemann (Integrity Ag and Environment) and Geordie Galvin (Astute Environmental Consulting)
November 2021
Planning and environment guideline for establishing meat chicken farms (Guide 1 – Assessment guide)
Publication no. 21-080
Project no. PRJ-011090

The information contained in this publication is intended for general use to assist public knowledge and discussion and to help improve the development of sustainable regions. You must not rely on any information contained in this publication without taking specialist advice relevant to your particular circumstances.

While reasonable care has been taken in preparing this publication to ensure that information is true and correct, the Commonwealth of Australia gives no assurance as to the accuracy of any information in this publication.

The Commonwealth of Australia, AgriFutures Australia, the authors or contributors expressly disclaim, to the maximum extent permitted by law, all responsibility and liability to any person, arising directly or indirectly from any act or omission, or for any consequences of any such act or omission, made in reliance on the contents of this publication, whether or not caused by any negligence on the part of the Commonwealth of Australia, AgriFutures Australia, the authors or contributors.

The Commonwealth of Australia does not necessarily endorse the views in this publication.

This publication is copyright. Apart from any use as permitted under the Copyright Act 1968, all other rights are reserved. However, wide dissemination is encouraged. Requests and inquiries concerning reproduction and rights should be addressed to AgriFutures Australia Communications Team on 02 6923 6900.

Researcher contact details
Eugene McGahan
10511 New England Highway
Highfields QLD 4352
07 4615 4690
eugenemcgahan@gmail.com

In submitting this report, the researcher has agreed to AgriFutures Australia publishing this material in its edited form.

AgriFutures Australia contact details
Building 007, Tooma Way
Charles Sturt University
Locked Bag 588
Wagga Wagga NSW 2650
02 6923 6900
info@agrifutures.com.au
agrifutures.com.au


AgriFutures Australia is the new trading name for Rural Industries Research & Development Corporation (RIRDC), a statutory authority of the Federal Government established by the Primary Industries Research and Development Act 1989.
Acknowledgments

We wish to thank the AgriFutures Chicken Meat Program for its commitment to a thriving and environmentally sustainable chicken meat industry.

We also wish to acknowledge members of our steering committee for their valuable guidance and oversight – Georgina Townsend, Sue Hatcher, Annie Lane, Guy Hobbiewhite, Julia Seddon and Nick Mitrevski.

A special thanks goes to our technical reference group (TRG), comprised of state government regulators and expert consultants who have reviewed and contributed to the guidelines. The TRG consisted of:

- Mitch Furness (QLD DAF)
- Andrew Voigt (QLD DAF)
- Melinda Russ (QLD DESDMIP)
- Geordie Galvin (Astute Environmental Consulting)
- Byron Stain (NSW DPI)
- Andrew Scott (NSW DPI)
- Janelle Pickup (NSW EPA)
- Gary Whytcross (NSW EPA)
- Guillermo Restrepo (NSW DPIE)
- Eryn Bath (EME Advisory)
- Janine Price (Scolexia)
- John Grafdyck (VIC DLPR)
- Chris Bydder (VIC EPA)
- Michael Moore (ACCG)
- Vivien Kite (ACMF)
- Melinda Hunt (SA EPA)
- Anita Allen (SA DPTI)
- Patrick Page (WA DPIRD)
- Phillipe Najean (WA DPIRD)
- David Griffiths (WA DWER).

Lastly, a special thanks also goes to the Odour Working Group (OWG), which developed the technical background for the publication Best practice guideline: Odour and dust impact assessment for meat chicken farms. The OWG consisted of:

Project team
- Robin Ormerod (Chair)
- Geordie Galvin (Principal Environmental Engineer – Astute Environmental Consulting)

Consultant members
- Aleks Todoroski (Todoroski Air Sciences)
- Simon Welchman (Katestone Consulting)
- Johan Maline (ERM Consulting)
- John Hurley (EAQ Consulting)
- Graeme Starke (SLR Consulting)
- Tracy Freeman (Air Quality Professionals)
- Peter D’Abreron (EnviroSuite)
- Paul King (MWA Environmental)
- Mark Dunlop (QLD DAF)
- Mitch Furness (QLD DAF)
- Terry Schulz (The Odour Unit)

We wish to thank the AgriFutures Chicken Meat Program for its commitment to a thriving and environmentally sustainable chicken meat industry.

About the authors

Eugene McGahan is an agricultural and environmental engineering consultant, having worked for over 25 years on environmental sustainability issues for the intensive livestock industries. Eugene specialises in a range of areas: development approvals; assessing the environmental performance of individual farms; industry-specific research to provide solutions to environmental challenges; designing and providing environmental management training; and developing environmental and planning guidelines and codes of practice. He has consulted widely with the chicken meat, beef feedlot, dairy, piggery and egg industries.

Stephen Wiedemann is an agricultural scientist and principal of Integrity Ag and Environment. Stephen has led numerous research projects, including substantial work for the chicken meat industry in research and extension.
Abbreviations

AEP  Annual exceedance probability (AEP) is the likelihood that an event such as a storm or flood will occur in any one year.

AERMOD  AERMOD stands for the AERMIC Dispersion Model. AERMOD was designed by the AERMIC (the American Meteorological Society/Environmental Protection Agency Regulatory Model Improvement Committee) to treat elevated and surface sources in terrain that is simple or complex (Cimorelli et al, 1996; Perry et al, 2005).

Application  An application for approval to conduct a proposed activity/land use on a particular piece of land.

Approval  Permission under state planning or environment regulatory frameworks to conduct a proposed activity/land use on a particular piece of land. Terminology varies, but this includes planning consent, development consent, development approval, planning approval, planning permits, environmental licencing, environmental approvals, or other approval required for the proposed activity/land use under planning and environmental licencing regulations.

AS  Australian Standard.

AUSPLUME  AUSPLUME (EPA Victoria, 2004) is a Gaussian plume dispersion model that can simulate the effects of multiple sources, including stacks, volume sources and area sources.

Batch cycle  The growing period (see below), which is typically six to eight weeks, followed by a one-to-two-week empty period (see below). Also known as growth cycle.

Buffer distance  The distance between a source of potential impacts (such as nutrients, chemicals, or pathogens) and an environmental receptor (such as a creek or water storage). This is measured as the shortest distance between the edge of the impact source and the receptor’s boundary.

By-products  Outputs from the production system (other than finished birds) that can be used as inputs for a different process. For example, dead birds and spent litter both have high nutrient contents and could be used as inputs for composting or anaerobic digestion processes.

CALMET  CALMET is a three-dimensional meteorological pre-processor that includes a wind field generator containing objective analysis and parameterised treatments of slope flows, terrain effects and terrain-blocking effects.

CALPUFF  The CALPUFF (California Puff) model is a multi-layer, multi-species, non-steady-state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions on pollutant transport, transformation and removal (Scire, Strimaitis and Yamartino, 2000; Exponent, 2011)

CDA  A controlled drainage area (CDA) is an area designed to capture potentially contaminated stormwater runoff, excluding clean stormwater.

CFM  Cubic feet per minute (CFM) is a volumetric flow rate, where one CFM in SI units is 4.7195 x 10-4 m3/s (cubic metres per second).

Conventional production  Conventional production involves growing meat chickens indoors with no access to range areas. See Section 1 for further detail.

CSIRO  The Commonwealth Scientific and Industrial Research Organisation is an Australian Government agency responsible for scientific research.

Curtilage  The curtilage of a house or dwelling is taken as the land immediately adjacent to the premises (e.g., house yard), including any closely associated buildings and structures. It does not include any open paddocks or fields. It delineates the boundary where a home occupant can have a reasonable expectation of privacy and where home activities generally occur. For this guideline, it is taken to be a maximum of 25 m from the house’s exterior walls.

EIS  An Environmental Impact Statement (EIS) is a detailed report that focuses on identifying the potential impacts of a development, including environmental, social and economic considerations, and any applicable design/management measures to reduce impacts. May be required to accompany certain planning/development applications. Regional terminology may vary.

EMP  An Environmental Management Plan (EMP) is an environmental document that typically addresses the same issues as an EIS. An EMP is generally required to accompany a planning/development application. They typically include issue-specific management measures (where required) to address potential issues such as odour, surface water and traffic, among others. In some circumstances/jurisdictions, an EMP focuses on the day-to-day management of the farm and how operations will be undertaken to reduce impacts. Regional terminology may vary.

Empty period  Time when sheds are free of birds and when litter cleanout, sanitation, maintenance, fresh litter spreading and preheating of sheds takes place.

EMS  An Environmental Management System (EMS) is environmental documentation typically developed at an organisational (rather than site-specific) level and which addresses a wider range of issues, including resource use efficiency. An EMS incorporates the organisation’s environmental goals and the policies, plans, and procedures required to achieve these (such as training plans, SOPs, environmental monitoring and record-keeping). An EMS also includes measures to check the performance of the EMS (through the audit) and identifies corrective actions.

Environmental offset  An area of land secured and managed to counterbalance/replace the loss of environmental values on another piece of land.
### Farm complex
The cluster of buildings, storages and services that form the main production area on meat chicken farms. This typically includes all the sheds and ancillary structures (such as silos, water storages, and shed loading and offloading/hardstand areas, as well as any range areas associated with the sheds). If a meat chicken farm has multiple farm complexes, each could have its own chemical storage shed, generator shed, workshop, wheel wash and amenities block. As a minimum, the sheds and feed silos are typically located on the compacted farm pad. The farm complex typically excludes farm managers’ accommodation, staff/general parking areas, by-product management and by-product application areas.

### Farm infrastructure
The buildings, sheds, silos, roads, drainage works, and other alterations to the site associated with land use for farm purposes.

### Farm pad
An impermeable pad that (at a minimum) includes all the poultry sheds. It may also include other farm infrastructure.

### FNLI
The Farm Nutrient Loss Index (FNLI) was developed for dairy farms to assess nutrient loss risks, and uses several key indices.

### Free-range production
Free-range production involves growing meat chickens indoors, as in conventional production, however, once birds are fully feathered, they are allowed access to an outdoor area for a period of about 2-5 weeks until harvested.

### Fresh litter
Litter not yet used by birds that is ready for use in sheds. Also referred to as bedding.

### Friable
The ability to reduce a substance into smaller pieces. Therefore, friable litter is ‘free-flowing’, not caked or sticky. Friable litter should fall apart and can be ‘worked’ by the birds as they scratch, dig and forage (Lister, 2009). This maintains aerobic conditions and accelerates moisture loss.

### Grower
The company/individual(s) responsible for producing meat chickens on farms.

### Growing period
The length of time that birds are grown on farm between placement of chicks and pick-up of birds. There are typically five to six growth cycles in a year.

### Integrator
An integrator company operates multiple aspects of the chicken meat production and supply chain. These may include breeder farms, hatcheries, feed supply companies and processing facilities.

### K-factor
A relationship between the number of birds present, the stocking density of the birds, and the ventilation rate of odour emissions (derived from odour testing data).

### LS
Length-slope.

### Meat chicken farm
The land parcel(s) where the growing of meat chickens and ancillary land uses occurs (or will occur).

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML</td>
<td>Megalitre, which is equivalent to 1,000,000 litres.</td>
</tr>
<tr>
<td>MSDS</td>
<td>Material safety data sheet.</td>
</tr>
<tr>
<td>NGERS</td>
<td>National Greenhouse Energy Reporting Scheme is a national framework for reporting and disseminating company information about greenhouse gas (GHG) emissions, energy production and energy consumption.</td>
</tr>
<tr>
<td>NPI</td>
<td>National Pollutant Inventory is a database used to collect information about emissions and transfers of various substances across Australia. If a facility exceeds reporting thresholds for one or more substances, there is a requirement to calculate and report the annual emissions and transfers that result from the operations.</td>
</tr>
<tr>
<td>Odour source</td>
<td>The point of measurement to calculate separation distances. The odour source for tunnel-ventilated sheds is taken to be 10 m from the exhaust end of each shed. For naturally ventilated sheds, the odour source is the shed wall nearest to the sensitive land use.</td>
</tr>
<tr>
<td>OER</td>
<td>Odour emission rate.</td>
</tr>
<tr>
<td>OWG</td>
<td>Odour Working Group.</td>
</tr>
<tr>
<td>Peak discharge volume</td>
<td>For this guideline, the peak discharge volume for an area is taken to be the runoff associated with the 5% AEP design storm, when the rainfall duration is equal to the time of concentration for the area under consideration.</td>
</tr>
<tr>
<td>PM$_{10}$</td>
<td>Particulate matter with a particle size less than 10 micrometres.</td>
</tr>
<tr>
<td>PM$_{2.5}$</td>
<td>Particulate matter with a particle size less than 2.5 micrometres.</td>
</tr>
<tr>
<td>PPU</td>
<td>Poultry Production Unit. See Farm Complex.</td>
</tr>
<tr>
<td>ppm</td>
<td>Parts per million, equivalent to milligrams/kilogram (mg/kg).</td>
</tr>
<tr>
<td>Processor</td>
<td>The company/facility responsible for processing live chickens to produce chicken meat.</td>
</tr>
<tr>
<td>Producer</td>
<td>See ‘Grower’.</td>
</tr>
<tr>
<td>QA/QC</td>
<td>Quality assurance/quality control is the combination of quality assurance (the process or set of processes used to measure and assure the quality of a product), and quality control (the process of ensuring products and services meet consumer expectations).</td>
</tr>
</tbody>
</table>
Ruminants must not be permitted access to Restricted Animal Material (RAM), irrespective of whether they eat it or not. RAM is any material that consists of, or contains, matter from an animal, including fish and birds. RAM does not include gelatine, milk or milk products. Tallow and used cooking oil are not RAM if processed to the standard approved in state regulations.

Reused litter
Litter that is used for more than one production cycle.

RIRDC
Rural Industries Research & Development Corporation, the previous trading name of AgriFutures Australia.

RSPCA
Royal Society for the Prevention of Cruelty to Animals. For the purposes of this document, it refers to a production standard.

RUSLE
Revised Universal Soil Loss Equation – see ‘USLE’.

SBMP
Site-based management plan – Farm plan similar to an EMP but that may include additional information beyond environmental management.

SEE
Statement of Environmental Effect (SEE) is a document that describes the environmental impacts of a development proposal and is required by all local government councils for a Development Application in NSW, except for major developments where an EIS is required. An SEE is a slightly simpler, cheaper and shorter version of an EIS. It has less opportunity for objections because it is based on proposals that do not trigger the same level of risk with regards to water quality, sensitive receptors and the scale of development, among other considerations.

Sensitive land use
A non-rural land use where potential amenity impacts may be experienced. Sensitive land may be zoned commercial, industrial or residential, and may contain private outdoor recreation areas (including detached dwellings, multiple dwellings, flat/apartment buildings, row dwellings and semi-detached dwellings), caravan parks, childcare centres, community centres, consulting rooms, educational institutions, hospitals, hotels, motels, nursing homes, retirement villages, tourism accommodation, parkland, recreation areas and reserves with regular public use, e.g., sporting fields. To measure separation distances, the point of measurement is the boundary of the non-rural zone.

Sensitive receptor
A site (e.g., rural residence) where potential amenity impacts may be experienced. The curtilage of the sensitive receptor is used as the point from which separation distances are measured.

Separation distance
The distance between a source of potential impacts (such as odour, dust or noise) and sensitive receptors/sensitive land uses. For odour, this should be measured as the shortest distance from the odour source to the sensitive receptor’s curtilage in a rural (or equivalent) zone or closest boundary of the non-rural zone.

Shed litter
Litter in meat chicken sheds that is being, or has been, used by birds.

Abbreviations

RAM
Restricted Animal Material

Reused litter
Litter that is used for more than one production cycle.

RIRDC
Rural Industries Research & Development Corporation

RSPCA
Royal Society for the Prevention of Cruelty to Animals

RUSLE
Revised Universal Soil Loss Equation

SBMP
Site-based management plan

SEE
Statement of Environmental Effect

Spent litter
Litter that has been removed from the sheds.

TAPM
The Air Pollution Model, or TAPM, is a coupled three-dimensional meteorological and air pollution model produced by the CSIRO Division of Atmospheric Research. It was released in late 1999. TAPM can be used as a dispersion model, however it is primarily used to produce weather data for input into other models.

Thinning regime
The timing and number of birds removed throughout a growth cycle. Over the course of a growth cycle, multiple pick-ups may occur to meet market needs for different numbers and weights of birds.

TKN
Total Kjeldahl Nitrogen is the sum of ammonia-nitrogen (NH₃-N) plus organically bound nitrogen, but does not include nitrate-nitrogen (NO₃⁻-N) or nitrite-nitrogen (NO₂⁻-N).

TSP
Total suspended particles. A measure of airborne particles (e.g., dust) up to about 100 micrometres.

USLE
The Universal Soil Loss Equation predicts the long-term average annual rate of erosion on a field based on rainfall pattern, soil type, topography, crop system and management practices. USLE only predicts the amount of soil loss that results from sheet or rill erosion on a single slope and does not account for additional soil losses that might occur from gully, wind or tillage erosion. This erosion model was created for use in selected cropping and management systems, but it is also applicable to non-agricultural conditions such as construction sites.

VEB
Vegetative environmental buffer. A VEB is a dense, multiple-row planting of trees, shrubs and grasses positioned immediately downwind of tunnel-ventilated livestock buildings to filter, intercept and adsorb particulates (dust) and aerosols (odour and ammonia) from the exhaust fans’ emission plume. See Bielefeld et al (2015) for the VEB guideline.

VFS
A vegetative filter strip (VFS) is a defined area of vegetation below sites that can generate run-off (i.e., range areas). The primary aim of a VFS is to reduce nutrient concentration by slowing its velocity, trapping particles and increasing infiltration.

WRF
Weather Research and Forecast (WRF) is the prognostic meteorological model in which cloud cover is calculated from the approach used in global and synoptic scale models.
Independent research has shown that chicken meat production has the lowest greenhouse gas footprint of all intensive meat production industries (Wiedemann, 2018). Furthermore, chicken meat production uses the least water of all intensive meat production systems, a critical consideration for food security in the Australian environment.

In the past two decades, AgriFutures Australia has demonstrated its proactive commitment to improving the environmental performance and sustainable production of the chicken meat industry by funding and publishing the results of many research projects in this area. These projects are listed in Appendix D and the reports are available on the AgriFutures Australia website.

This Planning and environment guideline for establishing meat chicken farms (Guide 1 – Assessment guide) and its companion document (Guide 2 – Applicant guide) are the first national planning and environmental guidelines developed for Australia’s chicken meat industry.

Recent research conducted by AgriFutures Australia showed that the chicken meat industry contributes about $7.9 billion to the Australian economy and generates 58,000 jobs (Henderson, 2020), with demand for chicken meat increasing by about 3% per year. Additional shed capacity is required to meet this increased demand.

The principal aim of these guidelines is to ensure that the chicken meat industry’s ongoing economic growth upholds the principles of environmentally sustainable and socially responsible development. This will be achieved by ensuring that future meat chicken farms are located, designed and managed sustainably and provide confidence for ongoing industry investment.

