



EGG INDUSTRY ENVIRONMENTAL GUIDELINES

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Produced for Australian Eggs Limited by:

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Glossary

Aerobic – Contains dissolved or free oxygen.

AEL – Australian Eggs Limited. The peak industry body for egg production in Australia. Formerly AECL.

Anaerobic – Contains no dissolved or free oxygen.

Aviary system – A variation of a barn shed where poultry are housed on several levels including the shed floor (with litter) and may have manure removal belts.

Barn sheds – Housing system in which birds are free to roam within a shed which may have more than one level (aviary). The floor may be based on litter and/or other material such as slats or wire mesh.

Bedding – Material placed on the floors of sheds to absorb the manure produced by hens.

Biosecurity – Managing risk to prevent the introduction of infectious disease agents to poultry; to prevent the spread of disease agents from an infected area to an uninfected area; and to minimise the incidence and spread of microorganisms of public health significance.

Breeding farms – Farms which keep breeding hens and roosters to produce fertile eggs.

Buffer distances – Distances used to protect non-amenity resources and improve biosecurity measures. They are measured as the distance between the impact source (sheds, manure stockpiles, by-product utilisation area, range areas) and the resources to be protected (e.g. watercourse, bore, other poultry farms).

Bunding – An embankment to exclude run-on and run-off.

By-product – Manure (from cage, aviary and wire systems), spent litter (from barns and free range systems), egg washing water, liquid waste water and cracked/broken eggs (from grading floors).

By-product utilisation area – A managed area used for land-spreading of the by-products from egg production.

Cage production – A system of housing where the birds are continuously housed in cages with a wire floor, usually in a multi-tiered system.

Community amenity – The comfortable enjoyment of life and property, particularly in terms of air quality (i.e. odour and dust), noise, lighting and visual appearance (Tucker et al., 2010).

Contaminant – Can be a gas, liquid or solid, an odour, an organism (including viruses, whether dead or alive), energy (including noise and heat), or a combination of these.

Contamination – The release of a contaminant to the environment in the form of a gas, odour, liquid, solid, organism or energy.

Eco-efficiency – A business-oriented approach to environmental management that focuses on reducing resource inputs and avoiding the generation of wastes and pollutants.

Egg industry facilities (for the purposes of these guidelines) – Includes layer pullet rearing facilities, egg production sheds (cage, free range, barn and aviary), grading floors, manure storages, litter storages, or any other areas where organic by-products are located or stored. It does not include by-product utilisation areas and range areas on free range farms, as these have separate separation distances to manage community amenity impacts.

Erosion – The wearing away of the land surface by rain water, water-flow or wind, removing soil from one point to another e.g. gully, rill or sheet erosion.

Furnished cages – Cages containing furnishing such as nest boxes, perches and scratch-pads.

Free range – A production system where birds housed in fixed or mobile sheds have access to an outdoor range.

Grading floor – A facility where eggs are candled, cleaned, sorted and packed for distribution to market/s.

Groundwater – All water below the land surface that is free to move under the influence of gravity.

Groundwater recharge – The replenishment of a groundwater body, by gravity movement of surplus soil water that percolates through the soil profile.

Housing – Structures provided for bird safety. Birds typically perform a majority of their sleeping, eating, watering and manure deposition inside their housing.

Katabatic drainage – When air sinks (typically due to night-time cooling) and flows over the land surface, along drainage lines.

Leaching – The process where soluble nutrients, e.g. nitrogen, are carried by water down through the soil profile.

Litter – The composite of poultry manure and absorbent bedding.

Major water supply/storage – A public drinking water supply storage.

Measuring point – For a watercourse, this is the maximum level to which the water surface can reach before overtopping of a bank begins (bank-full discharge level). For a public road it is the surveyed boundaries of the road on the same side of the road as the operation. For tunnel ventilated sheds, without impact walls, the measuring point should be taken from a point 25m out from the exhaust end of the shed. All other operations should measure the distance from the shed perimeter.

Nutrient – A food essential for a cell, organism or plant growth. Phosphorus and nitrogen are major nutrients essential for plant growth. In excess they are potentially serious pollutants encouraging nuisance growth of algae and aquatic plants in water. Nitrate-nitrogen poses a direct threat to human health. Phosphorus is the major element of concern in relation to algal blooms.

Organic matter – Chemical substances of animal or plant matter.

Pathogens – Organisms that can cause infections or disease, such as a bacterium, viruses, fungi or protozoa.

pH – A measure of the acidity or alkalinity of a product. The pH scale ranges from 1 to 14.

Range area – Outdoor land area available for poultry to forage and roam, which includes any veranda areas.

Riparian land – Any land that adjoins or directly influences a body of water. It includes the land immediately beside creeks and rivers (including the bank), gullies that sometimes run with water, and the areas surrounding lakes and wetlands and river floodplains that interact with the river during flood times.

Runoff – All surface water flow, both over the ground (as overland flow) and in streams (as channel flow). It may originate from excess precipitation that can't infiltrate the soil, or as the outflow of groundwater along lines where the water table intersects the earth's surface.

Sensitive land use – Sensitive land uses are those which are most likely to be affected by potential environmental impacts such as noise, dust or odour. They include residential buildings, hospitals, schools, child care centres, caravan parks and other use involving the presence of people for an extended period.

Separation distances – The distances between production facilities and a sensitive land use which may be impacted by production activities. They are measured as the shortest distance from the odour source (sheds) to the nearest wall of a building associated with a sensitive land use, or to the closest boundary of the non-rural zone. They do not apply to by-product utilisation areas or range areas. Separation distances may be calculated for certain matters or defined by regulators.

Sheds – A form of fixed housing used in egg production. Unless otherwise specified sheds are not considered to be moveable housing.

Soil profile – A vertical cross-section of soil from the surface to the parent material or substrate.

Spent hen – A laying bird that has reached the end of her economic egg laying life and is sent for processing.

Spent litter – The litter that has been used as bedding but is no longer suitable for that purpose. It contains other organic materials such as bird excreta and feathers etc.

Surface water – Includes dams, impoundments, rivers, creeks, reservoirs, billabongs, springs, lakes, swamps, nature channels and all waterways where rainfall is likely to collect.

Topography – The shape of the ground surface as depicted by the presence of hills, mountains or plains; that is, a detailed description or representation of the features, both natural and artificial, of an area, such as are required for a topographic map.

Total solids (TS) – The dry matter content of a material or substance.

Vegetative environmental buffer (VEB) – A dense, multiple-row planting of trees or shrubs and grasses positioned immediately downwind of tunnel ventilated livestock buildings to specifically filter, intercept and adsorb particulates (dust) and aerosols (odour and ammonia) from the exhaust fans' emission plume.

Vegetative filter strip (VFS) – A vegetated area separating a watercourse or drainage line from an area where organic matter is deposited (e.g. by-product utilisation area or shed surrounds/range areas).

Watercourse – A naturally occurring drainage channel that includes rivers, streams and creeks. It has a clearly defined bed and bank, and the flow may be intermittent. Refer to relevant state or territory acts for legal definitions.



1 INTRODUCTION

1.1. Purpose of the Document

These guidelines are a proactive approach by the Australian egg industry to ensure both the economic and environmental sustainability of the industry. They are designed to assist in the establishment of new farms or the expansion of existing operations, and to encourage existing egg producers to improve their environmental management practices. This revision incorporates updated scientific knowledge surrounding key environmental issues and addresses changes to egg industry practices and regulations.

Industry, regulators and the community can use these guidelines to ensure egg production facilities are developed, designed and managed to minimise the risk and severity of adverse environmental and amenity impacts. The guidelines also provide a source of information that can be utilised by operators of existing facilities to improve the environmental management of their enterprises. It is further envisaged that the guidelines will assist the industry to address inconsistencies and omissions in the laws and regulations in relation to environmental management.

1.2. Scope of the Document

1.2.1. Facilities to Which This Guideline Applies

The Egg Industry Environmental Guidelines detail the development, design and management options to assist the egg industry with planning and environmental sustainability issues when developing egg production facilities and associated infrastructure.

This includes breeder farms, pullet rearing facilities, egg production facilities (cage, free range and barn) and on-farm grading floors and feed mills. While the focus of the document is layer farms, the principles outlined in this document are equally applicable to pullet rearing and breeder farms. These guidelines are not designed to cover hatcheries and off-farm facilities that manufacture egg products.

While the threshold for layer farm regulatory approvals varies throughout Australia, the principles outlined in this document are equally applicable to small enterprises as to large ones.

1.2.2. Content is Not Legal Advice

While the guidance contained in this document has been developed with reference to state (all references to 'state government' contained in these guidelines include 'territory government') regulatory frameworks, it is not a guide to regulatory compliance. This guideline makes no claims to the regulatory acceptability of its recommendations and only provides advice on environmental management considerations that are important to address in the establishment and ongoing management of layer farms.

It is important to be aware that each state/territory and local government area may have specific laws and regulations that need to be followed. These regulatory requirements change over time and it is the responsibility of all business operators to ensure they are aware of and comply with all current relevant regulatory requirements.

1.2.3. Guidance Does Not Preclude Alternative Practices

The information in these guidelines is based on current information, knowledge and practice and can be used as a reference standard. However, research and innovation may establish new accepted standards and redefine appropriate practice in the egg industry in the future. This guideline seeks to provide industry with the information needed to take a risk based approach to environmental management. Where potential solutions have been identified, there may be other solutions which achieve the desired outcome.

1.2.4. Guidance is Subject to Other Requirements

Egg industry facilities are subject to other requirements such as biosecurity, animal welfare and labelling standards. The Welfare Code is currently under revision, and will be released as the "Australian Animal Welfare Standards and Guidelines for Poultry". Further changes are also likely to be made to egg labelling requirements, and these may affect the management of free range areas. Changes to these requirements can have flow-on effects with respect to environmental management of farms and must be considered when making decisions regarding the environmental management of layer farms.



1.3. Review of the Guidelines

This second edition of the guidelines was completed ten years after the first edition. This revision incorporates updated scientific knowledge surrounding key environmental issues and addresses changes to egg industry practices and regulations.

Key updates were:

1. Updated research on environmental emissions from layer farms, and associated management strategies.
2. Development of an industry specific separation distance formula for managing odour impacts for new and expanding farms.
3. Updated information about manure production, characteristics and deposition.
4. Incorporation of new research regarding nutrient impacts on range areas.

5. Development of a risk assessment tool to assess nutrient loss risk on range areas.
6. Alignment with the various biosecurity codes (Grimes and Jackson, 2015, DAFF, 2009a, DAFF, 2009b).
7. Alignment with the Animal Welfare requirements as specified in the “Code of Practice for Biosecurity in the Egg Industry – 2nd Edition” (Grimes and Jackson, 2015), the “National Farm Biosecurity Technical Manual for Egg Production” (AHA, 2015), and the “National Water Biosecurity Manual: Poultry Production” (DAFF, 2009b).

The guidelines will be revised as new information and expertise on facility siting, design and management in the egg industry becomes available. Major reviews are envisaged every ten years, with a minor review to be conducted every five years, or more often if justified.

1.4. Guideline Contents

Chapter 1 – “Introduction” covers the purpose and scope of the guidelines, and gives a short review of the previous iteration of the guideline, the “Environmental Guidelines for the Australian Egg Industry.”

Chapter 2 – “Establishment of Farms” focuses on siting, design and construction of these new and expanding facilities. It is aimed at industry participants, as well as other stakeholders that would be involved in the assessment and approval of new and expanding developments.

Chapter 3 – “Management of Farms” is specifically aimed at existing operations and details management practices to minimise potential environmental impacts.

Included at the back of the document are several references and appendices containing technical information that expand on topics covered in the guidelines.

1.5. Australian Egg Industry

1.5.1. Industry Location

AEL (2017) reports the Australian flock to be 19.3 million layer hens, producing 459.2 million dozen eggs annually. The location and bird density throughout Australia can be seen in Figure 1, which shows that largest production regions are in the eastern states. Cage housing systems produce most of the grocery sale eggs (~48.9%), followed by free range (~41.3%), with the remainder being barn (~8.4%) and specialty sales, such as organic (1.4%) (AEL, 2017).

Most eggs are sold as fresh shell eggs, but a proportion is also processed to make egg products such as pulp (liquid eggs) or powder.

Servicing these egg producers are breeding facilities, hatcheries, pullet rearing facilities, grading facilities and egg product manufacturers.

1.5.2. Egg Production

To understand how egg production can interact with the environment, an appreciation of production systems is needed. This section provides a brief description of these systems, and Figure 2 describes the structure of the industry from production to retail.

The production cycle begins with breeder farms and hatcheries, which produce day old chicks. There are a small number of breeder farms and hatcheries, located

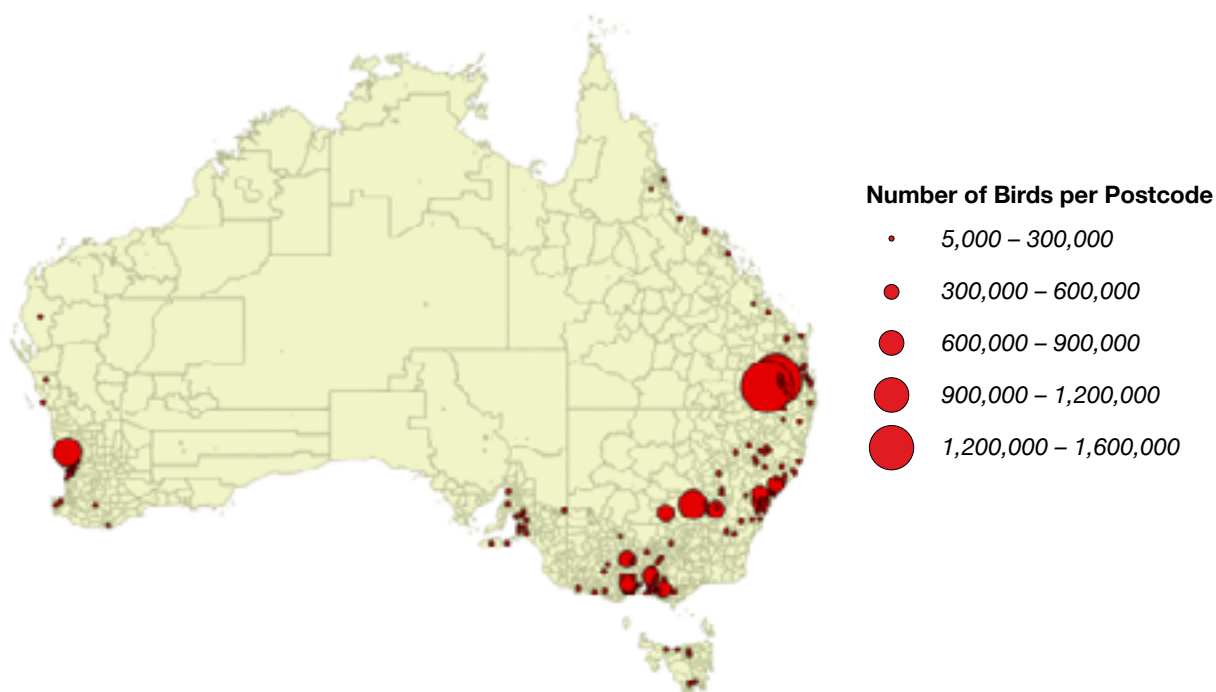


Figure 1 Egg producing areas by postcode

in isolated areas away from other poultry production to maintain a high level of biosecurity. This minimises the risk of disease outbreaks and consequently egg supply issues.

Day old chicks are transported to rearing (pullet) production systems, which are often co-located with layer farms. Pullets are reared to around 17 weeks of age before being moved into layer sheds, where they begin producing eggs. To ensure replacement stock for laying birds, approximately one pullet place is required for every four layer hen places, as the pullet production cycle is shorter than the laying cycle.

Egg production farms (cage, free range, barn, organic) produce eggs for human consumption. The location of these farms is primarily driven by the location of feed ingredients (mainly cereal grains) and population centres.

In recent years there has been a shift from cage production to free range and barn systems.

Some layer farms may also have a packing shed or a grading floor, whereas other farms will send their eggs off-farm to a separate grading floor for cleaning, sorting and packaging. Some farms will also have a feed mill on-farm.

There are also a small number of manufacturing plants that process egg components into various products. These are not typically located on egg production farms and are not covered by these guidelines.

Most layer farms and other industry facilities are regularly audited and registered under a range of schemes related to food safety requirements (i.e. Food Authorities, Quality Assurance Programs, etc.).

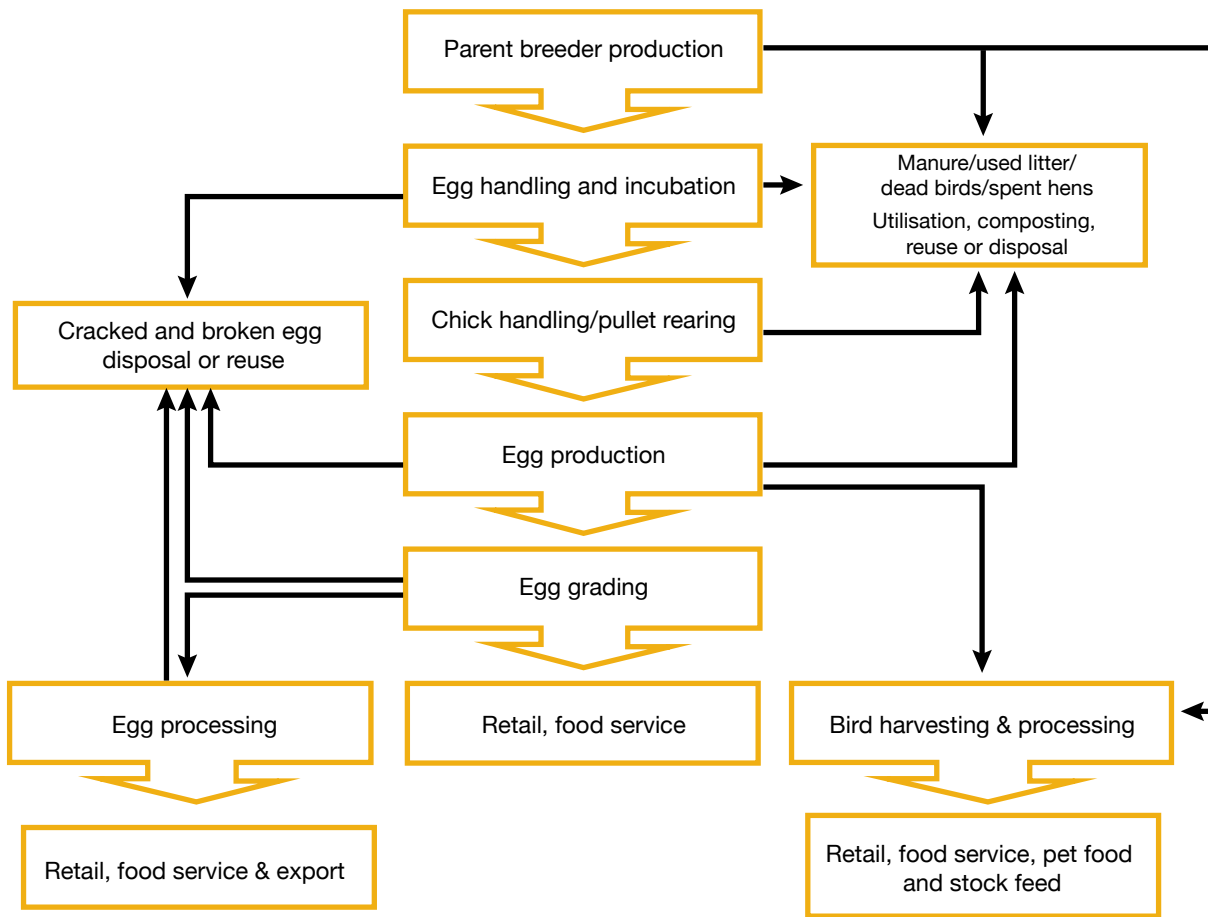


Figure 2 Flow diagram of egg production



Breeding Farms

Breeding farms keep hens and roosters to produce fertile eggs and are known as parent or secondary stock. They are housed in sheds with either litter, slats or wire mesh flooring. The fertile eggs produced by the parent stock are collected daily and stored for transport to a hatchery. The parent stock are productive for about 12 months. At the end of their productive life they are removed for meat processing or other disposal methods outlined in section 3.10. The used manure or spent litter is cleaned from the sheds at the end of each 12-month cycle and the process is repeated.

Because of the different requirements of egg farms and breeder farms, egg producers purchase day old chicks or pullets, rather than operating their own breeding farm.

The main wastes from breeder farms are dead birds, spent litter or manure, spent breeding stock, and a small amount of broken/cracked eggs.

Pullet Rearing

The rearing of day old chicks to point of lay pullets (approximately 17 weeks of age) may occur on a specialist pullet rearing farm, or in a dedicated facility on the egg production farm.

Specialist rearing farms transfer the pullets off-site to other egg enterprises, and thus no eggs are produced in this system. Pullets are generally reared in cages or barn systems.

The main waste products from pullet rearing facilities include manure, spent litter and dead birds.

Egg Production Facilities

Modern layer farms range in size from small scale movable sheds up to large environmentally controlled sheds which can house 40,000-100,000 birds. Egg production facilities are described as either cage, barn or free range sheds, and several sheds may be located on the same farm. Layer hens will typically remain on the farm for about 60 weeks. At this time birds are removed, and the sheds are cleaned ready for the placement of a new batch of hens.

Eggs are collected at least daily and then packed and graded for sale in accordance with food safety standards and QA schemes in each state.

Cage Systems

A large proportion of cage layer sheds in Australia are environmentally controlled, meaning they have ventilation systems to exchange air (tunnel ventilation) and maintain acceptable indoor thermal conditions and air quality all year round. A small proportion of cage systems in southern Australia are cross flow ventilated rather than tunnel ventilated. The remainder are naturally ventilated. Environmentally controlled sheds use tunnel ventilation to draw air through evaporative cooling pads at one end of the shed and extract the air with large capacity fans at the opposite end during hot weather. Tunnel ventilated sheds also have a minimum ventilation system for supplying ventilation during cold weather. One or more fans draw air through small inlets mounted in the sidewalls. These sheds typically utilise manure belts under the cages, allowing manure to be removed when required, typically 2-3 times per week. In locations that experience cold wet winters, each belt can be fitted with a drying system that removes moisture from the manure to improve the shed environment and production. Cages are designed to allow eggs to roll clear of the hens for daily collection. Collection is done automatically via conveyor belts.



Some cage systems are fitted with additional equipment for the hens, such as nest boxes, perches and scratch-pads. These systems are referred to as furnished cages.

Barn Systems



Barn systems comprise weatherproof shedding where hens are free to move about the floor of the shed. These systems generally comprise an automated nesting, feeding and drinking system, with the hens group-housed in sheds with litter and perches. Some of these sheds are designed with slatted floors and manure removal belts. A variation of a barn shed is an aviary shed, where poultry are housed on several levels including the shed floor (with litter) and they may have manure removal belts. Some of the barn systems also use tunnel ventilation.

Free Range Systems

The shedding used for free range production is essentially the same as the barn systems, where the sheds are fixed and the internal infrastructure is the same. The main difference is that the birds have access to an outside range area. The sheds protect the birds from the elements and predators while the free range area allows them access to open space and vegetation.



Some smaller free range operations use mobile sheds/ caravans that are moved regularly around a paddock. There are also some systems where larger sheds are moved between locations on skids.



The prevalence of each system varies between states. Table 1 shows the relative proportion of layers housed by each production system by state.

Table 1 Proportion of layers house in each production system. (ABS, 2017)

	NSW	QLD	VIC	SA	WA	TAS	AUS
Caged	52.6%	65.6%	60.6%	37.7%	58.0%	33.3%	58.1%
Barn	11.4%	16.4%	8.4%	0.5%	5.7%	23.9%	11.4%
Free Range	36.0%	18.0%	31.0%	61.8%	36.3%	42.8%	30.5%

Egg Packing and Grading Facilities

From the layer sheds, eggs will either go directly to an on-site grading facility (floor) or a packing shed. If they are sent to an on-farm packing shed, from there they will be transported to an off-farm grading floor. At the packing shed or grading floor, cracked, dirty and unsuitable eggs are removed in accordance with food safety standards and regulations. The remaining eggs are cleaned, weighed and sorted before packing for dispatch.



Waste products from packing sheds and grading floors include small volumes of waste water from the washing and sanitising process, cracked/broken eggs, as well as rejected packaging.





ESTABLISHMENT OF FARMS

2



2.1. Introduction

The establishment of layer farms requires consideration of legislative requirements, access to markets, operational efficiency, cost and environmental risk. This Egg Industry Environmental Guidelines primarily relates to the mitigation of environmental risks associated with egg farms, however guidance is given where other considerations (such as operational decisions, or legislative requirements) may affect the environmental performance of the operation.

It should also be noted that farms of a certain size typically require approvals under environmental/planning frameworks. These approvals (and requirements for the associated applications) vary widely in the detail required, though typically they require a thorough understanding of the proposed operation and the associated impacts. Consult with local government and state environmental/agricultural agencies to determine application requirements.

Although consultants and experts can be engaged to prepare the applications, site owners/operators must make important decisions which affect the potential impact of the site.

Important considerations which need to be addressed are:

- Community Amenity.
- Biosecurity.
- Facility Size.
- Land Use and Future Development.
- Natural Resources and Climate (including climate, land, surface and groundwater, and flora and fauna).
- Cultural Heritage.
- Traffic and Parking.
- Stakeholder Engagement.
- Infrastructure (including power, water and road access).
- Runoff and Drainage Control.
- Landscaping and Vegetation.
- Erosion Management During Construction.
- By-product Utilisation Site Assessment.

- By-product Treatment and Storage Systems (including estimating manure production and the design and construction of storage areas).
- Disposal of Dead Birds.
- Facility Infrastructure (including ventilation and feeding systems).
- Dispute Management.

These will be addressed in the following sections.

2.2. Community Amenity

Amenity impacts (including odour, dust and light, etc.) occur when the operation of an enterprise unreasonably interferes with the comfortable enjoyment of life for individuals or the community. The potential community amenity impacts of proposed layer farms on surrounding sensitive land uses can be assessed using a risk-based approach that incorporates a range of factors. These include:

- the size of the facility,
- the design features of the enterprise,
- the on-going management of the enterprise,
- the type of neighbouring sensitive land uses,
- the location of the enterprise in relation to sensitive sites,
- the adequacy of separation and buffer distances provided,
- land features surrounding an enterprise, and
- the communication between those operating the enterprise and neighbours. On-going two-way communication provides a basis to manage issues as they arise.

Separating egg facilities from sensitive land uses provides important protection against amenity impacts. However, separation distances alone do not always guarantee an absence of amenity impacts, and therefore careful management of an enterprise is important to avoid potential environmental or human health impacts.



State government departments and agencies and individual local governments may specify minimum separation distances between new/expanding farms and neighbouring houses, property boundaries, residential developments, roads and other sensitive land uses.

The guidance provided here has been developed from odour impact modelling and guidelines used for other intensive animal industries in Australia, including the “Queensland Guidelines: Meat Chicken Farms” (DAF, 2016) and The National Environmental Guidelines for Piggeries – Second Edition (Tucker et al., 2010).

Minimum fixed separation distances to sensitive land uses should also be adopted to account for inaccuracies with predicting odour impact at close distances. Both the variable (S-factor formula) calculated distance and the minimum separation distance to each sensitive land use should be calculated, and the greater distance of the two applied.

Separation distance guidelines that incorporate an empirical S-factor formula have been developed by McGahan and Galvin (2018) to determine risk based separation distances between layer farms and sensitive land uses (receptors). The S-factor formula approach (see Appendix A) can be used to assess if the available separation distances would be suitable for a proposed new development or expansion.

Sites that have multiple layer units in close proximity, on the one property, should apply the separation formula to the combined units and each sensitive land use. For separate layer units that have considerable distance between them, a method for assessing their cumulative impact is provided in Appendix A.

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

1. 500m between the impact source and any land use zone that is not compatible with the development (e.g. residential, rural residential).
2. 250m separation distance between the impact source and any sensitive land use (e.g. neighbouring houses) that is located on land that is compatible with the development (e.g. on land designated rural, farming or similar).

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

Appendix A also details a method for calculating minimum separation distances that takes into account local meteorological conditions. The administering authority should be consulted before the use of this modified method. Where separation distances cannot be met with this modified approach, site specific odour impact assessment may be required. This would involve the use of an appropriate odour model, that uses appropriate odour emission rates and hourly meteorological data, that

is representative of the site. A specialist in odour impact assessment should be consulted for expert advice.

2.3. Biosecurity

Providing biosecurity buffers assists in minimising the risk of potential off-site impacts between poultry facilities. Buffers from other poultry facilities can provide protection against the spread of disease organisms via aerosols, and should be considered when building new farms (Grimes and Jackson, 2015).

However, buffers are not a substitute for using effective biosecurity management practices. Buffers must be used in combination with appropriate siting, design and management. The “Code of Practice for Biosecurity in the Egg Industry – 2nd Edition” (Grimes and Jackson, 2015), the “National Farm Biosecurity Technical Manual for Egg Production” (AHA, 2015) and the “National Water Biosecurity Manual: Poultry Production” (DAFF, 2009b) are designed to assist in the development of effective biosecurity plans, to minimise the occurrence and impacts of disease outbreaks in the egg industry and minimise the incidence and spread of microorganisms of public health significance.

Disease outbreaks can significantly affect the egg industry through substantial loss of income and can create significant environmental problems, with the disposal of large numbers of birds. Selecting a site that is well separated from other poultry facilities and away from wild waterfowl habitats in conjunction with appropriate biosecurity management practices can reduce the risk of disease transmission within the industry. Australia has an Emergency Animal Disease Response Agreement (EADRA). It is a formal, legally binding agreement between Animal Health Australia (AHA), the Australian Government, all state governments, and thirteen livestock industry signatories (‘parties’). The EADRA covers the management and funding of responses to emergency animal disease (EAD) incidents. Its full title is “Government and Livestock Industry Cost Sharing Deed in respect of Emergency Animal Disease Responses”. More information on the agreement can be found at the Animal Health Australia website, <http://www.animalhealthaustralia.com.au/what-we-do/emergency-animal-disease/ead-response-agreement/>.





There are no recommended buffer distances between poultry farms and off-site grading floors. For an on-farm grading floor that services only the farm on which it is located, it is best to position the grading floor on a site that is central to all egg production sheds for logistical reasons. On-farm facilities that receive eggs from off-site facilities should be situated away from the poultry sheds to reduce biosecurity risks.

Although not eliminating the risk, locating poultry farms a reasonable distance from other poultry farms will minimise the risk of disease transfer between farms. This will also reduce the potential for cumulative environmental effects of closely located enterprises. There is no set distance that will eliminate the risk of disease transfer, but generally the greater the distance the lower the risk. Other factors that will reduce the risk and should be considered are: prevailing winds, surrounding topography and vegetation. The following buffer distances are recommended:

- 1000m between an existing farm and any proposed alternative form of intensive poultry farming.
- 1000m between a new farm and any existing alternative form of intensive poultry farming.
- 5000m between any intensive poultry farm and a poultry breeder farm.

Note: These distances are only a guide and the distance applied should be based on the level of risk from a proposed farm to an existing poultry enterprise. For example, greater distances should be applied between free range farms, farms that keep ducks and/or geese and larger commercial operations (>100,000 birds) because of the higher risk, and higher impacts caused by a disease incident.

When locating a new farm, also consider the risks associated with:

- proximity to waterways and wetlands that are used by waterfowl, as these birds may carry avian diseases,

- distance to roads that transport live birds, as feather/dander drift from passing transport trucks can be an important biosecurity issue, and
- potential disease spread within the farm, by providing adequate buffer distances between sheds.

2.4. Facility Size

During the planning stage, consider the possibility of future expansion.

Ideally, a property should be large enough to contain the facility itself and any required by-product utilisation areas. However, selling by-products for utilisation off-farm is an option to reduce land area requirements. Owning sufficient land around the operation to cater for the recommended separation distances prevents encroachment by other developments on nearby land.

State government departments and agencies, and individual local governments may have requirements for minimum land areas for certain land uses (such as agriculture or animal keeping), and these need to be determined during any application process.

It is also important to consider the additional land area required for free range production, as this will result in a much larger footprint per bird place than systems where the birds are fully housed indoors.

2.5. Land Use and Future Development

When developing a proposal for a new facility it is critical to consider current and future land use zonings and existing and planned developments in the adjacent areas, including potential 'as of right' (that is, without a planning permit) or equivalent dwellings. Locate developments on land that is appropriately designated under the local planning schemes, with future land use planning considered,

and where possible avoid locations near urban or rural residential development. Also protect existing operations from incompatible future development by encouraging suitable provisions in local planning schemes.

To consider whether an area affected by a separation distance may contain a sensitive use in the future, assess the potential for the development of a dwelling on an adjoining vacant property 'as of right'. Where a lot is identified as having potential for an 'as of right' dwelling, the separation distance is generally calculated to the centre line of the vacant lot or the likely location where a dwelling would be located regarding road and power access.



2.6. Natural Resources and Climate

2.6.1. Climate

When establishing a farm that will not include mechanically ventilated sheds (tunnel ventilation), the climate of the location is an important consideration. Management of welfare and production issues associated with temperature will be easier in a moderate climatic zone.

While annual rainfall and rainfall intensity are not very significant factors for cage or barn production, they are more significant for free range farms as they influence the ability to maintain groundcover and the management and containment of nutrients on the range (see Appendix B for more details).

In areas of high rainfall, management of nutrient losses and erosion may be more difficult because of the increased frequency of runoff and drainage, requiring a higher degree of management. In areas of low rainfall, groundcover may be difficult to maintain, and supplementary irrigation may be required to improve plant growth in the range area.

2.6.2. Land

In addition to the land required for building sheds and associated infrastructure, larger land areas on egg farms may be required as a means of by-product utilisation (land application of manure, spent litter, composted birds, egg shell waste), and for free range areas.

By-products can be used as a valuable organic fertiliser/soil amendment when applied at appropriate rates. However,

by-product application and storage need to be carefully managed in accordance with state and local regulations to avoid both on-site and off-site impacts, noting that land for by-product utilisation is not essential if by-products can be transported off-site for sustainable use elsewhere.

Hens and pullets utilise the soils in free range areas for foraging and for exhibiting natural behaviours such as scratching and dust bathing, which results in reduced groundcover close to the bird housing. They deposit manure onto the soil surface, which contains a range of beneficial micro and macro nutrients for plant growth, and low levels of salts and heavy metals. At low deposition rates, manure can have a beneficial effect on soil health and plant growth. However, at high rates the risk of losing nutrients to the surrounding environment increases.

Appendix B provides greater detail on-site selection for range areas and details a nutrient risk assessment approach for assessing a selected site.

Where moveable housing systems have an open/slatted/cage floor, manure from the house is deposited directly to land. Regular movement of housing systems allows for a more even distribution of nutrients in the range area. However, nutrient deposition from these systems may still result in increased environmental risk (compared to sealed floors). In contrast, most nutrients in fixed-shed systems are deposited inside and not at risk of loss to the environment.

Nutrient loss risk in free range areas is exacerbated where groundcover is difficult to maintain, because nutrients are not taken up by plants and runoff and drainage volumes are increased, potentially leading to nutrient loss and erosion. Erosion risks must therefore be considered in the siting, design and management of free range areas, and steps taken to mitigate identified risks. For more details and a discussion of nutrient loss risks see Appendix B.

Other considerations that affect land are the:

- correct storage and use of hazardous chemicals in accordance with relevant standards and regulations (section 3.14),
- effects of on-site by-product utilisation (see section 2.14), and
- on-site disposal of dead birds (see section 2.16).

2.6.3. Surface and Groundwater

Nutrients exported in surface water runoff from free range areas, waste storage sites and areas where organic by-products are spread, may cause eutrophication in water bodies (e.g. creeks, rivers, dams, lakes). This may promote the growth of algae, including toxic blue-green algae. High nitrate levels in water are also toxic to fish, birds, wildlife, stock and humans. Elevated organic matter levels in water reduce oxygenation, affecting fish and other aquatic life. Hence, practices that elevate the nutrient content of runoff should be avoided or the runoff to waterways avoided.

Nutrients, salts and chemicals (e.g. those used for cleaning and veterinary purposes) can leach through the soil and contaminate groundwater. Contamination from nutrients, salts and chemicals can lead to health problems for humans, animals and ecosystems. Incorrect by-product management can also promote excess nutrients in the soil profile and increase the risk of runoff and leaching. Once groundwater contamination has occurred, remediation is difficult and expensive.

All sources of nutrients, salts and chemicals on the layer farm (including poultry sheds, grading floors, packing sheds, manure, spent litter and composting stockpiles), should be assessed for environmental risk, with commensurate design and management options to mitigate the risk.

The risk to groundwater is influenced by a range of features of the site, for example hydro-geology, depth to groundwater, soil type and the existing quality of the ground water. Nutrients in ground water can also influence surface water where shallow aquifers are linked to the surface water system.

Nutrients can also be lost when they are dissolved or entrained with runoff from manure storage or utilisation areas, or free range areas. Minimising nutrient and sediment losses is the first step to containing these impacts, by minimising the nutrients entrained in runoff, and minimising the volume of nutrient rich runoff leaving the site (see Appendix B for more details).

Assessing the environmental risk of a site is critical in determining the appropriate layout, design and management to minimise impacts to surface and groundwater. Where



high risk of nutrient loss exists (see Appendix B), site design and layout can incorporate features which minimise these losses. These include:

- Features that slow the movement of runoff (vegetative filter strips, swales, contour banks, etc). These reduce runoff volume and allow greater deposition of eroded soil and nutrients, as well as providing opportunity for nutrients to be adsorbed to soils. Maintaining or rehabilitating vegetative cover, including riparian vegetation, is an effective way of reducing the movement of contaminants and eroded soil into surface waters.
- Provision of an adequate buffer distance between the operations of the enterprise (including manure/spent litter utilisation areas and free range areas) and any nearby groundwater and surface waters. Buffer distances aim to reduce the risk of nutrient impacts on surface and ground water, as well as biosecurity impacts to water storages. These distances allow greater opportunity for potential contaminants to be deposited or adsorbed.

These site design and layout measures should be responsive to the level of risk for the site. For instance, a relatively small buffer would be needed if there is a well-developed and maintained Vegetative Filter Strip (VFS) between a relatively flat utilisation area and a watercourse, and where low risk application methods are carried out. See Appendix I for information on risk based design of a VFS. Refer to the glossary for definitions of a watercourse, and the measuring point for a watercourse.

Major water supply storages and watercourses within drinking water catchments generally need the greatest protection. However, it is also important to protect groundwater from the infiltration of nutrients.

State authorities, water boards or local authorities may apply other restrictions or specify buffer distances in their catchment areas, and these should be checked. In most states a minimum buffer distance applies to water supply storages, watercourses and groundwater bores.

It is recommended that a buffer distance of 800m be provided between egg industry facilities and any major water supply/storage. The relevant regulatory authority needs to be consulted where an operation is proposed within a declared catchment area or a declared groundwater area. This buffer distance of 800m is also recommended for by-product and free range areas.

The recommended buffer distance from by-product utilisation and free range areas to watercourses will also depend on the environmental risk that the operation or management practices pose to the resource. Greater distances are required for higher risk areas, such as where fresh manure and litter are stockpiled, spread on the soil surface and not incorporated, or in the sections of range areas where high nutrient deposition is likely to occur (<10m from sheds, under shade structures/trees).



If a site is located within or partly within a flood plain, it may present additional risks of environmental impacts on water. As such, additional management and mitigation may be required to address the risks to operate. Information on flood levels should be available from the state agencies responsible for natural resources and water and/or local authorities.

When establishing a new farm, it is also good practice to consider any possible future expansions when assessing appropriate buffer distances.

Most states have declared water catchments or groundwater recharge areas in which intensive livestock industries, including poultry farms and associated facilities, are not permitted. Consult with the relevant authority/agency (e.g. local government, water board, state government agency) for assistance in selecting a suitable site.

2.6.4. Flora and Fauna

Site and manage poultry operations to avoid disruption to remnant vegetation, wildlife habitats and natural wetlands. Information on remnant vegetation and tree clearing restrictions can be obtained from state government agencies that manage vegetation and from local governments.

Attention should be paid to the range area of free range production systems. Farm poultry can impact on remnant vegetation (both tree and pasture) by denuding grassed areas and adding high rates of nutrients in the areas immediately outside the sheds. This may kill some trees and shrubs that may be sensitive to elevated nutrient levels and should be considered when locating sheds.

2.7. Cultural Heritage

Sites of Aboriginal or European cultural heritage may need to be investigated and considered when selecting sites for a poultry development. Site history and proposed works can affect the need for cultural heritage investigations. Consult with the relevant authority in your state to determine the need and scope of investigations. If items of significance are found at the site, consultation must be undertaken with traditional land owners and other appropriate groups to decide the best approach for managing cultural heritage. This may involve recording, preserving or relocating items discovered at the site to allow for development. In rare instances, areas must be preserved in-situ if items of high significance are discovered.

2.8. Traffic and Parking

Consult with the local government and transport department (or equivalent) regarding road usage at an early stage of the planning process. This helps to determine appropriate routes, access and road layout requirements and to identify whether approval with the state transport authority is required. Consider the following:

1. Plan, design and locate lighting to avoid interference with nearby sensitive land uses.
2. Design access points, including acceleration and deceleration lanes (if required), to ensure that sufficient road width is provided for the turning of all anticipated vehicles.
3. If the access point has gates, ensure there is sufficient distance from the road to allow for the whole vehicle to be off the road (when undertaking wheel wash/sign in, etc.).
4. Provide adequate parking space for the anticipated number of vehicles.
5. Locate and design access points, on-farm roads, parking areas and turning areas (where required) with consideration for possible noise and vehicle-light impacts on nearby sensitive land uses.
6. Design to minimise biosecurity risks (see section 2.3). For example, your design could include:
 - a single lockable point of entry for biosecurity concerns,
 - minimise movements near production area, and/or
 - designated and signed parking area for site personnel and visitors.

2.9. Stakeholder Engagement

Maintaining good relationships and open communication with nearby landholders is important. Engaging with the community can be useful to identify potential problems and concerns with the proposed site and address them if needed. Establishing and maintaining lines of communication from the beginning is always better than dealing with complaints issued against the operation.



Community consultation during the planning stage will often provide the information necessary to address relevant community concerns. For this to be effective, structure the consultation process to suit each individual situation. There is no set formula, approach or certainty in undertaking effective consultation, but good planning from the outset is important. Poorly planned and ineffective consultation can lead to a breakdown in the process, which can be time consuming and expensive.

It is also important to maintain communications with the relevant regulatory bodies including both state and local government. Communication with regulators can provide clarification regarding any questions relating to regulatory requirements, legislative amendments, and emerging issues, which may affect the development. An effective relationship with regulatory bodies is beneficial to both parties when dealing with issues of community concern, and during the resolution of issues.

Inform neighbours in advance of the proposed development including any aspects that may cause an unavoidable odour, dust or noise problem. Neighbours should also be informed of any proposed practices to mitigate the problem and the expected timing/duration of the potential problem.

More information on community consultation can be found in Appendix J.

2.10. Infrastructure

2.10.1. Power

Power must be provided to supply water, deliver feed to the birds, operate conveyor belts, run grading sheds, run feed mills, provide heating requirements for chicks in rearing sheds and to light and ventilate sheds. Access to a reliable, adequate and constant power supply (possibly three phase) is required. In addition to mains power, standby generators with auto-switch control are also required to manage power supply failures. This is critical for environmentally controlled sheds, where even brief interruptions to ventilation and cooling equipment in hot weather can cause mass bird deaths. Standby generators

need to have sufficient power output and be appropriately connected to run all critical equipment for which manual alternatives are not available. Refer to section 3.17.2 for information on planning for power and water supply failure.

Consider the requirements for possible future expansions of the facilities. Research by Wiedemann and McGahan (2011) showed that electrical energy use ranged from 1.7-3.2 kWh/yr per bird place/yr for environmentally controlled sheds. Pullet rearing used between 0.5-1.0 kWh/pullet reared, and gas usage ranged widely from 0.03-0.15 L/pullet reared.

2.10.2. Water

Egg production farms, breeder farms and pullet rearing facilities must have an adequate and reliable supply of water for drinking, cooling and shed cleaning (sanitisation). On-farm grading floors require a clean and reliable supply of water for cleaning plant and equipment.

Generally, water is sourced from groundwater or from town water supplies. If surface water is used it will require treatment to minimise the risk of health impacts, including disease transmission from wild birds and contamination of eggs as per the National Water Biosecurity Manual: Poultry Production (DAFF, 2009b). The National Farm Biosecurity Technical Manual for Egg Production (AHA, 2015) provides minimum standards for water quality for drinking, cooling and cleaning used in egg production facilities.

Drinking water requirements – The Hyline Red Book (Hy-Line International, 2016) provides a guide to bird water requirements. Drinking water usage should be about 150-200mL/adult bird/day, and during periods of high temperatures, water requirements can be up to twice as much as this amount. Thus, about 0.8ML/yr (800,000 L/yr) of drinking water per 10,000 birds is required. Additional water is also needed for cleaning, shed cooling and the irrigation of range areas to maintain vegetation cover if required.

State government guidelines and regulations for drawing water from surface watercourses or bores, or for catching water in dams must be adhered to.



2.10.3. Road Access

Suitable all-weather road access is required to support the number and size of vehicles that visit the site, including any articulated vehicles. Choose a transport route that considers the potential impacts on nearby sensitive land. Locate the farm access points to reduce impact on sensitive receptors.

Provide access to the site from a road that is constructed to a suitable standard to accommodate the anticipated types and numbers of vehicles.

2.11. Runoff and Drainage Control

Runoff from nutrient rich areas is controlled firstly by bunding, to restrict stormwater ingress. This should include manure storage areas and high traffic parts of a free range area close to housing (depending on risk rating as determined in Appendix C). Within these areas, runoff can be controlled and directed towards systems that reduce the nutrient and sediment load in the runoff before it leaves the site.

Runoff leaving the site can be managed by directing this to a vegetative filter strip (VFS), which is designed to reduce the flow rate of water, increase infiltration and reduce the nutrients and sediments contained in runoff.

More information on designing effective VFSs or alternative systems can be found in Appendix I. The design and construction of runoff and drainage control systems should follow state legislative and local catchment authority requirements.

2.12. Landscaping and Vegetation

Landscaping may be used to improve the visual amenity of an operation and to assist in reducing noise, light and dust impacts. The primary focus is vegetative landscaping, although earthen structures may also be used for screening.

State and local regulations may require approvals for earthworks and plans for any such works should be clearly shown in applications for approvals. Applications for approvals may also require a landscaping plan to be

prepared for the site. Consult with relevant authorities to determine if this is needed as part of your application.

There are many practical benefits in establishing trees on poultry farms, including:

- improving neighbour relations: by filtering dust, odour, noise and light emitted from sheds and surrounds, by providing a visual screen, and by improving public perception,
- environmental: reduction in ammonia, dust, odour, surface and groundwater nutrients leaving the farm, and
- production: by providing windbreaks, shade (natural cooling), filtering out airborne pathogens, and conserving energy.

Consider the following during the design and construction phase of a project:

1. Adhere to state vegetation management and tree clearing acts. This is a mandatory requirement.
2. Retain existing trees and incorporate them into the landscaping where practical.
3. Develop a landscape plan to ensure the long-term effectiveness of any screens.
4. Use the natural vegetation and terrain of the site to the best advantage to maximise visual screening and improve biodiversity.
5. Plant species that require little maintenance, do not attract wild birds and are suited to the location.
6. Preferentially select species indigenous to the region.
7. Plant deeply rooted species to increase nutrient absorption depth and provide greater stability against erosion.
8. Use a variety of different-sized trees and shrubs and/or earthen mounds to achieve effective upper and lower canopy screening.
9. Install Vegetated Environmental Buffers (VEBs) or other suitable emission reduction control measures at the exhaust end of tunnel ventilated sheds at a distance that does not affect the performance of the ventilation system. If a vegetative screen is used, the trees should be a suitable species for the area, consist of a low and high canopy and have slender leaves to trap dust. If a vegetative screen is used it should be at least 8m wide, however local government requirements may require greater widths and these need to be checked.

Further information on designing, establishing and managing vegetative screens (particularly VEBs for the control of emissions) can be found at <https://agrifutures.infoservices.com.au/items/14-063> (Bielefeld et al., 2015).



2.13. Erosion Management During Construction

The risk of soil erosion is increased where soil is disturbed and left uncovered, a situation that arises during the construction phase of a development. Good design and construction considerations include:

1. Preparation of a farm plan during the early stages of the development so that excavations can be used for multiple purpose, such as constructing sediment traps and using soil to build up shed pads, roads or earthen banks.
2. Promptly revegetating all disturbed areas on completion of construction. It is important to select species of grass, trees and shrubs that will rapidly establish to produce good groundcover. See section 2.12 for guidance on landscaping.
3. Diversion of upslope runoff from around the construction site.
4. Reduction of runoff velocities by constructing contour banks at regular intervals around the site and by increasing the surface roughness in areas of the site that are not being prepared for shed pad bases.
5. Installation of silt traps and barriers, similar to those used during road construction, to induce particle settlement. These should be retained until sufficient groundcover is established to minimise erosion.
6. For free range farms it is important that the range area close to the sheds is designed with gently sloping batters if cut and fill is required. This may require additional land formation around the sheds during the construction phase.



2.14. By-Product Utilisation Site Assessment

By-products (manure, spent litter, compost) can be used as a valuable organic fertiliser/soil amendment and can be beneficial when well managed and applied at appropriate rates. However, the application and storage of these by-products needs to be carefully managed and in accordance with local regulations to avoid soil degradation and nutrient loss risk. This degradation can occur via a range of mechanisms, including elevated nutrient levels and associated changes in pH and chemical and micro-organism contamination.

Manure, compost and spent litter by-products are not generally utilised near poultry sheds as:

- There may be insufficient land on smaller poultry farms to sustainably use all of the by-products or meet recommended separation distances from sensitive receptors. In this case by-products are sold to off-site users.
- Application of by-products near to poultry sheds poses a bird health risk.

For egg facilities located on larger farms in broad acre cropping regions, manure may be used on cropping or grazing paddocks, or sold off-farm.

Land application to crops (horticulture and broadacre) and pasture is the most widely adopted and cost effective way of utilising the nutrients in manure and spent litter from egg production. When used correctly, manure application reduces the need for synthetic fertilisers, potentially lowering the cost of crop production. Another advantage of applying these by-products is that the nutrients are contained in a slow release form, allowing the plant to access nutrients when they are required. Application of organic material also improves soil structure, reduces soil erosion and aids the infiltration and retention of water and nutrients.

To determine if a site is suitable for the application of by-products, it is important to consider potential impacts on the soil, surface waters and groundwater. Important factors that should be considered are the climate, topography, groundcover, and ensuring that application rates match crop requirements. For more information on the key factors associated with environmental risks, refer to section 2.6 and Appendix B.

The utilisation of by-products must also comply with relevant state legislation. More detailed information on by-product utilisation can be found in Appendix D.

The following practices should also be considered when planning a utilisation area on-site:

1. Only apply by-products on areas that are approved under a development approval/licence. In Western Australia, stable fly breeding is of particular concern and local regulations need to be checked with regard to storage, transport and land application of manure and spent litter, as designated areas (shires) require the material to be composted to the Australian Standard – AS 4454 (Standards Australia, 2003). Additionally, approval/permit conditions may specify or restrict methods of manure and spent litter utilisation.

2. Do not feed spent manure and litter to livestock. It is illegal to do so in all states due to the high risk of botulism. Exclude stock from spreading areas until pathogen risk has diminished. Refer to section 3.15 for more information.
3. Where high levels of environmental loss risk have been identified:
 - a. Avoid spreading manure and spent litter on steep slopes with inadequate groundcover. Slopes of greater than 10% are unsuitable.
 - b. Avoid spreading manure and spent litter on rocky or highly erodible land.
 - c. Avoid spreading manure and spent litter on highly impermeable soils.
 - d. Avoid spreading manure and spent litter on areas subject to waterlogging, inundation, or with high groundwater tables.
 - e. Avoid spreading manure and spent litter near watercourses and drainage lines (refer to section 2.6.3). Planting appropriate buffer strips (e.g. grass and trees) can also be useful in intercepting nutrients, dusts and other particles.
 - f. Protect riparian zones around watercourses with appropriate buffers zones, and VFSs. These assist in reducing the risk of surface water contamination from runoff. The greater the vegetative cover and width of the VFS/buffer zone, the greater the possibility of filtering out nutrients, particularly phosphorus.

2.15. By-Product Treatment and Storage Systems

2.15.1. Estimating Manure Production

To design manure and spent litter treatment and storage systems, the amount of manure produced needs to be calculated. Manure and spent litter varies in composition and quantity. The primary factors affecting this are:

- type of housing used,
- age of birds and duration housed,
- diet of the birds,
- stocking density of birds,
- whether manure belts are used,
- amount and type of bedding used (barn and free range), and
- the amount of nitrogen loss (via volatilisation) in the shed from the manure or litter.

Details on the spatial distribution of manure deposition in free range systems are given in Appendix B, though the majority of manure is deposited in the sheds.

It is difficult to provide standard values for the production and composition of manure or litter, but the following sections outline methods for estimating the amount and composition of manure or litter produced by individual egg farms.

With recent advancements in bird genetics and feed formulation, feed use efficiencies have improved. This in turn has reduced the amount of manure produced. Hence, many of the older references to poultry manure production do not accurately represent current production.

Mass Balance

The general principle of mass balance for estimating the amount of any nutrient excreted in the manure takes the following form:

$$\text{Amount excreted} = \text{amount fed} - \text{amount taken up as live weight} - \text{amount removed in eggs.}$$

Additional losses, such as the volatilisation of nitrogen in the shed, also need to be considered. For barn and free range systems, the amount of any nutrient added in the bedding also needs to be added as an input to the nutrient balance to determine the amount of nutrients in the by-product.

Production and mass balance data from the trial of Wiedemann et al. (2015) are shown in Appendix D as an indication of likely values for Australian production systems.

Typical Characteristics of Manure and Spent Litter

Appendix D provides chemical and physical properties of layer poultry manure and spent bedding taken from Wiedemann et al. (2008) and Wiedemann (2016).

Manure from environmentally controlled cage sheds and aviaries is removed two to three times a week from the sheds. Barn systems will generally remove spent litter and manure at the end of a bird cycle. The storage and composting of spent litter needs to comply with relevant state and local legislative requirements.

2.15.2. Design and Construction of Storage Areas

Good design and construction considerations for manure storage should be based on the level of environmental risk associated with the site. Some of the major factors that contribute to the risk of nutrient loss include climate, geography, and the location of sensitive areas. Important factors to be considered are discussed in section 2.6 and Appendix B.