These guidelines incorporate the latest research and innovation (both national and international). They have been developed through an extensive review of state environmental requirements and application guidelines for meat chicken farms and other intensive animal industries. These guidelines were developed in collaboration and consultation with researchers and industry experts, as well as local government and state departments of planning, environment, primary industries, and agriculture.
Contents

Acknowledgments 04
About the authors 05
Abbreviations 06
Preface 13

Section 1
Introduction 16

Section 2
What are meat chicken farms? 18

Section 3
Strategic planning and approval process overview 24
Location and design of farm complex and infrastructure 28
Management 40

Section 4

Section 5

Appendix A
Assessing odour impact on community amenity 50

Appendix B
Best practice guideline: Odour and dust impact assessment for meat chicken farms 60

Appendix C
Surface water and groundwater risk tools for range and by-product use areas 78

Appendix D
Chicken meat industry research 90

References 48

Figures

Figure 1
Typical inputs and outputs for a meat chicken farm 18

Figure 2
Meat chicken shed with tunnel ventilation fans in the background 19

Figure 3
Components of the broiler shed ventilation system (top – inside shed with roof removed; bottom – outside shed) 20

Figure 4
Example of a typical meat chicken farm complex 21

Figure 5
Per capita consumption of chicken, beef, pig meat and sheep meat in Australia 24

Figure 6
Common stages/phases in the approvals process 27

Figure 7
Example design measures to mitigate flood risk through (A) an elevated pad, above the design flood level, (B) construction to seal sheds against flood waters, (C) use of landscape and bunding to prevent flood ingress Flood height shown in blue 33

Figure 8
An example of a meat chicken farm shed with a controlled drainage area 37

Figure 9
Examples of TERRAD and RMAX settings in CALMET 70

Figure 10
CFD simulation of cross section of plume during ΔT = 8°, Wind = 1 m/s 72

Figure 11
FNLI locations and rainfall factors (from Melland et al, 2007) 81

Tables

Table 1
Summary of S-factors 54

Table 2
Values of sensitive land-use factors, S1 55

Table 3
Values of surface roughness factors, S2 56

Table 4
Values of terrain weighting factors, S3 57

Table 5
Values of locality/climate weighting factors, S4 58

Table 6
Key inputs 61

Table 7
Example target temperature by bird age (where d = days) 62

Table 8
Bird age factors (AF) by week of growth cycle 62

Table 9
Example ventilation profile as a percentage of maximum 63

Table 10
Main switches and settings for CALMET 68

Table 11
Main switches and settings for CALPUFF 69

Table 12
Australian odour criteria by state 74

Table 13
Inclusions and justification for modelling and recommended outputs 76

Table 14
Surface water risk assessment for range and by-product use areas 79

Table 15
Groundwater risk assessment 80

Table 16
Risk category thresholds for both surface water and groundwater 81

Table 17
Distance to waterways factors for the surface water risk assessment 82

Table 18
Soil profile factors for surface water risk assessment 83

Table 19
Soil profile factors for groundwater risk assessment 84

Table 20
Land shape factors for the surface water risk assessment 85

Table 21
Groundcover level factors for the surface water risk assessment 85

Table 22
Slope factors for the surface water risk assessment 87

Table 23
Soil P test factors for the surface water risk assessment 87

Table 24
Topsoil PBI factors for the surface water risk assessment 88

Table 25
Groundwater depth factors for the groundwater risk assessment 88

Table 26
Groundcover type factors for the groundwater risk assessment 89
Introduction

1.1 Background

Although some states have guidelines for the development and/or environmental management of meat chicken farms, others do not provide specific advice for planning or assessing new and expanding developments. Where guidance documents exist, and were best practice at time of publication, they are mainly now outdated, i.e., they do not reflect current industry practices or scientific understandings of the potential environmental impacts of meat chicken farming. This guideline and its companion document (Guide 2 – Applicant guide) are the first national planning and environmental guidelines developed for Australia’s chicken meat industry.

1.2 Purpose and scope

This guide details the key location, design and management criteria that need to be met to ensure environmentally and socially sustainable production on meat chicken farms. Prospective applicants may wish to refer to this guide and its companion document (Guide 2 – Applicant guide) to achieve a best practice approach for the siting, design and management of new meat chicken farms. Applicants will also need to ensure their proposal satisfies state or local provisions affecting the planning and development of proposed operations.

This guideline is intended to be used by planners, regulators and developers (and their consultants) to assess and prepare planning/development applications for new and expanding meat chicken farms.

While this guide’s general environmental principles are relevant to small mobile production systems, their unique design and management mean that the measures detailed will not always apply to these systems.

→ While these guidelines are not intended to replace state and local requirements, they can be used by planners, regulators and other stakeholders when assessing new or expanding meat chicken farm developments.

1.3 Guideline structure

Sections 2 and 3 of this guideline provide introductory detail on the industry and relevant strategic planning concerns. The remainder of this guide is structured to enable an efficient assessment of proposed farm locations and the layout and design of farm infrastructure. Developers of meat chicken farms should use this guide to develop their preliminary farm plans before applying for approval, as this will be used to support the community engagement and regulatory consultation stages.

Section 2 provides a brief overview of meat chicken farm production practices (intended for those unfamiliar with the industry).

Section 3 provides detail on the strategic planning concerns to be addressed to ensure ongoing industry growth while also managing and minimising any environmental, biosecurity and community amenity impacts.

Section 4 discusses matters relating to site selection, the location of farm infrastructure and the design of farm infrastructure, such as sheds, roads, stocking sites and range areas. Note that Section 4 does not cover a comprehensive set of issues and that other matters of state and local significance may be relevant.

Section 5 discusses the environmental management of meat chicken farms. Management criteria are located separately in this section to facilitate preparation and assessment of environmental management plans for the proposed development. Within Sections 4 and 5, the following headings and structure are used to detail how planning and environmental considerations will be addressed.

Section 4 – Location and design of farm complex and infrastructure

Performance goal/s – These are the required performance outcomes for the activity, such as minimising impacts to some part of the environment.

Mandatory criteria – These are important mandatory requirements that must be addressed to ensure legislative compliance.

Example site selection criteria – These are key considerations regarding the siting of farms and farm infrastructure, i.e., considerations necessary to achieve the relevant performance goal/s. Local governments may wish to use these examples to draft new provisions for, or to prepare guidance on, their planning schemes.

Siting criteria – These are key considerations regarding the siting of farms and farm infrastructure, i.e., considerations necessary to achieve the relevant performance goal/s. Local governments may wish to use these examples when drafting new provisions for, or preparing guidance on, their planning schemes.

Example design measures – Any proposal that meets the design criteria will meet the performance goal/s, however example measures are included to show how the design criteria can be met. The guide provides additional design examples for high-risk sites, with the risk determined using a risk assessment process. Alternative measures can also be implemented provided they meet the performance goal/s. Local governments may wish to use these examples when drafting new provisions for, or preparing guidance on, their planning schemes.

Example design measures – Any proposal that meets the design criteria will meet the performance goal/s, however example measures are included to show how the criteria can be met. Additional management examples are given for high-risk sites, with the risk determined using a risk assessment process. Alternative measures can also be implemented provided they meet the performance goal/s.

Alternative measures can also be implemented provided they meet the performance goal/s.
2.1 Industry structure

The Australian chicken meat industry is largely vertically integrated, where companies (integrators or processors) own or manage most aspects of their supply and production chain. These integrator companies typically operate breeder farms, hatcheries, processing plants, feed mills and laboratories. The grow-out stage (where meat chickens are grown from chicks to harvest weight) is often contracted to external parties (chicken growers/producers/farmers). The integrator companies generally own the birds, supply all the feed, and provide advice from veterinarians and production experts. As such, integrator companies’ policies and requirements can have a significant impact on the siting, design and operation of meat chicken farms.

As part of their contractual requirements with integrator companies, meat chicken farms are often subjected to regular external auditing through accreditation bodies or clients (such as supermarket chains or fast-food companies).

2.2 Production practices

Meat chickens are typically delivered to the farm as day-old chicks and grown in enclosed sheds for 5-8 weeks before they are harvested and transported off-farm to be processed. Birds may be harvested at several points throughout the growth cycle once they meet the desired weight. Bird pick-up and transport generally occurs during cooler periods (i.e., at night) to reduce bird stress. In cooler climates, this may only be required during warmer times of the year. One to two weeks is the typical length of time between growth cycles, during which time sheds are cleaned and disinfected.

For a good overview of production practices on meat chicken farms, see ACMF (2020c). For more detail about the industry, including grower farms, see ACMF (2018).

The main inputs and outputs for a meat chicken farm are shown in Figure 1.

Inputs

- Fresh bedding
- Day-old chicks
- Feed
- Water
- Energy

Growth cycle (5-8 weeks)

- Finished birds

Transport off farm

Spent litter and mortalities

Onsite management including composting, incineration and anaerobic digestion

Figure 1. Typical inputs and outputs for a meat chicken farm.

Meat chickens are never housed in cages but rather move freely within sheds. These sheds have a layer of bedding material or ‘litter’ on the floor, which serves a variety of purposes, including absorbing and releasing moisture and providing a warm, soft surface for the chickens. This litter is typically organic material such as wood shavings, sawdust, rice hulls or straw. Figure 2 is an example of a typical meat chicken shed.

Birds have constant access to feed and water, which is provided through automated systems located throughout the shed. Although the spacing and location of feeding and drinking stations is based on bird access requirements, it must also align with state animal welfare and protection legislation.

A small proportion of the industry provides access to outdoor, free-range areas once the birds are reasonably feathered (about 21 days old). The specified stocking densities and outdoor access requirements are detailed in state animal welfare and protection legislation.

2.3 Farm by-products

Spent litter from meat chicken farms is typically removed from sheds at the end of each growth cycle but, in some cases, can be re-used for several growth cycles (depending on processor agreement). As spent litter contains manure from the production cycle, it can be used in various agricultural applications.

Spent litter management options available to farm operators include spreading on- and off-farm as an organic fertiliser/soil amendment/compost, and incineration/anaerobic digestion for energy generation.

A mortality rate of about 4% is expected during each growth cycle, and mortalities provide another valuable agricultural by-product from meat chicken farms. The management options for dead birds are similar to spent litter. Local and state legislation may, however, limit some options. In NSW, for example, composted carcasses are not subject to a resource recovery exemption and cannot leave the property on which they are generated.

Figure 2. Meat chicken shed with tunnel ventilation fans in the background.
2.4 Sheds and ventilation

Sheds are ventilated to ensure bird thermal comfort, remove excess moisture, provide fresh air, and prevent build-up of ammonia (which can negatively affect birds and humans). Sheds can be naturally ventilated, mechanically ventilated, or use natural and mechanical ventilation, depending on requirements (hybrid ventilation).

In naturally ventilated sheds, airflow from prevailing winds and natural air circulation is generally sufficient to achieve the desired ventilation levels.

Mechanical ventilation relies on fans to exhaust air from the shed. Replacement air is drawn through vents and sheds generally use evaporative cooling pads during hot weather.

There are two general types of shed construction:

- **Solid wall with tunnel ventilation (modern style)** – These sheds have soft walls (curtains) typically made of canvass or polyethylene/polyvinyl chloride/polypropylene industrial fabrics. These curtains can be raised or lowered to control air movement and temperature within the shed. They are sometimes tunnel-ventilated, with fans and cooling pads helping maintain shed temperature and air quality, although they can be naturally ventilated in other cases.

- **Curtain-sided sheds (older style)** – These sheds have high walls (curtains) typically made of canvass or polyethylene/polyvinyl chloride/polypropylene industrial fabrics. These curtains can be raised or lowered to control air movement and temperature within the shed. They are sometimes tunnel-ventilated, with fans and cooling pads helping maintain shed temperature and air quality, although they can be naturally ventilated in other cases.

As shown in Figure 3, there are several elements to the ventilation systems used in modern tunnel-ventilated sheds; these elements can be operated in different modes depending on the required ventilation level. When minimal ventilation is required, duty fans and mini-vents can provide sufficient ventilation. When higher ventilation rates are required, the shed can be operated in full or partial tunnel mode, with tunnel fans drawing air from the tunnel inlets and through the shed’s length. When additional cooling is required, evaporative cooling pads (located at the tunnel inlets) can be used.

Farm infrastructure (such as sheds, entryways and parking areas) may be fitted with external lighting to ensure safe night-time operation, vehicle movements, staff safety and security. Sheds and other infrastructure may also be fitted with internal lighting, which is necessary to regulate bird sleeping behaviour and is required for night-time bird and litter removal.

2.5 Potential impacts of meat chicken farms

As most production occurs in enclosed, environmentally-controlled sheds, the risk of environmental and amenity impacts from on-farm activities is limited. That said, sheds must still be located and managed to minimise odour generation and impact, and farm by-products must be managed responsibly.

As litter is used to capture and absorb excreta, no effluent is produced from meat chicken production; excess moisture is removed from the sheds via ventilation to keep litter dry and friable. As this litter is typically cleaned out at the end of each growth cycle and sheds are designed to prevent stormwater entry, potential impacts to surrounding surface water and groundwater are limited.

2.6 Site layout

Depending on the production practices on the farm, the site may contain any of the following:

- Farm pad
- Production sheds
- Feed silos
- Water treatment system and storage
- Chemical and fuel storage areas
- Generator and shed
- Farm machinery shed(s)
- Range areas (free-range only)
- Dead bird and spent litter management areas
- Access roads
- Workers’ accommodation

An example of a typical farm layout is shown in Figure 4.

![Figure 3. Components of the broiler shed ventilation system (top – inside shed with roof removed; bottom – outside shed). Source: Dunlop and Duperouzel, 2014.](image)

![Figure 4. Example of a typical meat chicken farm complex.](image)
2.7 Small-scale production

The following sections include information relevant to proposed small-scale farms.

2.7.1 Applicability

Depending on state planning and environmental regulations (as well as the requirements of any applicable planning scheme or similar), meat chicken farms below a certain size may not require planning approvals or environmental licensing. Although the measures outlined in this guideline have been prepared for larger farms participating in the planning and development assessment process, many of the same considerations can enable successful design and operation of small-scale farms. Some jurisdictions (e.g., Victoria) have developed guidelines on gaining approval for small-scale farms. For more details on the Victorian system, see Department of Economic Development, Jobs, Transport and Resources (2018).

2.7.2 Typical practices

Small-scale production is typically less intensive than large-scale production, with lower stocking densities in sheds and on range areas. If fixed sheds are used, they are typically naturally ventilated, with basic food and water systems. Small-scale production typically provides chickens with access to range areas. Alternative production methods include the use of mobile housing units, sometimes known as ‘caravans’. These housing units are typically open-floored and readily moved, and provide basic shelter, with some units having integrated food and water systems.

2.7.3 Important considerations

Although many people view small-scale production as having less impact, many of the same considerations that apply to the wider industry also apply to smaller systems. These include:

- Siting to minimise biosecurity impacts and risks.
- Siting sheds or housing units to minimise amenity (odour, dust and noise), surface water and groundwater impacts.
- Managing litter in sheds to minimise amenity impacts.
- Managing spent litter to minimise amenity impacts and nutrient export.
- Managing manure deposition under caravans to reduce nutrient export.
- Construction and management of composting infrastructure (if applicable) undertaken in accordance with local and state authorities’ guidelines to minimise impacts to soil, surface water and groundwater.
- Stormwater management.
- Chemicals stored in appropriate areas/sheds.
Section 3

Strategic planning and approval process overview

To ensure the ongoing growth of this vital agricultural industry, and the benefits of its increasing contribution to the Australian economy, new farms must have adequate access to markets and key inputs. This must be balanced with appropriate siting to avoid future land-use conflict with incompatible uses, and other potential environmental and social impacts. Furthermore, existing agricultural land uses, such as meat chicken farming, require protection from encroachment by incompatible land uses.

Planning for industry growth is fundamental to ensuring that the Australian chicken meat industry can keep pace with increasing domestic (and possible future export) demand. Failure to appropriately include the industry in strategic planning considerations would be detrimental to the Australian economy and Australian food security. This underlines the importance of robust and fair strategic planning and development assessment for meat chicken farms.

3.1 Industry value and growth

Australia’s chicken meat production has increased by more than 160% in the past 20 years, and chicken has become the most-consumed meat in Australia. There is minimal importation of chicken meat into Australia, and chicken produced and consumed in Australia is a high standard. The industry contributes about $7.9 billion to the Australian economy and generates 58,000 jobs, with consumption having risen at a steady rate of about 3% annually over the last few decades (Henderson, 2020). Australians consume an average of 47.4 kg of chicken meat each annually (ACMF, 2020a).

This steady growth in both production and domestic consumption of Australian chicken meat (Figure 5) is likely due to its perceived health benefits, low cost, convenience/versatility, popularity in foodservice/restaurants, acceptance by all cultures, popularity with children, and environmental efficiency. This increasing demand for chicken meat has resulted in ongoing industry growth via the development of both new and expanding existing farms.

Figure 5. Per capita consumption of chicken, beef, pig meat and sheep meat in Australia. Source: ACMF, 2020a

3.2 Industry location

Meat chicken farms are generally located within 200 km of processing plants (Henderson, 2020) and near a feed mill, and have guaranteed water, power and access to services. The major meat chicken-producing regions in Australia are:

1. New South Wales: Tamworth, Hunter Valley, Central Coast, Western Sydney, Wollondilly, Goulburn and Griffith.
2. Queensland: South-eastern Queensland, Maniella and other areas south, south-west and north of Brisbane.
4. South Australia: Port Wakefield, Murray Bridge, Blanchetown, Gawler and Two Wells.
5. Western Australia: Outlying districts of Perth.
6. Tasmania: Outer metropolitan Hobart and Devonport.

3.2.1 Land use planning

The following sections detail land use considerations when assessing a proposed meat chicken farm.

3.2.1.1 Separation distances

Separation distances are an important tool in managing the risk of amenity impacts on sensitive receptors. To accommodate industry development in any given area, the settlement pattern and mix of land use in the area should be arranged to provide adequate separation distances between incompatible uses. For meat chicken farms, this is typically characterised by a low geographic density of sensitive receptors, allowing farms to have sufficient separation distances.

3.2.1.2 Zoning

Meat chicken farming is typically suited to agricultural/rural zoning or similar. Farms depend on access to fresh litter and feed, and often sell spent litter and compost for use on other farms. As such, locating industry in these zones reduces road use and hence transport costs between enterprises. Furthermore, the settlement pattern in agricultural and rural zones is generally the best to facilitate suitable separation distances, provided that rural residential developments are not located among these zones. In areas that are home to other forms of agriculture, communities may also have more reasonable understandings of agricultural production practices and potential impacts.

Industrial zones are sometimes suitable for meat chicken production. This typically reduces transport distance to processing facilities and increases the availability of labour, though the provision of adequate separation distances (based on the predicted size and nature of industry development) and access to markets may be limiting factors.

3.2.1.3 Protection from incompatible land uses

As part of the planning and development assessment process, many state planning frameworks require planning schemes, rezonings and development assessments to consider the impacts on rural uses. To achieve this, the separation distance that applies between meat chicken farms and other land uses should also be applied to any incompatabilil land use that is proposed near existing meat chicken farms. This will protect the existing meat chicken farms right to continue operating (under both existing and potential future approvals) and by not placing sensitive receptors near to an existing or approved land use, will minimise impacts on sensitive receptors.
3.2.2 Biosecurity

Disease outbreaks can cause a substantial loss of income in the chicken meat and other avian industries. Biosecurity separation distances can help minimise the risk to (and from) the farm. A risk-based approach is required to determine suitable distances. Typically, biosecurity separation distances reflect the likelihood of impacts at other bird and poultry-related industry facilities and the potential economic value of those impacts. In the event of an emergency animal disease, AUSVETPLAN requirements may restrict movement within the quarantined area, and farms should be located to minimise potential impacts at hatcheries and other high-value enterprises (e.g., breeding operations) that may be affected by bird diseases (AHA, 2011).

To minimise the risk of inter-farm disease transfer, poultry farms should be located at reasonable distances from one another. Published biosecurity separation distances from several sources are outlined in Section 4.8.

3.2.3 Land size

The production capacity of the farm is the primary consideration when determining the required land size. Many modern farms produce millions of birds annually to achieve economies of scale and, as such, require significantly higher development footprints. If planning to accommodate significant production capacity in the region, areas with larger land sizes may be needed. Farms that produce fewer birds are still valuable contributors to the industry and can be suitably located in areas with smaller lot sizes.

The development footprint of each farm varies depending on operational practices and site-specific location and design considerations. The size and number of sheds is dependent on farm capacity and stocking density. A 400,000 bird-farm, stocked at 15.88 birds/m², would require a little over 25,000 m² of production floor.

If litter and dead bird composting occurs on-farm, an additional 1,000 to 1,500 m² could be required for temporary spent litter storage, another 2,000 to 3,000 m² for litter composting, and 200 to 600 m² for composting dead birds. Whether additional areas for vehicle washdown, worker accommodation, chemical sheds, machinery sheds and a generator shed are required will depend on the proposed development’s nature. For free-range farms, range areas are typically an additional 150% of the shed area. Some farms, however, offer larger range areas, particularly if rotational practices are adopted. Details of composting area design can be found in the companion document – Planning and environment guideline for establishing meat chicken farms (Guide 2 – Applicant guide).

Buffer distances may be required to address planning considerations and processor/integrator requirements. The obligation to meet these and other site constraints (such as protected vegetation, existing infrastructure, slopes, etc.) can affect the location of farm infrastructure and the overall footprint of the farm layout.

When considering whether the land sizes in a region/zone will be suitable for meat chicken farms, it is also important to consider the possibility of future expansion. If existing farms expand in the future to meet increasing demand, they are likely to require an additional development footprint.