Design measures to be adopted include:

- Use bunding to prevent entry and contamination of stormwater runoff. Alternatively, manure and spent litter can be stored in covered sheds to overcome weather impacts.
- Installation of an impermeable base on any manure or spent litter stockpiling or composting areas. This avoids leaching and possible groundwater contamination. This can be achieved with compacted clay, gravel and clay, lime or cement stabilised soils. They should be designed to achieve a design permeability of $1 \times 10^{-9} \text{m/s}$ over a depth of 300 mm. A sealed concrete base is the most preferred option to minimise leaching.
- Design manure and spent litter stockpiles or composting facilities to ensure they do not cause water to pool.

- If the storage area is not roofed, installation of a dam is required to catch runoff from outdoor manure and spent litter compost or stockpile sites. Design the dam to hold a 1 in 10 year, 24-hour storm event. Runoff collected in the dam can be applied to land at sustainable nutrient loading rates or reapplied to compost piles to maintain optimal moisture content (50-55% wet basis). This practice must comply with the relevant acts and legislation, and not impact surrounding land or waters. Dams should not be located near sheds to minimise biosecurity risk.
- In some states, a separate licence or works approval is needed for compost production. Consult with state regulators to determine the need for additional approvals.



- On high risk sites, it may be appropriate to store by-products in enclosed vessels or sheds.

On-farm egg production facilities do not generate significant volumes of effluent, however small volumes of wastewater can be generated from cleaning activities and should be handled appropriately. If volumes and waste loads are considered sufficient to warrant specific design and control measures, criteria from Tucker et al. (2010) are recommended.

2.16. Disposal of Dead Birds

Consideration should be given to disposal options for dead birds. If methods of on-site disposal are chosen, the appropriate areas/facilities should be located with consideration to:

- operational needs,
- traffic movements,
- biosecurity, and
- environmental impacts.

Information on selection of disposal methods and important considerations is given in section 3.10.

As with manure storage areas, installation of an impermeable base is required.

2.17. Facility Infrastructure

2.17.1. Ventilation System

Adequate ventilation is required for maintaining adequate air quality for bird health and welfare. It aids in controlling shed

temperatures and is also critical in maintaining acceptable moisture content in the manure and litter to help prevent excessive odour generation and control the accumulation of water vapour, heat, gases and dust particles.

Consider the following during the design and construction phase of a project:

1. Provide adequate shed ventilation to control shed temperature and minimise gas build up. This may include the monitoring of ammonia.
2. Provide drainage to ensure excess water from cool pads drains away from the shed and avoids pooling.
3. Provide air movement at floor or manure belt level to allow manure and litter to dry.

2.17.2. Feeding Systems

Feeding systems need to be designed and located to allow all birds equal access to feed. Refer to the current animal welfare standards and guidelines for poultry for guidance. This helps to ensure the welfare and performance of the birds.

Consider the following during the design and construction phase of a project:

1. Design feeding systems to ensure adequate access to feeding space.
2. Install feeding systems that can be adjusted to meet the requirements of the birds.
3. Design feeders to minimise retention of old feed.
4. Install and properly maintain feeders to minimise feed wastage.
5. Design and maintain silos and feed-lines to minimise feed spillage and the ingress of water. Wet and spoiled feed can produce offensive odours and be harmful to poultry.
6. Design feed storages to prevent access by rodents.
7. Design feed transfer systems (truck to silo) to minimise spillage, as this creates risk with regards to wild birds and animals, rodents and biosecurity.
8. Design the feed transfer system to minimise truck movements near production areas.





2.17.3. Watering Systems

Egg industry facilities need an adequate and reliable supply of water (see section 2.10.2).

Consider the following during the design and construction phase of a project:

1. Design, maintain and manage watering systems to ensure adequate access to the watering space.
2. Provide allowance for use of vaccines, treatments, vitamins, etc., in the watering system.
3. Install watering systems that can be adjusted to meet the requirements of the birds.
4. Install waterers that can be easily cleaned.
5. Design watering systems to minimise spills and leakages.

2.17.4. Monitoring and Control Systems

Most modern 'environmentally controlled' sheds are fitted with automatic controllers for feed, water, fans and blinds (temperature and ventilation).

Consider the following during the design and construction phase of a project:

1. Install automated systems to continuously monitor relative humidity and temperature levels in tunnel ventilated sheds. This allows the shed environment to be optimised.
2. Fit alarm systems to alert farm management to malfunctions or extended abnormal shed conditions. Alternatives to audible alarms include visual alarms, telemetry-based systems, or wireless/handheld alarm monitors. Audible or visual alarms are only suitable if they do not impact on sensitive land uses.

2.18. Dispute Management

This is one of the most contentious and difficult areas for all parties. It is important to note that various sides in any conflict situation can quickly make assumptions on views and positions that may be difficult to change. Litigation rarely provides a satisfactory outcome for anyone and the damage to community relations and industry image can be substantial. For this reason, the development and maintenance of good relations between the operator and the local community is extremely important.

While appropriate stakeholder engagement can help reduce opposition to new sites, good management involves ongoing communication and monitoring of community sentiment. As such it is a good idea to keep a record of community feedback as detailed in section 3.18.2.



3) MANAGEMENT OF FARMS

3.1. Introduction

This chapter provides guidance to assist existing operations to maintain and improve environmental management, and to assist planned operations to develop environmental management plans, which are commonly required as part of the approval process. The chapter covers all aspects of environmental management, including:

- Traffic.
- Managing Sheds and Surrounds.
- Visual Appearance.
- Eco-efficiency (including lighting, ventilation and water use efficiency).
- Pest Management.
- Shed Manure Management.
- Shed Bedding Materials and Litter Management.
- Managing Free Range Areas (including nutrient and soil erosion management).
- Management of Dead Birds and Spent Hens (including off-site disposal, on-site composting, incineration, anaerobic digestion and on-site burial).
- Manure and Spent Litter Clean-out.
- Manure and Spent Litter Storage and Compost Management.
- Managing Cracked/Broken Eggs.
- Management and Disposal of Packaging and General Waste.
- Manure and Spent Litter Utilisation.
- Chemical Storage and Use.
- Contingencies and Management of Emergencies (including mass bird deaths and contingency planning).
- Stakeholder Engagement (including community liaison and community feedback register).
- Environmental Management Systems (EMS) (including need for and components of an EMS).
- Environmental Monitoring (including by-products, soil analysis, ground and surface water and community amenity).
- Greenhouse Gas and Ammonia Emissions.

3.2. Traffic

Likely traffic movements on egg production facilities include deliveries of feed and hens, staff cars, removal of waste, and transport of eggs. However, traffic movements of poultry are infrequent on layer farms. Traffic movements typically occur during daylight hours, however all traffic movements need to be managed to minimise off-site impacts from noise and dust. Site layout and design can have significant impact on traffic movements, see section 2.8. for details.

Farm managers should liaise with truck drivers to ensure they understand the possible effects of traffic nuisance on nearby sensitive land uses. Management practices to minimise off-site impacts from traffic movements include:

- Vehicles need to be driven at moderate speeds on-site,

especially with regards to unsealed roads and trucks. This includes displaying speed limit signs to reduce dust generation and damage to road/lane surfaces.

- Informing workers, visitors, drivers and contractors of the potential noise conflicts caused by vehicle use.
- Avoiding the use of truck air/exhaust brakes near sensitive land uses.
- Avoid using unnecessary flashing lights or other suitable warning devices (at night) and reverse warning beepers (during the day) on trucks and machinery. However, safety warning devices should only be modified and used if a site-specific risk assessment has been conducted. All people on-farm (owners, operators, contractors, visitors) will also need to be informed of any modifications. State workplace health and safety regulations must be checked and adhered to.
- Watering unsealed on-farm roads as needed during dry and dusty climatic conditions.
- Developing and implementing a plan to ensure off-farm vehicle movements have minimal detrimental amenity impacts.
- Scheduling truck movements (feed delivery, etc.) for daylight hours wherever practical. Local and state government requirements may limit traffic movements to certain hours to avoid noise conflicts.



3.3. Managing Sheds and Surrounds

There are a range of management practices that can be employed to minimise off-site environmental impacts from sheds, including:

- Properly maintaining silos and feed-lines to avoid feed spillage and the ingress of water. Clean up any feed spillage during feed deliveries and around the feedmill. Wet and spoiled feed can produce excessive odours.
- Fill water holding depressions around sheds to minimise biosecurity risk.
- Gradually opening naturally ventilated sheds first thing in the morning, to avoid a large and sudden release of odorous gases.
- Maintain ventilation and evaporative cooling systems in good working order to ensure optimum efficiency (e.g. evenly distributed water flow over the evaporating

surface), clean and maintain cool pads and foggers to prevent salt and bacteria buildup.

- Ensure excess water from cool pads is drained away from sheds to prevent pooling.
- Ammonia levels in sheds should be controlled for both bird and human health. Ammonia levels should not be consistently above a level that can be detected by smell (10-15ppm). When ammonia levels cause irritation (>25ppm) immediate action must be taken to reduce levels by reducing manure and litter moisture content and/or increasing ventilation. By maintaining an optimum environment for the birds, risks associated with high ammonia exposure to workers will be minimised.
- Maintain watering systems to avoid leaks and maintain sheds to avoid extraneous water entering the sheds.

3.4. Visual appearance

Well-maintained operations improve the visual amenity of layer farms and help to reduce odour emission and dust generation. Maintain landscaping and vegetative screens to ensure they operate effectively. Visual appearance can also be enhanced by maintaining poultry sheds, buildings and surrounds to ensure they are clean and tidy.

3.5. Eco-efficiency

Eco-efficiency is a business-oriented approach to environmental management. It focuses on reducing resource inputs and avoiding the generation of wastes and pollutants. Eco-efficiency not only provides improved environmental performance but can also provide financial savings and improved competitiveness in a market where consumers are more environmentally aware.

Electricity is the primary energy source used on poultry farms and grading floors. It is used for running lights, fans, pumps, conveyor belts and machinery. Liquid petroleum gas is generally used for heating poultry sheds and buildings. The following sections outline ways to improve energy efficiency.

3.5.1. Lighting

While lighting costs vary across farms depending on the number of lights and type of lighting systems used, lighting can account for a significant component of electricity usage. Lighting technology is rapidly evolving with more energy efficient bulbs becoming available.

Consider installing compact fluorescent lamps, triphosphor bulbs and cold cathode fluorescent lamps. Replacement of fluorescent tube lighting with LED tubes will save significant amounts of energy and will not require new infrastructure. Simply switching off lighting when not required or using natural lighting in sheds will also reduce energy costs.

3.5.2. Ventilation (for Mechanically Ventilated Sheds)

The ventilation system is generally the major component of the energy requirements for an environmentally controlled poultry shed. The following measures can be used to reduce energy costs:



- Use automatic control systems to improve efficiency by continuously monitoring parameters such as light, temperature, humidity and static pressure, and by continually adjusting ventilation to suit the conditions.
- Minimise air leaks in sheds to reduce the load on fans. For controlled ventilation systems, sheds with air leaks use more power, have poorer temperature control and have higher heating and cooling costs. Heated air can leak out of the shed in winter, while warm air drawn into the sheds in summer increases the load on the cooling system. Regular maintenance requires checking the seals of sidewall curtains, ensuring shutters open and close correctly, filling of cracks around doors and shutters, and patching holes in ceiling insulation.
- Select the correct ventilation program to reduce energy use and consider natural ventilation options in the operation where possible.
- Regularly maintain fans to ensure optimum efficiency, by cleaning blades, motors and shutters. Dirty shutters can reduce the air-moving capacity of a fan by up to 30% with a similar increase in electricity usage and can result in reduced bird performance.
- Replace burnt out motors with energy efficient motors.
- Invest in capital upgrades (e.g. energy efficient fans and cowlings).
- Ensure shed ventilation (e.g. fan performance) is meeting manufacturer requirements.
- Reduce the fan speed with a variable frequency drive (VFD).
- Maintain pulleys and belts.
- Maintain and clean cool pads and foggers to ensure airflow is not restricted.

Detailed information on potential energy savings can be found at: <https://www.australianeggs.org.au/dmsdocument/646-evaluation-of-energy-usage-and-ventilation-performance-of-tunnel-ventilated-layer-sheds> (McGahan et al., 2013).

3.5.3. Water Use Efficiency

Drinking, cooling and cleaning of sheds, grading floors and other equipment are the main uses of clean water on a layer farm. Reducing water use, without compromising

production, is a good environmental practice and can potentially reduce costs, particularly if water is purchased via a scheme or town water supply.

The first step, if it is not already done, is to meter and monitor total operation water use. Water use will vary between seasons, but total water use will allow trends or spikes in water use to be observed and corrected where possible. At a later point, a more comprehensive breakdown at a shed level (drinking, cooling, cleaning) may be beneficial if there are concerns with total water use.

Some strategies to improve water use efficiency include:

- Ensure drinkers are not leaking and are set at the correct height in barn sheds.
- Provide the optimum environment for birds to reduce the risk of heat stress, lowering drinking water requirements.
- Install and maintain cooling pads to achieve the optimum operating performance as per the supplier's recommendations.
- Maintain control valves and repair any leaks around cooling pad sumps.
- Maintain and repair fogging systems when required.
- Use cleaning hoses with attachments designed to clean efficiently with less water.

3.6. Pest Management

Pests (e.g. flies, rodents, darkling beetles and wild birds) increase the risk of disease on-farm, cause nuisance to neighbours and can damage equipment. Effective pest control is achieved through appropriate design and management of the farm. Control measures for common pests, including flies, rodents and darkling beetles can be found in Appendix H.

3.7. Shed Manure Management

Depending on the type of production system used, manure from birds is managed either as manure, litter (manure plus bedding) or is naturally spread by the birds in free range systems. As described in Appendix B, the majority of manure in free range systems is deposited inside the sheds.



Manure deposition in sheds is captured either:

- on manure belts,
- on bedding materials,
- in collection pits via slatted floors, or
- some combination of the above.

Where manure is deposited on belts, it is typically removed one to three times per week.

Cages with wire mesh floors are fixed above conveyor belts that are rotated to carry the manure out of the shed. Housing systems without manure belts generally store this manure in the shed and remove it between batches.

For systems with less permanent fixtures, such as barns and free range, all the fittings inside the shed are generally removed or raised. Bobcats or other machinery are then used to transport manure from the shed.

It is critical to manage the moisture content in manure to minimise odour generation, regulate fly breeding, and maintain the welfare of the birds. This is less critical in systems where manure is only stored in the sheds for short periods. Nevertheless, drier manure is easier to handle and in-situ drying equipment can assist in this process. Drier manure also provides a better environment for the birds. Options to manage manure moisture content include: providing good ventilation, drying on belts and minimising water added to manure.

3.8. Shed Bedding Materials and Litter Management

Where bedding material is used in sheds, such as for barn or free range systems, it should have the following characteristics:

- Dry.
- Light.
- Highly absorbent.
- Low dust generation.
- Water activity (needs to absorb and then dry quickly).
- Remain friable.
- Free of contaminants such as heavy metals.
- Suitable for use as a soil conditioner, compost or fertiliser.
- Cost effective.

The type of bedding selected depends on local availability and price. Examples of suitable bedding materials include: hardwood sawdust, softwood sawdust, timber shavings, rice hulls and chopped straw. Alternative materials may be used but their suitability should be determined against the above characteristics.

Good litter management is integral to a well-operated poultry farm that houses birds on bedding. It has implications for both the health of the flock and for dust and odour levels. Evenly distribute enough clean bedding at the beginning of a cycle of birds and add additional bedding throughout the length of the cycle if required.

The moisture content of shed litter has the greatest



influence on odour and dust nuisance potential. Litter that is too dry (less than 15% moisture, wet basis) may cause dust, poor bird condition and health problems for farm workers. When the litter is too wet (greater than 40% moisture, wet basis) it can become anaerobic, and odour and ammonia emissions increase. This may lead to odour nuisance, poor bird health and possibly to health problems for farm workers. Immediate action should be taken to reduce the litter moisture content or to remove the litter from the shed. Table 2 provides a guide to litter moisture content and properties, and management procedures to maintain optimum litter moisture contents. The following will also assist in maintaining appropriate litter conditions:

1. Minimise interruptions in diet by gradually changing feed formulation and diet composition. Maintaining bird health

is important in preventing wetter manure. Wet manure increases litter moisture content and subsequently increases ammonia generation and odour emissions.

2. Regularly observe and record details of litter moisture content. This should be done throughout each shed, with emphasis on likely high moisture areas (e.g. near drinkers).
3. Maintain drinkers, as leaking nipples and trays as well as incorrect pressures can cause significant issues and can be a major source of wet manure and litter.
4. Regularly turn litter over with a hand rake/fork under drinker lines, or other areas where excess moisture is becoming a problem.

Table 2 Description of litter at corresponding moisture contents and management responses

Litter Description	Moisture Content (% wet basis)	Management Response
Dusty	<15	Increase shed humidity.
Dry to friable	15 – 20	No response.
Friable to moist	20 – 30	No response.
Sticky – beginning to cake	30 – 40	Increase ventilation rates and/or manually turn litter.
Wet and sticky – heavy caking	40 – 50	Increase ventilation rates. Add additional bedding and/or manually turn litter.
Very wet and sticky	>50	Remove wet litter and replace with fresh bedding.

3.9. Managing Free Range Areas

3.9.1. Nutrient Management

It is important to manage nutrients in the range area to ensure they do not cause off-site environmental impacts to surface and ground waters. As discussed in Appendix B, ranges should be designed and managed based on the risk rating of the site and the likely nutrient deposition rates in the various zones (distances from the sheds). Management options to minimise environmental impacts from range areas include:

- Use of rotation and spelling to allow denuded areas to recover, which ideally includes hay production or cropping during the rotation phase, as this allows nutrients to be removed from the site. Grazing livestock on the area is significantly less effective than a cropping/pasture production for hay, as most of the nutrients are recycled back onto the site.
- If moveable shade structures are used, ensure they are regularly shifted to allow pasture to recover.
- Manure swept or scraped from veranda areas is removed from the site, rather than spread on the range area.
- If moveable houses/caravans are used, ensure they are regularly shifted to allow pasture to recover and to reduce nutrient build-up. These operations can also consider a cropping/pasture harvest rotation or manure capture and removal if conducted on a high risk site.
- Monitor soil nutrients to allow management for soil constraints and excess nutrients.

3.9.2. Soil Erosion Management

Maintenance of groundcover is the best strategy for minimising soil erosion. Groundcover is made up of materials that cover the immediate surface of the soil (e.g. grasses and dead plant material). This material protects the soil from wind and water erosion by reducing the erosivity potential of rainfall, slowing flow rates and improving infiltration rates.

Maintaining groundcover in free range areas can be difficult, particularly in high traffic areas near the houses. Similar strategies to those used for nutrient management are appropriate:

- Rotate range areas to allow denuded areas to recover.
- If moveable shade structures are used, ensure they are regularly shifted to allow pasture to recover.
- Spread straw in denuded areas to increase groundcover.

Where groundcover is particularly difficult to maintain, erosion controls are recommended. These include:

- Installing contour banks.
- Constructing drains that minimise flow convergence and slow/spread flow where possible.
- Repairing rills before gullies form.
- Maintaining groundcover in drain areas, and fencing these areas off where necessary.
- Reducing the flow rate of runoff with control measures (e.g. swales, contour banks, VFSs).
- Using rock/gravel groundcover in high traffic areas such as Zone 1 and 2 (see Appendix B).
- Directing runoff to a VFS. Information on the how VFSs operate, their effectiveness and how they should be designed can be found in and Appendix I.

3.10. Management of Dead Birds and Spent Hens

Bird deaths result from a range of routine health and disease issues through the production cycle. Management of dead birds is a daily operation on poultry farms.

Mass mortality may also occur from catastrophic equipment failure or a significant disease event. This section deals with safe disposal of dead birds arising from routine operations. Mass death events are covered in section 3.17.1.

Disposal practices must not contaminate ground and surface water, cause odour nuisance, or contaminate land. Poor management of dead birds can also spread infectious diseases and attract vermin. Facilities need to be designed,

planned, located and managed to minimise potential biosecurity risks. Furthermore, state or local regulations may specify or restrict disposal options. Consult with the relevant authority to determine requirements.

Disposal of dead birds should minimise environmental risk by choosing a method of disposal as dictated by Figure 3. The decision hierarchy outlined in this figure prioritises disposal methods that have the least environmental impact and greatest potential benefit.

Important information on each method is contained in the following section to determine an appropriate disposal method for the site. Tables outlining risks and controls for each of these methods are contained in Appendix E.

3.10.1. Off-site Disposal

Off-site disposal of dead birds and spent hens can involve rendering or disposal to an appropriate waste management facility. Check with the waste facility to ensure they can accept dead birds. Contractors may be required to collect

birds for disposal at waste refuse sites. Check regulated waste requirements in your state. Rendering is an option for dead bird and spent hen disposal if a rendering plant is located nearby.

These options depend on the capacity of the rendering plant or waste disposal contractor, particularly in the case of shed de-stocking where large numbers of birds may be involved. This option may include temporary storage of dead birds on-site, in an approved vessel (e.g. sealed compost bin or freezer) to reduce odour and biosecurity risk. Allow for additional storage capacity to cope with fluctuations.

Benefit of Off-site Disposal

Off-site disposal significantly reduces the risks faced by the producer, by removing the source of the risks off-farm.

Risks and Control Measures

Table 29 in Appendix E outlines some of the risks that must be considered when assessing this disposal method, along with necessary control measures.

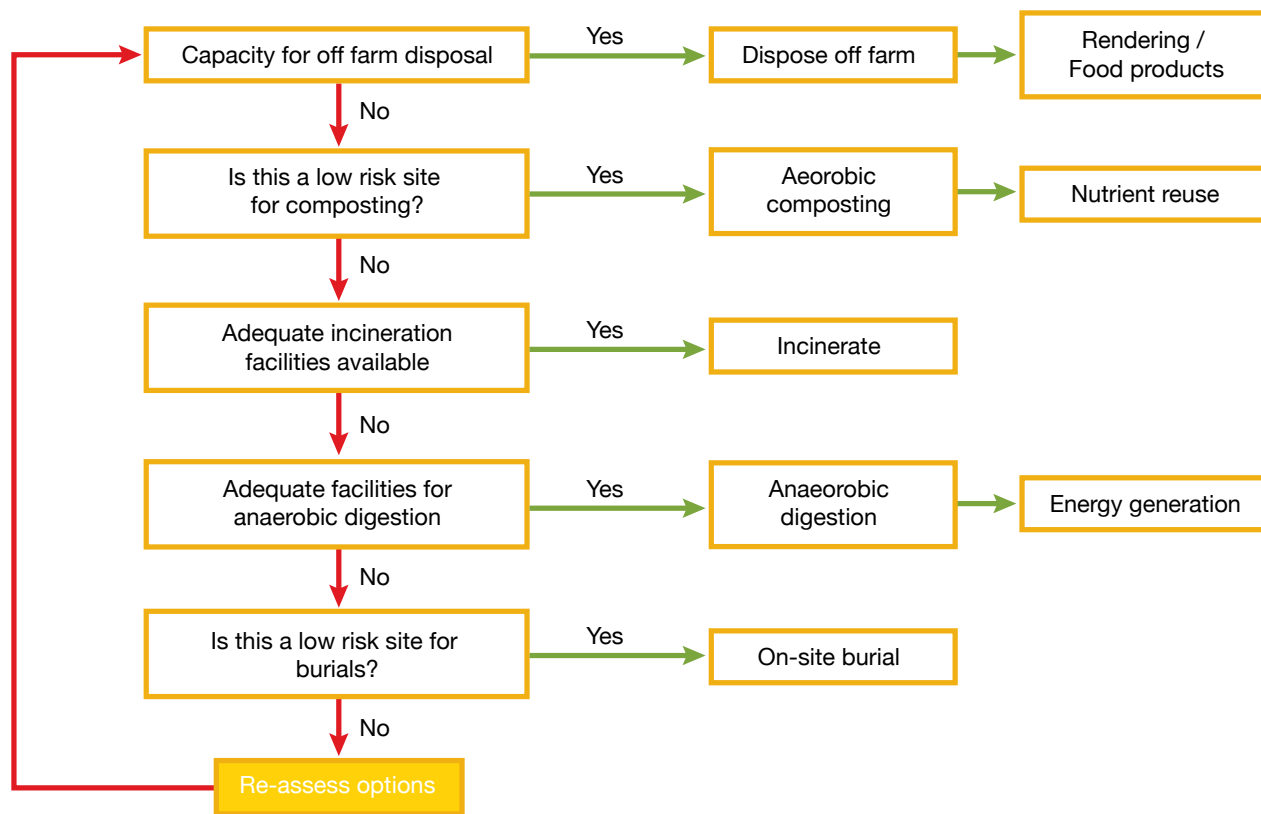


Figure 3 Decision hierarchy for disposal of dead birds

3.10.2. On-site Composting

Benefits of Composting

If performed correctly, composting dead birds in open bays and piles is an environmentally and biologically safe method of disposal. A major advantage is the production of a nutrient rich humus-like material that can be used as a replacement for inorganic fertiliser and/or a soil amendment. When managed correctly the bird composting process can be completed in approximately six weeks.

Risks and Control Measures

Table 30 in Appendix E outlines some of the risks that must be considered when considering this disposal method, along with necessary control measures.

Design of Compost Bins

The sidewalls of these bins can be timber, concrete or plywood with timber supports. Bins are generally about 2m deep and 2.5m wide. The width needed depends on the implements available for turning the compost and removing it when the process is complete (e.g. front-end loader, bobcat).

Compost areas should be sized to accommodate more than the predicted number mortalities to ensure sufficient capacity is available for unforeseen circumstances.

Exclude scavenging animals from carcass composting facilities with appropriate fencing/gates (e.g. chain wire, electric).

More information on composting poultry can be found in the report titled "Composting Every Day Mortality and Other Waste from Layer Farms (Wiedemann et al., 2008) that is available on the AEL website.



3.10.3. Incineration

As opposed to simply burning waste, 'incineration' here refers to the high temperature burning of waste in a furnace with appropriate flue gas management controls.

Benefits of Incineration

When carried appropriately the risk of odour generation and nutrient runoff is minimal compared to most other disposal methods. It is biologically the safest method of disposal for dead birds due to the destruction of common pathogens.

Risks and Control Measures

Table 31 in Appendix E outlines some of the risks that must be considered when considering this disposal method, along with necessary control measures.

As with all disposal methods, requirements may vary between states and state and local regulators should be contacted to ensure compliance.

3.10.4. Anaerobic Digestion

Benefits of Digestion

When carried out correctly anaerobic digestion can provide an option for managing dead birds

Risks and Control Measures

Table 32 in Appendix E outlines some of the risks that must be taken into account when considering this disposal method, along with necessary control measures.

As with all disposal methods, requirements may vary between states and state and local regulators should be contacted to ensure compliance.

3.10.5. On-site Burial

On-site burial involves the construction of purpose-built pits into which mortalities are placed and covered with appropriate materials.

Benefits of Burial

On-site burial presents few benefits and several risks.

Risks and Control Measures

Table 33 in Appendix E following table outlines some of the risks that must be considered when considering this disposal method, along with necessary control measures. As with all disposal methods, requirements may vary between states and state and local regulators should be contacted to ensure compliance.