3.2.4 Access to water

Meat chicken production is one of the most water-efficient forms of meat production. The economic return per ML is also significantly higher than competing agricultural uses (McGahan et al., 2021). As adequate and reliable water is required for the operation of meat chicken farms, industry should be located where there is sufficient access to reticulated water or surface water capture, or where groundwater availability is sufficient to service the industry’s demands. Given that regulatory approval and appropriate licensing may be required for use of ground or surface water, potential industry development may be limited in some regions.

The water supplied to meat chickens must be of suitable quality to meet animal welfare and biosecurity requirements (Scott and Ahern, 2008). Where available water does not meet these standards, on-site treatment of water is required.

3.2.5 Access to power

Power is required to operate the ventilation, lighting, heating and cooling systems necessary to ensure the welfare and thermal comfort of meat chickens and staff. This may vary depending on the type of shedding and ventilation system in use. Power is also required to operate automated feeders (including transport belts and augers) and to pump water.

To provide sufficient power, the region should be serviced by a reliable network power supply. For tunnel-ventilated sheds, this typically requires three-phase power. Where reliable power is unavailable, alternative energy sources (including gas, solar, biogas, waste-to-power, gas/diesel generators and others) may be able to supply the complete energy needs of the site, either alone or in combination. The use of non-grid power in isolation, however, may affect the economic viability of the proposal.

3.2.6 Access to markets

The availability of farm inputs is essential to ensure that the farm has all the necessary inventory to operate effectively. Bird welfare requirements also dictate transport limitations, restricting the distance that birds can travel to processing plants. Transportation can be a considerable cost to farm operations, with farm labour availability in the surrounding area another important consideration.

The choice of fresh litter can impact meat chicken farm operation (Watson and Wiedemann, 2018) and is largely determined by availability and transport price. Litter materials typically have a low bulk density and can therefore be expensive to transport to site.

Unless otherwise constrained by separation distances (including biosecurity separation distances), zoning, planning regulations, available infrastructure or future expansion plans, meat chicken farms should be located as close as practical to processing facilities, feed suppliers, litter suppliers and any other suppliers that the farm relies on. Due to bird welfare considerations, meat chicken farms are typically located 1–2 hours from processing facilities. As transport systems improve, the time to processing can increase.

3.3 Overview of the planning process

Information on each state’s planning process is detailed in the companion document – Planning and environment guideline for establishing meat chicken farms (Guide 2 – Applicant guide). Although each state process uses different steps and timelines, the phases involved are similar. Figure 6 summarises the process from pre-application through to the decision phase.

Figure 6. Common stages/phases in the approvals process.
Section 4  Location and design of farm complex and infrastructure

4.1 Planning scheme suitability

Performance goal
To ensure that the proposed development is in a suitable area as defined by local planning regulations, state government regulations and referral agency guidelines/codes.

Mandatory criteria
The development proposal complies with the local planning instrument’s requirements and gains approval before works commence. This means that:
- The proposed development must be in an appropriate land-use zone and meet the requirements of any zone codes, overlays, planning policies or other planning criteria that apply to the proposed development.
- The applicant must seek and receive approval for the use, in accordance with the relevant requirements of the state planning framework. To do so, the applicant must provide all necessary information, forms and fees at the time of lodgement.

Siting criteria
The farm is sited in an appropriate zone in accordance with the provisions of the local planning instrument, and the proposed land use is not limited by planning scheme overlays. Farm infrastructure is sited considering any minimum buffer distances mandated by the planning scheme and state government guidelines/codes. The farm is in an area that supports the adequate provision of farm staff accommodation.

Example siting measures to mitigate risk
The proposed farm complex is in a zone (e.g., a rural zone or similar) that does not prohibit the proposed use (Intensive Animal Farming or similar). Additional siting measures may be required to demonstrate compliance with the requirements of the zone.

The farm complex is located on land that is not affected by planning overlays due to areas of ecological value, bushfire risk, flooding or other constraints. Alternatively, for sites affected by planning overlays, the development is sited, designed and managed to reduce potential impacts.

Where possible, locate meat chicken farms in zones where planning regulations do not allow for the encroachment of incompatible land uses that may then be affected by emissions from the meat chicken farm.

Design criteria
Where applicable, the farm complex, including sheds, chemical storage areas, range areas, litter management areas and dead bird management areas, is designed and constructed in accordance with the requirements of relevant local and/or state government planning instruments.

Example design measures to address planning scheme requirements

To ensure that the proposed development is in a suitable area and meets the requirements of the local planning instrument with regards to (but not limited to) the following requirements:
- Building heights, materials, colours, and form.
- Stormwater management requirements.
- Road access, parking, and site traffic.
- Building compliance/certification.
- Plumbing and drainage.

Measures to address impacts on the environment and amenity are included in sections 4.2 to 4.10.

4.2 Amenity (odour, dust and noise)

Performance goal
To limit or minimise amenity impacts (e.g., odour, dust, and noise) that arise because of meat chicken farm operations.

Theses Performance goals are met when the proposal achieves the following Mandatory criteria, Siting criteria and Design criteria.

Mandatory criteria
The proposal complies with state odour, dust and noise assessment requirements, including state impact criteria/trigger levels/assessment thresholds. This means that:
- Odour, dust and noise impacts at sensitive receptors are not to exceed the levels specified in any state environmental or planning regulation.
- Additional regulatory approvals may be required to conduct dead bird and spent litter management activities.

Siting criteria
The farm is separated from incompatible land use by a distance sufficient to limit or minimise impacts from odour, dust and noise.

Example siting measures to mitigate risk

The risk of odour, dust and noise impacts at sensitive receptors is considered acceptable when:
1. Siting of farm infrastructure complies with minimum separation distances outlined in Appendix A.
2. Siting of farm infrastructure complies with the separation distances determined by the S-factor formula in Appendix A, or odour modelling carried out in accordance with the best practice guideline for odour and dust impact assessment of meat chicken farms when undertaking modelling demonstrates that the risk of odour impacts to sensitive receptors is acceptable.

The site is considered a high risk of odour, dust, and noise impacts, and may require additional design and management to meet the performance outcomes, if any of the following apply:
- The farm uses on-site management of dead birds or spent litter.
- The farm conducts on-site spreading of by-products.

Temporary by-product storage, by-product management areas, by-product application areas and runoff capture dams should be located where they are least likely to impact sensitive receptors (considering distances, topography and prevailing meteorological conditions). In accordance with the industry biosecurity manual (ACMF, 2020b), spent litter cannot be stored in the production area. To minimise dust and noise impacts on sensitive receptors, entry points should be determined by considering distance, topography, wind direction and screening. Concerning noise impacts, an alternative measure involves a suitably qualified person preparing a noise impact report, which shows whether the predicted impacts at sensitive receptors meet state noise impact criteria/trigger levels.

In addition to the separation distances required to address odour risk, the risk of noise impacts can be further reduced, where possible, by locating farm infrastructure (including access points and on-site roads) to reduce line of sight to public areas or sensitive receptors via screening with existing topographical features and/or on-site vegetation.

Design criteria
Where applicable, the farm complex, including sheds, chemical storage areas, range areas, litter management areas and dead bird management areas, is designed and constructed to minimise the potential for amenity impacts.

Example design measures to mitigate risk

Dust

Sites with range areas, spent litter stockpiles and compost heaps, or those that spread by-products on-site, may be classified as ‘high risk’ sites due to the increased risk of dust impacts on nearby sensitive receptors. Vegetative environmental buffers (VEBs) may be used to reduce dust impacts from exposed areas if separation distance alone does not achieve the Performance goal. Refer to the AgFutures Australia publication Vegetative environmental buffers for meat chicken farms (Bisielefeld et al, 2010) for more information.

Noise

Sites with entry/exit points close to nearby sensitive receptors, or sites that conduct operations that generate noise away from the development complex (e.g. composting spent litter), can be classified as ‘high risk’ sites. The risk of noise impacts can be reduced by screening the line of sight using earthen bunds, buildings, acoustic fences, vegetated environmental buffers or timing activities if separation distance alone does not achieve the Performance goal.

By-product management

A best practice measure for by-product management is, for example, having a designated and suitable site for temporary by-product storage in case of emergencies (i.e., if a contractor fails to arrive, flooded roads prevent site access, equipment breakdown, the composting area is full). For dead birds, cold storage areas or specially designed bins (e.g., Biobins®) can meet this requirement.

The temporary storage areas for spent litter and dead birds, and any on-site management system, must be appropriately designed and sized for the production schedule, and appropriate site disposal practices must be adhered to. The expected quantity of spent litter produced is about 1.5 tonnes (~5 m³) per 1000 birds per growth cycle. The expected quantity of dead birds is about 4% per growth cycle in conventional production systems, with slightly higher losses expected in free-range systems.
When determining the size of stockpiles and composting areas, fresh spent litter piles should be limited to 2 m high and 4 m wide to minimise fire risk via self-combustion.

If incineration of by-products is undertaken on the site, the incinerator’s emissions control systems should be compliant with relevant state emissions standards.

Specially designed composting vessels and indoor composting facilities offer alternatives to outdoor composting sites with a ‘high risk’ of odour or dust impacts; however, these options are costly and should not be used if the risks can be mitigated otherwise.

Details on composting design can be found in the companion document – Planning and environment guideline for establishing meat chicken farms (Guide 2 – Applicant guide).

4.3 Visual impacts

Performance goal

To limit or minimise impacts caused by meat chicken farm operations on visual amenities.

This Performance goal is met when the proposal achieves the following Mandatory criteria, Siting criteria and Design criteria.

Mandatory criteria

The proposal complies with state amenity assessment requirements, including state impact criteria/trigger levels/assessment thresholds.

Siting criteria

Where applicable, the farm complex, including sheds, chemical storage areas, range areas, litter management areas and dead bird management areas, is sited to minimise the potential for visual amenity impacts.

Example sitting measures to mitigate risk

In addition to the separation distances required to address odour risk, the risk of visual impacts can be further reduced by locating farm infrastructure (including access points and on-site roads) where screening by existing topographical features or on-site vegetation can be used.

Visual impacts can be avoided by locating farm infrastructure (including dead bird pick-up) to provide no line of sight to public areas or sensitive receptors.

Design criteria

Where applicable, the farm complex, including sheds, chemical storage areas, range areas, litter management areas and dead bird management areas, is designed and constructed to minimise the potential for visual amenity impacts.

Example design measures to mitigate risk

Retain existing trees and vegetation in areas not used for farm infrastructure to act as a visual screen.

On sites where visual impacts to nearby sensitive receptors have been identified, impacts can be reduced by:

- Screening the line of sight using earthen bunds or vegetated screening.
- Creating screening that blocks direct light sources from vehicle movements or fixed lighting.
- Designing external lighting in accordance with AS4282 – Control of the obtrusive effects of outdoor lighting to further reduce the risk of impacts.
- Selecting shed design and materials to suit the surrounding landscape or built form.

Note that, due to the size of meat chicken sheds, such options may be prohibitively expensive, and this must be considered when framing any approval conditions.

4.4 Traffic

Performance goal

To limit or minimise impacts caused by traffic from the meat chicken farm operations.

This Performance goal is met when the proposal achieves the following Mandatory criteria, Siting criteria and Design criteria.

Mandatory criteria

Entry and exit points are constructed in accordance with local and state government requirements, to allow adequate vehicle slowing and turning width, using suitable materials and construction methods.

Siting criteria

Entry and exit points are constructed in accordance with local and state government requirements, to allow adequate vehicle slowing and turning width, using suitable materials and construction methods.
4.5 Cultural heritage

Where applicable, the farm complex and associated infrastructure are sited to minimise the potential impacts from traffic.

Example siting measures to mitigate risk

Entry and exit points located to minimise dust and noise impacts on sensitive receptors by considering distance, topography, wind direction and screening.

The road network that services the farm is suitable for the number and type of vehicle movements generated by the development. Entry and exit points located to ensure good visibility in both directions.

Design criteria

Where applicable, the farm complex and associated infrastructure are designed and constructed to minimise potential impacts of traffic.

Example design measures to mitigate risk

Sufficient turning width and slowing distance for site access (according to relevant state and local requirements) are provided.

The entry gate is a sufficient distance from a boundary, with a public road to enable parking of transport vehicles while gates are opened and closed.

Additional traffic design measures include:

- Roads and parking areas designed to allow vehicles to continuously move forward, from the site entry to parking and loading/unloading areas, through to site exit (e.g., loop road).
- Roads and parking areas designed to minimise sharp turns and ensure sufficient road width for safe vehicle movement.
- Roads and parking areas designed to allow all-weather vehicle movements.
- Entry and exit points designed to minimise dust and noise generation.
- Hardstand parking areas included for all vehicles (feed, litter and bird delivery, bird mortality, and spent litter pick-up).
- Parking areas provided for vehicles not permitted in the production area.

Performance goal

To prevent or minimise impacts on areas of cultural heritage.

This Performance goal is met when the proposal achieves the following Mandatory criteria, Siting criteria and Design criteria.

Mandatory criteria

The proposal complies with any cultural heritage legislation, including Indigenous and non-Indigenous cultural heritage, heritage buildings, and other legislation that protects Australian cultural heritage.

Siting criteria

The site is sited to prevent or minimise impacts on areas of cultural heritage.

Example design measures to mitigate risk

Where possible, meat chicken farms are located in areas that do not have cultural heritage significance.

As an alternative, farm infrastructure and roads are sited to minimise disturbance to areas of cultural significance, and consultation is undertaken with local Indigenous groups, heritage groups or other relevant bodies and experts. Any activities that affect culturally significant areas are only undertaken once all relevant permits and approvals have been obtained, and where no feasible alternative is available.

In some states, developments above a certain size may be required to undertake additional cultural heritage assessments.

Design criteria

Where applicable, the farm infrastructure is designed to minimise impacts on areas of cultural heritage.

Example siting measures to mitigate risk

Where impacts on cultural heritage cannot be avoided by careful siting, the design and construction of farm infrastructure should be carried out in consultation with relevant local Indigenous groups, heritage groups or other relevant bodies and experts to minimise impacts.

4.6 Flooding

Performance goal

To limit or minimise the impacts of flooding.

This Performance goal is met when the proposal achieves the following Mandatory criteria, Siting criteria and Design criteria.

Mandatory criteria

The proposal complies with any applicable legislation and planning requirements regarding flooding impacts. This means that:

- Where applicable, any levees/diversion banks/bunding used to protect farm infrastructure must be approved by the relevant authorities.

Siting criteria

The farm is sited to limit or minimise the impacts of flooding.

Example siting measures to mitigate risk

Land that is subjected to the 1% annual exceedance probability (AEP) of flood is considered ‘high risk’. Where possible, farm infrastructure, litter stockpiles, compost areas, by-product application areas, supply traffic networks, site entry and site roads that service the farm should be sited to avoid ‘high risk’ land.

Infrastructure should be sited to minimise increases to peak discharge volumes and flowrates concerning nearby infrastructure and residences. As an alternative, infrastructure and roads should be sited to minimise impacts from flooding, and design and management measures that minimise residual risk should be employed.

Design criteria

Where applicable, the farm infrastructure is designed to minimise impacts from flooding.

Example design measures to mitigate risk

On ‘high risk’ sites, farm infrastructure is designed using materials and stormwater/floodwater management techniques that result in a flood-free area for farm infrastructure.

Farm pads, for example, can be created from fill to ensure that the finished floor level of farm sheds is above the design flood height. Alternatively, levees or bunds can be used around sheds to ensure that they are free from flooding.

Shed walls, such as sealed concrete ‘rat-walls’ (for naturally ventilated sheds) or metal-clad insulated panels (such as those used in tunnel-ventilated sheds), should be designed and constructed to ensure that they are waterproof.

Other points of potential water ingress, such as doors or low-elevation ventilation fans, should be designed so that they are sealed against the ingress of water. Flood-proof doors should be included in the design, and rubber door seals can be used (such as those used for cold room and shipping container door seals). Shed ventilation fans need to be located above the flood level, as fan shutters are unlikely to provide sufficient watertight sealing.

Where risks cannot be fully managed through siting and design measures, emergency management plans and measures (such as sandbagging) must be developed and be ready to implement to prevent flooding at potential points of water ingress that cannot otherwise be sealed. In addition to the on-farm effects of flooding, infrastructure should be designed to avoid increases to peak discharge volumes and flowrates at nearby infrastructure and residences. The design stage must consider the size and runoff characteristics of developed areas on the farm. Infiltration trenches, swales, detention systems and retention systems can be used to manage peak discharge characteristics (Figure 7).

Section 4
4.7 Bushfire

Performance goal
To limit or minimise the impacts of bushfire.
This Performance goal is met when the proposal achieves the following Mandatory criteria, Siting criteria and Design criteria.

Mandatory criteria
The proposal complies with the requirements of any applicable legislation and planning requirements regarding bushfire. This means that:
• Any buildings on the site, including farm infrastructure, must comply with the National Construction Code (NCC).
• Any buildings on the site must comply with any state fire safety requirements.

Siting criteria
Farm infrastructure is sited to limit or minimise impacts of bushfire.

Example siting measures to mitigate risk
• Areas mapped as being affected by bushfire, or those known to be at risk from bushfire by local fire or emergency services, are considered a high-risk. To address the potential risk of impacts from bushfire, farm infrastructure should be sited to avoid high-risk areas. Alternatively, for sites where high-risk areas cannot be avoided, bushfire risks should be addressed through appropriate design and management measures.

Design criteria
Where applicable, the farm infrastructure is designed to limit or minimise impacts of bushfire.

Example design measures to mitigate risk
Where farm infrastructure is located in high-risk areas, the site-specific bushfire attack level (BAL) should be determined in accordance with AS 3959:2019 (Standards Australia, 2019) or equivalent methods, and infrastructure constructed in accordance with the requirements of that Standard. Exclusions or exemptions granted to farm buildings under the National Construction Code (NCC) may apply. Note that poultry sheds are generally regarded as NCC Class II buildings; when Class II buildings have 500 m² of floor space or more, and a fire brigade can attend, AS 2419 – Fire Hydrant Installation (Standards Australia, 2009a) applies.

4.8 Biosecurity

Performance goal
To limit or minimise biosecurity impacts to on-farm operations and the environment.
This Performance goal is met when the proposal achieves the following Mandatory criteria, Siting criteria and Design criteria.

Mandatory criteria
The proposal complies with all applicable biosecurity requirements, including state biosecurity legislation. This means that:
• The proposal must comply with any state treatment or application requirements. These may require putting biosecurity control orders in place from time to time that may impose mandatory biosecurity measures, practices and infrastructure. It is recommended that development applicants determine whether mandatory biosecurity measures are currently enforced, as these may require the adoption of certain measures/practices/capital infrastructure and may have a bearing on development applications and assessment.

Siting criteria
The farm is sited to limit or minimise the risk of biosecurity impacts.

Example siting measures to mitigate risk
Poultry farms (including those with meat chickens, layer hens, turkeys, ducks and other waterfowl, as well as hatcheries and breeder, rearing and pullet farms) should be separated to minimise the risk of disease transfer between farms. Management practices are a major determinant of biosecurity risk, and separation distances alone cannot eliminate that risk entirely; using the following separation distances, however, can minimise biosecurity impacts. Alternatively, advice from a state biosecurity officer or an avian vet specialist can help to determine appropriate biosecurity separation distances.

Based on existing national and state biosecurity recommended distances between poultry farms (Agriculture Victoria, 2020; Carroll, 2012; DAF, 2016; DoE, WA, 2004; McGahan et al, 2014; McGahan, Gould et al., 2018), the risk of biosecurity impacts can be reduced by siting new meat chicken farms a minimum of 1,000 m from other poultry farms. For low-risk farms (e.g., where both farms share the same owner), shorter buffer distances of 500 m may be appropriate given the greater degree of control over potential risks and the lower externalities in the event of a biosecurity issue.

Where one or more farms are considered high-risk, a separation of up to 5,000 m may be appropriate.

For this section’s purposes, a high-risk farm is one with increased risk of poultry disease transmission (due to additional transmission sources, size or increased severity of economic impacts due to longer occupancy times and higher-value products). For example, the following are considered high risk for this section:
• Breeder farms, hatcheries and grandparent farms that are essential to the operation of multiple farms.
• Farms with range areas, due to the increased exposure of birds.
• Farms with spent litter or dead bird composting, or litter/compost spreading areas, due to the quantity of exposed material.
• Farms/industries that grow and produce ducks and other waterfowl.
• Farms close to open freshwater sources, such as dams and rivers, that are frequented by migratory waterfowl.

The farm complex should be sited away from wild waterbird habitats where possible to minimise the spread of disease from wild birds. Where farms are in areas that are frequented by waterbirds, additional design and management measures may be required.