3.11. Manure and Spent Litter Clean-out

When manure and spent litter are cleaned out from sheds it requires careful management to avoid impacts on amenity (e.g. odour, dust and noise) and health, as well as nutrient contamination. To achieve this:

1. Implement a well-managed manure removal and shed clean-out program.
2. Clean out sheds during daylight hours to minimise noise impacts. This also reduces dust and odour impacts because of the increased dispersion potential of atmospheric conditions during daylight hours.
3. Clean up any manure and spent litter that are spilt outside the shed.
4. Cover vehicles that transport manure and spent litter off farm to minimise potential dust and odour impacts.
5. Open the side shutters/curtains of sheds during manure or spent litter removal, to prevent the build-up of gases in the shed that may threaten the health and safety of workers.

6. Consider wind direction and strength during shed clean out. If possible, shed clean out should occur when the wind is blowing away from sensitive receptors/areas.
7. Consider contacting neighbours if the clean out of manure and spent litter may affect them, so they are aware that odour impacts may occur over a short period of time before returning to normal operating conditions.
8. Consider neighbour's movements when cleaning out manure and spent litter. Try to avoid clean out at times that will have the greatest impact on neighbour amenity (weekends, holiday periods).

3.12. Manure and Spent Litter Storage and Compost Management

Any manure and spent litter that are stored or composted on farm needs to be managed to avoid contamination of surface water and groundwater, causing nuisance (e.g. odour, dust and noise) to neighbouring residents, or excessive fly breeding. This material must be managed to comply with relevant state legislation. The following guidance will assist in minimising any potential impacts.

1. Minimise the amount of manure and spent litter stored or composted on-farm, as this may contribute to odour generation, possible contamination of watercourses and groundwater, as well as creating additional biosecurity risks.
2. Appropriately design, construct and manage suitable storage areas that keep stockpiled manure and spent litter dry until it can be removed or utilised as per section 3.15.
3. Cover manure and spent litter that require storage on-site for a short period of time after shed clean-out. This will assist in avoiding nutrient leaching from rainfall and minimise dust, odour and greenhouse gas emissions.
4. Minimise fly breeding during storage and composting. Stored heaps may need to be turned and/or sprayed to control fly breeding. In Western Australia, stable fly breeding is of particular concern and local regulations need to be checked with regard to storage, land application and transport of poultry manure and spent litter.

Further guidance for compost management is provided in Appendix G and on the Australian Eggs Limited website.

3.13. Managing Cracked/Broken Eggs

A small amount of egg waste is generated at egg production farms, and on the grading floors. Effective disposal or utilisation of this material is needed to avoid disease transfer, amenity impacts (odour) and contamination of surface water and groundwater. Egg waste needs to be effectively contained by either securing it in a sealed container for disposal to an approved land site or disposed of via composting.

Additional information on composting for this material can be found in Appendix G and on the Australian Egg Limited website. It is important to ensure that this material is managed to comply with state Legislation and frameworks, including any guidance.

3.14. Management and Disposal of Packaging and General Waste

Egg facilities can produce other waste besides manure and spent litter. As always, refer to state specific guidance to determine disposal requirements. For example, regulated wastes such as chemical drums, and biologically hazardous materials such as syringes and sharps have specific requirements in some states. These include:

- plastic packaging used during the transportation of eggs (particularly grading floors),
- cardboard packaging used during the transport of eggs,
- used chemical drums,
- used vaccination bottles and containers,
- sharps and syringes, and
- general rubbish (including disused and obsolete plant and equipment).

The waste management hierarchy should be used when dealing with packaging and other waste. This hierarchy moves from the most preferred to least preferred method, that is:

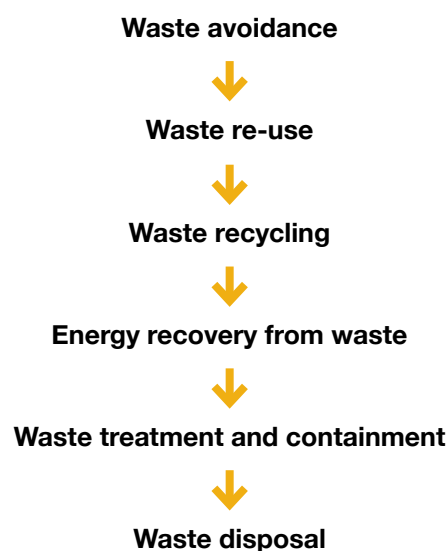


Figure 4 Waste disposal hierarchy

Consider the following to reduce the environmental impacts from packaging and other waste:

1. Minimise waste generation.
2. Investigate alternative options that use less packaging.
3. Recycle wastes such as cardboard and empty chemical containers in accordance with manufacturer's specifications.
4. Place all unwanted waste products in sealed refuse containers for removal to approved landfill.
5. Place all sharps in specific sharps containers for collection. In some states it is illegal for sharps to be buried at landfill sites.



6. Use cardboard waste as an alternative carbon source in any composting operations that are used on the farm (e.g. composting dead birds, egg wastes and manure).

3.15. Manure and Spent Litter Utilisation

When establishing an area for manure or spent litter application it is important to consider potential impacts on the soil, surface waters, groundwater and sensitive receptors. Important factors that should be considered include: climate, topography, groundcover, and ensuring that application rates match crop requirements. Refer to section 2.6 for a discussion of factors affecting the risk of nutrient loss.

The utilisation of these by-products must comply with relevant state legislation. More detailed information on by-product utilisation can be found in Appendix D.

The following management practices will also assist in minimising impacts from manure and spent litter utilisation on-site:

1. Match application rates to crop uptake, plus safe soil nutrient storage, plus allowable losses (nitrogen volatilisation).
2. Allow a minimum of three weeks between application of manure and spent litter before grazing. Relevant state biosecurity regulations may specify longer times.
3. Do not apply manure and spent litter to the foliage of crops to be consumed by humans.
4. Do not spread manure and spent litter near watercourses and drainage lines (refer to section 2.6.3). The planting of appropriate buffer strips (grass and trees) can also be useful in intercepting nutrients, dusts and other particles.
5. Protect riparian zones around watercourses with appropriate buffers zones, and VFS. These assist in reducing the risk of surface water contamination from runoff. The greater the vegetative cover and width of the VFS/buffer zone, the greater the reduction in nutrient levels, particularly phosphorus. Refer to Appendix I for information on designing a VFS.
6. Cover manure and spent litter during transportation to prevent spillage and minimise odour emissions.
7. Avoid spreading material that is too dry (<15% moisture wet basis) to avoid dust problems.
8. Consider the wind speed and direction at the time of spreading, to minimise dust and odour nuisance with nearby receptors.
9. Only apply manure and spent litter when the soil is not saturated, and when heavy rain is not expected.
10. Incorporate manure and spent litter that are spread on bare soil, as soon as possible after application. This minimises the chance of contamination from wind drift or rainfall runoff and will also maximise the nutrient value of the material by reducing potential losses.
11. Monitor (soil test) utilisation areas at least annually for the parameters listed in Table 3 (section 3.20.2) and compare the results with crop/pasture requirements and background monitoring sites to determine if application rates need to be adjusted.
12. Maximise the time between application and crop harvest. Do not apply untreated animal manure where direct or indirect contact may occur with the edible part of the crop.
13. Refer to state biosecurity and biosolids application guidelines to determine appropriate by-product utilisation practices. Visit <http://www.biosolids.com.au/guidelines> for links to relevant state guidelines.
14. Where applying manure to horticultural crops greater controls are required. Only apply properly composted manure or treated proprietary organic products that contain less than 100 E. coli per gram, as side dressing. Refer to "The Freshcare Code of Practice – Food Safety and Quality" (Freshcare, 2016) and the Department of Agriculture, Fisheries and Forestry – Australia guidelines for "On-farm Food Safety and Fresh Produce" (DAFF, 2004) for information regarding the application of organic manures to vegetable crops.
15. Retain a record of where manure and spent litter went off farm and the quantities involved.

16. Inform end users of manure or spent litter of the composition of the product. This may include fact sheets on typical or actual composition, application rates, biosecurity implications and amenity impacts.

3.16. Chemical Storage and Use

Chemical storage and use is covered by state workplace health and safety regulations (not covered here) and may have environmental and planning implications. The following list provides guidance to minimise potential environmental impacts from chemical use:

1. Correctly store and use chemicals to avoid spills that may contaminate groundwater and surface waters.
2. Bund the bases of fuel storage areas and construct these of an impermeable material such as concrete. Compliance with the Australian Standard AS1940:2004 (Standards Australia, 2004) is required.
3. Adhere to any requirements in relation to chemical and fuel storage and use stipulated by the local government.
4. Strictly adhere to manufacturer's instructions for chemical storage and use. Volatile components in some shed disinfectants may affect neighbours if not used in accordance with manufacturer and workplace health and safety requirements.
5. Maintain a register of all dangerous goods and combustible liquids stored or handled. If required, Material Safety Data Sheets (MSDS) must be available for all chemicals stored and used. The website <https://www.msds.com.au> contains a comprehensive list of MSDS.
6. Supply appropriate signage (e.g. HAZCHEM).
7. Store incompatible chemicals in a manner that allows for adequate separation from each other.
8. Implement procedures and make equipment available to contain and clean up a spill or leak. These procedures must be documented in an emergency response plan.
9. Select only chemicals with low toxicity and water contamination potential.
10. Avoid spraying chemicals near waterways or drainage lines and avoiding run-off.
11. Use chemicals in a manner that minimises spray drift, by using well maintained equipment and avoiding application during windy weather. Regularly calibrate to ensure correct application rates.
12. Carry out washing of chemical containers or mixing of chemicals in a bunded and sealed area to contain any spills.
13. Dispose of empty drums in accordance with manufacturer's instructions and regulated waste requirements. Take advantage of chemical container collections and drum recycling programs such as DrumMuster that operate in some states. Contact your local government for details on recycling programs in your area and seek advice on regulated waste disposal from state environmental regulators.

14. Dispose of unwanted or out of date chemicals in accordance with manufacturer's instructions and regulated waste requirements. If the chemical is considered a regulated waste, legislation may require disposal by an approved waste contractor and the keeping of certain records.

3.17. Contingencies and Management of Emergencies

Contingency plans should be developed to manage emergency situations. A contingency plan should have contacts and phone numbers of suppliers, veterinarians, state government departments and emergency contacts and be placed in a location that is known to and accessible by all staff.

3.17.1. Mass Bird Deaths

A contingency plan is required to manage high mortality events. The contingency plan will depend on whether the mortalities were due to disease or environmental conditions. The cause of death (disease or environmental conditions) will dictate the procedures to be used, including biosecurity requirements.

Disease outbreaks

For emergency animal disease outbreaks, the industry and the poultry farm operators have to follow the AusVetPlan (AHA, 2017) under the direction of the relevant state chief veterinary officer and state legislative requirements. Operations should also refer to AusVetPlan in their Quality Assurance program or farm plan.

Environmental conditions

For mass bird deaths that are not caused by an emergency animal disease, follow management strategies in section 3.10. Australian Eggs Limited has published a report titled "Composting Ever Day Mortality and Other Waste from Layer Farms" (Wiedemann et al., 2008) which contains more detailed information on composting mortalities, which has been used effectively for managing large numbers of mortalities in Australia.

3.17.2. Contingency Planning

The operation of layer farms can be impeded by fire, flooding, storms, cyclones, road closures or other unforeseen circumstances. These events may result in loss of power, water supply failure, water contamination, damage to farm infrastructure, or isolation.

Standby generators are required for managing power supply failures and maintaining a constant supply of water, feed delivery, lighting and ventilation (particularly running fans), as well as operating necessary equipment at grading floors. These should be regularly run (at least fortnightly) to ensure they are working effectively. These standby generators should be fitted with mufflers to avoid potential noise impacts. Also consider acoustic screening if necessary.

Isolation caused by flooding, fallen debris, bushfire or emergency management requirements can affect feed deliveries, bird delivery, removal of by-products and

dead birds, and dispatch of products. Human/business failures such as failure of transport contractors should also be considered. As such, poultry farms require an adequate and continuous supply of feed, and water for drinking and cooling sufficient to meet these needs. This contingency supply should be sufficient for at least two days requirements, though in areas prone to flooding or bushfires adequate supply for up to two weeks may be necessary. Contact your local emergency services for information on preparing for emergencies, likelihood of risks, and early warning systems where available.

Storage areas for materials awaiting collection (products or wastes) should be adequate to cope with delays in collection. Business practices should also have due regard to the impacts caused by these delays, including delivery of birds and the associated delays in production.

3.18. Stakeholder Engagement

3.18.1. Community Liaison

Maintaining good relationships and open communication pathways with neighbours is useful to identify problems, confirm complaints and successfully apply appropriate remedies to minimise the impact of the farm operations. Important considerations regarding community liaison for established farms are outlined in section 3.18, and section 2.18 for new farms.

Attempt to resolve disputes by participating and cooperating in any dispute resolution mechanism. Gather relevant evidence and identify and implement strategies to remedy the problem, then follow up the complainants to inform them of the outcome of any investigations and any actions taken to avoid future associated problems. Monitor weather conditions daily if complaints are ongoing, because many community amenity impacts are closely related to weather conditions. This can also help in assessing the validity of complaints. Consider installing and maintaining an automatic weather station for operations where separation distances are constrained or where regular complaints begin to arise. This will aid in complaint investigation and also for extreme weather management.

More information on community consultation can be found in Appendix J.

3.18.2. Community Feedback Register

The main method for measuring the community amenity impact is the number of complaints received. While this is an imperfect measure, because some people will not complain when there is a problem and others will complain when there is no problem, it does aid in identifying when neighbours perceive that a farm is having an unreasonable impact on their enjoyment of life.

Record full details of any known complaints received, along with the results of investigations and corrective actions taken in a "Community Feedback Register". An example of this form is shown in Appendix M. Also consider correlating complaint data to identify trends in complaints received. Neighbours should be encouraged to phone the operator directly with complaints.

3.19. Environmental Management Systems (EMS)

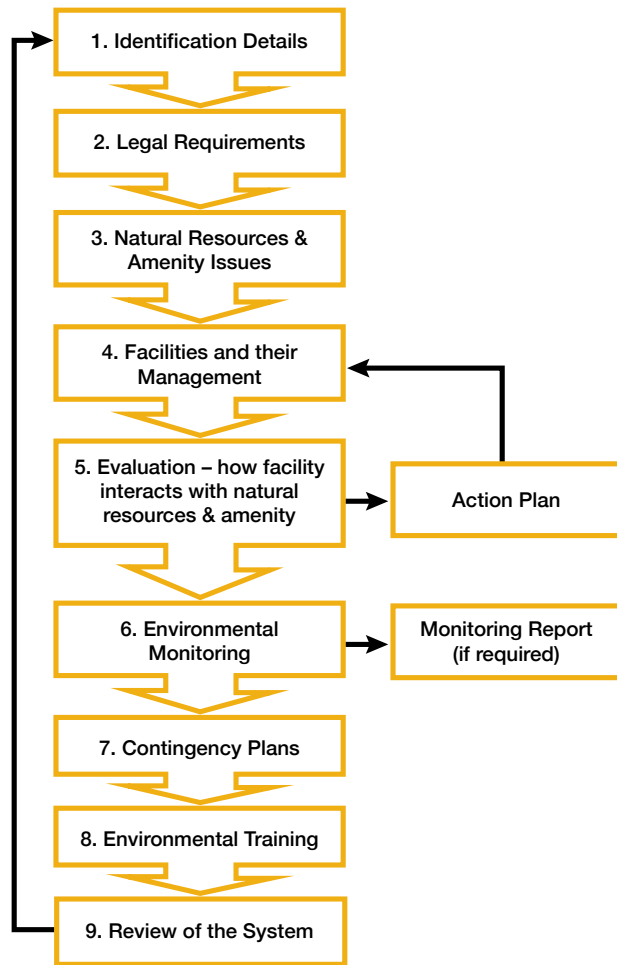


Figure 5 Flow diagram of an EMS for an egg industry facility

3.19.1. Need for an Environmental Management System

Operators of egg industry facilities are encouraged to either develop an EMS or include an assessment of environmental risks and mitigation strategies into their management program/s (e.g. quality assurance) to demonstrate that the farm is effectively managing potential environmental impacts. This may also assist in improving farm management and productivity. It is important to continually operate in accordance with the EMS or equivalent farm management program and aim to achieve accreditation via an external auditing system.

A site-specific EMS should:

1. Identify and evaluate potential environmental risks.
2. Include the implementation and maintenance of an environmental management plan (EMP). This may include a nutrient management plan, waste



management plan, stormwater management plan – or other plans which specifically relate to a particular aspect of environmental management.

3. Include auditing to verify that the system is working.

The development of the EMP for an enterprise is a formal commitment that all reasonable and practical efforts will be made to operate the farm in an environmentally sustainable manner. It provides a system for documenting:

1. The environmental risks of the enterprise.
2. How these risks will be minimised by design and management.
3. Measurement of the effectiveness of these strategies by monitoring.
4. Reporting of monitoring results.

The development of an EMP (or similar) is also a requirement for the licensing or approval of egg production farms in some states.

3.19.2. Components of an Environmental Management System

The key components of an EMS are shown diagrammatically in Figure 5 and include:

1. Identification and contact details, with a brief description of the operation and a commitment that it will be operated in an environmentally sustainable manner.
2. Legal requirements of the enterprise, including applicable consents, approvals and/or licences to operate the enterprise and use water, etc.
3. Information on the natural resources and amenity issues of the property and surrounding areas.
4. Description of all the environmentally relevant design and management facets of the operation.
5. Identification of any environmentally vulnerable areas, by examining how the location, design and management of the operation interact with the environment. Identification of a risk may mean regular monitoring or a change in design and management is required to minimise the risk.

6. Monitoring to measure any environmental impacts. This may be soil sampling if by-products are utilised on-farm or chemical analysis of manure and spent litter sold off-farm.
7. Contingency plans for emergency situations.
8. Environmental training undertaken by staff.
9. The periodic review of the system to update changes in regulatory requirements, operation, environment, design or management.

3.20. Environmental Monitoring

The need for environmental monitoring should be based on the potential risk of environmental impacts from layer farm activities. Testing of by-products is useful for determining nutrient levels available for crop production or loss to the environment, and it may also be necessary to determine the levels of any potentially harmful pathogens. Soil monitoring can be useful for determining the productive potential of land and monitoring long term trends on range areas or by-product utilisation areas.

Surface and groundwater monitoring can provide useful information about the suitability of water sources for use on-farm. This is unlikely to be sufficient for assessing any environmental impacts from the production process, though is considered unlikely to reflect impacts from production processes. Monitoring impacts on community amenity allows producers to determine the timing and nature of events that affect community members, and to determine potential ways of mitigating the impact.

While the need for environmental monitoring should be based on the risk of impact, some environmental monitoring may be required as a condition of planning approvals, environmental licencing, or biosecurity requirements. Refer to the relevant approvals, regulations or guidelines to establish monitoring needs.

3.20.1. By-products

Monitoring of by-products is required to determine levels of beneficial nutrients and potential contaminants. From the monitoring, application rates can be determined.

Suggested parameters to monitor in manure, spent litter, and compost include:

1. total nitrogen (TN) or total Kjeldahl nitrogen (TKN), ammonium nitrogen (NH₄N) and nitrate-nitrogen (NO₃-N),
2. total phosphorus (P),
3. potassium (K),
4. copper (Cu),
5. zinc (Zn),
6. carbon (C),
7. sulphur,
8. moisture content,
9. pH, and
10. electrical conductivity (EC).

Additionally, all facilities should ensure that their by-products are used sustainably and meet state legislative requirements.

When by-products are sold off-site, record the destination and amount. Also provide the end user with fact sheets or analysis sheets that include typical or actual composition,

and the typical nutrient uptakes of crops or pastures on which manure, spent litter, and compost may be used as an organic fertiliser.

Information on collecting, storing and handling samples can be found in Appendix K. Refer to Appendix L for details on contacting laboratories that undertake analyses.

3.20.2. Soil Analysis – Free Range and By-product Utilisation Areas

Regular monitoring of soils in by-product utilisation and range areas assists in determining if the application rates that have been previously calculated are sustainable.

If soil monitoring is required as part of a licence or approval condition, analysis parameters will usually be specified. Monitoring should identify changes in soil properties caused by by-product utilisation. The frequency of monitoring for each parameter should depend on the likely rate of change for each parameter. Mobile or soluble parameters (e.g. Nitrate-nitrogen – NO₃-N) change more quickly and should therefore be monitored more frequently than parameters that change more slowly.

Typical monitoring parameters and soil depths are given in Table 3.

Table 3 Typical soil analysis parameters

Soil Test	Depth	Frequency
pH	0-0.1m	Annually
	0.3-0.6m	3 yearly
	Base of root zone	3 yearly
Electrical conductivity (EC) – (1:5 soil/water)	0-0.1m	Annually
	0.3-0.6m	3 yearly
	Base of root zone	3 yearly
Nitrate-N	0-0.1m	Annually
	0.3-0.6m	Annually
	Base of root zone	Annually
Available phosphorus (Colwell, Olsen or Bray)	0-0.1m	Annually
	0.3-0.6m	3 yearly
	Base of root zone	3 yearly
Phosphorus sorption capacity or phosphorus buffering index (PBI)	0-0.1m	Annually
	0.3-0.6m	3 yearly
	Base of root zone	3 yearly
Organic carbon	0-0.1m	3 yearly
Potassium	0-0.1m	Annually
	0.3-0.6m	3 yearly
	Base of root zone	3 yearly
Exchangeable cations and CEC (calcium, sodium, potassium, magnesium)	0-0.1m	Annually
	0.3-0.6m	3 yearly
	Base of root zone	3 yearly

3.20.3. Groundwater and Surface Water

Strictly follow the requirements of any development approval/licence (or equivalent) and state legislative requirements regarding any ground or surface water monitoring, recording and reporting.

Refer to Appendix K for information on protocols and equipment required for ground and surface water monitoring. Local government or state agencies may also provide information regarding water quality sampling.

3.20.4. Community Amenity

1. Assess background noise levels before commissioning a new enterprise or changing an existing enterprise (e.g. adding a mechanical ventilation system).
2. Regularly undertake subjective checks to monitor potential sources of noise, dust and odour. These should be performed at potential high impact times (manure and spent litter clean-out, shed cleaning or manure/spent litter application) at the most sensitive land uses (e.g. near neighbours). Examples of blank monitoring forms can be found in Appendix M.
3. Record details and proposed solutions to any problems encountered.
4. Document any changes made to the design and management of the operation and assess the effectiveness of these changes in reducing the problem.
5. For larger enterprises, consider utilising equipment for monitoring air quality and noise levels, as it is becoming more economically feasible. Operators with nearby sensitive receptors should keep informed about technological advances in these areas so that their viability can be assessed periodically.

3.21. Greenhouse Gas and Ammonia Emissions

Greenhouse gas and/or ammonia emissions are predicted and reported in two Australian inventories: The Australian National Inventory Report for greenhouse gas (NIR – Commonwealth of Australia, 2017) and the National Pollutant Inventory (NPI – DSEWPaC, 2013). In some instances, egg producers may be required to report ammonia to the NPI or may be required to predict greenhouse gas emissions for reporting to state agencies in the development phase.

To determine whether you will need to report, or for help predicting emissions refer to the relevant sections (and Appendix F) outlined below.

National Greenhouse Gas Inventory

The Australian National Inventory (NIR) report (Commonwealth of Australia, 2017) is the standard reference for prediction of greenhouse gases in Australian agricultural industries. Methods and inventory defaults are provided in Appendix F.

National Pollutant Inventory

The national pollutant inventory method for calculating emissions from poultry was updated most recently in 2013 (DSEWPaC, 2013). These emission rates and factors are reported in Appendix F.



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5

The following list contains examples of important legislation, guidance and scientific information that relate to egg farms. This list is not guaranteed to be exhaustive and is only meant to be indicative of the range of materials that may apply to the environmental management of layer farms. Furthermore – guidance, science and regulations/legislation are continually updated. As such these resources and their location may change over time. Consult with the regulators, research bodies or authors that produce these materials to determine the most up to date version.

Site operators should also consult with regulators regarding information on state specific odour impact criteria and modelling requirements, if required.

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Appendix A. Calculating Separation Distance Using the S-Factor Formula

An industry specific S-Factor formula was developed for Australian Eggs by McGahan and Galvin (2018 – see Chapter 4: References) and the full background and explanation of the method is available in the cited reference (available on the Australian Eggs website, see reference list). The method is summarised below.

Separation Distance Formula Overview

The separation distance provided between egg industry facilities (such as bird housing) and sensitive land uses depends upon several factors, including:

- size (defined as the number of birds in the complex), and
- farm site, considering:
 - proximity to a sensitive land use (within a rural zone),
 - proximity to a non-rural zone,
 - land surface roughness (vegetation and other features) between the layer farm and the sensitive land use,
 - terrain effects around the site that particularly influence local meteorology of the area, and
 - wind frequency in the direction of a sensitive receptor.

Separation distances are measured as the shortest distance from the odour source (sheds) to the nearest wall of a building associated with a sensitive land use, or to the closest boundary of the non-rural zone. For tunnel ventilated sheds the measuring point is 25m out from the exhaust end of the sheds. They do not apply to by-product utilisation areas or range areas.

Site-specific separation distances are based on the dispersion of odours from their source. Different air quality objectives were chosen depending on whether the distance is to be calculated to a sensitive land use in a rural zone or to a non-rural zone. Calculation of separation distances for each sensitive land use within a rural zone and the closest boundary of the non-rural zone is as follows:

$$\text{Separation Distance} = (\text{Number of birds}/1000)^{0.63} \times S1 \times S2 \times S3 \times S4 \text{ (Optional)}$$

Where:

S1 – Sensitive land use factor for estimating the relative odour impact potential of a development.

S2 – Land surface roughness factor for estimating the potential changes to odour dispersion due to changes in the roughness of the land surface.

S3 – Terrain weighting factor for estimating the potential changes to odour dispersion in situations where meteorological conditions may be influenced by local terrain features.

S4 – Wind frequency factor (optional) for estimating the relative odour impact due to the frequency of wind direction for wind speeds less than 3m/s.

The available separation distances between the layer farm and sensitive land uses are generally the key factors limiting the number of birds that can be accommodated on a site. 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 close proximity to the proposed layer farm, the cumulative odour impact from all sites may require more detailed assessment.

Table 4 summarises the S factors (S1, S2 and S3) used in the above equation. A more detailed description of these three S-factors and how they should be applied is provided below. Also included below is how the optional S4 wind frequency factor should be applied. Before applying this optional S4 factor, first consult with the administering authority on whether it can be used in assessing impacts before detailed modelling and the appropriate safety factor is chosen.

Table 4 Summary of S-factors

Factor Description		Factor
S1 – Sensitive Land Use Factor		
Receptor Type		
Sensitive land use (within a rural zone)		20
Non-rural zone (closest boundary of the non-rural zone)		30
S2 – Surface Roughness Factor		
Surface Roughness Features		
Limited groundcover/short/grass/cropland, few trees		1.00
Undulating hills		0.93
Level wooded country		0.85
Heavy timber		0.77
Significant hills and valleys		0.68
S3 Factor – Terrain Weighting Factor		
Terrain	Weighting Factor	
	Downslope of site	Upslope of site
Flat – <2% from source to receptor	1.0	1.0
Valley drainage zone – Broad valley >10 km and/or a valley or gully with low side walls, where the average slope from centre of valley/gully to confining ridgeline is <2%*	1.2	1.0
Valley drainage zone – Average slope from centre of valley/gully to confining ridgeline is 2-5%*	1.5	1.0
Valley drainage zone – Average slope from centre of valley/gully to confining ridgeline is >5%*	2.0	1.0
Low relief at >2% from farm site – Not in a valley drainage zone, but the source lies above the receptor at an average grade of more than 2%*	1.2	N/A
All other situations*	1.0	1.0

*If there is an associated risk of katabatic drainage

Sensitive land use type factor, S1

The sensitive land use factors presented in Table 5 account for the variation in odour sensitivity and risk of exposure of residents neighbouring a layer farm. The sensitive land use factor will require calculation for all relevant neighbouring sensitive land uses.

Table 5 Sensitive land use type factor, S1

Sensitive land use	Factor
Sensitive land use (within a rural zone) – i.e. rural dwelling	20
Non-rural zone (closest boundary of the non-rural zone)*	30

* The non-rural zone includes rural residential zones, rural living zones and similar definitions, as well as aggregations of small (<2 ha) rural lots.

Surface roughness factor, S2

The surface roughness factor varies according to the roughness of the land surface between the layer farm and the relevant feature (closest sensitive land use). The principal elements that determine surface roughness are vegetation density and surface topography. Recommended surface roughness factors are provided in Table 6. The factors presented in this table are not to be summed (i.e. only the factor for the single category which best represents the site conditions should be selected).

The roughness factors given in Table 6 assume that the selected roughness is continuous between the layer farm and the sensitive land use. Where roughness is variable or non-continuous, judgement should be used in selecting an appropriate composite factor.

The factors in Table 6 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 over different sections of the separation distance. In this instance, the surface roughness factor applied should be selected after considering the relative weighting of the different factors. When selecting factors based on the presence of vegetation, some consideration should be given to the potential for the vegetation to be cleared during the life of the layer farm. For example, off-site vegetation is beyond the control of the layer farm but may be regarded as permanent depending on the owner of the land (e.g. national park/state forest where no timber harvesting is undertaken, or where vegetation legislation permanently restricts clearing).

Table 6 Surface roughness factor, S2

Surface roughness features	Factor
Limited groundcover/cropland/grass, few trees	1.00
Undulating hills	0.93
Level wooded country	0.85
Heavy timber	0.77
Significant hills and valleys	0.68

Cropland or grass, few trees – Open country with few or scattered trees. 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 sufficient 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, providing a continuous canopy. There is limited 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 relevant feature and the layer 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. The terrain weighting factor must take into account the direction in which each factor must be applied (eg. east). The slope referred to is determined by the topographical features of each site. These are explained in Table 7.

Table 7 Terrain weighting factor, S3

Terrain weighting	Weighting factor	
	Downslope	Upslope
Flat – <2% from source to receptor	1.0	1.0
Valley drainage zone – Broad valley >10 km and/or a valley or gully with low side walls, where the average slope from centre of valley/gully to confining ridgeline is <2%*	1.2	1.0
Valley drainage zone – Average slope from centre of valley/gully to confining ridgeline is 2-5%*	1.5	1.0
Valley drainage zone – Average slope from centre of valley/gully to confining ridgeline is >5%*	2.0	1.0
Low relief at >2% from farm site – Not in a valley drainage zone, but the source lies above the receptor at an average grade of more than 2%*	1.2	–
All other situations*	1.0	1.0

**If there is an associated 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), and/or
 - b. odour is emitted from elevated vent sources.
2. These terrain weighting factors should be applied by checking the location of the layer farm in relation to the topography, for the range of distances applicable to layer farm impacts. However, the application of these weighting factors is dependent on the homogeneity of terrain between source and sensitive land use. For example, if the terrain remains similar between the layer farm and sensitive land use the weighting factor can be applied for an indefinite distance. The weighting factor is, however, less reliable if significant terrain changes occur between source and sensitive land use.
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.

Optional Wind Frequency Factor, S4

The optional S4 factor applies wind direction frequencies for the 16 compass points by calculation of the percentage of the wind direction for wind speeds $\leq 3\text{m/s}$. Wind speeds above 3m/s are excluded from the analysis, as the dispersion conditions predicting the greatest odour impact occur in low wind speed conditions.

The steps used to calculate the 16 wind frequency factors (S4 factors) for a given location are:

1. Obtain a meteorological file representative of the site that has been approved by the administering authority. This would generally need to include 3 years of representative data for the site. Some administering authorities may require additional years of data.
2. Calculation of wind direction frequencies for the 16 compass points (wind rose) for wind speeds $\leq 3\text{m/s}$. All wind speeds $> 3\text{m/s}$ need to be deleted before the analysis is conducted.
3. Division of the wind direction frequency for each of the sixteen compass points by that for the direction that has the highest frequency, expressed as the number of hours per year. This will achieve a reduction of the previously calculated separation distances from the highest frequency that is set to 1.0. For example, if the wind from the NNE sector is the most prevalent and occurs 400 hours in a year, the value of it will be set to 1.0. If the wind from the east only occurs 200 hours in a year, its factor will be 0.5 (200 divided by 400).
4. Assigning of wind direction frequencies S to N, NNE to SSW etc., to account for wind blowing from odour source (poultry farm) to impact area (downwind). This means that wind direction frequencies need to be switched 180° to account for winds blowing from source to receptor.
5. Addition of a safety factor agreed to by the applicable regulatory authority, generally 0.2 (20%) is used to calculate the wind direction frequencies. This value may need to be increased to 0.3 (30%) if the meteorological data is computer generated rather than observational or site where there is a dominant wind direction and complex terrain. Note, any of the 16 directions that have a wind frequency value greater than 1.0 after the addition of a safety factor need to be adjusted to a value of 1.0.

Dealing with multiple odour sources and cumulative impacts

Odours from intensive livestock facilities are complex mixtures of many odorants. The cumulative and interactive effects of individual odorants are not well understood but it is generally assumed that where two or more sources of a complex mixture of odorants are in close proximity, the potential odour impact on sensitive land uses is the sum of the potential individual impact of all odour sources. This approach is likely to provide a conservative assessment (overestimating separation distances) of the potential cumulative odour impacts.

Figure 6 shows a simple process for determining the need for cumulative impact assessment.

1. Use the S-factor formula to calculate separation distance for each facility. The calculated separation distances essentially approximate the extent of any potential odour impact.
2. Where the 'odour plume' from any neighbouring facility overlaps the 'odour plume' from the facility being assessed, cumulative odour impact is recommended, and the neighbouring facility should be included in the assessment.
3. It is suggested that if the neighbouring facility's calculated 'odour plume' from the separation distance formula overlaps, then the calculated separation distances will need to be increased by 50% (i.e. multiply the distance by 1.5).
4. Determine if the calculated separation distances are likely to impact on sensitive land uses. If so, proceed to step 5
5. Detailed odour modelling is required to determine variable separation distances, with all facilities included.

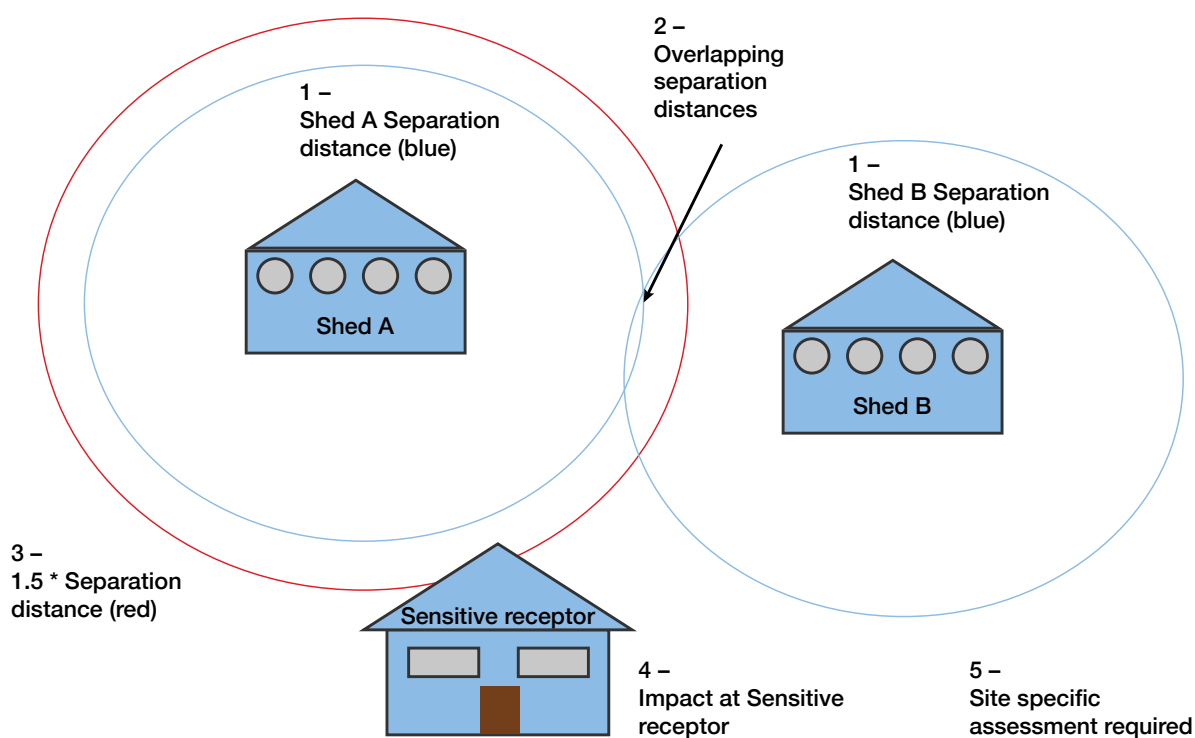


Figure 6 Assessment of Cumulative Impacts

Other methodologies are available for assessing cumulative impacts, such as the method described in the National Guidelines for Beef Cattle Feedlots in Australia (MLA, 2012 – see Chapter 4: References). Consult with the administering authority to ensure the most appropriate method is applied in your jurisdiction. The necessity of including other odour sources in odour modelling needs to be judged based on individual site assessments. The major factors influencing the potential interaction of odour plumes will be the:

- size of each facility,
- prevailing meteorological conditions and topography of the area, and the
- design and management of each facility.

Appendix B. Free Range Site Selection and Design Principles

Site Selection for Free Range Areas

Introduction

Many of the constraints outlined above must be considered in the selection of free range areas, however this appendix provides additional information on the application of these principles to range areas.

Free range areas are provided for birds to exhibit their natural behaviours of grazing and scratching. The area required for a range is determined by the required stocking density. Current labelling guidelines (Commonwealth of Australia, 2017 – see Chapter 4: References) require a maximum stocking density of 10,000 birds per hectare for products to be labelled as “Free Range”. Some free range accreditation programs require a maximum stocking density of 1500 birds/ha to receive accreditation (RSPCA, 2015 – see Chapter 4: References). It should be noted that bird behaviour dictates how the range is used, and many factors can influence this.

Birds range predominantly in the areas immediately adjacent to the sheds, with reduced activity as the distance increases.

For example, Larsen et al. (2017 – see Chapter 4: References) found that hens spent only 13.6% of their time outside the sheds. Of the time spent outside, birds spent 52.5% of this time in veranda areas within 2.4m of sheds, and a total of 81.5% within 11.4m of the sheds, when averaged across two study flocks. Nutrient deposition is closely correlated with the amount of time spent in each area, with most deposition expected to occur inside housing, due to the relatively small amount of time spent on the range. Research by Wiedemann et al. (2018 – see Chapter 4: References) across 14 free range farms showed that higher nutrient levels were found in a small area (<0.05ha) close to the sheds, even though the birds may range a considerable distance from the shed. The distribution of nutrient levels reported in Wiedemann et al. (2018 – see Chapter 4: References) follows the observed pattern of bird ranging behaviours.

Because of the high proportion of bird activity close to the sheds, groundcover in these areas is difficult to maintain. Consequently, free range site selection requires greater consideration of climate, topography, soil types and buffer distances to nutrient sensitive receptors. The factors influencing nutrient loss risks from these areas have been used to develop a risk assessment methodology for assessing the suitability of sites for free range production (see below). This allows design and management options that are commensurate to the determined risk to be applied.

Site Attributes

Soil Type

Selecting ideal soil types is a balance between providing ideal conditions for birds, while minimising nutrient influences to the surrounding environment. Ideal soils are suitable for growing pastures/crops, have low erosivity and have a reasonable water holding capacity. Soil type impacts the level of environmental risk, and the appropriate design and management practices required to minimise the risk. Consult the relevant state legislation and guidelines at the planning stage to assist in reducing potential impacts once the development is being constructed and operated.

Topography

Range areas are ideally located on gently sloping areas, which helps avoid waterlogging or localised flooding. Steep sites (>10%) should be avoided, as these are more susceptible to erosion and nutrient losses. Where there is a high risk of nutrient runoff, features that accelerate runoff (such as drains or gullies), should be managed or avoided to minimise environmental risk.

In the broader landscape, it is ideal to locate range areas where visual barriers (hills or ridges) block the line of sight from roadways or nearby infrastructure. It is also desirable to separate ranges from waterways (or other natural resources and sensitive receptors) at a distance commensurate with the level of environmental risk.

Drainage

Choose a site where suitable drainage occurs or can be easily constructed. Range areas that don't adequately drain should be avoided to reduce the risk of disease transmission from water birds.

Water Courses and Groundwater Depth

State government guidelines and regulations for managing impacts to surface waters and ground waters must be adhered to.

The location of free range farms should ensure there are adequate buffers from watercourses and other surface waters to minimise impacts on water quality. However, buffers should be used in combination with good nutrient management, particularly in the higher nutrient deposition areas (e.g. adjacent to sheds, shaded areas).

Also consider the aquifer type and depth to groundwater. For example, risk to groundwater is lower in areas where groundwater is deep and in confined aquifers, or where protected by an impermeable layer. Information on local groundwater can now be obtained on-line in most states via a bore log search. Conducting these searches at the

planning stage will enable the risk to groundwater to be assessed, as well as the subsequent development of design and management strategies that minimise any impact on groundwater.

In addition to concerns about nutrient management, watercourses also represent a biosecurity concern, as they may attract waterbirds to the site. Please check biosecurity requirements concerning the impacts of watercourses on-site selection.

Nutrient Risk Assessment for Surface and Groundwater

The risk of nutrient losses to surface or ground water is driven by source and transport factors (McDowell and Nash, 2012, Melland, 2003, Nash, 2002 – see Chapter 4: References). Source factors determine how much nutrient is available to cause potential impacts. Transport factors determine how likely it is that these nutrients will reach the receiving environment.

Some typical source factors are:

- the amount of nutrients deposited in different parts of the range,
- the distribution of these nutrients, and
- background nutrient levels.

Some transport factors are the:

- erodibility of soil (affects mobilisation of soil bound contaminants),
- erosivity of rain (severity of rain events in the local area),
- slope and shape of the land,
- groundcover,
- permeability of soil,
- phosphorus buffering capacity of the soil,
- runoff modifiers (contour banks, vegetative filter strips),
- distance to waterways, and
- depth to groundwater.

Not all these factors are of equal importance based on their impact on risk. These risk factors are considered in the nutrient risk assessment method, which can be found in Appendix C.

Scores derived from the nutrient risk assessment table can be used to determine the need and scale of interventions to reduce risk. Appropriate design and management requirements are specified according to the risk rating identified by the assessment tool. The risk rating associated with risk scores is shown in Table 8 in Appendix C.

If a site is located within or partly within a flood plain, it may increase the risk of environmental impacts to water. As such, additional management and mitigation may be required to address this risk. Flooding information is generally available from on-line maps supplied by local or state government agencies.

Range and Shed Area Design Principles

Range Area Design

Range areas should be designed to minimise erosion and nutrient export off-site via runoff or drainage.

Although most nutrient deposition occurs inside bird housing, nutrients deposited on the range are highest close to sheds and shade areas. Wiedemann et al. (2018 – see Chapter 4: References) divided the range areas into three zones based on the soil nutrient levels at 14 free range farms, and a review of bird behaviour studies. The zones correspond to the following distances from the exit points of the sheds:

- Zone 1 – 0-10m
- Zone 2 – 10-25m
- Zone 3 – >25m

This research showed that most of the nutrient deposition on the range occurs in Zone 1. For Zone 2 areas (10-25m) from the shed, nutrient deposition was found to be substantially lower, but field observations revealed that pasture cover is difficult to maintain, and nutrient accumulation can still be elevated. For Zone 3 areas (> 25m from the sheds), the research showed that <25% of nutrients deposited in the range area are expected to occur in this zone. The nutrient levels in this zone, considering differences in background soil fertility, were typically within acceptable agronomic ranges for crop and pasture production and management.

Wiedemann et al. (2018) describes design and management strategies for a site depending on the management zone and site risk determined using the nutrient risk assessment tables in Appendix C.

Low Risk Sites

On low risk sites, increased nutrient deposition close to sheds does not pose a significant risk of nutrient loss. As such, for sites which achieve a low risk score, minimal controls may be adequate to reduce nutrient loss risks. Recommended controls include compacted gravel from 0-6m from sheds to reduce drainage, and diversion of water from roofs to reduce runoff. Build up of manure on the compacted gravel pad should be removed as needed. No further controls are considered essential, though monitoring of nutrient levels is recommended as good practice.

High Risk Sites

Zone 1 (0-10m): The installation of roofed verandas with impermeable flooring and bunding to control manure nutrient loss immediately outside the exit point of each shed (i.e. 2-3m) is recommended to restrict nutrient loss. Verandas will require cleaning (as manure builds up in these areas), and removal of this manure/litter. Manure should not be spread in the range area. Verandas of 2-3m are expected to restrict 50% of nutrient losses. Diversion of rainwater from these verandas and the shed roof is also recommended, to reduce water movement and subsequent nutrient loss.

In the area between the verandah edge and 10 m, drainage may be controlled by constructing an impermeable pad, or by using coarse rock or aggregate underlain with an impermeable base, to avoid problems with birds scratching through the pad. Bunding should be provided to exclude stormwater from running onto these areas. Use of bunding (or other diversion measures) to control stormwater flows is shown in Figure 7.

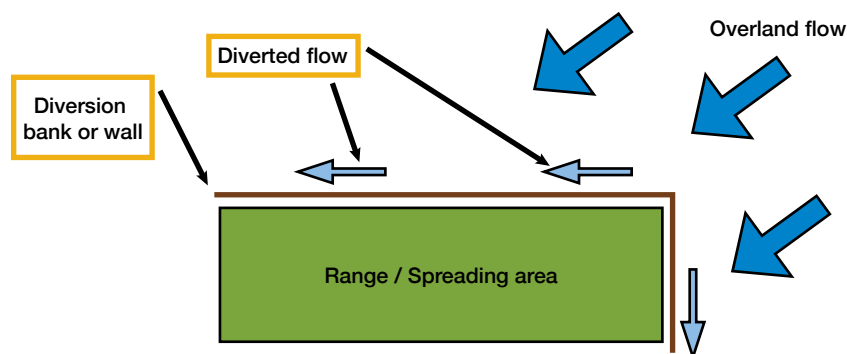


Figure 7 Effect of diversion measures on overland flow

Runoff from these areas may be managed using vegetative filter strips (VFS). More detail on how VFSs operate, their effectiveness and how they should be designed can be found in Appendix I.

Zone 2 (10-25m): Monitoring of soil nutrient levels is warranted to ensure unacceptable levels of nutrient accumulation do not occur. Where nutrient accumulation is observed, management strategies applied in other intensive livestock systems (e.g. pigs – see Tucker et al., 2013) such as long-cycle rotations of range areas and nutrient removal via crop production could be used where site conditions allow. Rotation can also be achieved by using movable shelters. Alternatively, runoff control may be used to minimise off-site impacts. Bunding should be provided to exclude stormwater from running onto these areas.

Zone 3 (25m+): The lower nutrient concentration, and higher groundcover in this area poses a reduced environmental risk even on high risk sites. Wiedemann et al. (2018) showed that <25% of nutrients deposited in the range area are expected to occur in this zone. The nutrient levels in this zone, considering differences in background soil fertility, were typically within acceptable agronomic ranges for crop and pasture production and management. Nutrient levels in this zone should be periodically monitored to check that levels do not increase substantially beyond pasture or crop requirements. If nutrient levels increase substantially, practices adopted in other intensive livestock systems would be suitable in these zones. These include: paddock rotation; periodic crop removal; together with ongoing monitoring to ensure soil nutrient levels do not pose unacceptable risk.

If trees are provided for shade, consider the nutrient tolerance and bushfire risk of the species planted. Also choose species that are less likely to attract wild birds (Bielefeld et al., 2015 – see Chapter 4: References). Avoid the use of trees in range areas close to drainage lines, as trees have been demonstrated to lead to higher nutrient deposition rates (Wiedemann et al., 2018).

Another alternative to fixed housing in free range systems is to have readily moveable/mobile housing. Provided these are moved frequently, this allows denuded areas to recover, and aids in distributing the nutrients over a wider area of the range. These systems are more suited to smaller farms.

More details on runoff control from range areas can be found in section 2.11.

Shed and Production Area Design

Well planned shed design and layout can reduce potential environmental impacts and operating costs.

Most of the newly constructed cage sheds are tunnel ventilated. They generally have curtains or solid sides and are fitted with large fans at one end that draw air through the length of the building for discharge. Careful positioning of the discharge end of these buildings is necessary to prevent odour, dust, feather and noise impacts.

Sheds for free range and barn systems are generally steel framed, clear span, gable roofed structures or they may be hooped metal frames covered in a weatherproof fabric, similar in structure to greenhouses used in horticulture. Sidewalls are generally solid from ground level to 300-400mm. The balance of the wall is usually netted and fitted with woven plastic curtains, hinged metal shutters or solid sides. The curtains or shutters are raised or lowered either manually or automatically to control ventilation and temperature, and to provide protection from adverse weather conditions. The flooring of sheds may comprise litter, slats or wire. Hens housed in free range and barn systems generally lay in specially made nests and roost on installed perches. They need to be designed to enable the effective and easy removal of manure and spent litter.

Consider the following during the design and construction phase of a project:

1. Provide a parallel distance of at least 15m between sheds to improve ventilation and lower temperature and humidity in the sheds. This distance is less critical with tunnel-ventilated sheds. Sheds on free range farms may need to be located much further apart to accommodate sufficient range areas.
2. Orientate the long axis of sheds east-west to minimise solar heat absorption during hot weather. With tunnel ventilated sheds, consider the impact of shed orientation with respect to odour, dust and noise impacts on the surrounding community.
3. Aim to avoid light nuisance from reflection (e.g. orientation to sun, material selection) that may affect neighbouring residences and traffic on local roads.
4. Consider the separation and buffer distances needed between the sheds and sensitive land uses, natural features and other features to prevent odour, dust and noise nuisance.
5. Provide sufficient roof overhang and sidewall height to prevent rainwater from entering the shed.
6. Build and maintain poultry sheds to exclude feral animals and other birds.
7. Establish a perimeter fence that clearly defines a biosecurity zone for the production area.
8. Provide a stock proof fence around the production area if livestock graze the property. This perimeter fence should also be designed to exclude ground based predators.
9. Use drainage to exclude surface water runoff from entering the production area.

Appendix C. Nutrient Risk Assessment for Range Areas

Nutrients deposited with soil in free range areas are a potential source of environmental risk, which needs to be managed by appropriate siting, design and management of the range area. To assist with appropriate siting and design, a risk management approach has been developed for these guidelines. This has been developed with reference to the basic principles influencing soil loss as outlined in the Revised Universal Soil Loss Equation (RUSLE) and the original USLE and nutrient losses, as outlined in the Environmental Risk Assessment National Environmental Guidelines for Piggeries – Second Edition (NEGP) (Tucker et al., 2010 – see Chapter 4: References) tool and the Farm Nutrient Loss Index (FNLI – Melland et al., 2007 – see Chapter 4: References). The latter has been used as a starting point for the risk assessment tool provided below. The FNLI uses a numerical weighting system that provides a risk score and overall rating. The system is influenced primarily by site attributes, providing a basis for choosing a good site and avoiding one that will lead to higher inherent risks. The rating system in the original FNLI has been adapted in the present application using expert judgement to provide factors relevant to poultry stocking rates and farm sizes. This has been done with reference to known soil nutrient impacts caused by these differences, as documented in Wiedemann et al. (2018).

The risk tool is a theoretical approach, and while soil nutrient data in free range areas are available, there is no Australian research quantifying nutrient losses in runoff or drainage from layer free range areas. Information from the meat chicken industry (Brown and Gallagher, 2015) indicates relatively low nutrient losses, as discussed in Wiedemann et al. (2018). Risk ratings have been determined with this in mind, and with comparison to similar situations and requirements in other intensive livestock industry guidelines. It should be noted that while the basis for the tool is robust, the risk ratings require validation at the field scale via measurement of nutrient and sediment losses in runoff, and nutrient losses in drainage. The system represents a first attempt to provide a risk rating for an intensive livestock system which considers the relative importance of each factor in determining overall risk levels. This tool can also be modified and revised as new information comes to hand. This was considered a superior approach to risk tools that treat each impact and consideration independently.

Factors and weightings used in this risk assessment are based on the conditions that primarily influence the nutrient source and transport risks. Nutrient transport in runoff is driven by rainfall, slope, erodibility and infiltration rate of the soil, and features which slow the passage of runoff. Nutrient leaching in soils is driven by the permeability of the soil, rainfall, and the depth of soil through which transport occurs.

The weighting of similar factors in the FNLI and RUSLE were determined and adjusted to better represent the range of factors relevant to layer farms. Factors which were not relevant to free range farms have been removed, and others combined or averaged where necessary. Factors and weightings are a combination of FNLI, RUSLE and expert judgement. A description of each of the factors used in the risk tables is given, following the tables. The description of factors also provides greater clarity on the ratings for each of these factors.

To use the risk tool, select the relevant risk assessment table for impacts to surface waters (Table 9) or groundwater (Table 10). Complete both assessments to determine which receptor is most at risk.

1. Assess each risk factor on a scale of 1-8 as indicated.
2. Multiply the score by the weighting for the factor and record it in the right hand column.
For example, when assessing land shape
 - A highly concentrated gully flow has a score of 8.
 - The weighting for land shape is 10.
 - Therefore the risk score for land shape is $8 \times 10 = 80$.
3. Complete this process for each of the factors listed in the risk table. Sum the factors to determine the total risk for the site.
4. Compare the total risk score for each table to the ratings shown in Table 8. This is your overall risk rating for the site (for the given receptor), and determines the need for management and control interventions.

Table 8 Risk scores and ratings

Risk Rating	Risk Score
Low	100 – 400
High	400 – 600
Very High*	>600

* A Very High rating indicates that the site is not suitable for a free range operation.

Where a risk score for a factor is highlighted in red, it is considered to make the site unsuitable for range areas. In determining the amount of nutrients deposited on the range, the presence of trees was noted to significantly increase the nutrient levels in soil, on the range (Wiedemann et al., 2018). As such, the score for stocking rate is doubled if trees are present on the range.

While this tool was primarily developed for use in the assessment of range areas associated with fully enclosed sheds, it can be adapted for use with other housing systems.

- For open floored housing (such as slatted floor mobile sheds) where manure is not collected, the stocking rate score should be doubled. A large proportion of manure deposition is expected to occur within sheds and failure to collect these nutrients makes it available for loss.
- For mobile systems, the total nutrients deposited on the range is proportional to the time that the shed is in each new location and a unique range area is used. If a mobile housing system is rotated between three unique range areas (no overlapping), the risk at each range area is 1/3 of the total risk. As such the score for 'Stocking Rate' should be reduced accordingly. The number of rotations and period between them should be sufficient to allow reestablishment of groundcover.