Temporary litter stockpiles and by-product spreading areas should be sited to minimise the potential biosecurity impacts of other intensive livestock systems. Additional best practice examples include:
• Not siting temporary litter storage areas in the biosecurity area.
• Not locating the dead bird pick-up area (if applicable) within the biosecurity area.
• Not locating chemical storage areas and other areas of frequent use (such as car parks) within 250 m (in the direction of ventilation) of the exhaust end of tunnel-ventilated sheds.

Design criteria
Where applicable, the farm infrastructure is designed to minimise the risk of biosecurity impacts.

Example design measures to mitigate risk
Farms should be designed in accordance with the requirements of the industry biosecurity manual and any state-specific biosecurity Acts and regulations. Dead bird storage, by-product composting or dead bird burial areas should be fenced to exclude pests and ruminants.

Storage of water in open dams should be minimised to avoid attracting wild birds, as wild birds increase the biosecurity risk. Risk can be further reduced by covering storage dams or using tanks. Additional biosecurity measures can be employed on sites that may attract waterbirds.

Some vegetation types may attract wild birds and increase biosecurity risks. To reduce risk, vegetation types that do not attract wild birds (e.g., non-fruit-bearing plants and trees) should be selected for landscaping purposes.

4.9 Land, surface water and groundwater

Performance goal
To prevent or minimise impacts to land, surface water and groundwater from meat chicken farms.

These Performance goals are met when the proposal achieves the following Mandatory criteria, Siting criteria and Design criteria.

Mandatory criteria
The proposal complies with all state and local regulations affecting impacts to surface and groundwater. This means that:
• The proposal must comply with all state and local regulations requiring minimum distances from water bodies.
• The proposal must comply with all state and local regulations regarding siting activities in groundwater areas.
• The proposal must comply with all state and local regulations regarding the need for additional approvals to undertake any dead bird management and spent litter treatment/management.

Siting criteria
Where applicable, sheds, chemical storage areas, range areas, litter management areas and dead bird management areas are sited to prevent or minimise runoff impacts on surface water and leaching on groundwater, unless those impacts can be prevented or minimised by design and management measures.

Example design measures to mitigate risk
...
Example sitting measures to mitigate risk

The farm complex is considered to have a ‘low risk’ of surface water or groundwater impacts in accordance with the Surface Water and Groundwater Risk Tool in Appendix C.

Production sheds, litter stockpiles, litter/dead bird composting areas, by-product application areas, range areas and chemical storage areas are not located in areas considered ‘high risk’ for surface water or groundwater impacts, in accordance with the Surface Water and Groundwater Risk Tool in Appendix C. Some farm elements may be in ‘high risk’ areas if they are designed and constructed appropriately.

For farms that manage their litter through means other than stockpiling, an emergency litter storage area should be defined for use if the primary litter management method fails. In accordance with the industry biosecurity manual (ACMF, 2020b), spent litter cannot be stored in the production area.

Design criteria

Sheds, chemical storage areas, range areas, litter management areas and dead bird management areas are (where applicable) designed and constructed to prevent or minimise impacts of runoff on surface water and leaching on groundwater.

Example design measures to mitigate risk

Example design measures that meet the outcomes include:

- When dead birds are not disposed of within 24 hours, they are stored in Biobin® (or similar), a sealed cold room or freezer below 4 °C, or cold storage areas large enough to hold the expected number of mortalities generated between collection events. Dead bird storage requires protection from extreme weather events (i.e., storage bins are not affected by weather).

- If dead bird management involves on-site burial, it should occur in specially constructed burial pits. The base of the burial pit must be at least 2 m above the seasonal high water table level.

The spent litter management system, dead bird management system and emergency litter storage area must be appropriately designed to meet the production schedule. Proposed disposal practices must include suitable storage between collection/spraying events.

If stockpiling/composting is used to manage spent litter, sufficient space should be set aside to handle the expected quantity of litter. Specially designed composting vessels and indoor composting facilities provide alternatives to outdoor composting on constrained sites. These options are costly, however, and should not be needed if the risks can be otherwise addressed. For more detail on compost area design, refer to the companion document – Planning and environment guideline for establishing meat chicken farms (Guide 2 – Applicant guide).

On sites rated as being of ‘high risk’ to surface water (as determined in Appendix C), dead birds should not be buried on-construction. For more detail on compost area design, refer to the companion document – Planning and environment guideline for establishing meat chicken farms (Guide 2 – Applicant guide).

When captured water is directed to a VFS, it should first pass through a detention basin to reduce sediment and nutrient load and attenuate peak flow rates associated with storm conditions. VFSs are most effective with uniform, controlled flow rates. The detention basin should be appropriately sized to manage peak discharge and achieve a maximal horizontal flow velocity of 0.005 m/s. Refer to MLA (2012) for design guidance and calculations.

Discharge from the detention basin should be applied uniformly to the VFS using a level spreader or similar device.

A CDA is constructed to minimise the risk of impacts to surface water and groundwater. CDA bases are made of an impermeable material, with a crossfall of 1-5% towards a runoff collection point. Stormwater control measures, such as bunding, diversion banks or drainage ditches, divert clean stormwater around the CDA.

Additional stormwater control measures can be included in the design to direct runoff from the CDA to a collection point for capture (where these areas are roofed and runoff from roofs is unnecessary). Captured water can be directed across an appropriately sized vegetated filter strip (VFS), irrigated to land at sustainable rates, or evaporated. For more detail on designing VFSs, refer to the companion document – Planning and environment guideline for establishing meat chicken farms (Guide 2 – Applicant guide).

Where captured water is stored for irrigation to land or evaporation, the size of storage facilities must be sufficient to manage the peak discharge from the CDA. Irrigation and evaporation dams should be designed with an annual overtopping likelihood no greater than 5%. This can be determined using the design storm method, the tabulated method or a daily water balance model. Land irrigated with captured water is considered ‘low risk’ in accordance with the Surface Water and Groundwater Risk Tool in Appendix C.

Many state and local guides provide information on appropriate stormwater and drainage control measures to help achieve the above measures for ‘high risk’ sites.

On sites with a high risk of impacts to groundwater (as determined in Appendix C), the first 5 m of range areas (closest to the shed) and other areas of high manure deposition on free-range farms can be constructed as a CDA overlain by suitable range material (such as soil or stone).

On sites with a high risk of impacts to groundwater (as determined in Appendix C), dead birds should not be buried on-site, unless there are additional design and construction measures that adequately address the risk.

Figure 8. An example of a meat chicken shed with a controlled drainage area.
4.10 Flora and fauna

**Performance goal**
To prevent, minimise or mitigate disturbances to the ecology of the Australian environment, especially important areas of native vegetation, essential habitats and protected fauna species.

This Performance goal is met when the proposal achieves the following Mandatory criteria, Siting criteria and Design criteria.

**Mandatory criteria**
The proposal complies with the requirements of any ecological protection legislation.

**Siting criteria**
The farm is sited to prevent or minimise impacts to areas of ecological significance.

**Example siting measures to mitigate risk**
Where possible, meat chicken farms should be in areas that are not mapped as areas of protected flora and fauna, and areas that comply with any necessary buffer distances specified in state environmental legislation. Where this is not possible, farm infrastructure and roads should be sited to minimise the disturbance to areas containing protected flora and fauna. Disturbance of protected species is only undertaken once all relevant permits and approvals have been obtained. Disturbance of protected species is only undertaken when no feasible alternative is available. Impacts from required clearing or changes to natural ecology are assessed by an appropriately qualified person and, if required, are addressed through an approved environmental offset.

**Example design measures to mitigate risk**
On ‘high risk’ sites, disturbance of protected species is only undertaken once all relevant permits and approvals have been obtained. Disturbance of protected species is only undertaken when no feasible alternative is available. Impacts from required clearing or changes to natural ecology are assessed by an appropriately qualified person and, if required, are addressed through an approved environmental offset.
5.1 Odour and dust impacts

Performance goal
To limit or minimise any odour and dust impacts caused by meat chicken farm operations that affect amenity.

Mandatory criteria
The proposal complies with state legislative requirements for odour and dust, including impact criteria and trigger levels.

Management criteria
Where applicable, the farm complex (including sheds and shed litter, range areas, litter management areas, and dead bird management areas) are managed to minimise the potential for odour and dust impacts.

Example management measures to mitigate risk

Litter management
Shed litter and spent litter should be managed to reduce odour and dust impacts and documented as part of an Environmental Management Plan (EMP) or equivalent. Key management areas to address (if applicable) include:

- Fresh litter selection and sourcing, including:
  - Meeting characteristic specifications.
  - Quality control.
  - Risk assessment of alternative fresh litter.
- Litter pre-treatment management, including:
  - Storage of litter.
  - Management and checks before check placement.
- Pre-treatment quality control.
- Use of pre-treatment additives.
- Shed heating and cooling management, including:
  - Shed and equipment maintenance.
  - Ventilation operation.
  - Monitoring and recording of system performance.
- In-shed litter management, including:
  - Shed and infrastructure design.
  - Ventilation and cooling systems.
  - Regular litter and shed inspections.
  - Bird stocking density.
  - Litter conditioning.
  - Caking and tillage management, including:
    - Cake removal.
    - Equipment required.
  - Litter clean-out management, including:
    - Timing and communication with sensitive receptors.
    - Removal practices.
    - Loading and transport off-site.
  - Litter re-use management, including:
    - Treatment processes.
    - Shed management.
    - Regular litter and shed inspections.
    - Bird stocking density.
    - Litter conditioning.
    - Sport litter use, including:
      - Storage and composting.
      - Environmental hazard mitigation.
      - Nutrient management plan.
      - Horticultural crop management considerations.
      - Restricted uses.
      - Testing spent litter.
      - Alternative uses, e.g., energy generation.

Refer to the AgriFutures Australia publication Best practice litter management manual for Australian meat chicken farms (McGahan et al., 2021) for detailed information on fresh litter selection, litter pre-treatment, managing-in-shed litter, caking and tillage management, pests and diseases, in-shed litter re-use, litter clean-out from sheds and spent litter use.

By-product management
By-product management procedures can help minimise the risk of amenity impacts. Depending on the site risk, example measures could include:

- Managing by-products from dead bird management in a way that does not result in odour impacts.
- Removing dead birds from sheds daily and disposing of them appropriately. Where birds are not disposed of within 24 hours, they are stored in Biobins® (or similar), a sealed cold room, or a freezer below 4 °C.
- If composting or burying dead birds, each placement of dead birds is covered with a 300 mm layer of soil or odour-absorbing material (e.g., sawdust). The depth of this cover can be reduced to 150 mm when the next layer of birds is added. The top-most layer must always be covered with 300 mm of the odour-absorbing material, and birds should be placed no closer than 300 mm from the edge of the pile. Filled pits should be covered with a domed layer of impervious material.

Infrastructure maintenance
Regular maintenance of all equipment and infrastructure can help to reduce the risk of odour impacts. Example considerations include:

- Feeders, drinkers, and automated supply systems are maintained regularly to minimise waste.
- Site infrastructure (e.g., roads) are maintained to reduce visual impact. The site is kept tidy and free of rubbish. The sheds and surrounding areas are maintained in a tidy and professional manner.

Mandatory criteria
The proposal complies with state legislative requirements for dust and noise, including impact criteria and trigger levels and Australian Standards for light spill.

Management criteria
Where applicable, the farm complex and associated infrastructure are managed to minimise impacts from traffic and machinery operations.

Example management measures to mitigate risk

Traffic management
Traffic management measures should be adopted to reduce on-site dust and noise generation. Example measures to consider in a traffic management plan are:

- Vehicle movement timing to limit noise generation.
- Speed limits that minimise dust and noise generation.
- Ensuring vehicles maintain a forward direction of travel (reducing reversing noise).
- Use of high-beam lights limited, unless justified for safety reasons.
- Use of compression brakes and other secondary retarding systems limited, unless justified for safety reasons.
- Loads covered to reduce dust and odour generation.
- Dust suppression measures used, e.g., water sprays, to reduce road dust.
- Hardstand parking areas for delivery and pick-up from sheds used where this does not impede safe flow of traffic on the property.
- Vehicles not needed in the production area parked outside the production area.
- Site roads maintained to reduce noise (riils and potholes in roads increase truck noise).
- Contractors informed of any Traffic Management Plan or similar that has been developed for the site.

Where possible, have suppliers and transport contractors that service the site use transport routes that minimise truck movements through towns and near sensitive land uses.

Note that this is likely to be at the discretion of the integrator/processor.
5.3 Visual amenity impacts

Performance goal
To prevent or minimise impacts of chemicals used on meat chicken farm operations.
This Performance goal is met when the proposal achieves the following Mandatory criteria and Management criteria.

Mandatory criteria
The proposal complies with state legislative requirements and Australian Standards for storing and using chemicals.

Management criteria
Where applicable, the farm is managed to minimise impacts from chemicals.

Example management measures to mitigate risk
Impacts from chemical use should be minimised by ensuring that manufacturer instructions for chemical use are adhered to, including application rates and methods. Application/use rates can also be at the discretion of a vet.
Spray drift can be minimised by using well-maintained equipment, adhering to correct application rates and applying chemicals during suitable weather conditions (e.g., wind direction is not towards sensitive receptors).
When required, repair chemical storage sheds, bases and bunds.

Litter management
Example measures to help reduce risk include:
• Control litter moisture within recommended levels; lower litter moisture is associated with lower fly breeding.
• Control litter pests using suitable pesticides (considering bird health and spent litter management requirements). Alternatively, seek post-free litter sources or regularly remove and replace litter from the shed to interrupt pests' breeding cycles. Approved insecticides should be used to treat infested litter before spreading.
• Maintain and repair shed materials to exclude pests.
• Regularly inspect silos and feed lines to ensure there is no spillage and that they are rodent/pest-proof. Any split feed should be promptly cleaned up to avoid attracting pests.
• Minimise pest breeding sites. Rodent breeding sites, such as burrows and rubbish piles, should be removed.
• Undertake rodent monitoring and baiting in compliance with the industry biosecurity manual (ACMF, 2020b), and follow any state regulatory requirements for pesticide or chemical use and recording.
• Properly dispose of dead birds to reduce the likelihood of scavenging.
• Slash grass regularly to reduce seed production, which may attract pests.
• Select vegetation to avoid attracting wild pests and birds.
• Manage shed litter and spent litter to reduce pest impacts, and document this as part of an EMP or equivalent. Measures could include:
  • General housekeeping.
  • Control of rodents.
  • Control of darkling beetles.
  • Control of flies, including stable flies.
5.6 Land, surface water and groundwater

Performance goal
To prevent or minimise impacts to land, surface water and groundwater from meat chicken farm operations. Impact sources include dead birds, spent litter, range areas, chemicals, nutrients, sediment and pathogens. This Performance goal is met when the proposal achieves the following Mandatory criteria and Management criteria.

Mandatory criteria
The proposal complies with state regulations regarding impacts to land, surface water and groundwater. This means that:

- Management activities must comply with all state and local regulations specifying minimum distances from water bodies.
- Management activities must comply with all state and local regulations regarding siting activities in groundwater areas.
- Management activities must comply with all state and local regulations regarding the need for additional approvals to undertake any specific activities (e.g., dead bird management and spent litter management).

Management criteria
Where applicable, the farm complex (sheds, litter, chemical storage areas, range areas, litter management areas and dead bird management areas) are managed to minimise the potential for impacts to land, surface water and groundwater.

Example management measures to mitigate risk

By-products
Dead bird management must be undertaken in a manner that minimises the risk of impacts on land and water resources. Some example management measures are:

- If litter is disposed off-site, split litter is cleaned up before transport vehicles leave the site to reduce potential impacts.
- If required, representative samples of soil amendments (such as treated and untreated spent litter, and composted dead birds) can be tested to ensure contaminant levels are within limits prescribed by state requirements or Australian Standards.
- Litter/dead bird management by-products (compost, incinerator ash, digestate) are disposed in a way that does not result in impacts on land and water resources.

Land application of by-products
By-product application must be undertaken in a manner that minimises the risk of impacts to land and water resources. Some example management measures are:

- Refer to Fertcare (Fertilizer Australia, 2020) for advice on applying litter or litter/dead bird management by-products (compost, incinerator ash, digestate) to land.
- Ensure plans are in place to manage any residual environmental risk.
- Contact state biosecurity officers to check biosecurity and human health requirements if by-products are to be spread to cropping or grazing areas.
- If the site uses a water treatment system that results in liquid by-products (e.g., reverse osmosis brine), the by-product is managed sustainably (i.e., treated, disposed to a licenced waste facility or applied to the land for irrigation or dust suppression while ensuring application rates are sustainable).

Range areas
If range areas are used on the farm, a nutrient management plan can be prepared that details the nutrient application rates, the expected removal rates from cropping the environment, and plans to mitigate any residual risk. Representative samples of soils in range areas can be tested to ensure nutrient levels are within agronomic levels for the region. Soils outside of the range area can be tested to assess range nutrient levels to background levels.

To reduce the impacts of erosion, the following measures could be enacted:

- Denuded range areas are seeded with species suited to the region.
- Denuded range areas are watered where groundcover loss is increased due to water stress.

- Exposed areas are covered with temporary forms of groundcover, such as straw or crushed stone, to reduce soil erosion and runoff.
- Rills are repaired with erosion-resistant material to prevent further erosion.

Where nutrient hotspots are observed near shaded areas, consider using movable shade structures to encourage birds to move to different parts of the range. Where possible, use machinery to remove accumulated manure from shed surrounds.

Runoff
To reduce the risk of impacts from runoff, the following management measures could be enacted:

- Regularly inspect and either maintain or adapt erosion and sediment control/stormwater measures to minimise the impacts of erosion.
- Where runoff or washdown water is captured, either evaporate it, use it to irrigate land at a sustainable rate, re-use it, or discharge it to a vegetative filter strip (VFS).

- Where VFSs are used on the site, environmental management, ensure a high degree of groundcover is maintained. VFSs should be slashed regularly to control weeds, woody vegetation should be removed and, where possible, any cut material should be removed. Vehicles and livestock should be excluded from VFS areas, range areas and other landscaped areas.

Maintenance
The surface of shed floors, composting pads and emergency litter stockpiles should be inspected between growth cycles and, if necessary, repaired to ensure they are impermeable.

Mandatory criteria
The proposal complies with all applicable environmental management regulations. This means that:

- Farm management must be carried out in accordance with all local, state, and federal environmental requirements.

Management criteria
Environmental management measures that address potential risks are developed and documented.

Example management measures to mitigate risk

Environmental management measures are prepared and detail how the site will be managed to reduce impacts to amenity (including odour, dust, noise, visual amenity), traffic, pests, soil, surface water, groundwater, flora and fauna. Sections 5.1 to 5.6 above provide details of management practices to consider when preparing an EMP.

Other sections that can be included in the EMP are:

- Stakeholder engagement measures on how to improve relationships with stakeholders.
- Emergency management measures to reduce the risk of environmental impacts during or following an emergency. These measures can include natural disaster (fire, flooding), mass bird death (due to power failure, feed/water failure of disease), and other interruptions to operations (such as power failure, water failure, contractor failure, feed and water contamination).
- Effective record-keeping practices to demonstrate that environmental management measures are in place to reduce the risk of environmental impacts from the farm.
- Legislative reporting requirements, including details of any National Pollutant Inventory (NPI) and National Greenhouse and Energy Reporting System (NGERS) reporting that needs to be undertaken.
- Any environmental monitoring practices, such as odour, dust, noise and soil assessments.

For more detail on the preparation of an Environmental Management Plan (EMP) for meat chicken farms, refer to the companion document – Planning and environment guideline for establishing meat chicken farms (Guide 2 – Applicant guide).
5.8 Farm management

Performance goal
To ensure farm management measures are specified for the development and that these ensure regulatory compliance and effective farm management practices.

This Performance goal is met when the proposal achieves the following Mandatory criteria and Management criteria.

Mandatory criteria
The proposal complies with state regulations, animal welfare requirements, biosecurity requirements and environmental requirements. This means that:

• Farm management must be carried out in accordance with all state and federal planning, environment, biosecurity and animal welfare requirements.

• Farm management must be carried out in accordance with state and federal workplace health and safety requirements.

Management criteria
Farm management practices are developed and documented, covering management requirements for biosecurity, traffic, emergency response, legislative compliance and other key farm management considerations.

Example management measures to mitigate risk
All farm management measures are developed in compliance with relevant legislation and include considerations specified as mandatory criteria in this section. The farm management system could also provide details of stakeholder engagement activities, QA/QC requirements and contractual requirements with processor/integrator companies and others.

Environmental management measures should also be documented to ensure compliance. These are addressed in sections 5.1 to 5.7.

Farm management measures can detail procedures to identify any non-conformance with relevant legislation and licences, and then identify means to rectify the situation. This commitment can include measures to monitor progress and contingency measures if ongoing non-conformance occurs.
Assessing odour impact on community amenity

Introduction

This methodology is primarily based on calculating odour separation distances. These distances are also generally acceptable to mitigate any risk of dust impacts and are likely to be sufficient for noise impacts on low-risk sites.

This community amenity impact assessment guidance is based on previous guidelines established by the authors and others, and the findings of an Odour Working Group established to develop these guidelines. The key sources used were: the Queensland Guidelines for Meat Chicken Farms (DAF, 2016), the National Environmental Guidelines for Piggery (Tuckier et al, 2018), and the Egg Industry Environmental Guidelines (McGahan, Wiedemann et al, 2018). The predicted distances have also been validated against complaint data provided by state environmental protection agencies and local government jurisdictions.

Several factors determine the minimum separation distances needed between a meat chicken farm and sensitive land uses to manage amenity impacts. These include the type of neighbouring sensitive land use, local topographical features (terrain), land surface roughness between the farm and sensitive land uses, local climatic conditions, and the size of the facility.

The method used in these guidelines for assessing community amenity impacts is based on a three-tiered approach:

Tier 1 – Minimum fixed separation distances.

Tier 2 – Separation distances calculated using an empirical (S-factor) formula.

Tier 3 – Detailed impact assessment using plume dispersion modelling or other methodologies approved by the state administering authority. See Appendix A for details on undertaking a Tier 3 assessment.

Both the site-specific separation distances calculated via the S-factor formula (Tier 2) or plume dispersion modelling (Tier 3) and the fixed separation distances to other features (Tier 1) must be complied with.

Tier 1 – Fixed separation distances

State government departments and agencies and individual local government departments and agencies may specify minimum separation distances between new/expanding farms and sensitive land uses, including neighbouring houses, property boundaries, residential developments, roads etc. These authorities should be consulted to determine the fixed minimum separation distances or methods for their calculation.

Where distances are not specified by state and local government jurisdictions, the following minimum fixed separation distances are suggested:

- 500 m between the impact source and any land-use zone that is not compatible with the development (e.g., residential, rural residential).
- 250 m separation distance between the impact source and any sensitive land use (e.g., neighbouring houses), located on land that is compatible with the development (e.g., on land designated rural, farming or similar).

When calculating appropriate separation distances for sheds, it is necessary to measure the shortest distance between the odour source and the curtilage of the sensitive land use in a rural (or equivalent) zone, or the closest boundary of the non-rural zone. The Odour source for tunnel-ventilated sheds is taken to be 10 m from the exhaust end of each shed. For naturally ventilated sheds, the odour source is the shed wall nearest to the sensitive land use.

Separation distances also apply to other permanent or semi-permanent odour sources on-farm, such as manure/litter stockpiles and compost sites.

Note: Separation distances do not apply to by-product use or range areas. See definitions in the glossary for clarity on what separation distances apply to.

Minimum fixed separation distances should be applied, regardless of the distances calculated under Tier 2 or Tier 3.

Tier 2 – Separation distance formula

To calculate appropriate minimum separation distances using this Tier 2 approach, an empirical formula, referred to as an ‘S-factor’ formula, is applied. The S-factor formula described below can be used to assess whether the available separation distances are suitable for a proposed new farm development or expansion.

As with Tier 1, the shortest distance should be measured from the shed’s odour source to the curtilage of sensitive land use in a rural (or equivalent) zone, or from the shed’s odour source to the closest boundary of the non-rural zone.

A shed odour source is a point 10 m from the exhaust end of a tunnel-ventilated meat chicken shed. This assumes that fans discharge 90 per cent or more of the total emissions from the shed and that the shed is operated as a fan-forced tunnel shed. Each shed has its own odour source for the purposes of calculating separation and buffer zone distances. Where it cannot be demonstrated that 90 per cent of the emissions will be discharged from fans in sheds operated as fan-forced tunnel sheds, the odour source concept is not applicable, and the measuring point is from the shed wall.

Sites that have multiple production sites near each other on the one property should apply the S-factor formula to the combined units and each sensitive land use. For separate production facilities with a considerable distance between them, the S-factor formula can be applied to individual units. If there is overlap in the predicted odour impact contours, these units can generate a cumulative impact at neighbouring sensitive land use. A system for assessing the cumulative impact of multiple units is provided below.

The separation distance formula only applies to farms with a maximum of 600,000 birds. For farms larger than this, detailed assessment should be undertaken using odour plume dispersion modelling (refer to Tier 3 – Plume dispersion modelling guidance below) or other methodologies approved by the state administering authority. For farms with more than 600,000 birds, the separation formula is unreliable for several reasons: the more complex layout, the larger spread of sheds around the site, and the increased distance of odour plume travel, which can create more complex plume patterns. The formula is designed to be used for simple farm layouts where odour sources are not located hundreds of metres apart. Plume dispersion modelling or other methodologies approved by a state administering authority can also be used for meat chicken farms with less than 600,000 birds if available separation distances are less than those required by the S-factor methodology.

Separation distance formula overview

The separation distance provided between a meat chicken farm and sensitive land uses depends on several factors, including:

- Size – defined as the number of birds in the complex.
- Farm management – where it is assumed the best practice management is adopted for new and expanding farms as detailed in these guidelines.
- Location, considering:
  - Proximity to sensitive land use (within a rural zone).
  - Proximity to a non-rural zone.
  - Land surface roughness (vegetation and other features) between the proposed meat chicken farm and the sensitive land use.
  - Terrain around the site that influences weather conditions in the area.
- Local climatic conditions.
Site-specific separation distances are based on the dispersion of odours from their source. Different air quality objectives should be chosen depending on whether the distance is calculated to sensitive land use in a rural zone or a non-rural zone. Calculation of separation distances for each sensitive land use within a rural zone (e.g., farmhouse) and the closest boundary of the non-rural zone (e.g., a village or town boundary) are as follows:

\[
\text{Separation distance (m) = } \left( \frac{\text{Number of birds}}{1,000} \right)^{0.63} \times S_1 \times S_2 \times S_3 \times S_4 \times S_5
\]

Where:
- \( S_1 \) = Sensitive land-use factor for estimating the relative odour impact on different receptor types.
- \( S_2 \) = Surface roughness factor for estimating the potential changes to odour dispersion due to changes in the roughness of the land surface.
- \( S_3 \) = Terrain weighting factor for estimating the potential changes to odour dispersion in situations where terrain may influence weather conditions.
- \( S_4 \) = Locality/climate factor for estimating the potential changes in shed odour emission rates due to local climate (e.g., rainfall and humidity).
- \( S_5 \) = Optional wind frequency factor for estimating the relative odour impact due to wind direction frequency, for wind speeds less than 3 m/s.

The available separation distances between a proposed meat chicken farm and sensitive land uses are generally the key factors that limit the number of birds a site can accommodate. Separation distances require assessment in all directions to ensure that the potential for unacceptable odour nuisance is minimised. Where other significant odour sources are in proximity to the proposed farm development, the cumulative impact from all odour-producing sites may require more detailed assessment.

Table 1 summarises the \( S \)-factors (\( S_1, S_2, S_3 \) and \( S_4 \)) used in the above equation. A more detailed description of these \( S \)-factors and how they should be applied is provided below. Also included is how the optional \( S_5 \) wind frequency factor should be applied. Before applying this optional \( S_5 \) factor, consult with the administering authority on whether it can be used to assess impacts before undertaking more detailed modelling and the appropriate safety factor to apply, if one is required.
### Table 1

**Summary of S-factors**

<table>
<thead>
<tr>
<th>S1 – Sensitive land use factor</th>
<th>Receptor type</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitive land use (within a rural zone)</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Non-rural zone (the closest boundary of the non-rural zone)</td>
<td>50</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S2 – Surface roughness factor</th>
<th>Features</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limited ground cover/short grass</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Undulating hills</td>
<td>0.93</td>
<td></td>
</tr>
<tr>
<td>Level wooded country</td>
<td>0.85</td>
<td></td>
</tr>
<tr>
<td>Heavy timber</td>
<td>0.77</td>
<td></td>
</tr>
<tr>
<td>Significant hills and valleys</td>
<td>0.69</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S3 – Terrain weighting factor</th>
<th>Weighting factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terrain</td>
<td>Downslope of farm</td>
</tr>
<tr>
<td>Flat (≤2.0 from source to sensitive land use)</td>
<td>1.0</td>
</tr>
<tr>
<td>Valley drainage zone – broad valley &gt;10 km and/or a valley or gully with low sidewalls, where the average slope from centre of valley/gully to confining ridgeline is ≤2%</td>
<td>1.2</td>
</tr>
<tr>
<td>Valley drainage zone – average slope from centre of valley/gully to confining ridgeline is 2-5%</td>
<td>1.5</td>
</tr>
<tr>
<td>Valley drainage zone – average slope from centre of valley/gully to confining ridgeline is &gt;5%</td>
<td>2.0</td>
</tr>
<tr>
<td>Low relief at &gt;2% from odour sources (not in a valley drainage zone, but the source lies above the sensitive land use at an average grade of more than 2%)</td>
<td>1.2</td>
</tr>
<tr>
<td>All other situations</td>
<td>1.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S4 – Locality/climate weighting factor</th>
<th>Weighting factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>Avg. rainfall ≤650 mm/year and avg. daily humidity (avg. of 3pm and 9am data) is ≤60%</td>
<td>0.7</td>
</tr>
<tr>
<td>Avg. rainfall &gt;1500 mm/year and avg. daily humidity (avg. of 3pm and 9am data) is &gt;70%</td>
<td>1.3</td>
</tr>
<tr>
<td>All other situations</td>
<td>1.0</td>
</tr>
</tbody>
</table>

---

### Sensitive land use factor – S1

The sensitive land use factors (S1) presented in Table 2 account for the variation in odour sensitivity and risk of residents’ exposure to a proposed meat chicken farm on neighbouring land. The sensitive land-use factor will require calculation for all relevant neighbouring sensitive land uses.

### Table 2

**Values of sensitive land-use factors, S1**

<table>
<thead>
<tr>
<th>Sensitive land use type (see description below table)</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitive land use within a rural zone – i.e., rural dwelling</td>
<td>30</td>
</tr>
<tr>
<td>Non-rural zone (the closest boundary of the non-rural zone)</td>
<td>50</td>
</tr>
</tbody>
</table>

**Notes**

- **Sensitive land use within a rural zone** – Individual houses on land designated as rural, farming or similar definition.
- **Non-rural zone** – Rural residential zones, rural living zones, villages, towns and similar definitions, and aggregations of small (<2 ha) rural lots.
Surface roughness factor – S2

The surface roughness factor (S2) varies according to the roughness of the land surface between the proposed meat chicken farm and the relevant feature (closest sensitive land use). The principal elements that determine surface roughness are vegetation density and surface topography. Recommended values of surface roughness are provided in Table 3. The surface roughness values presented in this table are not to be summed (i.e., only the value for the single category that best represents the site conditions should be selected). The roughness factors given in Table 3 assume that the selected roughness is continuous between the proposed meat chicken farm and the sensitive land use. Where roughness is variable or non-continuous, judgement should be used when selecting an appropriate composite factor.

The values in Table 3 should be used with care, and several qualifications apply to their use. For sensitive land uses located at larger distances, multiple surface roughness factors may apply between the proposed meat chicken farm and the sensitive land use. In this instance, the surface roughness factor selected should consider the relative weighting of the multiple factors.

When selecting factors based on the presence of vegetation, consideration should be given to the potential for the vegetation to be cleared during the life of the meat chicken farm operation. Vegetation beyond the meat chicken farm boundary that is controlled and owned by others, for example, may be regarded as permanent (e.g., national park/state forest where no timber harvesting is undertaken, or where vegetation legislation permanently restricts clearing).

<table>
<thead>
<tr>
<th>Surface roughness features</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cropland or grass, few trees</td>
<td>1.00</td>
</tr>
<tr>
<td>Undulating hills</td>
<td>0.93</td>
</tr>
<tr>
<td>Level wooded country</td>
<td>0.85</td>
</tr>
<tr>
<td>Heavy timber</td>
<td>0.77</td>
</tr>
<tr>
<td>Significant hills and valleys</td>
<td>0.68</td>
</tr>
</tbody>
</table>

**Notes:**
- Cropland or grass, few trees – Open country with few or scattered trees. The topography would be predominantly flat to slightly undulating.
- Undulating hills – Situations where topography consists of continuous rolling, generally low-level hills and valleys, but without sharply defined ranges, ridges or escarpments (assumes minimal vegetation).
- Level wooded country – Open forest country with tree density not enough to provide a continuous canopy but sufficiently dense to influence air movement. There would be little or no lower-storey vegetation. The density is such that the vegetation can be considered as a continuous belt.
- Heavy timber – Generally tall forests with dense timber stands that provide a continuous canopy. There is some understorey vegetation mainly associated with regrowth.
- Significant hills and valleys – Situations where one or more lines of hills sufficiently large enough to influence air movement exist between the sensitive land use and the meat chicken farm.

Terrain weighting factor – S3

The terrain weighting factor (S3) relates to the potential for an odour plume to be exaggerated in particular directions depending on local topography. Table 4 describes the terrain weighting factors, along with the direction (upslope or downslope from the proposed farm) where each factor should be applied. The slope referred to is determined by the topographical features of each site.

<table>
<thead>
<tr>
<th>Table 4 Values of terrain weighting factors, S3</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Terrain weighting (see notes below table for application of weighting factors)</strong></td>
</tr>
<tr>
<td>Downslope of farm</td>
</tr>
<tr>
<td>Flat (&lt;2% from source to sensitive land use)</td>
</tr>
<tr>
<td>Valley drainage zone* – Broad valley (&gt;10 km and/or a valley or gully with low sidewalls, where the average slope from centre of valley/gully to confining ridgeline is &lt;2%)</td>
</tr>
<tr>
<td>Valley drainage zone* – Average slope from centre of valley/gully to confining ridgeline is 2–5%</td>
</tr>
<tr>
<td>Valley drainage zone* – (Average slope from centre of valley/gully to confining ridgeline is &gt;5%)</td>
</tr>
<tr>
<td>Low relief at &gt;2% from source to sensitive land use at an average grade of more than 21%)</td>
</tr>
<tr>
<td>All other situations</td>
</tr>
</tbody>
</table>

*If there is a risk of katabatic drainage.

**Notes:**
1. These factors may not apply where:
   a. Sea breezes are a significant influence on weather patterns (i.e., in coastal regions)
   b. Odour is emitted from elevated vent sources (e.g., stacks).
2. These terrain weighting factors should be applied by checking the proposed meat chicken farm’s location in relation to the topography for the range of distances applicable to the proposed farm impacts. The application of these weighting factors is dependent on the homogeneity of terrain between the proposed farm (source) and sensitive land use. For example, if the terrain remains similar between the meat chicken farm and sensitive land use, the weighting factor can be applied for an indefinite distance. The weighting factor is less reliable if significant terrain changes occur between the source and sensitive land use. The use of it should be first discussed with the administering authority where there is significant hilly terrain, and a Tier 3 assessment may be required.
3. The use of these terrain weighting factors does not affect the application of surface roughness factors above.
4. Downslope factors should be applied across an angle of 90° centred on the terrain feature. Upslope factors should be applied across an angle of 60° centred on the terrain feature.
Localities/climate weighting factor – S4

Litter moisture conditions are known to affect odour production and subsequent emissions from poultry sheds. A factor that influences this is local climatic conditions; wetter climates make maintaining both a continual dry state for litter and sufficient ventilation rates problematic. Local climatic data was assessed for the major chicken production areas in Australia against complaint data to derive a locality/climate weighting factor (S4) (see Table 5).

Wind frequency factor – S5 (optional)

The optional wind frequency factor (S5) applies to wind direction frequencies for the 16 compass points and considers the percentage of the wind direction for wind speeds below 3 m/s. Thus, all wind speeds ≥ 3 m/s need to be deleted before the analysis is conducted.

1. Obtain a meteorological file representative of the site that has been approved by the administering authority.
2. Calculate wind direction frequencies for the 16 compass points for wind speeds ≥ 3 m/s. Thus, all wind speeds ≤ 3 m/s need to be deleted before the analysis is conducted.
3. Divide wind direction frequencies for each of the 16 compass points by the highest frequency direction. This will achieve a reduction of the previously calculated separation distances from the highest frequency that is set to 1.0.
4. Assign wind direction frequencies S to N, NNE to SSW etc., to account for the wind blowing from odour source (proposed meat chicken farm) to impact area (downwind). This means that wind direction frequencies need to be switched 180° to account for winds blowing from source to sensitive land use.
5. Present wind direction frequencies values.
6. Add a safety factor (agreed to by the applicable regulatory authority but generally 20% is used) to the wind direction frequencies. This value may need to be increased to 50% if the meteorological data is prognostic rather than site-specific, where there is a dominant wind direction and complex terrain.
7. Divide adjusted wind speed frequency by 100 to determine the 16 wind speed frequency factors for the site.

Table 5

Values of locality/climate weighting factors, S4

<table>
<thead>
<tr>
<th>Locality/climate conditions</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average rainfall ≤450 mm/year and average daily humidity (average of 3pm and 9am data) ≤60%</td>
<td>0.7</td>
</tr>
<tr>
<td>Average rainfall &gt;450 mm/year and average daily humidity (average of 3pm and 9am data) &gt;60%</td>
<td>1.3</td>
</tr>
<tr>
<td>All other situations</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Notes

This data can be extracted from the Bureau of Meteorology.
Appendix B

Best practice guideline: Odour and dust impact assessment for meat chicken farms

Introduction

The AgriFutures Chicken Meat Program commissioned a project to develop the national environmental and planning guidelines for the chicken meat industry. This project was developed following the recommendations from an earlier project (Streamlined planning and development in the chicken meat industry) that investigated the planning constraints and needs of the chicken meat industry in relation to its future growth. The project’s wide stakeholder consultation process highlighted the uncertainties and inconsistencies in the assessment and approval process for new sheds, particularly the contentious issue of odour impact assessment.

While there is common agreement with the overall odour assessment methods, different approaches are used for some important aspects, which can lead to costly disagreement in court cases. This difficulty is further confounded by differences between the guidelines issued from one state to the next, and because of a lack of accord between some guidelines and results of previous industry research. In some cases, the existing guidance is also outdated and does not reflect industry practices.

To address these inconsistencies, an Odour Working Group (OWG) was convened. The primary purpose of the OWG was to develop and outline best practice odour modelling methods. This was achieved by forming consensus around the key scientific issues relating to estimating odour emissions, modelling the odour dispersion and assessing the impacts. Estimating and modelling dust emissions was also included, as this is a related topic relevant to the chicken meat industry. The OWG was made up of invited air quality specialists and was led by a nationally recognised independent chair.

This document presents the findings of the OWG in the form of a best practice guide for undertaking impact assessment of odour and dust. It provides recommendations on a best practice approach for modelling meat chicken farms while considering other relevant information, including farm complaint histories. Modelling practices and recommendations are provided as the basis of a suitable approach, with the focus on currently accepted models and methods that are widely used and accepted for modern, tunnel-ventilated meat chicken farms. The guidance can be adapted for broader and breeder-rearer farms, however the relevant methodology is not included in this document.

The document is intended for use by consultants, regulators and researchers with experience in odour modelling and assessment.

Emissions

Emissions

Some management decisions and factors that will influence emission rates include feed and water management, stocking densities, litter type and amount used, and litter management. With the introduction of the RSPCA growing requirements along with shed design, shed management is relatively consistent between all integrators.

Key inputs

Key factors when modelling meat chicken farms are summarised below in Table 6.