Risk Assessment Tables

Table 9 Risk assessment of range area impacts to surface waters

RUNOFF FACTORS	FACTOR WEIGHT	FACTOR SCORE				RISK FOR FACTOR = WEIGHT X SCORE
		LOW	MODERATE	HIGH	VERY HIGH	
		1	2	4	8	
RAINFALL FACTOR	20	<5000	5,000 – <10,000	10,000 – 20,000	>20,000	
DISTANCE TO WATERWAYS	15	>200m	100 – 200m	30 – 100m	<30m	
FARM SIZE	15	<10,000	10,000 – <60,000	60,000 – <250,000	>250,000	
SOIL PROFILE	10	Refer to explanatory notes				
LAND SHAPE	10	Swales and contour banks	Uniform flat or sloping land	Slightly uneven, minor rills	Highly concentrated gully flow	
GROUNDCOVER	10	80 – 100%	60 – <80%	45 – <60%	<45%	
STOCKING RATE*	5	<750 birds/ha	750 – <1,500 birds/ha	1,500 – <5000 birds/ha	>5,000 birds/ha	
SLOPE	5	<1	1 – <3.75	3.75 – 15	>15	
SOIL P	5	Refer to explanatory notes				
TOPSOIL PBI	5	>280 (clay)	140 – 280 (clay loam)	35 – <140 (sandy loam)	<35 (sand)	

* Double stocking rate if trees are present on the range

Table 10 Risk assessment of range area impacts to groundwater

LEACHING FACTOR	FACTOR WEIGHT	FACTOR SCORE				RISK FOR FACTOR = WEIGHT X SCORE
		LOW	MODERATE	HIGH	VERY HIGH	
		1	2	4	8	
SOIL PROFILE	25	Refer to explanatory notes				
GROUNDWATER	20	>10m to groundwater where protected by clay or impermeable strata (otherwise >20m)	>2m to groundwater where protected by clay or impermeable strata (otherwise >10m)	>2m to unprotected groundwater	<2m to groundwater	
RAINFALL FACTOR	20	<5000	5,000 – <10,000	10,000 – 20,000	>20,000	
PASTURE TYPE	15	>30% Lucerne	>30% deep rooted perennials	>30% shallow rooted perennials	<30% perennials	
FARM SIZE	15	<10,000	10,000 – <60,000	60,000 – <250,000	>250,000	
STOCKING RATE*	5	<750 birds/ha	750 – <1,500 birds/ha	1,500 – <5000 birds/ha	>5,000 birds/ha	

* Double stocking rate if trees are present on the range

Factors Used in Risk Assessment for Nutrient Impacts to Surface and Ground Waters

Rainfall Factor

One of the most important factors affecting nutrient loss is the amount of water available for runoff and leaching. The power of this water to erode soils is also important, as it affects the amount of soil bound and particulate nutrients in runoff. The rainfall factor is the highest weighted factor in runoff risk assessment, as it is a major driver of sediment bound, particulate and dissolved nutrient loss. The weighting of this factor in groundwater assessments indicates the lower risk associated with particulate and sediment bound nutrients. The effect of the rainfall factor in this case is mediated by the infiltration capacity of the soil and is therefore a ‘second highest’ rating.

The rainfall factor was based on the R factor in the revised universal soil loss equation as reported by the CSIRO (Lu et al., 2001 – see Chapter 4: References). Risk thresholds are proportionate to the range of erosivity ratings in Australia given in CSIRO mapping. The erosivity of the rain also correlates well with total rainfall and is thus useful for determining risk of soluble nutrient runoff as well as losses to groundwater.

The rainfall factor is determined from Figure 8 below. Note also that the rainfall factor has seasonal variability not accounted for in this assessment. As such, reducing nutrient applications to range areas and spreading areas during periods of increased rainfall intensity will reduce risk.

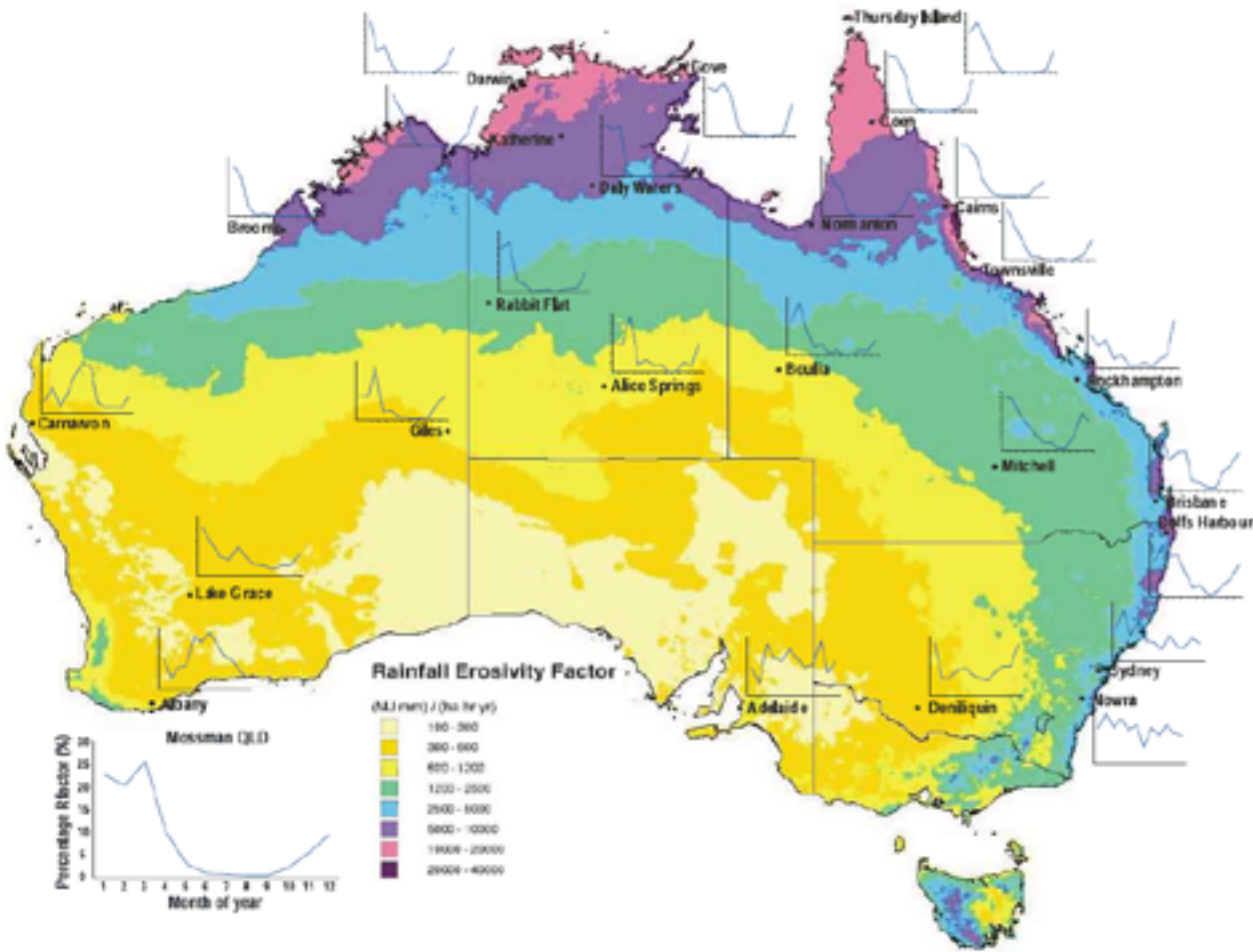


Figure 8 Map of rainfall erosivity (R factor) and its monthly distributions for selected locations (reproduced from Lu et al., 2001 – see Chapter 4: References)

Table 11 Rainfall factors

	1	2	4	8
RAINFALL FACTOR	<5000	5,000 – <10,000	10,000 – 20,000	>20,000

Soil Profile

The soil profile rating describes both the erodibility and infiltration capacity of the soil. The erodibility of soil has direct implications for the quantity of particle bound nutrients in runoff. Soluble nutrients, such as dissolved phosphorus, are not directly linked to sediment load and therefore are not linked to the erodibility of the soil. For soluble nutrients, the amount of runoff produced is of greater concern and is inversely proportional to the infiltration capacity of the soil.

For assessing runoff, the weighting of this factor is based on the relative impact that permeability has on total runoff produced. For assessing impacts to groundwater, this is more significant as regardless of the quantity of water present, the potential loss to groundwater is mediated by infiltration capacity.

N.B. When assessing risk of impacts to ground water, the risk scores are reversed.

For risk to groundwater, erodibility of the soil is not an important factor, unless erosion reduces soil structure and causes crusting at the surface, which affects infiltration. The effect of the soil profile on impacts to groundwater is related to its infiltration capacity and permeability. As such, the risk associated with each soil type is the inverse of that associated with runoff. As the effect of soil type on sediment bound nutrient transport doesn't apply here, the relative importance of this factor may be lower for groundwater infiltration.

The soil profile ratings presented in Table 12 were adapted from the FNLI, with soil profile description examples provided from the soil risk categories of Karssies and Prosser (1999 – see Chapter 4: References). The risk ratings from Karssies and Prosser (1999) are based on erodibility, which correlate closely with the permeability of the soils and represents a good metric to measure both erodibility and levels of runoff. These have been adjusted to differentiate infiltration rates of similarly erodible soils.

The soil profile should be determined through soil tests or from soil maps for the region. For additional help, contact your local Natural Resource Management (NRM) agency, or agricultural group.

Table 12 Soil profile factors

	1	2	4	8
SOIL PROFILE	Well structured/ draining soils Examples: • structured earths, • structured loam soils, • sand	Poorly structured soils Examples: • massive earths	Constrained soils Examples: • duplex soils • solodic soils	Heavy Clay to surface Examples: • black earths • cracking clays

Groundwater

Risk of impacts to groundwater is dependant upon the depth to groundwater and the level of protection afforded by impermeable layers in the soil profile. Deeper groundwater tables result in longer flow paths for leached nutrients and afford a greater chance for nutrients to be assimilated by the soil. Greater depth to groundwater also determines the soil volume and thus mediates the water holding capacity of the soil in conjunction with the soil type. The greater the percentage of infiltrated water that can be held, the less is available for loss to groundwater.

The weighting for the depth to groundwater reflects that along with the soil profile and rainfall factor, it has a direct relationship on the quantity of water that can reach the watertable.

Risk categories for depth to groundwater were based on the National Environmental Guidelines for Piggeries – Second Edition (Tucker et al., 2010 – see Chapter 4: References). Groundwater depth should be determined by a bore log search or contacting your local Natural Resource Management agency.

Table 13 Groundwater factors

	1	2	4	8
GROUNDWATER	>10m to groundwater where protected by clay or impermeable strata Otherwise >20m	>2m to groundwater where protected by clay or impermeable strata Otherwise >10m	>2m to unprotected groundwater	<2m to groundwater

Distance to waterways

As the distance to nearby waterways increases, adsorption of dissolved nutrients in surface runoff increases, as does the likelihood of sediment deposition and an associated reduction in particulate bound nutrients. Sediment deposition is dependent upon decreasing energy of runoff waters through runoff modifying features, groundcover, or decreasing slope. The lower energy of runoff waters is also associated with increased infiltration, and thus less nutrient laden water being available for runoff.

The weighting of this factor is based on the sensitivity of nutrient transport to the distance transported, however this is only true when considered in conjunction with the groundcover of the site, and the combined weightings represent this.

An approximation of this effect can be demonstrated by assuming that the distance between nutrient sources and waterways is roughly equivalent to a vegetative filter strip (81% reduction in TKN, 90% reduction in P for a width of 21.4m) (Chaubey et al., 1995 – see Chapter 4: References). This allows calculation of residual risk based on distance from the waterway. Using the lower reduction rate (~80% for N) and applying an efficiency factor of 50% to account for the un-managed nature of the area results in the following residual risk.

Table 14 Sediment load reduction from vegetative filters

Distance to waterway (m)	Estimated residual nutrients
30	49%
100	9%
200	1%

These distances therefore correspond to approximately 50%, 90% and 99% reduction in nutrient load and the associated environmental risk. The threshold values shown in Table 15 are comparable to those in the FNLI for higher risk categories, and are similar to separation distances recommended in the National Environmental Guidelines for Piggeries – Second Edition (Tucker et al., 2010 – see Chapter 4: References).

Proximity to waterway is the distance from the centre of the area under consideration to a waterway. It can be measured through site assessments or mapping.

Table 15 Distance to waterways factor

	1	2	4	8
DISTANCE TO WATERWAYS	>200m	100 – 200m	30 – 100m	<30m

Stocking Rate

Stocking rate of range areas is an important consideration as it relates to the capacity of the range area to assimilate and utilise nutrients.

The nutrient deposition associated with common industry stocking rates for range areas as presented in Table 16, was calculated and compared to the FNLI risk scores associated with fertiliser applications at comparable rates. Nutrient deposition varies across the range as shown in Wiedemann et al. (2018 – see Chapter 4: References) and the associated risk was calculated for the largest zone, in addition to range totals. The (average) corresponding risk scores for fertiliser application at similar rates from the FNLI are 2 (for 1500 birds/ha) and 6.5 (for 10,000 birds/ha). However, average risk for higher bird placement rates is not indicative of the degree to which phosphorous deposition exceeds the trigger values. As such the associated risk score has been set to 8, and the threshold adjusted as shown in Table 16. Other values were interpolated.

In addition to this, Wiedemann et al. (2018) showed that the presence of trees on the range more than doubled the nutrient deposition. As such, where trees are present on the range area, the initial score based solely on stocking rate should be doubled.

The weighting of this factor represents the importance of nutrient availability in determining total nutrient losses. Due to the critical nature of transport factors, increases in nutrient availability do not proportionately affect loss.

Table 16 Stocking rate factors

	1	2	4	8
STOCKING RATE*	<750 birds/ha	750 – <1,500 birds/ha	1,500 – <5000 birds/ha	>5,000 birds/ha

**Double rating if trees on range*

Farm Size

Farm size can determine the total amount of nutrients available for loss from range areas. Therefore, even for a low risk site, a large farm may represent a larger total risk simply by means of having more nutrients available for loss.

Farm size has been determined from regulation thresholds for similar industries throughout Australia. In particular, beef feedlotting shares many characteristics with range areas, such as high nutrient deposition in small areas. Regulatory thresholds for beef feedlots vary between states, with the lowest threshold found to be 50 head of cattle, in both NSW and Victoria. The requirements associated with these thresholds also varies, though it is considered indicative of the need to manage potential risks at these levels. It is worth noting that regulatory thresholds for beef feedlots are as high as 500 units in SA and WA.

The equivalent number of birds associated with this trigger value was determined by equating the nutrient production from a standard cattle unit (DAF, 2011 – see Chapter 4: References) and nutrient production from layer hens (Wiedemann et al., 2018). This value, which is the minimum to trigger environmental licencing was set to be the limit of the low risk (score 1) range of farm sizes.

Queensland environmental licencing thresholds for feedlots are tiered, with the second category of feedlot corresponding to sizes of up to 1000 head of cattle. This is echoed in NSW, Victorian and SA feedlot guidelines/codes produced by state environmental agencies, which categorise feedlots of greater than 1000 units as a different class of feedlot. This size of operation is associated with recognised environmental concerns and usually requires measures to reduce risk, such as compacted feedpads. The equivalent number of birds was determined using the same method as above. This value, associated with the need to implement additional control measures, was set to be the limit defining transition into the high risk (score 8) category.

The weighting of this factor represents the importance of total nutrient load in determining total nutrient losses. Due to the critical nature of transport factors, increases in total nutrient deposition do not proportionately affect loss. Furthermore, this factor is modified by the timing of nutrient deposition and therefore it is the combined score that more accurately reflects the total availability of nutrients.

Table 17 Farm size factors

	1	2	4	8
FARM SIZE (# of birds)	<10,000	10,000 – <60,000	60,000 – <250,000	>250,000

Groundcover

Groundcover can protect soil from the erosive power of rainfall or overland flow and also slows runoff thereby reducing the erosive potential and increasing infiltration, resulting in lower runoff.

The USLE accounts for the effect of groundcover on soil loss. The associated reduction of soil loss (and sediment bound nutrients) associated with increasing groundcover was estimated from Landcom (2004 – see Chapter 4: References). Karssies and Prosser (1999 – see Chapter 4: References) estimate the associated reduction in USLE soil loss for permanent pasture to be closer to 80% for 40% cover, and 98% reduction for 80% cover. However, the more conservative values of Landcom (2004) have been used.

Butler et al. (2006 – see Chapter 4: References) show that dissolved P is reduced by 30% at low cover levels (45%) and this was chosen as a maximum acceptable risk. The cut-off for the highest risk score was set as 45% groundcover, corresponding to a 30% reduction in Dissolved Reactive Phosphorus (DRP) and <70% reduction in sediment transport. The remaining intervals represent 80, 90, and 98% reduction in soil loss and associated nutrient loss. This is similar to the range of values used in the FNLI.

The percentage of groundcover in range areas can be determined from visual inspection of the site. Groundcover in range areas is expected to be lower once farms are operational.

The weighting of this factor represents its importance to reducing nutrient load in surface runoff. It affects the amount of soil that is eroded during rainfall events, but it also mediates the effects of the distance to waterways. When assessing reduction in nutrient loss between source and waterway, groundcover has a significantly lower effect than total distance. This factor combines both erosion and mediation weightings.

Table 18 Groundcover factors

	1	2	4	8
GROUNDCOVER	80 – 100%	60 – <80%	45 – <60%	<45%

Pasture type

Pastures of different types have different rooting depths, with deeper rooted plants being better able to utilise soil moisture and nutrients. This ability to utilise moisture and soil nutrients results in a lower risk of nutrients draining to groundwater.

This risk assessment has adopted the recommendations for risk scores associated with pasture type found in the FNLI.

The weighting of this factor was based on the relative importance in the FNLI when compared with similar factors used in this assessment.

Table 19 Pasture type factors

	1	2	4	8
PASTURE TYPE	>30% Lucerne	>30% deep rooted perennials	>30% shallow rooted perennials	<30% perennials

Slope

The range of slopes under consideration for range areas is expected to be <15% because of the difficulties in building sheds and other necessary infrastructure on major slopes. The Manning Equation for open channel flow states that flow rate is proportional to the square root of the slope. As such, thresholds for risk ratings were selected such that the square root of slope was proportional to the change in risk score between ratings.

The slope can be determined from a simple site inspection of the proposed range areas or spreading areas. Alternatively, topographic maps or GIS could be used for remote assessment.

The weighting of this factor was determined by considering the responsiveness of total runoff to changes in slope.

Table 20 Slope factors

	1	2	4	8
SLOPE %	<1	1 – <3.75	3.75 – 15	>15

Land Shape

Land shape is an important factor which determines the speed of runoff waters and therefore their erosivity and likelihood of infiltration. Where flat land, or uniformly sloping land results in an even distribution of water across the surface, the presence of rills and gullies results in a concentration of water and a resulting increase in the speed of runoff.

As such, highly concentrated flows such as where a single large gully services the entire area, are considered the highest risk. Land shapes that slow water movement, such as swales and contour banks are considered to have the least risk (Karssies and Prosser, 1999). This is reflected in the risk ratings shown in Table 21. This approach combines the 'land shape' and 'runoff modifying features' factors found in the FNLI.

The weighting of this factor is based on the effect the increasing hydraulic radius associated with larger channels has on flow velocity. While the effect of swales and contour banks cannot be modelled in the same way, their notable effect on flow velocity justifies their inclusion as the lowest risk category regardless of the weighting.

Table 21 Land shape factor

	1	2	4	8
LAND SHAPE	Swales and contour banks	Uniform flat or sloping land	Slightly uneven, minor rills	Highly concentrated gully flow

Soil P

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

Soil P values were related using nutrient availability recommendations in CCMA (2013 – see Chapter 4: References) and thresholds were set based on these values and those published in Gourley et al. (2007 – see Chapter 4: References). These thresholds represent the ability of plants to utilise the phosphorus in soil, with high levels being above plant requirements and available for loss.

The weighting of this factor represents the fact that phosphorus from layer farm activities must first be present in sufficient quantity and have sufficient transport available for it to pose a risk. It is only where a potential risk is present that phosphorus in the soil modifies the risk.

Soil phosphorus can be determined from soil testing.

Table 22 Soil P factors

		1	2	4	8
OLSEN P	all soils	<8	8-12	12-18	>18
	sandy	<13	13-19	19-24	>24
COLWELL P	loam	<16	16-24	24-36	>36
	clay	<24	24-36	36-45	>45

Topsoil PBI

The Phosphorus Buffering Index (PBI) of the soil describes its ability to moderate changes in the level of available phosphorus in soil. This in turn influences the soil's ability to bind with phosphorus making it unavailable for loss.

The weighting of this factor represents the fact that phosphorus from layer farm activities must first be present in sufficient quantity and have sufficient transport available for it to pose a risk. It is only where a potential risk is present that the phosphorus buffering ability of the soil modifies the risk.

The Phosphorus Buffering Index can be determined from inexpensive soil testing.

Table 23 Topsoil PBI factors

	1	2	4	8
TOPSOIL PBI	>280 (clay)	140 – 280 (clay loam)	35 – <140 (sandy loam)	<35 (sand)

Appendix D. By-product Utilisation

The application of manure and spent litter needs to comply with relevant state legislation. It is important to maximise the value of manure as a fertiliser and soil conditioner, maximising crop or pasture performance. Inappropriate use and over application can cause nutrients and organic matter leaching through the soil profile or lost via runoff and eroded soil.

In calculating the required utilisation area for by-products, nutrient applications (particularly nitrogen and phosphorus) should not exceed the sum of the following:

- The amount required for crop or pasture performance (in the long term, this is closely linked to the amount removed from the site in crops, by animals and through losses).
- The amount that can be safely stored in the soil, where permitted.
- The amount released to the atmosphere in an acceptable form (primarily the gaseous loss of nitrogen via ammonia volatilisation).

This can be expressed for each element/nutrient as:

$$\begin{aligned} \text{Amount applied} &= \text{Amount removed by plant/grazing} \\ &+ \text{Amount safely stored in the soil} \\ &+ \text{Safe losses (ammonia loss)}. \end{aligned}$$

When determining the required size of a utilisation area, each element (nitrogen, phosphorus, potassium, salt, metals, etc.) needs to be considered individually. Manure and spent litter is not a balanced fertiliser, so the sustainable application rate will be determined by the most limiting nutrient (the nutrient that limits the amount that can be applied). State agricultural departments, agronomists, or consultants can provide details of crop removal and soil requirements.

When applying by-products, the aim should be to make the maximum use of the nutrients as fertiliser, while avoiding any potential negative effects, such as soil degradation and contamination of ground and surface water.

Manure and spent litter may contain traces of pesticides used for insect and rodent control in the shed. They also contain pathogens but the level of these is unlikely to pose a risk to human health. The level of risk depends on the period between applying the by-product and crop harvest (particularly crops for direct human consumption without post-harvest treatment/processing). Pathogens will die off when applied and exposed to the sun (dehydration, temperature and UV exposure all contribute to this). However, care should be taken when handling and applying manure by-products. Refer to biosolids handling requirements, workplace health and safety guidance and biosecurity regulations for more information on correct handling procedures.

For application to horticultural crops, refer to specific Quality Assurance requirements relevant for the crop/supply chain of interest. Refer also to “The Freshcare Code of Practice – Food Safety and Quality” (Freshcare, 2016 – see Chapter 4: References) and the Department of Agriculture Fisheries and Forestry – Australia guidelines for “On-farm Food Safety for Fresh Produce” (DAFF, 2004 – see Chapter 4: References) for information regarding the application of organic manures to vegetable crops.

In some states, environmental legislation dictates that industries that produce organic by-products have a duty of care to ensure their by-products sold or taken off-site are used sustainably. Although the egg industry may not control the management of manure or spent litter after sale, their environmental responsibility for the sustainable utilisation of the by-products still exists. A contract between producers of manure and end users can define the quantity of by-product involved and the application method. It is helpful for the producer to inform the purchaser of their environmental responsibilities and give the purchaser some idea of the composition of the material (nutrient analysis). The composition of the by-products can be determined by chemical analysis. The composition of any compost sold will also need to be in accordance with any state legislation.

In Australia, poultry manure and spent litter is considered a risk linked to botulism in ruminants. Botulism is a serious form of food poisoning caused by the bacteria *Clostridium botulinum*, which may be present in poultry litter. Due to this risk, it is illegal in Australia to feed material containing poultry manure to stock, or to allow stock access to animal matter or animal contaminated matter. Animal Health Australia provides details of the individual relevant state legislation (AHA, 2016 – see Chapter 4: References).

Crop Uptake

The type of crops grown on the by-product utilisation area determines the nutrient removal via the amount of harvested material and its nutrient content. Table 24 shows typical dry matter nutrient contents and expected yield ranges for a variety of pasture, silage, hay and grain crops. The yields presented are for typical cropping soils.

Grazed pasture is rarely an effective method of removing nutrients from by-product utilisation areas since most of the nutrients are recycled through the grazing animal and returned to the utilisation area. Grazing systems typically require at least five to ten times more area than a system using a crop removal process (e.g. cut and cart).

Table 24 Nutrient content and anticipated dry matter yield of various crops (adapted from Tucker et al., 2010)

Crop	DM nutrient content (kg/t)			Normal yield range* (DM t/ha)	Normal nutrient removal range (kg/ha)		
	N	P	K		N	P	K
Dry land pasture (cut)	20	3	15	1 – 4	20 – 80	3 – 12	15 – 60
Irrigated pasture (cut)	20	3	15	8 – 20	160 – 400	24 – 60	120 – 300
Lucerne hay (cut)	31	3	25	5 – 15	155 – 465	15 – 45	125 – 375
Maize silage	22	3	20	10 – 25	220 – 550	30 – 75	200 – 500
Forage sorghum	22	3	24	10 – 20	220 – 440	30 – 60	240 – 480
Winter cereal hay	20	3	16	10 – 20	200 – 400	30 – 60	160 – 320
Seed barley	19	3	4	2 – 5	38 – 95	6 – 15	8 – 20
Seed wheat	19	4	5	2 – 5	38 – 95	8 – 20	10 – 25
Triticale	19	4	6	1.5 – 3	29 – 57	6 – 12	9 – 18
Rice	14	3	4	4 – 8	56 – 112	12 – 24	16 – 32
Seed oats	15	3	4	1 – 5	15 – 75	3 – 15	4 – 20
Grain Sorghum	20	3	3	2 – 8	40 – 160	6 – 24	6 – 24
Grain maize	20	3	4	2 – 8	40 – 160	6 – 24	8 – 32
Chickpea	40	4	4	0.5 – 2	20 – 80	2 – 8	2 – 8
Cowpea	30	4	20	0.5 – 2	15 – 60	2 – 8	10 – 40
Faba bean	40	4	12	1 – 3	40 – 120	4 – 12	12 – 36
Lupins	45	3	8	0.5 – 2	22.5 – 90	1.5 – 6	4 – 16
Navy bean	40	6	12	0.5 – 2	20 – 80	3 – 12	6 – 24
Pigeon peas	26	3	9	0.5 – 2	13 – 52	1.5 – 6	4.5 – 18
Cotton	20	4	8	2 – 5	40 – 100	8 – 20	16 – 40

*Yields may vary from these ranges (refer to historical data for the region for more accurate estimates).

Typical Manure and Spent Litter Production and Composition

The following tables provide information regarding the prediction of manure production and the characteristics of layer hen manure.

Table 25 Average layer hen performance for birds housed in two environmentally controlled sheds with manure belts over the three week mass balance trial (Wiedemann et al., 2015)

Performance parameter	Total
Hens – start of trial (no.)	141,543
Hens – end of trial (no.)	141,199
Daily mortalities (no.)	16.4
Age at end of trial (weeks)	61.0
Average bird mass (kg)	2.1
Average egg mass (g)	63.4
Hen-day egg production (%)	88.1
Average daily feed intake (g/bird/day, as fed)	114.5
Feed conversion (kg feed/kg eggs)	2.05
Total solids excretion (t/1000 birds/yr)*	10.6
Ash excretion (t/1000 birds/yr)*	2.9
Nitrogen excretion (t/1000 birds/yr)*	0.6

* Calculated from Wiedemann et al. (2015)

Table 26 Manure analysis results for caged layer hen systems with belt removal (Wiedemann et al., 2008)

Parameter	Units	Range		Average
Moisture	%	32.4	73.7	58.9
pH – water		5.7	6.9	6.25
Electrical conductivity	dS/m	4.8	15.7	12.25
Organic carbon	%	34.2	40.7	37.75
Nitrogen	%	4.8	7.5	5.95
Ammonium nitrogen	mg/kg	91	17780	6449
Nitrate-N	mg/kg	<200	<200	<200
Phosphorus	%	1.1	3.1	2.3
Ortho-phosphorus	mg/kg	594	6492	3223.5
Potassium	%	1.6	2.5	1.9

n = 9 (includes sheds with and without manure drying)

Table 27 Manure analysis results for layer hen systems (fresh manure)

Parameter	Rowlings (2016)	Wiedemann et al. (2015) unpublished data	Pratt et al. (2015) (eggs fresh)	Jenkins et al. (2015) (eggs cage fresh)	Jenkins et al. (2015) (eggs barn litter)
Moisture, %	58.3	63.8	61.7	60.6	25.4
pH	7.7	-	-	6.8	8.4
Electrical conductivity, dS/m	11.4	-	-	10.5	9.4
Organic carbon, %	24.1	-	21.0	31.5	39.7
Nitrogen, %	7.2	5.8	5.2	5.3	3.1
Ammonium nitrogen, mg/kg	16735	-	32367	419	397
Nitrate-N, mg/kg	128.7	-	60.7	-	-
Phosphorus, %	1.8	1.4	-	-	-
Available-phosphorus, mg/kg	3459	-	-	-	-
Potassium, %	-	2.0	-	-	-
Volatile solids, % of total solids	-	77.4	62.5	61.2	84.3

Note: All references in this table reproduced from Wiedemann (2016 – see Chapter 4: References)

Table 28 Manure analysis results for caged layer hens (treated)

Parameter ^A	Rowlings (2016) forced aeration pile	Jenkins et al. (2015) forced aeration pile (composted)	Rowlings (2016) windrow compost	Pratt et al. (2015) eggs composted	Jenkins et al. (2015) stockpiled experiment 1	Jenkins et al. (2015) stockpiled experiment 2
Moisture, %	37.4	43.2	33	20.5	28.9	43.6
pH	8.4	8.5	8.4	-	8.7	7.3
Electrical conductivity, dS/m	12.2	12.7	12.7	-	11.6	8.4
Organic carbon, %	20.5	35.6	20.2	24.0	22.3	30.1
Nitrogen, %	2.7	1.6	4.5	3.0	4.4	4.9
Ammonium nitrogen, mg/kg	7455	642	7260	3475	485	-
Nitrate-N, mg/kg	152.1	-	190.7	66.2	-	-
Phosphorus, %	1.8	-	1.6	-	-	-
Ortho-phosphorus, mg/kg	4660	-	4526	-	-	-
Volatile solids, % of total solids	-	74.4	-	-	57.4	-

^A Potassium omitted as these data were not reported in any of the cited studies.

Note: All references in this table reproduced from Wiedemann (2016 – see Chapter 4: References)

Appendix E. Dead Bird Management

Table 29 Risks and controls associated with off-site disposal

Risk	Control
<p>Contractor failure</p> <p>Disposal contractor may not have sufficient capacity, especially when dealing with large numbers of birds.</p>	<p>Ensure contractor agrees to regular disposals/removals at predicted loads.</p> <p>Ensure adequately licensed contractor.</p>
<p>Odour</p> <p>Storage of dead birds while waiting for removal by contractors may generate significant odours.</p>	<p>Dead birds must be stored in a refrigerated storage area, adequately enclosed to minimise odour generation.</p> <p>Ensure sufficient cold storage space is available for predicted/known mortalities.</p>
<p>Dust</p> <p>Additional dust may be generated by movement of disposal trucks, or producer vehicles when moving dead birds.</p>	<p>On-site vehicle movements should be minimised by careful planning of site layout and timing of operations.</p> <p>In addition, dead bird storage should be located close to the access point for the property to minimise the need for disposal contractors to enter the site.</p> <p>See below for additional information on traffic management.</p>
<p>Traffic</p> <p>Additional traffic on local roads will be generated by using disposal contractors.</p>	<p>This will usually be assessed by regulators at the time of approval and may require additional contributions to the upkeep of the road network.</p> <p>Site layout and timing of contractor visits should seek to minimise impacts on other road users. Ensure sufficient space for vehicles to enter and leave the property without causing nuisance to road users.</p> <p>Refer to sections 2.10.3, 2.8 and 3.2 for more information.</p>
<p>Noise</p> <p>Noise may be generated by vehicle movements associated with disposal, and the operation of refrigeration equipment for storage.</p>	<p>Try to minimise vehicle movements as outlined above, and mitigate any noise generated through appropriate separation distances and noise reducing screening such as vegetated buffers.</p> <p>Refer to section 2.12 for landscaping information.</p>
<p>Groundwater</p> <p>Groundwater contamination can occur where bird material leaches into the ground.</p>	<p>Dead birds should be stored in a sealed container to prevent leaching. Birds should be stored in a refrigerated area to minimise decomposition. Birds should only be stored short-term to minimise decomposition.</p> <p>Refer to sections 2.6.3 and Appendix B for more information.</p>
<p>Surface water</p> <p>Surface water contamination can occur where bird material is entrained in runoff from the site.</p>	<p>Dead birds should be stored in a sealed container to prevent contamination of runoff. Birds should be stored in a refrigerated area to minimise decomposition. Birds should only be stored short-term to minimise decomposition.</p> <p>Refer to sections 2.6.3 and Appendix B for more information.</p>
<p>Biosecurity</p> <p>Movement and storage of dead birds are potential sources and transmission vectors for bird disease.</p>	<p>Dead birds must be stored in a refrigerated storage area, adequately enclosed to minimise the spread of pathogenic microorganisms.</p> <p>Ensure sufficient cold storage space is available for predicted/known mortalities. Allow for additional storage to cope with fluctuations.</p> <p>Although daily pick-up and short-term freezing on-farm reduces the chance of pathogen spread, they do not completely eliminate the risk. Ensure site pick-up occurs outside the production area to minimise biosecurity risks.</p> <p>Develop a contingency plan (e.g. short-term refrigeration, composting or burial) for use in the event of a failure to dispatch carcasses.</p> <p>If birds are not collected daily (e.g. over weekends), treat dead birds with chemicals to preserve/disinfect the carcasses or provide short-term refrigeration. Check with the destination plant or waste facility to ensure that the chemicals used are suitable.</p>

Table 30 Risk and controls associated with on-site composting

Risk	Control
<p>Legislative compliance</p> <p>State legislation and other regulations may apply to the composting of dead birds, failure to comply presents financial and legal risk.</p>	<p>Consult with state regulators to determine legislative requirements (if applicable).</p>
<p>Odour</p> <p>Composting of dead birds can produce significant odour if done incorrectly.</p>	<p>Consult with state regulators or seek professional guidance on appropriate composting methods.</p> <p>The physical and chemical characteristics of the compost must be maintained to ensure adequate processing of wastes (see Wiedemann et al., 2008 and the Australian Eggs Limited website). Temperature, moisture, pH and nutrient ratios should be maintained within appropriate ranges.</p> <p>Compost in open bays, piles or rows (such as windrows) to maximise exposure to air. Turn the compost regularly to allow adequate ventilation.</p> <p>Alternatively, compost in specially designed ‘tumblers’. These containers can be rotated to ensure mixing and airflow throughout the compost.</p> <p>Composting areas should be sited to minimise off-site impacts.</p>
<p>Dust</p> <p>Dust may be generated from vehicle movements or from compost turning if it is not adequately dampened.</p>	<p>On-site vehicle movements should be minimised by careful planning of site layout and timing of operations.</p> <p>Ensure compost piles or rows are adequately dampened prior to turning.</p> <p>Exercise caution as excessive application of water can result in nutrient runoff or result in anaerobic conditions, thus increasing odour.</p> <p>Reduce transport of dust using vegetated buffers or other screening.</p>
<p>Traffic</p> <p>No risk to local traffic as conducted on-site.</p>	<p>No impact to the local road network.</p>
<p>Noise</p> <p>Noise may be generated by vehicle movements associated with disposal and turning of compost piles.</p>	<p>Minimise vehicle movements and mitigate any noise generated through appropriate separation distances and noise reducing screening such as vegetated buffers.</p> <p>Refer to section 2.12 for landscaping information.</p>
<p>Groundwater</p> <p>Groundwater contamination can occur where bird material leaches into the soil.</p>	<p>Refer to sections 2.6.3 and Appendix B for more information on risks to groundwater. Where risks are present, composting should be carried out on an impermeable surface or compacted clay pad. Where leachate is produced it should be captured for immediate reuse in the compost or applied to land.</p>
<p>Surface water</p> <p>Surface water contamination can occur where runoff mixes with bird material.</p>	<p>Refer to sections 2.6.3 and Appendix B for more information on risks to surface water. Where risks are present, water should be excluded from the composting area through bunding or diversion banks/swales. Rain should be excluded using roofed structures. Where runoff is produced it should be captured for immediate reuse in the compost or applied to land.</p>
<p>Biosecurity</p> <p>Movement and storage of dead birds are potential sources and transmission vectors for bird disease.</p>	<p>Composting areas should be located at a sufficient distance from production facilities to minimise the risk of pathogen spread.</p> <p>Risk from aerosolised pathogens should be minimised by ensuring appropriate moisture in the piles prior to turning, and timing operations to avoid strong winds blowing towards production areas.</p> <p>Equipment used in moving birds/processing compost should be sanitised/quarantined prior to use in production areas.</p>

Table 31 Risks and controls associated with incineration

Risk	Control
<p>Legislative compliance</p> <p>State legislation and other regulations may apply to incineration.</p>	Consult with state regulators to determine legislative requirements (if applicable).
<p>Odour</p> <p>Odour emissions can occur if incineration system not functioning correctly.</p>	<p>Incineration should be undertaken at high temperatures to ensure clean burning of waste material.</p> <p>Flue control and emissions management are necessary to ensure that odour is minimised. Air pollution control devices such as scrubbers may be needed to achieve this outcome.</p>
<p>Dust</p> <p>Particulate emissions may arise from incineration if system not functioning correctly.</p>	<p>Some dust generation may be associated with on-site vehicle movement. On-site vehicle movements should be minimised by careful planning of site layout and timing of operations.</p> <p>Incineration should be undertaken at high temperatures to ensure clean burning of waste material. Flue control and emissions management are necessary to ensure that particulate matter is minimised. Air pollution control devices such as scrubbers may be needed to achieve this outcome.</p>
<p>Traffic</p> <p>Minimal risk to local traffic if process conducted on-site.</p>	No impact to the local road network.
<p>Noise</p> <p>Noise may be generated by vehicle movements associated with disposal, and the operation of incineration equipment.</p>	<p>Noise generated by the incineration process is likely to be minimal.</p> <p>Minimise vehicle movements and mitigate any noise generated through appropriate separation distances and noise reducing screening such as vegetated buffers.</p> <p>Refer to section 2.12 for landscaping information.</p>
<p>Groundwater</p> <p>Minimal risk as system is enclosed.</p>	No impacts to groundwater.
<p>Surface water</p> <p>Minimal risk as system is enclosed.</p>	No impacts to surface waters.
<p>Biosecurity</p> <p>Improper burning of wastes can disperse pathogens and increase biosecurity risks.</p>	Incineration must only be undertaken in a purpose built high temperature incinerator capable of reaching appropriate temperatures for safe incineration of potentially pathogenic materials. The incinerator must have appropriate emissions controls to minimise risk of pathogen spread.
<p>Waste</p> <p>Production of ash is a by-product of the incineration process.</p>	Waste must be disposed of in accordance with state regulations and the waste management plan for the site.

Table 32 Risks and controls associated with anaerobic digestion

Risk	Control
<p>Legislative compliance</p> <p>State legislation and other regulations may apply to use of anaerobic digesters.</p>	<p>Consult with state regulators to determine legislative requirements (if applicable).</p> <p>In addition to environmental guidelines, seek specialist advice regarding the health and safety requirements of operating a digester, as these facilities produce a range of hazardous gases.</p>
<p>Odour</p> <p>Odour emissions from open storage tanks and digesters that are not functioning correctly.</p>	<p>Digesters should be adequately enclosed to prevent the release of dangerous and odorous gases.</p> <p>The digestion process should be carried out within the range of operating parameters (physical and chemical) specified by the system designer, or as a condition of your approval (where required).</p> <p>Thermophilic digesters are particularly sensitive to disruption and require predictable size and composition of loads, which makes them difficult to use for disposing of birds when destocking sheds due to the large quantity of waste produced.</p>
<p>Dust</p> <p>Some dust generation may be associated with on-site vehicle movement.</p>	<p>On-site vehicle movements should be minimised by careful planning of site layout and timing of operations.</p>
<p>Traffic</p> <p>Minimal risk to local traffic if conducted on-site.</p>	<p>No impact to the local road network.</p>
<p>Noise</p> <p>Noise may be generated by vehicle movements associated with disposal, and the operation of digester equipment.</p>	<p>Noise generated by the digestion process is likely to be minimal.</p> <p>Minimise vehicle movements and mitigate any noise generated through appropriate separation distances and noise reducing screening such as vegetated buffers.</p> <p>Refer to section 2.12 for landscaping information.</p>
<p>Groundwater</p> <p>Properly designed and operating digesters present a minimal risk to groundwater.</p>	<p>Digesters should be located on a sealed and bunded pad to contain leaks or system failures.</p> <p>Digester tanks should be inspected regularly for leaks.</p>
<p>Surface water</p> <p>Properly designed and operating digesters present a minimal risk to surface waters.</p>	<p>Digesters should be located on a sealed and bunded pad to contain leaks or system failures.</p> <p>Bunded areas should be roofed to prevent entry of rain and inspected regularly to ensure that they are free of leaks.</p>
<p>Biosecurity</p> <p>Properly designed and operating digesters present a minimal risk to biosecurity.</p>	<p>Digesters should be adequately enclosed to prevent the release of pathogens.</p> <p>The digestion process should be carried out within the range of operating parameters (physical and chemical) specified by the system designer, or as a condition of your approval (where required).</p>
<p>Waste</p> <p>Production of liquid effluent and digester sludge (digestate) is a by-product of the process.</p>	<p>Waste must be disposed of in accordance with state regulations and the waste management plan for the site.</p> <p>Where disposal to land is allowed, assess the risks of the application site in accordance with guidance given in sections 2.6, 2.14 and Appendix B.</p>

Table 33 Risks and controls associated with on-site burial

Risk	Control
<p>Legislative compliance</p> <p>State legislation and other regulations may apply to use of on-site burial.</p>	Consult with state regulators to determine legislative requirements (if applicable).
<p>Odour</p> <p>Odour emissions from dead bird burial can be significant if not done correctly.</p>	<p>Consult with state regulators or seek professional guidance on appropriate burial methods and odour management methods.</p> <p>Burial areas should be sited to minimise potential odour impacts off-site. Consider factors such as the location of sensitive receptors, and prevailing meteorological conditions.</p> <p>Burials should be immediately covered with soil or sawdust, etc., to reduce emissions of odour. Requirements vary between states, however a minimum of 30cm of covering material is recommended.</p> <p>Burial sites should be sized appropriately to ensure adequate space for burials and covering materials for each disposal. This can present significant operational and financial challenges.</p> <p>Cover full pits with at least 50cm of compacted clay.</p>
<p>Dust</p> <p>Dust may be generated when constructing, using and managing burial areas.</p> <p>Some dust generation may be associated with on-site vehicle movement.</p>	<p>Burial areas should be sited to minimise potential dust impacts off-site. Consider factors such as the location of sensitive receptors, and prevailing meteorological conditions.</p> <p>On-site vehicle movements should be minimised by careful planning of site layout and timing of operations.</p> <p>Reduce transport of dust by using vegetated buffers or other screening.</p>
<p>Traffic</p>	No impact to the local road network.
<p>Noise</p> <p>Noise may be generated by vehicle movements associated with disposal, and the operation of heavy equipment.</p>	<p>Time the operation of heavy plant to avoid nuisance at sensitive receptors.</p> <p>Minimise vehicle movements and mitigate any noise generated through appropriate separation distances and noise reducing screening such as vegetated buffers.</p> <p>Refer to section 2.12 for landscaping information.</p>
<p>Groundwater</p> <p>Groundwater contamination can occur where bird material leaches into the soil.</p>	<p>Refer to section 2.6.3 and Appendix B for more information on risks to groundwater.</p> <p>Ensure that the base of the burial area is at least 2m above the seasonal high water table level.</p> <p>Where risks are present, burial areas should be lined with an impermeable liner or compacted clay lining. This can be difficult to achieve effectively and may present significant operational and financial challenges.</p>
<p>Surface water</p> <p>Surface water contamination can occur where runoff mixes with bird material.</p>	<p>Refer to section 2.6.3 and Appendix B for more information on risks to surface water.</p> <p>Where risks are present, water should be excluded from the burial area through bunding or diversion banks/swales. Rain should be excluded by using roofed structures.</p>
<p>Biosecurity</p> <p>Burial of dead birds on-site presents significant biosecurity risk.</p>	<p>Burial areas should be adequately sealed when full as noted above, to minimise transmission vectors for pathogens.</p> <p>Risk of contaminated runoff should be minimised as noted above.</p> <p>Burial areas should be adequately fenced to prevent the entry of pests and feral animals.</p>

Appendix F. Greenhouse Gas (GHG) Emission Factors and NPI Reporting Values

Table 34 Manure greenhouse gas emission factors applied in the national inventory report

Emission source	Emission	NIR (CofA, 2015)
Poultry housing (manure with litter)	N ₂ O	0.001
	CH ₄	0.015
	NH ₃	0.3
Poultry housing (manure without litter)	N ₂ O	0.001
	CH ₄	0.015
	NH ₃	0.05
Free range (dry lot)	N ₂ O	0.02
	CH ₄	0.03 – QLD and NT 0.01 – All other states
	NH ₃	0.3*
Stockpile	N ₂ O	0.005
	CH ₄	0.02
	NH ₃	0.2
Composting (passive windrow)	N ₂ O	0.01
	CH ₄	0.005 – TAS 0.01 – All other states
	NH ₃	0.2
Direct processing	N ₂ O	0
	CH ₄	0
	NH ₃	0
Anaerobic digester/covered pond	N ₂ O	0
	CH ₄	0.1
	NH ₃	0
Atmospheric deposition		0.003

*This value is not explicitly reported in the NIR, however it is reported in the technical document underpinning the GHG emissions methods, cited in the NIR as Wiedemann et al. (2014 – see Chapter 4: References).

Table 35 Layer hen manure ammonia emission rates and factors applied in the National Pollutant Inventory

Housing type	Stock capacity required to trigger reporting ^A	NH ₃ (kg)/stock capacity ^A	NH ₃ -N (kg/kg excreted N) ^B
Layer – high rise	36,400	0.275	0.4
Layer – belt	294,100	0.034	0.05
Layer – barn	50,800	0.197	0.25
Layer – free range	40,500	0.247	0.30

^A (DSEWPaC, 2013 – see Chapter 4: References), ^B (FSA Consulting, 2007 – see Chapter 4: References).

Appendix G. Composting Manure and Poultry By-products

Any composting of by-products must comply with state legislation and frameworks, including guidance for composting facilities where required.

Composting can turn manure, spent litter and other organic by-products (e.g. mortalities, egg waste, waste cardboard etc.) into more marketable, value added and environmentally acceptable products. Composting is defined as the process whereby organic materials are microbiologically transformed under aerobic conditions for a period of not less than six weeks, which includes a pasteurisation phase (AS 4454) (Standards Australia, 2012 – see Chapter 4: References).

A range of factors influence the speed and completeness of composting. These factors can be controlled through appropriate selection of raw materials and management methods. The main factors influencing the compost process include:

- Carbon:Nitrogen ratio (ideally between 20:1 and 30:1 to avoid excessive loss of nitrogen).
- Surface area and particle size (rows approximately 1.2 m high and 2.4 m wide).
- Aeration.
- Porosity.
- Moisture content (ideally 40-50%).
- Temperature.
- pH of materials.
- Nutrients.
- Toxic substances.

Stabilised compost is easier to handle than untreated manure and spent litter (due to a decrease in volume and particle size). It does not emit odours or attract flies, is free of pathogens, does not contain viable weed seeds, is a more reliable source of nutrients for plants and an excellent soil conditioner.

A significant disadvantage of composting is that the process requires equipment, labour, water and management. Producers also need sufficient land, a suitable site and adequate storage facilities when composting. Other considerations include odour management, marketing (if producers wish to sell the product), loss of nitrogen and possible emissions of greenhouse gases.

Practical and detailed technical information is readily available for people seeking advice on how to compost. There is also an Australian Standard for Composts, Soil Conditioners and Mulches (AS4454:2012). This document is the benchmark for compost quality in Australia and applies to organic products and mixtures of organic products used to amend the physical and chemical properties of soils and other growing media.

The Australian Standard provides manufacturers, suppliers and government agencies with the minimum processing requirements for the elimination of pathogens and weeds. It also details reporting requirements for the physical, chemical and biological properties of products treated by pasteurisation or composting procedures. Table 36 lists the limits for contaminants in composts, soil conditioners and mulches.

Table 36 Limits for contaminants in compost, soil conditioners and mulches for unrestricted use (mg/kg)

Contaminant	ARMCANZ	NSW EPA	VIC EPA
Arsenic	20	20	20
Boron	–	–	100
Cadmium	3	3	1
Chromium (total)	400	100	100
Copper	200	100	150
Lead	200	150	150
Mercury	1	1	1
Molybdenum	4	–	–
Nickel	60	60	60
Selenium	3	5	5
Zinc	250	200	300

Sourced from: NRMCC (2004), NSW EPA (2000) and VIC EPA (2017 – see Chapter 4: References).

Australian Eggs has produced a series of factsheets on composting, covering the composting of by-products on egg farms through to composting equipment selection. These are available from Australian Eggs.

Wiedemann et al. (2008) produced an extensive report on composting organic waste in the egg industry, titled: “Composting Every Day Mortality and Other Wastes from Layer Farms. This can be found at: <https://www.australianeggs.org.au/dmsdocument/515-composting-every-day-mortalities-and-other-wastes-from-layer-farms>.

Appendix H. Managing Pests

Fly management

To manage and control flies:

- Monitor fly numbers to note population increases by:
 - keeping weekly records of population counts using white spot cards, sticky tapes of fly traps or a visual scoring system.
- Monitor for water leaks both in sheds and shed surrounds to control manure and litter moisture by:
 - regularly checking for drinker water pressure, leaking nipples/drinkers and pipes,
 - maintaining and repairing any faults identified during inspections,
 - providing adequate ventilation over manure and litter to aid rapid drying, and
 - diverting surface water around sheds and providing sufficient gradient to allow good drainage from by-product storage areas.
- Carefully manage manure and litter by:
 - cleaning out manure in low fly periods, if possible, and
 - preventing flies breeding in manure and litter after cleanout – both in temporary storage areas and when manure and litter are applied to soil as a fertiliser.
- Enhance populations of natural biocontrol agents by:
 - avoiding killing predators and parasites through inappropriate spraying, and
 - leaving a pad of manure at cleanout to encourage predators and parasites if biosecurity and other practical considerations allow.
- Use good sanitation practices, such as:
 - cleaning up spilt feed,
 - removing dead birds from sheds daily and storing them in a sealed container, and
 - mowing grass and clearing bushes from around sheds to facilitate airflow and remove fly resting sites.
- Selectively use insecticides to treat flies, including:
 - treating surfaces where large numbers of flies rest,
 - rotating insecticide groups,
 - using an ongoing baiting program, and
 - using fogging or misting (if fitted) for rapid knock down of high fly populations.
- Consider selectively using larvicides to treat manure and litter, including:
 - using only products safe to use with poultry and eggs,
 - using only products containing chemicals safe for natural predators and parasites,
 - using a spot treatment if problem sites with high maggot numbers can be identified,
 - strategically timing manure and litter treatments for problem periods,
 - using feed additives for periods of 4-6 weeks and then discontinue use for a similar period, or until maggots are again seen in manure and litter.

In the designated areas (shires) of Western Australia all poultry manure and spent poultry litter stored, used and transported must be treated to the Australian Standard for Composts and Mulches (2012) (Standards Australia, 2003 - see Chapter 4: References) to control fly problems. Local regulations must be checked to ensure compliance.

Rodent management

Design and maintain sheds to minimise rodents. This includes:

- Installing rat walls on sheds and blocking entry points with durable materials (iron grills, heavy gauge sheet metal and concrete), while avoiding the use of plastics, wood and soft metals.
- Regular monitoring of rodent numbers and response with a rodent control program.
- Minimising feed spillage and promptly cleaning up any spillage.
- Storing all potential feed sources and nesting materials in rodent-proof containers.
- Removing all rubbish (e.g. timber piles).
- Keeping all grass around complexes short.
- Minimising rodent breeding sites (e.g. holes, burrows).
- Maintaining a baiting program of anticoagulant rodenticides, tracking powders (e.g. poisonous dust) or gels and fumigants. If there is resistance to some baiting chemicals use an alternative chemical.
- Keeping baits in a dark safe place out of the reach of birds, other animals and children.

Darkling Beetles

Darkling beetles, *Alphitobius diaperinus*, breed in manure and litter within sheds or stockpiles on-farm. They damage insulation and wood structures and increase the risk of disease spread, including *Salmonella*. Lambkin (2001 – see Chapter 4: References) investigated management strategies for controlling the pest. This work found from a literature review and field studies that the beetle has an ability to avoid contact with insecticides, which contributes to control strategies failing. This behaviour, together with the use of clay floors also contributes to control problems, as many of the insects stay concealed in the floor and do not receive a lethal dose of insecticide. This work advocates an integrated pest management approach where the application of insecticides is varied to suit the geographical location. Composting, in combination with insecticides has been shown to be an effective management strategy (Roland et al., 2007 – see Chapter 4: References).

McGoldrick (2004 – see Chapter 4: References) suggests a number of control strategies, including:

- Improved facility design.
- New insecticides
- Biological control.
- Improved insecticide application techniques.
- Improved farmer awareness.
- Employing effective husbandry and hygiene techniques.

Appendix I. Vegetative Filter Strips

This appendix contains guidance on determining VFS width, as well as guidance on maintaining VFS to ensure on-going functionality.