Key inputs

<table>
<thead>
<tr>
<th>Key Input</th>
<th>Typical value</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growing period</td>
<td>42-56 days</td>
<td>Confirm with grower/processor</td>
</tr>
<tr>
<td>Empty period</td>
<td>Up to 14 days</td>
<td></td>
</tr>
<tr>
<td>Thinning regime</td>
<td>Varies between free range and conventional and dictated by prescribed farm standards</td>
<td></td>
</tr>
<tr>
<td>Target temperatures</td>
<td>Typical values are 31°C at day 1 down to 20°C at day 41 onwards.</td>
<td>Confirm with grower/processor target temperatures for the region.</td>
</tr>
<tr>
<td>Maximum ventilation rate</td>
<td>9-12 m³/hr/bird</td>
<td>Based on long-term farm test data. Sheds can have slightly higher design ventilation rates, but these often do not include backpressure associated with shed operation, leading to a typical value of 10 m³/hr/bird at maximum.</td>
</tr>
</tbody>
</table>
An analysis of target temperatures at several farms has shown that Equation 2 from Dunlop and Duperouzel (2014) can be used to estimate typical targets. Typical target temperatures can be found in Cobb (2018), Aviagen (2019) and Cobb-Vantress (2018). Target temperature should be confirmed prior to modelling and exit temperature should be based on target temperature. Table 7 provides an example of how to determine target temperature.

### Table 7

**Example target temperature by bird age (where d = days)**

<table>
<thead>
<tr>
<th>Age</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ≤ d &lt; 35</td>
<td>(-0.2857 \times d + 31)</td>
</tr>
<tr>
<td>35 ≤ d &lt; 42</td>
<td>(-0.1429 \times d + 26)</td>
</tr>
<tr>
<td>d ≥ 42</td>
<td>20°</td>
</tr>
</tbody>
</table>

### Odour emissions

There are two methods currently used in Australia, the K-factor method (Ormerod and Holmes, 2005) and the weight-age factor method, also known as the GHD method (see Pollock and Friebel, 2000; Pollock and Friebel, 2002). The GHD method is based on testing in Victoria over several years, whereas the K-factor method has been primarily based on odour test data from farms in Queensland and NSW.

The selection of a method should be based on an understanding of current industry practices in the locale in which it is to be used, as well as understanding other factors (see section detailing ‘Reporting of inputs and outputs’ in this appendix). Such factors may include odour testing at the site or at other farms in the area to confirm the efficacy of the emissions model.

### Table 8

**Bird age factors (Aₜ) by week of growth cycle**

<table>
<thead>
<tr>
<th>Week</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age factor (Aₜ)</td>
<td>0.036</td>
<td>0.074</td>
<td>0.24</td>
<td>0.62</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Note: Age factor (Aₜ) from GHD (2014).

In NSW, the Environmental Protection Authority prefers the use of the K-factor method.

The two methods are discussed below.

### GHD method

The current formulation of the method, as described in GHD (2008; 2013) and elsewhere is summarised below.

The odour emission rate (OER) for each shed is calculated from the number of birds placed, an age factor (Aₜ), ambient temperature (T) and a temperature factor (Tᵢ). The age factor is from GHD (2014), and is shown in Table 8. These relationships are shown in Equation 1 and Equation 2.

In simple terms, the calculation of emission rates is based on the number of birds placed and the age factor (Table 8), before adjusting the emissions to match the density and number of birds present. Ambient temperature is used to determine emissions, which vary as a function of ventilation rate. The temperature factor (Tᵢ) accounts for the fact that the odour emission rate varies as a function of ventilation (Equation 1) and is derived from ambient temperature using Equation 2.

Note that where the ambient temperature T > 24.3°C, Tᵢ = 800, and that where T < 12.3°C, Tᵢ = 200.

### Equation 1

\[
\text{OER} = Aₜ \times \text{#birds} \times T \times Tᵢ
\]

### Equation 2

\[
Tᵢ = 51.12 \times T(°C) - 458.2
\]

### Example ventilation profile as a percentage of maximum

<table>
<thead>
<tr>
<th>Temperature (°C) above target</th>
<th>Ventilation rate (percent of maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.7 2.5 5.1 7.6 9.8 11.5 17.0 17.0</td>
</tr>
<tr>
<td>1</td>
<td>1.7 12.5 25.0 25.0 25.0 25.0 25.0</td>
</tr>
<tr>
<td>2</td>
<td>1.7 25.0 37.5 37.5 37.5 37.5 37.5</td>
</tr>
<tr>
<td>3</td>
<td>1.7 37.5 50.0 50.0 50.0 50.0 50.0</td>
</tr>
<tr>
<td>4</td>
<td>1.7 37.5 50.0 50.0 50.0 50.0 50.0</td>
</tr>
<tr>
<td>5</td>
<td>1.7 37.5 50.0 50.0 50.0 50.0 50.0</td>
</tr>
<tr>
<td>6</td>
<td>1.7 37.5 50.0 50.0 50.0 50.0 50.0</td>
</tr>
<tr>
<td>7</td>
<td>1.7 37.5 50.0 50.0 50.0 50.0 50.0</td>
</tr>
<tr>
<td>8</td>
<td>1.7 37.5 50.0 50.0 50.0 50.0 50.0</td>
</tr>
<tr>
<td>9</td>
<td>1.7 37.5 50.0 50.0 50.0 50.0 50.0</td>
</tr>
</tbody>
</table>

Note: Minimum ventilation rate based on typical values combined with maximum shed ventilation rate of 152 m³/s.

### K-factor method (Ormerod and Holmes)

The Ormerod and Holmes emissions method (K-factor method) is based on the relationship between the number of birds present, the stocking density of the birds, the ventilation rate and overall farm management. Further details can be found in Ormerod and Holmes (2006).

Based on the work of Clarkson and Misserbroek (1991), Ormerod and Holmes (2006) concluded that a well-managed farm with dry and friable litter would have fewer emissions than a farm with wet litter. Hence, the ‘K-factor’ method uses ‘K’ as a scaling factor to represent different emissions profiles relating to farm size, shed management and site-specific considerations. For a given farm, the K-factor can be calculated using Equation 3.

### Equation 3

\[
K = \frac{OER}{0.025 \times A \times D \times V^{0.5}}
\]

Where K is an emission rate factor, OER is the odour emission rate in ou/s, A is the shed floor area in square metres (m²), D is the bird density in kilograms per square metre (kg/m²), and V is the ventilation rate in cubic metres per second (m³/s).

Or conversely, the odour emission rate for a given K-factor at a point in time can be calculated based on measured data using Equation 4.

### Example target temperature by bird age (where d = days)

<table>
<thead>
<tr>
<th>Age</th>
<th>Equation</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ≤ d &lt; 35</td>
<td>(-0.2857 \times d + 31)</td>
</tr>
<tr>
<td>35 ≤ d &lt; 42</td>
<td>(-0.1429 \times d + 26)</td>
</tr>
<tr>
<td>d ≥ 42</td>
<td>20°</td>
</tr>
</tbody>
</table>

Note: Minimum ventilation rate based on typical values combined with maximum shed ventilation rate of 152 m³/s.
Contemporary data collected from farms mainly located in NSW between 2017 and 2019 showed that the K-factor for modern meat chicken farms is, on average, 1.3. Care should be taken, however, when estimating emissions for new farms. It is important to ensure that when the K-factor method is applied in the planning process, it predicts a realistic range of emissions rather than adopting an average K-factor from farms elsewhere. It is recommended that when modelling a ‘greenfield’ site that will be operated to best management practice, a K-factor of no less than 1.9 should be used, as it represents the most recent test data from new farms. Based on specific-site test data, further development at that site may be conducted once the farm is operational, to show it can achieve fewer emissions than assumed for the modelling. Therefore, when modelling a farm expansion or a new farm with a similar design and management practices in the same region, site-specific odour measurements can be taken and a lower K-factor may be justified, following consultation with the administering authority.

For a site where compliance is not easily demonstrated via the modelling, growth cycle staging (i.e., a different assumed placement date) may be required by the regulator.

Dust emissions

It is generally accepted that if a farm has a sufficient buffer for odour, the dust impacts will not occur and modelling to demonstrate compliance is not required. If dust modelling is required, the following relationships can be used to establish emission rates of TSP, PM₁₀, and PM₂.₅. The results of a linear regression, which compares maximum emission rates (Dunlop et al., 2011) and bird age, highlighted that the emission rate in mg/s/1000 birds can be estimated using the following equation:

\[
D_{(PM_{10})} = 0.0387 \times A
\]

Where:
- A = bird age (days)
- D = maximum PM₁₀ emissions at growth cycle age (mg/s/1000 birds)

If total suspended particles (TSP) or particulate matter less than 2.5 \(\mu\)m in diameter (PM₂.₅) is to be modelled, ratios of 2.8:1 TSP:PM₁₀ and 3.98:1 PM₁₀:PM₂.₅ should be used (Poultry CRC, 2011).

Model selection

Inappropriate model selection is a potential source of large inaccuracies in results. It is recommended that the CALMET and CALPUFF models be used for modelling poultry farm facilities. Consequently, this section will concentrate on these models and their input requirements.

Gaussian plume models (e.g., AUSTRALM and AFRCOD) could be used under certain circumstances. These models should not be used in the following circumstances:
- For long-range dispersion.
- In coastal areas where recirculation could occur.
- Where there is evidence of significant effects of non-steady-state meteorology. Evidence of non-steady-state meteorology includes:
  - Meteorological data or meteorological model results from the area which show significant and commonly occurring spatial variations in surface winds in the region between the source and important receptors, particularly at night or under stable meteorological conditions.
  - On-site meteorological data shows a persistent pattern of winds that are aligned to or steered by local terrain features (local or regional complex meteorology), and which would imply significant changes in wind direction between the source and receptors. Most importantly, this is likely where a poultry facility is located within a valley or drainage flow path, where the measured or modelled winds are persistently aligned with the local valley or drainage path orientation, and where receptors are located either outside the valley or in the valley where it has a different orientation than at the source.
  - Where more than one facility is being considered in the same model application.
  - When low-level odour sources are being modelled where light winds and/or terrain drainage is likely to affect the dispersion of odour.

For further guidance on model selection see NZMFE (2004) or NSW EPA (2016).

Meteorological data

Meteorological data are a key input in dispersion models. As noted in OEH (2011), there are three broad ways of running CALMET:
- No-observation method (run only using output from meteorological models such as TAPM).
- Hybrid approach (run using a combination of output data from meteorological models such as TAPM, along with measured meteorology).
- Observation only (run using observed data only).

Where observed data are used, the various inputs required are detailed below.

Data sources

There are four factors that affect the representativeness of the meteorological data. These are:
- The proximity of the meteorological site to the area being modelled.
- The complexity of the terrain.
- The exposure of the meteorological measurement site.
- The time-period of the data collection (MOE, 2017).

The design, sensors and data logging frequency used on the meteorological station.

While site-specific data is preferred, data from the nearest off-site meteorological station can be used when on-site data are not available. The station data can be compared to a prognostic models prediction, or the data can be included either in the prognostic model (i.e., nudging TAPM) or in CALMET in the hybrid or observation only methods.

If there is more than one weather station in the area, these data can be used as an input into the model. Additional care must be taken when setting a Radius of Influence (ROI) in TAPM; RMAX in CALPUFF), to ensure that the weight given to the model or the data is consistent with the string of the station. For example, a station in a sub-valley away from a site is likely to be less relevant to that site than a closer station that sits in the same general area. Further guidance on this can be found in OEH (2011).

Observed data for use in models

Wind speed and direction

Wind speed and direction data are critical model inputs. Therefore, the quality of the dataset is critical, and the data should be checked before being used.

A wind sensor should ideally have a threshold of no more than 0.3 m/s, which is below that required in most guidance documents. As a minimum, direction data should be resolved to within 1 degree. The best practical option is the use of data from a sonic anemometer, which determines instantaneous wind speed and direction. If non-ultrasonic sensors are proposed for areas where light wind speeds are expected, these should have performance parameters consistent with those of ultrasonic stations that meet the regulatory standards.

Where state government data (i.e., Queensland DES or NSW EPA) is used, the data already comes checked and is appropriately averaged (as it is typically measured using sonic anemometers). These data can be directly input into the meteorological model.

Where data from an on-site weather station or the Bureau of Meteorology (BOM) are used, care should be taken with the processing of the data. For example, a first step is to plot the various parameters and look for trends in the data (i.e., flattening of the data), yearly trends or data gaps. The station information should also be checked regarding the age of the sensors. See section on ‘Missing data and substitution’ in this appendix for guidance on missing data.

Where BOM data are used, it is recommended that one-minute data are obtained, and an hourly average derived using appropriate methods (see USEPA, 2000). The wind speed value from the weather should be a scalar hourly-averaged wind speed, not a vector average. Wind direction should be vector averaged. Automatic weather stations often provide both parameters, meaning that care is needed to select the correct one.

If no one-minute data are used, and it is proposed to use 30-minute data from BOM, the data should be validated (prior to use) against the prognostic model for stations in the region.
Temperature
Air temperature is an important influence on the buoyancy of plumes emitted into the atmosphere. Buoyancy affects the extent of plume rise, with more buoyant plumes tending to rise higher above the ground, thus reducing the ground-level impact. It is wise to check temperature data against data from a recognised (e.g., BOM) site nearby with similar conditions (e.g., similar altitude, terrain and distance from coast).

Cloud data
Cloud height and amount data are essential for most dispersion models. The model pre-processor (CALMET) uses this data to estimate stability class, which is employed in the dispersion model to facilitate estimates of lateral and vertical dispersion parameters.

Cloud data is not always available. The Bureau of Meteorology manually records cloud data, on average, every three hours at selected stations. The data should then be interpolated to produce hourly data. In addition, some BOM stations record cloud data using ceilometers. Care must be taken using this data as it only produces a reading for a minute portion of the sky directly above the instrument.

Often the area in which dispersion modelling is to be conducted does not coincide with such a station. In these cases, an alternative source of these data needs to be considered. Sources here include the Weather Research and Forecast (WRF) model and TAPM. When using CALMET in the hybrid method (with a surf. dat), cloud data should be calculated from prognostic relative humidity at all levels (MM5toGrads algorithm, see Table 10).

Data quality and representativeness of the data
Many weather stations are not operated to sufficiently high standards, and data quality can be seriously compromised. Caution should also be exercised when obtaining data even from reputable sources. For example, with certain Bureau of Meteorology data. ¹ Other data quality considerations are:

- Wind direction and speed is often stored as a 10-minute mean at the time of observation (i.e., at that point in time, not an average) in the dataset.
- Wind speeds are often recorded in whole numbers, and in knots.
- Very light wind speeds are problematic as it may take a couple of knots to restore the instrument cups after stalling, and once running, these cups will normally continue to rotate at a one knot wind speed. Therefore, anything less than a knot (0.5 m/s) is recorded as calm.
- Averaged data from BOM may be averaged via scalar or vector (Yamartino method).

Meteorological data from weather stations should be quality assured before use. The degree of assurance will depend on the age and operator of the station. As a minimum, a check whether wind speed, wind direction and temperature are within acceptable limits for a specific region should be performed. A wind rose could also be used to check whether there are shielding effects due to structures and vegetation for certain wind directions.

Generally, a minimum of one year of meteorological data is acceptable for dispersion modelling in Australia. The data must, however, adequately represent typical meteorological conditions and should be assessed in terms of representativeness against climatic averages. In other words, the meteorology for selected year(s) must be shown to be representative of the normal range of conditions in the area. This should include adequate representation of conditions likely to influence maximum plume impacts. Where there is cause for concern about the representativeness of a weather station for the assessment area, multiple years of meteorological data may be used. Some jurisdictions have their own requirements; EPA Victoria, for example, recommends ideal using five consecutive years of data from the last 5–10 years to ensure the dataset considers extreme weather events.

An accepted practice is to obtain a year of data from a weather station in the region and compare it with the average of at least five years of data from the regional station (or longer). It should be demonstrated that the data adequately describes the expected meteorological patterns at the station location. As a minimum, wind speed, direction and temperature for several years should be compared with long-term averages. A statistical test is preferred, as that would give an objective assessment as to whether the sample (i.e., a particular year) is different to the population (i.e., the long-term data). The local or state regulatory authority may have already identified a preference for “typical” years.

Missing data and substitution
Regulatory dispersion modelling requires a meteorological record for every hour in the analysis period (one to five years). Most dispersion models will not run successfully if they encounter missing meteorological data. Substitution for missing or invalid data is allowed for up to 10% of the data; conversely, the meteorological database must be 90% complete (before substitution) to be acceptable for use in regulatory dispersion modelling (USEPA, 2000).

Data substitution procedures include:

- Persistence – Persistence is the use of data from the previous time period (hour). This procedure is applicable for most meteorological variables for isolated one-hour gaps. Caution should be used when the gaps occur during day/night transition periods (USEPA, 2000).
- Interpolation – Interpolation is a method of constructing new data points within the range of a discrete set of known data points. This procedure is applicable for most meteorological variables for isolated one-hour gaps and, depending on circumstances, may be used for more extended periods (several hours) for selected variables, e.g., temperature. As in the case of persistence, caution should be used when the gaps occur during day/night transition periods (USEPA, 2000).

Missing data for periods longer than one week cannot be interpolated and must be regarded as missing. If there are other on-site or nearby representative off-site data, it may be used when the primary data are missing.

Prognostic meteorological models
Prognostic meteorological models can be used to derive or supplement observational meteorology in data-sparse areas and can also simulate spatial meteorological phenomena (such as lee eddies), which often occur downwind of topographical obstacles (e.g., mountain ranges, escarpments).

CALMET may be run with TAPM or WRF-derived data. This data may be used as an initial guess field, which will then be adjusted for mesoscale and local scale effects (Exponent, 2011; Scire et al., 2000). It is important to note that the use of prognostic models is generally acceptable if no other data are available, but should be supported by validation studies (USEPA, 2000). If the site is in complex terrain, the performance of the prognostic model should be assessed against data from a weather station in the region. Suitable benchmarks for comparing model performance to observed data can be found in Emery et al. (2003). If the performance of the prognostic model is not considered appropriate based on the statistical benchmarks, the use of an on-site weather station should be considered to validate the performance of the model in that area.

Prognostic models may incorporate observational data to “nudge” the model after a certain period to better reflect reality. A note of caution is that nudging may produce unrealistic or distorted wind fields where the prognostic data do not match the observational data very well.

Owing to the unsupported status of TAPM by CSIRO, the Weather Research and Forecast (WRF) model is the only readily available prognostic model.

Use of CALMET and CALPUFF – Settings and switches
CALPUFF is the recommended model for poultry farm assessments. The Generic Guidance and Optimum Model Settings for the CALPUFF Modelling System for Inclusion into the Approved Methods for the Modelling and Assessments of Air Pollutants in NSW, Australia¹ (OEH, 2011) is a comprehensive guideline on how to set up CALMET and CALPUFF; and the correct switches to use in the model. It is therefore recommended that this guideline be used in large part, however, several corrections and addendums to this guideline are presented here.

The following tables lists a few of the more complex switches and settings used in CALMET (Table 10) and CALPUFF (Table 11) applicable to poultry shed modelling. For a comprehensive list of switches and settings, refer to OEH (2011).
Table 10

Main switches and settings for CALMET

<table>
<thead>
<tr>
<th>Model code</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>THRESHL</td>
<td>Threshold buoyancy flux overland to sustain convective mixing height growth</td>
<td>0.05</td>
</tr>
<tr>
<td>ICLDUD</td>
<td>Cloud data options</td>
<td>0 if station cloud data is used 4 with noobs mode</td>
</tr>
<tr>
<td>IFRADJ</td>
<td>Fröde number adjustment</td>
<td>1</td>
</tr>
<tr>
<td>IKINE</td>
<td>Kinematic effects</td>
<td>1</td>
</tr>
<tr>
<td>IOBR</td>
<td>O'Brien procedure</td>
<td>0</td>
</tr>
<tr>
<td>ISELOPE</td>
<td>Slope flow effects</td>
<td>1</td>
</tr>
<tr>
<td>IEXTRP</td>
<td>Extrapolate surface winds</td>
<td>0</td>
</tr>
<tr>
<td>ICALM</td>
<td>Extrapolate surface winds vertically</td>
<td>0</td>
</tr>
<tr>
<td>BIAS</td>
<td>Vertical bias between surface and upper air data</td>
<td>Varying, Usually biased to surface data in lower layers (~100 m.)</td>
</tr>
<tr>
<td>TERRAD</td>
<td>Terrain radius of influence</td>
<td>Varying, See text</td>
</tr>
<tr>
<td>IMAK</td>
<td>Radius of influence of surface station</td>
<td>Varying, See text</td>
</tr>
<tr>
<td>MT</td>
<td>radius where surface station and 1st guess field weight are equal</td>
<td>Varying, See text</td>
</tr>
<tr>
<td>CRITFN</td>
<td>Critical Fröde number</td>
<td>1</td>
</tr>
<tr>
<td>CONSTB</td>
<td>Neutral, mechanical equation</td>
<td>1.41</td>
</tr>
<tr>
<td>CONSTE</td>
<td>Convective mixing height</td>
<td>0.15</td>
</tr>
<tr>
<td>CONSTN</td>
<td>Stable mixing height</td>
<td>2400</td>
</tr>
<tr>
<td>IAVEZI</td>
<td>Spatial averaging of mixing heights</td>
<td>1</td>
</tr>
<tr>
<td>IZMIN</td>
<td>Minimum overland mixing height</td>
<td>50.0</td>
</tr>
<tr>
<td>IZMAX</td>
<td>Maximum overland mixing height</td>
<td>3000.0</td>
</tr>
<tr>
<td>RAD</td>
<td>Interpolation type</td>
<td>1</td>
</tr>
<tr>
<td>TRADKM</td>
<td>Radius of influence for temperature interpolation</td>
<td>Varying, dependant on observation station density</td>
</tr>
<tr>
<td>IAVE</td>
<td>Spatial averaging of temperatures</td>
<td>1</td>
</tr>
<tr>
<td>TSZEFIB</td>
<td>Default overwater lapse rate below inversion</td>
<td>0.0098</td>
</tr>
</tbody>
</table>

*A large proportion of the switches are to be kept at DEFAULT. Only a selection is presented here*

Table 11

Main switches and settings for CALPUFF

<table>
<thead>
<tr>
<th>Bird age (weeks)</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGTIME</td>
<td>PG averaging time</td>
<td>60.0</td>
</tr>
<tr>
<td>MGAUSS</td>
<td>Gaussian vertical distribution used in the near field</td>
<td>1</td>
</tr>
<tr>
<td>MCTADJ</td>
<td>Terrain adjustment method</td>
<td>3</td>
</tr>
<tr>
<td>MTRANS</td>
<td>Transitional plume rise computed</td>
<td>1</td>
</tr>
<tr>
<td>MTIP</td>
<td>Stack tip downwash modelled</td>
<td>0</td>
</tr>
<tr>
<td>MMRSE</td>
<td>Method used to compute plume rise for point sources</td>
<td>1</td>
</tr>
<tr>
<td>MSHEAR</td>
<td>Vertical wind shear above stack top</td>
<td>0</td>
</tr>
<tr>
<td>MSPLIT</td>
<td>Puff splitting</td>
<td>0</td>
</tr>
<tr>
<td>MXSIP</td>
<td>Method used to compute dispersion coefficients</td>
<td>2</td>
</tr>
<tr>
<td>MTALUY</td>
<td>Method used for Lagrangian timescale for Sigma-y</td>
<td>Default = 0</td>
</tr>
<tr>
<td>MCTURB</td>
<td>Method used to compute turbulence sigma-v, w</td>
<td>1</td>
</tr>
<tr>
<td>MPRATL</td>
<td>Partial plume penetration of elevated inversion</td>
<td>1</td>
</tr>
<tr>
<td>MDPDF</td>
<td>PDF for dispersion under convective conditions</td>
<td>0</td>
</tr>
<tr>
<td>JSUP</td>
<td>Stability class used to determine plume growth rates above boundary layer</td>
<td>Default = 5</td>
</tr>
<tr>
<td>CONKH</td>
<td>Vertical disp. constant for stable conditions</td>
<td>0.01</td>
</tr>
<tr>
<td>CONK2</td>
<td>Vertical disp. constant for neutral/unstable conditions</td>
<td>0.1</td>
</tr>
<tr>
<td>XSAMLEN</td>
<td>Maximum travel distance of puff (in grid units) during one sampling step</td>
<td>Varying, See text</td>
</tr>
<tr>
<td>MNNEW</td>
<td>Number of puffs released per time step</td>
<td>Default = 99</td>
</tr>
<tr>
<td>MRSAM</td>
<td>Acceptable number of sampling steps per puff</td>
<td>Default = 99</td>
</tr>
<tr>
<td>SYMN</td>
<td>Minimum sigma y for a new puff</td>
<td>Default = 1.0</td>
</tr>
<tr>
<td>SZMIN</td>
<td>Minimum sigma z for a new puff</td>
<td>Default = 1.0</td>
</tr>
<tr>
<td>WSCALM</td>
<td>Minimum wind speed</td>
<td>Varying, See text</td>
</tr>
<tr>
<td>XMAX2I</td>
<td>Maximum mixing height</td>
<td>Default = 3000</td>
</tr>
<tr>
<td>XMNZ2I</td>
<td>Minimum mixing height</td>
<td>Default = 50</td>
</tr>
</tbody>
</table>
CALMET

Several key inputs are required to run CALMET. Information regarding the selection of these is provided below.

Setting TERRAD and RMAX, R1 values in CALMET

As TERRAD, RMAX and R1 values are dependent on the nature of the topography over the modelling domain, these are set on a case–by-case basis and hence no standard value can be given for these parameters.

TERRAD is the radius of influence of terrain features. This number is obtained by measuring the crest-to-crest distance of the dominant terrain feature in the model domain (or in the immediate area of the facility being modelled) – TERRAD is the crest-to-crest distance divided by two (Figure 9).

RMAX is the maximum radius of influence a surface meteorological station is given (Figure 9). As a rule, the radius of influence is restricted by the characteristics of the area the station is located. For example, in a narrow valley, RMAX is limited by the width of the valley, while in a flat region, RMAX is large. R1 is the radius at which the first guess field (obtained from upper air data) and surface station has equal weighting. This is usually 50% of RMAX. Note: Only one RMAX value can be set for multiple stations in a model domain.

Land use and roughness length

It is recommended that locally sourced or calculated roughness lengths be applied to Australian vegetation types. Australian eucalypt forests, for example, have been found to have lower roughness lengths than the default North American broadleaf forest type (0.75 m versus 1.0 m). The 2002 publication An improved land-use parameter dataset for Global and Regional Climate Models can also assist. Alternatively, a spatially-varying roughness length dataset can be calculated for the modelling domain by relating roughness height to the arrangement, spacing, and physical height of individual roughness elements, such as trees or houses (e.g., Counihan, 1971):

1

\[
z_0 = h \left(1.08 \frac{A_r}{A} - 0.08\right)
\]

Where \(z_0\) is the total surface area of the roughness element of height \(h\) in Area \(A\).

Figure 9. Examples of TERRAD and RMAX settings in CALMET.

THRESHL setting

To avoid spurious convective mixing heights at dusk and dawn, it is recommended that THRESHL be set to 0.06 based on the work of Ken Rayner (WA Department of Environment and Conservation, CALPUFF issue summary, 28 April 2011 and CALPUFF issue summary, 20 May 2011).

Model resolution

Horizontal

In setting up CALMET, the spatial resolution of the model must be fine enough to resolve local-scale drainage flow under light wind conditions. This is critical for odour dispersion. It is important to note that while extremely fine terrain resolution (1 m) data exists, CALMET is not designed to model at these resolutions. It is recommended that a minimum resolution of 100 m be used.

Where a resolution of greater than 100 m is used, justification should be given as to why a coarser resolution has been used.

CALPUFF

Dispersion coefficient and minimum turbulence velocity fluctuation

It is recommended that unless sub hourly modelling is performed that the USEPA default SVMIN setting (\(a_0\)) of 0.5 m/s be used. U. Barclay, personal communication, 8 August 2021.

WISCALM

It is recommended that unless site specific turbulence values are used for sub hourly modelling, the USEPA default value for WISCALM (0.5 m/s) should be used.

XSAMLEN

CALPUFF has a switch to set the maximum travel distance of a puff (in grid units) during one sampling step (XSAMLEN). The default for massscale applications is one grid unit with a unit size of 1 km. However, for assessments in the near-field, a finer grid resolution maybe required. For example, a finer resolution grid of 100 m and 200 m should have an XSAMLEN of about 10 and five, respectively.

It is noted that the setting of XSAMLEN typically has a negligible effect on model predictions.

Plume rise

Dunlop et al (2010) found that compared with the CFD model, CALPUFF did not accurately simulate plume rise from poultry sheds. This may result in overestimation of odour impacts at ground level.

The latest version of CALPUFF lets the user set the vertical momentum flux factor (0 or 1), where 1 is full momentum to represent the effect of physical configurations that reduce momentum rise associated with the actual exit velocity. Where the rain hat setting is used, the setting should be 0. In this set-up, stack diameter increases are not required to maintain volumetric flow rate. The point source should be located immediately adjacent to the fans on the end of the shed", with a point source diameter corresponding to the width of the bank of fans or shed" to capture the width of the source. Note that in the case of horizontal fluxes, stack tip downwash should not be activated.


4This reduces the turbulent mixing shown by Dunlop et al (2010) by restricting plume growth.
Source set-up

It is recommended that the plume mass be conserved when modelling. For example, if the shed is 15 m wide and has a volumetric flow rate of 120 m$^3$/s, the diameter of the source should reflect the number of fans and shed width and be in the centreline of the shed.\(^8\) The maximum velocity (at maximum ventilation rate) should be calculated by dividing the flow rate by the area of the source base on the source diameter. The vertical velocity for the point source would be varied through the year modelled, based on predicted ventilation rate and the fixed area.

The height of the source should be set at half of the fan bank height. For a single fan bank shed, this is about 1 m.

Other source setups may be used, subject to suitable justification by the modeller. Such justification may include local studies or other supporting information.

Plume merging

In the poultry industry, the point source configuration described in the previous section considers merging of plumes from the multiple fans. It does not, however, consider the merging of plumes for sheds facing each other. In rare cases where fans from two sheds face each other, plume merging may occur under suitable meteorological conditions (wind directions parallel to the shed), as demonstrated by CFD simulations (Figure 10). It is recommended that for this type of shed configuration, plume merging be considered under favourable wind conditions.

\(^8\)Dunlop et al (2010) showed that the plumes exhausted from sheds move away from the fans and then rise vertically. The vertical rise was a combination of turbulence and thermal buoyancy and is incorporated in the modelling using the point source with a rain hat.
Odour assessment criteria

Odour criteria are set by each state government in Australia and those for unknown mixtures of pollutants are summarised in Table 12. These vary in several ways:

- Victoria allows for a relaxation of the odour criteria for intensive animal husbandry if it meets a set of criteria (See EPA Victoria, 2017). This relaxation allows a risk assessment if the odour criteria are exceeded at or beyond the boundary.
- Western Australia does not specify odour impact criteria and uses a risk assessment approach that may have regard to odour impact assessment methodologies published by NSW EPA (i.e., S-factor methods). Modelling can be used to compare operational charges.
- Odour impact criteria in NSW and South Australia vary depending on population density.
- Odour impact criteria at a state level in some jurisdictions apply at and beyond the site boundary (e.g., Victoria), whereas others apply at the nearest existing or likely future off-site sensitive receptor (e.g., NSW).
- Processes for developing industry-specific odour assessment are provided for in NSW and Queensland.

Table 12
Australian odour criteria by state

<table>
<thead>
<tr>
<th>State</th>
<th>Magnitude (OU)</th>
<th>Percentile</th>
<th>Averaging period</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>2</td>
<td>7</td>
<td>99</td>
</tr>
<tr>
<td>QLD</td>
<td>0.5</td>
<td>2.5</td>
<td>99.5</td>
</tr>
<tr>
<td>VIC</td>
<td>1</td>
<td>5</td>
<td>99.9</td>
</tr>
<tr>
<td>SA</td>
<td>2</td>
<td>10</td>
<td>99.9</td>
</tr>
<tr>
<td>WA</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAS</td>
<td>2</td>
<td></td>
<td>99.5 or 100²</td>
</tr>
</tbody>
</table>

Notes: 1. Applies to intensive animal husbandry only if they meet a set of criteria. If exceeded, a risk assessment can be undertaken.
2. 100th percentile applies in cases where high-quality local meteorological and emissions data are not available.

Reporting of inputs and outputs

What to report

The methodology above provides a standardised method for producing representative model outputs. Where the methodology is followed, experience has shown that the risk of odour impacts is likely to be far lower than where a non-standardised method is used to predict impacts.

While the aim of the modelling exercise is to produce a contour around a proposed farm or existing farm, the user must be able to demonstrate:

1. The relevant inputs defined in this document have been incorporated in the assessment.
2. The land-use settings in the models are appropriate.
3. The terrain used in the models is appropriate.
4. The input meteorological data is relevant.
5. If local weather data are not present, that the prognostic model used has a suitable efficacy for the area.
6. The year modelled is representative of long-term averages.
7. The resultant meteorological data is consistent with expectations for the area.
8. The contours produced are consistent with expectations (based on other farms in the area or within the region, as well as complaint history).

The series of questions below provide guidance as to what should be included in the justification for modelling and the outputs in the report. (Table 13)

Other information

In addition to the model-based assessment, additional information can be useful for both greenfield sites and existing sites. Additional information may include:

1. Separation distances for existing sites with a similar size.
2. Complaint history for other farms with a similar separation distance.
3. Results of K-factor testing for farms in the area or other localities.
4. Results of field odour surveys.
5. Risk assessment using field odour surveillance data.

Some of these methods are detailed in literature from state government administering authorities (Department of Environment and Conservation Western Australia and Environmental Protection Authority Victoria).

Table 13
Australian odour criteria by state

<table>
<thead>
<tr>
<th>State</th>
<th>Magnitude (OU)</th>
<th>Percentile</th>
<th>Averaging period</th>
</tr>
</thead>
<tbody>
<tr>
<td>NSW</td>
<td>2</td>
<td>7</td>
<td>99</td>
</tr>
<tr>
<td>QLD</td>
<td>0.5</td>
<td>2.5</td>
<td>99.5</td>
</tr>
<tr>
<td>VIC</td>
<td>1</td>
<td>5</td>
<td>99.9</td>
</tr>
<tr>
<td>SA</td>
<td>2</td>
<td>10</td>
<td>99.9</td>
</tr>
<tr>
<td>WA</td>
<td>N/A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAS</td>
<td>2</td>
<td></td>
<td>99.5 or 100²</td>
</tr>
</tbody>
</table>

Notes: 1. Applies to intensive animal husbandry only if they meet a set of criteria. If exceeded, a risk assessment can be undertaken.
2. 100th percentile applies in cases where high-quality local meteorological and emissions data are not available.

Table 13
Inclusions and justification for modelling and recommended outputs

<table>
<thead>
<tr>
<th>Item</th>
<th>Question to be covered in report</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm size</td>
<td>Has the size of the farm been included?</td>
</tr>
<tr>
<td>Farm operation</td>
<td>Have key inputs relating to the farm operation been included?</td>
</tr>
<tr>
<td>Overall modelling method</td>
<td>What models have been used?</td>
</tr>
<tr>
<td></td>
<td>Have standard inputs been used? If not, why?</td>
</tr>
<tr>
<td>Emission estimation method</td>
<td>What method was used, why is it relevant for this farm operation?</td>
</tr>
<tr>
<td></td>
<td>What K-factor was used and, for existing farms, has testing been performed?</td>
</tr>
<tr>
<td>Weather station data</td>
<td>What was the source of the data?</td>
</tr>
<tr>
<td></td>
<td>What was the height of the station?</td>
</tr>
<tr>
<td></td>
<td>What was the data quality?</td>
</tr>
<tr>
<td></td>
<td>How were the data processed?</td>
</tr>
<tr>
<td></td>
<td>What processing was required?</td>
</tr>
<tr>
<td>Representativeness of year modelled</td>
<td>Has the year modelled been justified?</td>
</tr>
<tr>
<td>Meteorological modelling</td>
<td>What model(s) was used?</td>
</tr>
<tr>
<td></td>
<td>How was the model(s) set-up?</td>
</tr>
<tr>
<td></td>
<td>What spatial resolution was used?</td>
</tr>
<tr>
<td></td>
<td>How does it perform in that locale or region (e.g., does the prognostic model perform with a suitable degree of accuracy)?</td>
</tr>
<tr>
<td></td>
<td>Are the outputs consistent with expectations for that area?</td>
</tr>
<tr>
<td>Dispersion modelling</td>
<td>What model was used?</td>
</tr>
<tr>
<td></td>
<td>How were the sources set up?</td>
</tr>
<tr>
<td></td>
<td>Have all settings in Table 10 and Table 11 been used?</td>
</tr>
<tr>
<td></td>
<td>How do the results compare to a) expected terrain features; and b) buffers at other farms of a similar size?</td>
</tr>
</tbody>
</table>

Site-specific weather data – Weather station

An applicant may wish to install a weather station for a greenfield site, or for a site that wishes to expand. In an area where multiple farms exist, it would be prudent to install at least one station to cover the area, and this can be used by several farms.

When selecting a weather station, consideration should not only be given to the fact that it has an ultrasonic sensor but that the data outputs from the sensor should produce data required by the standards. The siting of a weather station to provide representative wind speeds is critical for air quality modelling applications. The standard exposure height of wind instruments over level, open terrain is 10 m above the ground. (USEPA, 2000,10 WMO, 2017.7). The weather station should be located clear of obstacles such as trees, buildings or local terrain features that can disrupt the free flow of air around the sensor. The sensor should be separated from obstacles by a distance of at least 10 times the height of the obstacle (WMO, 2017). Australian Standard 2923-1987 (Guide for the Measurement of Horizontal Wind for Air Quality Applications) should be consulted with (Standards Australia, 1987). It is noted that AS2923-1987 refers to USEPA (2000).

When siting on-site weather stations, air temperature should be measured as shade temperature, usually at a height of about 1.5 m above cut, vegetated ground. It is important that the temperature sensor is properly shielded from radiation effects. If it is not, the measured temperatures will be too high during sunny conditions and too low at night. Unnatural or artificial surfaces to consider are heat sources and reflective surfaces (for example buildings, concrete surfaces, car parks) (WMO, 2017). In addition, a screen close to a vertical obstacle may be shaded from the solar radiation or ‘protected’ against the night radiative cooling of the air, by receiving the warmer infrared radiation from this obstacle, or through reflected radiation.

Weather stations should be subject to regular maintenance and calibration to ensure high data quality. Calibration and testing are inherent elements of a quality assurance program to ensure that a sensor will meet its specified performance (WMO, 2017). The calibration of meteorological instruments should be carried out once a year in a laboratory where appropriate measurement standards and calibration devices are located to track instrument performance and enable appropriate correction (WMO, 2017). However, Methods for sampling and analysis of ambient air Part 14: Meteorological monitoring for ambient air quality monitoring applications – AS3580.14:2014 (Standards Australia, 2014) allows wind speed and direction calibration to occur no less frequently than every two years. Therefore, the relevant standard(s) should be consulted when installing and operating a weather station.

Calibration can be performed in a laboratory or in the field. The field check involves a comparison between the on-site reporting sensor and a collocated transfer standard (CTS) sensor of similar design (it is recommended that it be the same make to eliminate any bias) for a period of not less than 24 hours. Further information on this can be found in AS3580.14:2014.

If a station is installed, the supplier should confirm that it meets relevant requirements, and produces scalar-averaged wind speed and vector-averaged wind direction readings, as well as arithmetic averages for other data for the averaging periods monitored.

Surface water and groundwater risk tools for range and by-product use areas

The following risk-assessment tools were developed to assist with appropriate siting and design of range areas and by-product use areas.

The use of these tools is not required for most meat chicken farms, i.e., those that house the birds inside and where all spent litter is taken off-site when removed from the shed.

These site risk assessment tools are based on the Farm Nutrient Loss Index (FNLI) (Melland et al, 2007), with significant modifications. The FNLI uses weighted factors and scores for factors that correspond to levels of risk. The Revised Universal Soil Loss Equation (RUSLE) was also used in the development of this tool. The RUSLE provides an equation for determining the magnitude of soil erosion and transport-based on-site factors that correspond closely to risk factors for impacts to surface water.

Compared with methods and tools such as RUSLE and FNLI, these tools do not seek to quantify the likelihood or magnitude of soil and nutrient loss but seek to rate the site risks that contribute to these processes. These tools also consider each factor’s relative importance in determining overall risk levels, whereas some tools rate each factor as being of equal importance.

The factors and weightings used in the FNLI and RUSLE were revised to better represent the risk factors and transport processes relevant to site risks on meat chicken farms.

Two risk assessment tables have been developed due to the different factors that affect surface water risk and groundwater risk. Both tables should be used to develop a separate score for both surface water risk and groundwater risk. Once the score for each factor is determined, the associated risk rating (low, high or unacceptable) can be determined based on the risk thresholds.

The scores derived from the surface water risk assessment tool (Table 14) can be used to determine the risk category (low, high or unacceptable) in accordance with Table 16.

The risk rating is a central concept in determining a risk-based approach to siting, designing and managing range areas and by-product use areas on meat chicken farms to prevent impacts to surface water and groundwater.

### Surface water risk

Site risk for surface water impacts is based on a variety of factors. Determine the factor score (1-8) for each runoff factor shown in Table 14. Multiply the factor score by the factor weight to determine the factor risk.

For example, if the site is located between 30 and 100 m of a waterway, the runoff factor ‘Distance to waterways’ has a factor score of 4. The factor weight for ‘Distance to waterways’ is 15, so the factor risk is 4 x 15 = 60.

Once you have determined the factor risk for each factor, the total risk score is determined by summing all factor risk scores. The result should give an overall score between 80 and 640.

The scores derived from the surface water risk assessment tool (Table 14) can be used to determine the risk category (low, high or unacceptable) in accordance with Table 16.

### Table 14: Surface water risk assessment for range and by-product use areas

<table>
<thead>
<tr>
<th>Surface water (runoff factors)</th>
<th>Factor weight</th>
<th>Factor score</th>
<th>Factor risk = weight x score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rainfall factor</td>
<td>20</td>
<td>0 to 50</td>
<td>&gt;50 to 100</td>
</tr>
<tr>
<td>Distance to waterways (m)</td>
<td>15</td>
<td>&gt;200</td>
<td>100 to 200</td>
</tr>
<tr>
<td>Soil profile (Refer to factor description on soil profile below for more detail)</td>
<td>10</td>
<td>High infiltration and drainage.</td>
<td>Moderate infiltration and drainage.</td>
</tr>
<tr>
<td>Land shape</td>
<td>10</td>
<td>Land with a slope of less than 1.5% or where most runoff is retained on-farm.</td>
<td>Sloping land without concentration of flow or with features that slow runoff from leaving the farm.</td>
</tr>
<tr>
<td>Groundcover level</td>
<td>10</td>
<td>80 to 100%</td>
<td>60 to &lt;80%</td>
</tr>
<tr>
<td>Slope (for range areas only)</td>
<td>5</td>
<td>&lt;1%</td>
<td>1 to 4%</td>
</tr>
<tr>
<td>Slope (for by-product use areas only)</td>
<td>5</td>
<td>&lt;1%</td>
<td>1 to 5%</td>
</tr>
<tr>
<td>Soil P – Olsen</td>
<td>5</td>
<td>&lt;8</td>
<td>8 to &lt;12</td>
</tr>
<tr>
<td>Soil P – Colwell (sandy)</td>
<td>5</td>
<td>&lt;13</td>
<td>13 to &lt;19</td>
</tr>
<tr>
<td>Soil P – Colwell (loam)</td>
<td>5</td>
<td>&lt;16</td>
<td>16 to &lt;24</td>
</tr>
<tr>
<td>Soil P – Colwell (clay)</td>
<td>5</td>
<td>&lt;24</td>
<td>24 to &lt;38</td>
</tr>
<tr>
<td>Topsoil PBI</td>
<td>5</td>
<td>&gt;280</td>
<td>140 to 280 (default value for clay)</td>
</tr>
<tr>
<td>Note: Sites with &lt;30 m to waterways should not be used for range or by-product use areas. Sites with a slope of &lt;10% should not be used for range areas. Sites with a slope of &gt;15% should not be used for by-product use areas.</td>
<td>Refer to explanatory notes to complete</td>
<td>Risk score = Sum</td>
<td></td>
</tr>
</tbody>
</table>

(Appendix)
Groundwater risk

Site risk for groundwater impacts is based on several factors. First, determine the factor score (1–8) for each leaching factor shown in Table 15, then multiply the factor score by the factor weight to determine the factor risk.

For example, if the site has >30% lucerne groundcover, the leaching factor ‘Groundcover type’ has a factor score of 1. The factor weight for ‘Groundcover type’ is 15, so the factor risk is 1 x 15 = 15.

Once you have determined the factor risk for each factor, the total risk score is determined by summing all factor risk scores. The result should give an overall score between 80 and 640.

The scores derived from the groundwater risk assessment tool (Table 15) can be used to determine the risk category (low, high or unacceptable) in accordance with Table 16.

Table 15

<table>
<thead>
<tr>
<th>Groundwater (leaching factors)</th>
<th>Factor weight</th>
<th>Factor score</th>
<th>Factor risk = weight x score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil profile</td>
<td>25</td>
<td>1</td>
<td>25</td>
</tr>
<tr>
<td>Groundwater depth</td>
<td>20</td>
<td>&gt;10 m to groundwater where protected by clay or impermeable strata, Otherwise &gt;20 m</td>
<td>4</td>
</tr>
<tr>
<td>Rainfall factor</td>
<td>20</td>
<td>0 to 50</td>
<td>20</td>
</tr>
<tr>
<td>Groundcover type</td>
<td>15</td>
<td>&gt;30% lucerne</td>
<td>48</td>
</tr>
</tbody>
</table>

For sites with groundwater <2 m, sites should not be used for range or by-product use areas.

Risk thresholds

Table 16

<table>
<thead>
<tr>
<th>Risk category thresholds for both surface water and groundwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk score</td>
</tr>
<tr>
<td>&lt;200</td>
</tr>
<tr>
<td>200 to 400</td>
</tr>
<tr>
<td>&gt;400</td>
</tr>
</tbody>
</table>

Note: Sites with an overall risk score >400 should not be used for range or by-product use areas.

Risk thresholds

Table 16

<table>
<thead>
<tr>
<th>Risk category thresholds for both surface water and groundwater</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk score</td>
</tr>
<tr>
<td>&lt;200</td>
</tr>
<tr>
<td>200 to 400</td>
</tr>
<tr>
<td>&gt;400</td>
</tr>
</tbody>
</table>

Note: Sites with an overall risk score >400 should not be used for range or by-product use areas.

Factor descriptions

Rainfall factor

Note: The rainfall factor is used in both the surface water and groundwater risk assessment tables (Table 14 and Table 15).

The rainfall factor surface water risk is described in Melland et al (2007). One of the most important issues affecting nutrient loss is the amount of water available for runoff and leaching. This water’s ability to erode soils is also important as it affects the amount of soil-bound nutrients and particulate nutrients in runoff. While the rainfall factor (Figure 11) does not directly account for seasonal storm activity or the erosivity of rainfall, it does correspond strongly with rainfall erosivity throughout Australia, as described by Lu et al (2001).

Note: Sites with groundwater <2 m should not be used for range or by-product use areas.

Figure 11. FNLI locations and rainfall factors (from Melland et al, 2007).
Distance to waterways factor

Note: The distance to waterways factor is used only in the surface water risk assessment table (Table 14).

As the distance to nearby waterways increases, or the amount of nutrients dissolved in surface runoff increases, so too does the likelihood of sediment deposition and an associated reduction in particulate-bound nutrients. Sediment deposition depends on the decreasing energy of runoff waters through runoff-modifying features, ground cover, or decreasing slope. The lower energy of runoff waters is also associated with increased infiltration and less nutrient-laden water availability for runoff.

Proximity to the waterway is the distance from the nearest edge of the area under consideration to a waterway. This factor applies to all land between the point where runoff is generated (by-product reuse area) and the point of discharge (e.g., a receiving waterway). This can include parts of by-product reuse area if sufficient groundcover is present (i.e., the groundcover percentage factor is representative). It can be measured through site assessments or mapping. Table 17 shows the distance to waterways factors.

Table 17
Distance to waterways factors for the surface water risk assessment

<table>
<thead>
<tr>
<th>Distance to waterways</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to waterways</td>
<td>&gt;200 m</td>
<td>100 to 200 m</td>
<td>50 to &lt;100 m</td>
<td>30 to &lt;50 m</td>
</tr>
</tbody>
</table>

Note: Sites with <30 m to waterways should not be used for range or by-product use areas.

Soil profile factor

Note: The soil profile factor is used in both the surface water and groundwater risk assessment tables (Table 14 and Table 15). The factors are reversed for the groundwater risk assessment.

The soil profile factor describes the infiltration capacity of the soil. In well-draining soil, a larger proportion of rainfall or overland flow infiltrates the soil and therefore does not contribute directly to runoff. Thus, low infiltration capacity results in higher runoff and greater soil particle erosion, soil-bound nutrients, and particulate nutrients. Higher runoff also results in higher losses of dissolved nutrients in runoff. Table 18 shows the soil profile factors to be applied when using the surface water risk assessment tool.

A higher infiltration capacity results in more water in the soil profile, and therefore more dissolved nutrients being lost to the soil. Where the amount of water in the soil profile exceeds that holding capacity of the soil, this water and the associated nutrients are likely to be lost beyond the root zone, with potential to contaminate groundwaters. Table 19 shows the soil profile factors to be applied when using the groundwater risk assessment tool. Note that the factors are reversed for the groundwater risk ratings (Table 19) compared with the surface water ratings (Table 18).

Advice on likely soil types present on a site may be available from local natural resource management groups, Landcare groups, catchment management authorities or primary industries departments. Online mapping of soil types may be available from state or local mapping services, or the CSIRO Atlas of Australian Soils.
Table 19
Soil profile factors for groundwater risk assessment

<table>
<thead>
<tr>
<th>Soil profile factor</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infiltration and drainage</strong></td>
<td>Poor infiltration and drainage</td>
<td>Moderate infiltration but poor drainage</td>
<td>Moderate infiltration and drainage</td>
<td>High infiltration and drainage</td>
</tr>
<tr>
<td><strong>Description and examples</strong></td>
<td>Water is removed very slowly in relation to supply. Seasonal ponding resulting from run-on and insufficient outfall also occurs. The soil can remain wet for weeks to months. A perched water table may be present. Soils have a wide range of textures and depth. Many horizons are gleyed and strongly mottled. These generally include: • Fine textured (heavy clay) soils. • Soils with severe permeability restrictions, e.g., very poor structure, pans.</td>
<td>Water is removed only slowly in relation to supply. Soils can have a wide range of textures and depths. Some horizons may be mottled and/or have orange or rusty linings of root channels and are wet for periods of several weeks. These generally include: • Texture contrast soils. • Soils with subsoil constraints, e.g., pans, high density. • Sodic soils.</td>
<td>Water is removed from the soil readily but not rapidly. Excess water flows downward into underlying moderately permeable material or laterally as subsurface flow. Soils are often medium in texture or well structured. Some horizons may remain wet for several days after water addition. However, gley colours and mottles should not be present. These generally include: • Medium to coarse textured soils. • Friable structured soils. • Structured gradational soils.</td>
<td>Water is removed from the soil rapidly in relation to supply. Excess water flows downwards rapidly if underlying material is highly permeable. Soils are usually coarse textured, shallow or both. No horizon is normally wet for more than several hours after water addition. These generally include: • Very sandy soils. • Soils that are very stony or shallow. • Some highly structured soils.</td>
</tr>
</tbody>
</table>

Appendix C

Table 20
Land shape factors for the surface water risk assessment

<table>
<thead>
<tr>
<th>Land shape factor</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land shape</strong></td>
<td>Land with a slope of less than 1.5%, or where most runoff is retained on-farm e.g., tailwater collection systems.</td>
<td>Sloping land without concentration of flow, or with features that slow runoff from leaving the farm e.g., contour banks or vegetated filter strips.</td>
<td>Land with a uniform slope and features that neither slow nor accelerate runoff.</td>
<td>Land with features that accelerate runoff leaving the farm, e.g., gully, surface or tile drain.</td>
</tr>
</tbody>
</table>

Table 21
Groundcover level factors for the surface water risk assessment

<table>
<thead>
<tr>
<th>Groundcover level factor</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Groundcover percentage</strong></td>
<td>80 to 100%</td>
<td>60 to 80%</td>
<td>40 to 60%</td>
<td>&lt;40%</td>
</tr>
</tbody>
</table>

Guide 1 – Assessment guide
Note: The slope factor is used only in the surface water risk assessment table (Table 14).

The slope factor contributes to runoff speed, resulting in greater erosive potential and lower opportunity for infiltration. Slopes under consideration for by-product use areas are expected to have a gradient of <15% because of the difficulties of managing production on greater slopes. Slopes for range areas should be lower, due to greater difficulties in keeping them well-vegetated.

The slope can be determined from simple site inspection of the proposed by-product reuse areas. Alternatively, topographic maps or GIS could be used for remote assessment.

Table 22 shows the slope factors.

### Table 22

<table>
<thead>
<tr>
<th>Slope factor</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slope percentage (range areas)</td>
<td>&lt;1.5%</td>
<td>1.5 to 4%</td>
<td>&gt;4 to 7%</td>
<td>&gt;7 to 10%</td>
</tr>
<tr>
<td>Slope percentage (re-use areas)</td>
<td>&lt;2.5%</td>
<td>2.5 to 6%</td>
<td>&gt;6 to 10%</td>
<td>&gt;10 to 15%</td>
</tr>
</tbody>
</table>

Notes: Sites with a slope >10% should not be used for range areas. Sites with a slope >15% should not be used for by-product use areas.

Note: The soil P test factor is used only in the surface water risk assessment table (Table 14).

The soil phosphorus (P) level determines the availability of P for use by plants or loss. Where soil P is high, additional P in the system is likely to be lost. Soil P alone is not sufficient to determine risk and must be interpreted in conjunction with the soil’s buffering ability (PBI).

Soil P values were assessed against threshold values that represent the ability of plants to use the phosphorus in the soil, with high levels being above plant requirements and available for loss.

Soil P can be determined by inexpensive soil testing. Where testing results are unavailable, typical values for the soil type can be used, or a default score of 8 can provide a conservative assessment.

Table 23 shows the Soil P test factors.

### Table 23

<table>
<thead>
<tr>
<th>Soil test name</th>
<th>Soil type</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olsen P</td>
<td>All soils</td>
<td>&lt;8</td>
<td>8 to 12</td>
<td>12 to 18</td>
<td>&gt;18</td>
</tr>
<tr>
<td></td>
<td>Sandy</td>
<td>&lt;13</td>
<td>13 to 19</td>
<td>19 to 24</td>
<td>&gt;24</td>
</tr>
<tr>
<td></td>
<td>Loam</td>
<td>&lt;16</td>
<td>16 to 24</td>
<td>24 to 36</td>
<td>&gt;36</td>
</tr>
<tr>
<td></td>
<td>Clay</td>
<td>&lt;24</td>
<td>24 to 36</td>
<td>36 to 40</td>
<td>&gt;45</td>
</tr>
</tbody>
</table>
Groundcover type factor

Note: The groundcover type factor is used only in the groundwater risk assessment table (Table 15).

Plants of different types have different rooting depths, with deeper-rooted plants better able to use soil moisture and nutrients. This ability to use moisture and soil nutrients results in a lower risk of nutrients seeping to groundwater.

This risk assessment has adopted the recommendations for risk scores associated with pasture type found in the FNLI. This factor’s weighting was based on the relative importance in the FNLI when compared with similar factors used in this risk assessment tool (see Table 26).

Table 26

<table>
<thead>
<tr>
<th>Groundcover type factor</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant type description</td>
<td>&gt;30% lucerne</td>
<td>&gt;30% other deep-rooted plants that are actively growing all year round</td>
<td>&gt;30% crops or perennial pasture</td>
<td>&gt;30% crops or perennial pastures</td>
</tr>
</tbody>
</table>

Groundwater depth factor

Note: The groundwater depth factor is used only in the groundwater risk assessment table (Table 15).

The level of risk to groundwater depends on the depth of groundwater and the level of protection afforded to it by impermeable layers in the soil profile. Deeper groundwater tables result in longer flow paths for leached nutrients and provide a greater opportunity for nutrients to be assimilated by the soil. Greater depth to groundwater also determines the soil volume and thus mediates the soil’s water-holding capacity in conjunction with the soil type. The greater the percentage of infiltrated water that can be held, the less available for groundwater loss.

Table 25 shows groundwater depth factors.

Table 25

<table>
<thead>
<tr>
<th>Groundwater depth factor</th>
<th>1</th>
<th>2</th>
<th>4</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater depth and strata description</td>
<td>&gt;10 m to groundwater where protected by clay or impermeable strata. Otherwise &gt;20 m</td>
<td>&gt;5 m to groundwater where protected by clay or impermeable strata. Otherwise &gt;15 m</td>
<td>&gt;2 m to groundwater where protected by clay or impermeable strata. Otherwise &gt;10 m</td>
<td>&gt;2 m to unprotected groundwater.</td>
</tr>
</tbody>
</table>

Topsoil phosphorus buffering index (PBI) factor

Note: The topsoil PBI test factor is used only in the surface water risk assessment table (Table 14).

The phosphorus buffering index (PBI) of the soil describes its ability to moderate changes in available phosphorus levels in the soil. This, in turn, influences the soils’ ability to bind with phosphorus, making it unavailable for loss. Soil PBI can be determined from inexpensive soil testing. Where testing results are unavailable, typical values for the soil type can be used, or a default value of 8 can be used to provide a conservative assessment.

Table 24 shows the Topsoil PBI factors.

Table 24

<table>
<thead>
<tr>
<th>Topsoil PBI factors for the surface water risk assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater depth factor</td>
</tr>
<tr>
<td>Topsoil PBI and soil description</td>
</tr>
</tbody>
</table>

Groundwater depth factor

Note: The groundwater depth factor is used only in the groundwater risk assessment table (Table 15).

The level of risk to groundwater depends on the depth of groundwater and the level of protection afforded to it by impermeable layers in the soil profile. Deeper groundwater tables result in longer flow paths for leached nutrients and provide a greater opportunity for nutrients to be assimilated by the soil. Greater depth to groundwater also determines the soil volume and thus mediates the soil’s water-holding capacity in conjunction with the soil type. The greater the percentage of infiltrated water that can be held, the less available for groundwater loss.

Table 25 shows groundwater depth factors.

Table 25

<table>
<thead>
<tr>
<th>Groundwater depth factors for the groundwater risk assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater depth factor</td>
</tr>
<tr>
<td>Groundwater depth and strata description</td>
</tr>
</tbody>
</table>

Note: Sites where the depth to seasonal groundwater is less than 2 m are unsuitable for range or by-product use areas.
In the last two decades, AgriFutures Australia has demonstrated its proactive commitment to improving the environmental performance and sustainable production of the chicken meat industry by funding and publishing the results of many research projects in this area. The following projects are evidence of that commitment:

- Odour and ammonia emission reduction from broiler hens (2000)

- Sustainability improvements in the Victorian chicken meat industry (2003)

- Chicken Litter: issues associated with sourcing and use (2007)

- Control of odour and dust from chicken sheds – review of add-on technologies (2009)

- Separation distances for broiler farms – verifying methods including the effects of thermal buoyancy (2010)

- Trials of odour control technology on broiler farms (2010)

- Using life cycle analysis to quantify the environmental impact of chicken meat production (2012)

- Managing litter re-use for minimal nutrient run-off to surface water (2012)

- Conversion of waste to energy in the chicken meat industry (2013)

- Control of odour and dust from chicken sheds – evaluation of windbreak walls (2013)

- Monitoring mechanical ventilation rates in poultry buildings (2014)

- Chicken litter: alternative fertiliser and ways to increase soil carbon (2014)

- Odour dispersion modelling of meat chicken farms (2014)

- Solar guidelines for Australian meat chicken growers (2014)

- Two case studies of commercial viability for solar photo voltaic systems on meat chicken farms (2014)

- Quantifying on-farm energy usage in the Australian meat chicken industry (2015)


- Free range chickens – odour emissions and nutrient management (2015)


- Reducing costs and energy by replacing inefficient ventilation fans (2015)

- Guide – how to reduce costs by replacing inefficient ventilation fans on meat chicken sheds (2015)

- Vegetative environmental buffers for meat chicken farms (2015)

- Grocer options for spent litter utilisation (2015)


- Causal factors of ‘wet litter’ in chicken meat production (2016)

- Artificial ciliation system for on-site odour measurement (2016)


- Addressing odour abatement and assessment knowledge gaps using PTR-ToFMS (2018)

- Variable-speed exhaust fans for meat chicken sheds (2018)

- Review of fresh litter supply, management and spent litter utilisation (2018)

- Mass disposal preparedness for the poultry industries (2020)

- Review of rodent control for the Australian chicken meat and egg industries (2020)

- Suitability of litter amendments for the Australian chicken meat industry (2020)


- Water security in the chicken meat industry (2021)

- Best practice litter management manual for Australian meat chicken farms (2021)

- Final report summary: Risk assessment of alternative litter types (2021)

In submitting this report, the researcher has agreed to AgriFutures Australia publishing this material in its edited form.