Design of VFS Areas

The appropriate width of the vegetative cover strip depends on the slope of the land, the type of vegetative cover within the buffer area and whether there are other stormwater control devices, such as diversion banks. A vegetative filter strip (VFS) planted with runner-developing, non-clump forming grass can effectively reduce nutrient and sediment concentrations in the runoff. Wiedemann et al. (2018 – see Chapter 4: References) reviewed the literature on the effectiveness of VFSs. In areas amended with poultry manure, Chaubey et al. (1995), found vegetative filters reduced TKN by 81% and TP by 91%. Another investigation by Chaubey et al. (1994) reported similar results for areas treated with pig manure, with reductions in TKN of 65-87% and TP of 67-92%. Al-wadaey et al. (2012 – see Chapter 4: References) showed that vegetative filter areas reduced total P load by 68-76%, particulate P (PP) load by 66-82%: and dissolved reactive P (DRP) load by 73-66%, in a field experiment involving purpose-built nutrient-laden reservoirs. Carpenter et al. (1998 – see Chapter 4: References) in their review note that VFS reduce P transport to streams by 50-85% though the above studies demonstrate slightly higher nutrient removal.

Generally, wider VFSs reduce the soil loss rate from erosion. However, for the same soil loss rate, areas with higher slopes need a wider VFS than areas with lower slope due to the higher speed of runoff. To be most effective a VFS needs to be located as close as possible to the nutrient source to minimise additional runoff. It is also critical to locate the VFS before any convergence of runoff (i.e. drainage lines).

The design width recommendations that follow are based on the work of Karssies and Prosser (1999 – see Chapter 4: References). To determine the necessary width of a vegetative filter strip, consult Table 37 below. Figure 9 contains an example of using Table 37. Advice on determining each factor is given following Table 37.

Determine each factor from left to right, selecting the subsequent factor from within the sub-categories available. The process followed in the example is to:

1. First determine the rainfall factor – In this example, the site has a medium rainfall factor.
2. Then determine the soil erodibility – In this example: high.
3. Next determine the slope – In this example: low.
4. Finally determine the groundcover – In this example: good.
5. Determine the required VFS width – In this example: 5m.

If the capture of water is required as part of any condition of approval for a farm, a detention basin is preferred to a retention basin, as detention basins are designed to capture and settle nutrients and then slowly drain, rather than store water permanently which can create a higher biosecurity risk. These detention basins should be accompanied by a VFS to capture sediment and nutrients from the basin.

RAINFALL FACTOR	SOIL ERODIBILITY	SLOPE	FILTER WIDTH (Poor cover)	FILTER WIDTH (Good cover)	
Low	Low	Low	2	2	
		Medium	3	2	
		High	6	2	
	Medium	Medium	Low	2	2
			Medium	5	2
			High	11	2
	High*	High*	Low	2	2
			Medium	7	4
			High	16	10
Medium	Low	Low	2	2	
		Medium	6	2	
		High	12	2	
	Medium	Medium	Low	2	2
			Medium	13	2
			High	24	2
	High	High	Low	7	5
			Medium	22	5
			High	>30	5
High	Low	Low	2	2	
		Medium	13	2	
		High	24	2	
	Medium	Medium	Low	7	2
			Medium	26	2
			High	30	2
	High	High	Low	15	5
			Medium	>30	5
			High	>30	7
Very High	Low	Low	5	2	
		Medium	23	2	
		High	>30	2	
	Medium	Medium	Low	15	2
			Medium	>30	2
			High	>30	2
	High	High	Low	27	5
			Medium	>30	6
			High	>30	10
Extreme	Low*	Low	9	2	
		Medium	27	2	
		High	30	2	
	Medium	Medium	Low	20	2
			Medium	>30	2
			High	>30	2
	High	High	Low	>30	5
			Medium	>30	7
			High	>30	12

Figure 9 Example process for determining VFS width

Table 37 Determining vegetative filter strip width

RAINFALL FACTOR	SOIL ERODIBILITY	SLOPE	FILTER WIDTH (Poor cover)	FILTER WIDTH (Good cover)	
Low	Low	Low	2	2	
		Medium	3	2	
		High	6	2	
	Medium	Medium	Low	2	2
			Medium	5	2
			High	11	2
	High*	High*	Low	2	2
			Medium	7	4
			High	16	10
Medium	Low	Low	2	2	
		Medium	6	2	
		High	12	2	
	Medium	Medium	Low	2	2
			Medium	13	2
			High	24	2
	High	High	Low	7	5
			Medium	22	5
			High	>30	5
High	Low	Low	2	2	
		Medium	13	2	
		High	24	2	
	Medium	Medium	Low	7	2
			Medium	26	2
			High	30	2
	High	High	Low	15	5
			Medium	>30	5
			High	>30	7
Very High	Low	Low	5	2	
		Medium	23	2	
		High	>30	2	
	Medium	Medium	Low	15	2
			Medium	>30	2
			High	>30	2
	High	High	Low	27	5
			Medium	>30	6
			High	>30	10
Extreme	Low*	Low	9	2	
		Medium	27	2	
		High	30	2	
	Medium	Medium	Low	20	2
			Medium	>30	2
			High	>30	2
	High	High	Low	>30	5
			Medium	>30	7
			High	>30	12

* Based on author calculations and homogeneity with work of Karssies and Prosser (1999 – see Chapter 4: References)

Determining Rainfall Factor

The rainfall factor associated with the site is based on the erosivity of the rain and can be determined from mapping provided by CSIRO (Lu et al., 2001 – see Chapter 4: References).

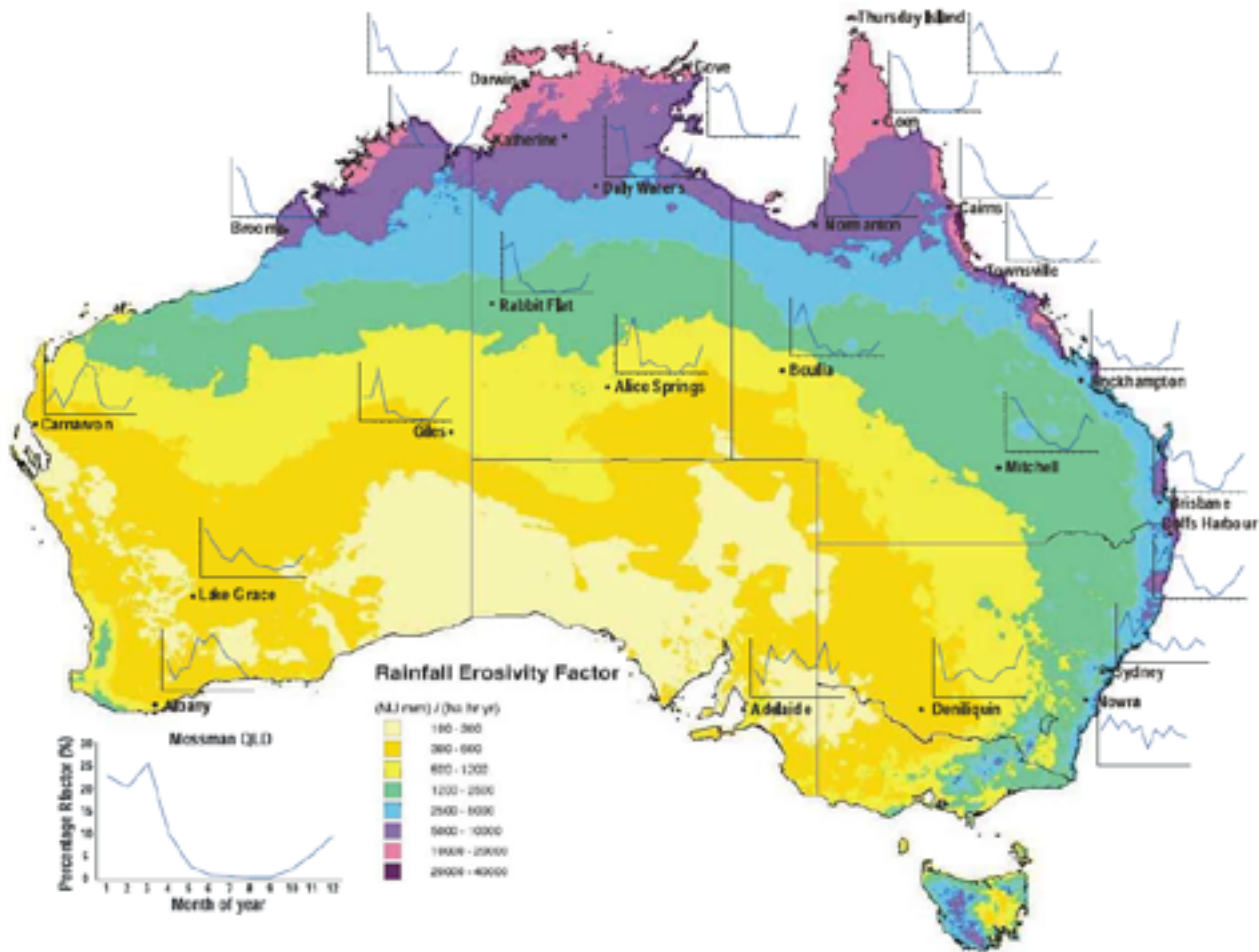


Figure 10 Map of rainfall erosivity (R factor) and its monthly distributions for selected locations (reproduced from Lu et al., 2001)

Table 38 Shows the risk rating associated with the rainfall erosivity. It is based on the risk ratings given in Karssies and Prosser (1999 – see Chapter 4: References).

Table 38 Rainfall erosivity factor

Rainfall Erosivity	Risk Level
<1425	Low
1425 – <3000	Medium
3000 – <5500	High
5500 – 8000	Very High
>8000	Extreme

Determining Soil Erodibility

Table 39 shows several soil types along with their erodibility factors as listed in Karssies and Prosser (1999). This table also shows the associated level of risk, based on those given in Karssies and Prosser (1999). Use this table to determine whether soil is a high, medium or low risk with respect to its erodibility.

Table 39 Soil erodibility factors

Soil Type	K factor	Risk
Black and red brown earths	0.05	High
Duplex soils	0.05	
Cracking clays	0.05	
Solodic soils	0.03	Moderate
Shallow loam soils	0.03	
Massive earths	0.03	
Podzol	0.03	
Non-calciic brown soil	0.02	Low
Structured earths	0.02	
Structured loam soils	0.02	
Sand	0.15	

Determining Slope Factor

The slope factor can be determined from Table 40 which is derived from the LS (length-slope) equation in the USLE (OMAFRA, 2015 – see Chapter 4: References). The level of risk associated with each score is based on Karssies and Prosser (1999) and determined by its contribution to total soil erosion.

To calculate the factor:

1. Determine the length of the slope in the direction of fall.
2. Determine the % slope (fall/length).
3. Lookup the LS value corresponding to these values from the table.
4. Determine risk, based on the colour of the cell:
 - o Red – High Risk.
 - o Orange – Moderate Risk.
 - o Green – Low Risk.

Table 40 LS factors

SLOPE	LENGTH												
	5	10	20	50	75	100	150	200	350	500	750	1000	1500
1	0.08	0.09	0.11	0.15	0.17	0.18	0.21	0.23	0.27	0.30	0.34	0.37	0.42
2	0.12	0.14	0.18	0.23	0.26	0.29	0.32	0.35	0.42	0.46	0.52	0.57	0.65
3	0.14	0.19	0.25	0.36	0.42	0.48	0.56	0.63	0.79	0.91	1.07	1.20	1.41
4	0.19	0.26	0.34	0.49	0.57	0.64	0.76	0.85	1.06	1.23	1.44	1.62	1.90
5	0.22	0.31	0.43	0.69	0.84	0.97	1.19	1.37	1.82	2.17	2.66	3.07	3.76
6	0.27	0.39	0.55	0.86	1.06	1.22	1.50	1.73	2.28	2.73	3.34	3.86	4.73
7	0.34	0.47	0.67	1.06	1.30	1.50	1.84	2.12	2.80	3.35	4.11	4.74	5.81
8	0.40	0.57	0.81	1.28	1.56	1.80	2.21	2.55	3.38	4.04	4.94	5.71	6.99
9	0.48	0.68	0.96	1.51	1.85	2.14	2.62	3.02	4.00	4.78	5.86	6.76	8.28
10	0.56	0.79	1.12	1.77	2.16	2.50	3.06	3.54	4.68	5.59	6.85	7.90	9.68

Derived from OMAFRA (2015). Available at: <http://www.omafra.gov.on.ca/english/engineer/facts/12-051.htm#6>

Determining Groundcover Type

Table 37 gives recommendations based on the site having different levels of groundcover cover. Descriptions of these ratings are shown in Table 41, where red cells correspond with 'Poor' cover, and green with 'Good'. These cover factors (C Factor) and associated risk ratings are based on the work of Karssies and Prosser (1999) and relate to the proportion of soil lost under each of these production systems.

Table 41 Groundcover type

Cover Type	C Factor
Traditional cropping	0.2
Improved cropping practices	0.1
Permanent pasture (80% annual groundcover)*	0.01
Permanent pasture (40% annual groundcover)	0.1

**Permanent pasture with 80% groundcover is understood to produce one tenth of the soil loss associated with either improved cropping or low groundcover pastures.*

Maintenance of VFS Areas

VFSs operate more effectively when they are maintained to allow water to evenly flow through them and avoid convergence of flow. This will slow the velocity of the runoff and allow contaminants to settle from the water and reduce the potential for erosion. When operating effectively they will be able to remove a majority of the soil and manure particles. They are however not as effective at removing dissolved nutrients.

To maintain effective operation of a VFS:

1. Remove sediment build up at the higher end of the drain or VFS to avoid any ponding.
2. If the VFS becomes denuded, consider treatments to maintain high rates of groundcover, or reseed the VFS with runner type grasses. Seek guidance on appropriate species.
3. Water during dry periods to maintain effective grass coverage over the VFS. Where appropriate (depending on environmental regulations), alternative water sources should be used to avoid use of potable water.
4. Maintain sediment and erosion control measures upslope of the drain or VFS to reduce the sediment load.
5. Ensure livestock do not damage the VFS.
6. Avoid using VFSs for traffic.
7. Avoid leaving tyre or tillage marks in VFSs when maintenance is required.
8. Remove any woody stem plants before they exceed 50 mm in diameter from VFSs.
9. Avoid damaging VFSs with herbicides and use mowing and slashing to control weeds.
10. Consider a cut and cart operation from the VFS to remove mature plant material and promote new growth.

Appendix J. Community Consultation

Henderson and Epps (2001 – see Chapter 4: References) summarised the benefits of community and regulator consultation for new and existing poultry farms. Implications for new farms include:

- It is recommended that industry participate in forums where state government departments are consulted at an early stage of a proposal, such as a planning focus meeting.
- Gaining necessary state permits and approval prior to seeking planning/development approvals can streamline the process. However, state and local government can have different requirements and information needs, and this may still result in duplication and delay. Furthermore, there is no guarantee that planning/development approval will be granted even once state approvals have been granted.
- If an environmental impact statement is required, it needs to be carefully considered and prepared. This document usually represents a small cost to the overall development. It can save time and hence money and overcome the problem of local government continually asking for additional information.

Implications for existing farms include:

- Farmers need to be seen to be doing something to resolve environmental problems. Simple actions may prevent neighbours from complaining, may improve local government attitudes and prevent state governments from introducing tougher forms of environmental regulation. Actions might include planting vegetative barriers, putting up light or dust screens, making sure dead birds and manure are properly and quickly disposed of, and watching for fly breeding activity and responding quickly with control measures.
- When approached by neighbours, farmers need to listen carefully and take their concerns seriously.
- Dealing openly with neighbours, perhaps by conducting a farm tour to explain how the farm operates and to show what is being done to minimise externalities, may prevent conflict from developing and local government may not become involved.
- Keep open lines of communication with local residents, especially in relation to notifying them of significant events, such as the removal of birds and by-products.

Appendix K. Collection, Storage, Handling and Treatment of Samples

When collecting, storing, handling and treating samples, state legislative requirements need to be consulted in the first instance. Where applicable, consult Australian standards for further guidance. The advice given in this appendix is based on that given in the National Environmental Guidelines for Piggeries – Second Edition (Tucker et al., 2010 – see Chapter 4: References).

Before undertaking any sampling, plan how this will be undertaken:

1. Select a laboratory.
2. Organise transport.
3. Identify sampling locations.
4. Assemble sampling equipment.
5. Understand the sampling procedure.
6. Find the monitoring intervals required.
7. Record sample information.
8. On-farm measurements.

Many regulatory agencies and/or laboratories have their own water quality monitoring guidelines. Advice should be sought from the relevant agency before planning sampling and monitoring procedures. In the absence of specific advice from the applicable agency, the following guidelines may be used.

1. Select a Laboratory

National Association of Testing Authorities, Australia (NATA) accredited laboratories are preferred for sample analysis. Check that the laboratory is NATA-accredited (or equivalent) for the analyses needed. Analysis methods vary between laboratories, which may affect results.

2. Organise Transport of Samples

Samples should arrive at the laboratory within two days of sampling and must be kept on ice over this whole time period. If this is not possible, you may need to freeze your samples (consult the laboratory). If you cannot take samples directly to the laboratory yourself, identify a courier that can transport the samples to the laboratory within the required time frame between collection and analysis. You should schedule sampling to coincide with courier dispatch to minimise the amount of time between sampling and analysis. Ideally, sampling should occur on a Monday or Tuesday so that samples arrive at the laboratory and are promptly analysed rather than having to sit over a weekend.

3. Identify Sampling Locations

Solid By-Products

For each type of solid by-product, a separate sample is needed (e.g. manure, spent litter and each type of compost). If manure is spread fresh, then a fresh sample should be collected. If manure is composted before spreading, then a composted sample should be collected.

Soils

For soils each sampling location should represent a particular type of soil and general land use (including land use and solids spreading rates).

The following steps will help you decide how many sampling locations are needed:

- Divide each area used for solids spreading according to soil types. Dig some holes and compare the soils of each hole (recording information as you go is important!).
- Divide each area on the basis of land use as sustainable spreading rates vary widely depending on whether the land is grazed or used to grow a crop. Areas with different land uses should be monitored separately. However, it is not necessary to provide a monitoring plot in each separate paddock if there are similar land uses between paddocks with the same soil type.

- Divide each area on the basis of by-product type (e.g. manure, spent litter or compost) and application rate. For instance, there might be two major soil types on your farm. If both soil types are used for growing cereal crops and for manure application, but at two different rates, you have four different soil type/land use combinations (soil 1 low rate, soil 1 high rate, soil 2 low rate, soil 2 high rate). Similarly, if there is one soil type, but two different land uses (e.g. cereal crops or grazing), you will have two soil type/land use combinations (soil 1 land use 1, soil 1 land use 2).
- Identify a 20m diameter sampling plot for each soil type, by-product and land use combination. This area should be representative of the area with the highest level of environmental risk. For instance, if you have two areas of land with similar soils and land uses but different manure application rates, you may monitor only the area with the highest manure application rate. This area should also be free from stumps, atypical rockiness, tracks, animal camps and other unusual features.
- For each soil type to be monitored, you should also locate a 20m diameter background monitoring plot on an area that has not been used for solids spreading or conventional fertiliser spreading. This will be used to compare with monitoring plot data from the solids spreading areas. It is recognised that it is not always easy to find a suitable background plot.
- Mark the location of the plots on your property map so that you can come back to the same area in subsequent years (keep using these sites from year to year). Use GPS waypoints where feasible to ensure consistency.

4. Assemble Sampling Equipment

The sampling equipment may include:

- Appropriate sample containers and preservatives. Most laboratories will supply suitable sample containers, as well as any necessary preservatives. Obtaining sample containers from the laboratory reduces the chance of sample contamination and ensures that the sample size is adequate.
- A sampling rod: A rod with a large clamp for holding the sampling container allows greater reach when sampling.
- A bucket that has been washed several times with clean water.
- Cheap, styrofoam eskies.
- Plenty of crushed ice to pack around the samples in the eskies.
- Waterproof pen to mark sample bottles.
- Waterproof tape to seal eskies.
- Personal protective clothing.
- Analysis request forms. Most laboratories have their own analysis request forms and prefer these to accompany samples. Some of the details on the forms can be completed prior to sampling. (e.g. name, sampling location and analysis parameters). However, some details can only be completed at sampling (e.g. time of sampling). If analysis request forms are not provided, you will need to make up your own.
- Envelope that analysis request forms will fit in.
- Pen to complete analysis request form.

Solid By-Products

Sampling containers will either be wide-mouthed sampling bottles or plastic bags. Bottles may better suit high moisture solids. It is recommended that you obtain these from the chosen laboratory. Bags will suit drier products.

Additional equipment may include:

- A shovel.
- A small garden trowel.

Soils

For sampling of soils, additional equipment may include:

- Soil auger or hydraulic soil sampling rig (these can be hired).
- Plastic sample bags. Most laboratories will supply suitable sample bags.
- Ruler or tape measure.
- Hand trowel.
- Plastic sheet.
- A bucket that has been washed several times with clean water.

5. Understand Procedures of Collection and Dispatch of Samples

Solid By-Products

1. Assemble the sample containers and the sample preservatives.
2. With a waterproof pen, label the sample containers with the enterprise name, your telephone number, a unique sample number (new numbers should be used at each sampling), the sampling location, and the date of sampling. Label the container instead of the lid, as lids can get mixed up in the laboratory.
3. Complete as many details of the analysis request forms as possible. This should include: contact details, sample numbers (matching those recorded on the sample bottles), sampling location, sampling date and analysis parameters.
4. Fill eskies with ice.
5. Put on disposable gloves and dust mask (if sampling dusty products). When sampling, do not eat, drink or smoke. Carry out standard hygiene practices.
6. If sampling from a stockpile (manure, spent litter, compost): Use a clean shovel to collect 25 samples of solids (sample size should be about a cup). As you collect each sample, place in the bucket and thoroughly mix with the garden trowel. Place about four cups of the mixed sample into a bottle or bag and seal. Put the bag or bottle inside another bag and seal well.
7. Immediately place the sample in an esky, pack crushed ice completely around it and replace the esky lid. Store the esky in the shade.
8. If samples will take longer than 48 hours to get to the laboratory, they should be frozen. Do not completely fill the sample bottle/bag if you intend to freeze the sample.
9. When all samples have been added to the esky, seal it with the waterproof tape.
10. Thoroughly wash your hands.
11. Complete the analysis request forms and photocopy for your own records (if you have access to a photocopier or fax machine). Place the original forms in an envelope. Clearly address the envelope to the laboratory and add their phone number. In smaller writing, put your own address and phone number on the envelope as "sender". Firmly tape the envelope to the top of the esky. Store the esky in the shade.
12. Deliver the samples or arrange for courier delivery.
13. Contact the laboratory to confirm that the samples were received within 48 hours of sampling.

Soils

Samples should be collected from the 0-0.1m (0-10cm), 0.2-0.3m (20-30cm) and 0.5-0.6m (50-60cm) depths. If the base of the root zone is below 0.6m, it is also useful to collect a deeper sample (1.5-2.0m).

Either a bulked sample representative of the entire crop or pasture root depth, or alternatively, a number of samples at different intervals, could be sampled and analysed to determine the PBI (see Appendix L for details).

It is important never to:

- bulk (mix) soils of two different types,
- mix soil layers (profiles) that are clearly different from each other, or
- bulk in depths greater than 0.3m.

1. Assemble the sample containers and the sample preservatives.
2. With a waterproof pen, label the sample containers with the enterprise name, your telephone number, a unique sample number (new numbers should be used at each sampling), the sampling location and the date of sampling. Label the container instead of the lid, as lids can get mixed up in the laboratory. When labelling the sample bags, remember to include the sampling depth (e.g. 0-0.1m).
3. Complete as many details of the analysis request forms as possible. This should include: contact details, sample numbers (matching those recorded on the sample bottles), sampling location, sampling date and analysis parameters.
4. Fill eskies with ice.

Topsoil Sampling

1. From random locations within each 20m diameter sampling plot, collect 25 equal-sized samples of soil to a depth of 0.1m (10cm). As you go, record a description of the soil sampled. Combine all of the samples in the bucket and thoroughly mix using a hand trowel. Remove rock fragments exceeding 2cm diameter and large roots. Break up large clods.
2. Pour the mixed composite sample into a small pile on the plastic sheet. Divide the pile into four quarters. Discard three and thoroughly mix the remaining quarter. Divide this remaining quarter into four further quarters, and keep repeating the procedure with the remaining quarter until the sample size is small enough to fill the sample bag (generally about 0.4-0.5kg or 1lb). Fill the sample bag and immediately place it in an esky.

Subsoil Sampling

1. From random locations within each 20 m diameter sampling plot, drill at least five holes to collect subsoil samples. (Drilling more holes provides a more reliable sample. Eight holes are preferred). As you go, record a description of the soil encountered.
2. Combine all the samples from the same depth in the bucket and thoroughly mix using a hand trowel. Remove rock fragments exceeding 2cm diameter and large roots. Break up large clods.
3. Use the same mixing and sub-sampling procedure as for the 0-0.1m sample to obtain a 0.4-0.5kg sample for each depth. Place the sample in the esky.

Storage and Transport

1. Immediately place the sample in an esky, pack crushed ice completely around it and replace the esky lid. Store the esky in the shade.
2. If samples will take longer than 48hours to get to the laboratory, they should be frozen. Do not completely fill the sample bottle if you intend to freeze the sample.
3. When all other samples have been added to the esky, seal it with the waterproof tape.
4. Thoroughly wash your hands.
5. Complete the analysis request forms and photocopy for your own records (if you have access to a photocopier or fax machine). Place the original forms in an envelope. Clearly address the envelope to the laboratory and add their phone number. In smaller writing, put your own address and phone number on the envelope as "sender". Firmly tape the envelope to the top of the esky. Store the esky in the shade.
6. Deliver the samples or arrange for courier delivery.
7. Contact the laboratory to confirm that the samples were received within 48 hours of sampling.

6. Find the Monitoring Intervals Required

Solid By-Products

This should be based on the level of environmental risk. If monitoring results for the quality of the solid by-products over several years indicates similar results, the level of monitoring should be reduced from every year to say every three years, unless unusual circumstances that could result in an adverse environmental impact occur in the meantime.

Soils

This should be based on the level of environmental risk. If on-going monitoring shows no adverse change in soil health or environmental risk, sampling frequency should be reduced. Sampling should occur before onset of the wet season (due to increased nutrient loss risk).

Plants

For most layer farms, analysis of plant composition should not be required. At a maximum, this should be once per crop (at harvest).

7. Record Sample Information

Solid By-Products

It is suggested that original copies of solid by-product analyses be kept for at least five years or as required by your licensing conditions. Each time solids are spread on-farm, record the date, the paddock involved and the quantity of solids (m³, t) involved. Use the analysis results to calculate appropriate spreading rates depending on possible land uses (m³/ha or t/ha).

If solids are removed off-site, record the date, the volume of material involved, the type of material involved, the recipient's name and the proposed use (e.g. where the material will be spread, the land use of the area involved and the application rate).

If solid by-products are reused off-site, provide recipients with a copy of the analyses each time these products are analysed. Recipients can use the analyses to calculate appropriate spreading rates depending on preferred land uses. Advise by-product recipients of the appropriate spreading rates.

Soil Properties

Original copies of soil analyses should be kept indefinitely along with records of sampling locations and land use. This assists with long-term farm management.

Production from Land Area

Each time crops are harvested from by-product spreading areas record the yield harvested. Calculate the dry matter yield and the approximate nitrogen and phosphorus removal rates.

8. On-farm Measurements

Quantity of Solid By-Products Spread

If a manure or fertiliser spreader is used to spread solids, the spreading rate may be calculated from the volume of the storage hopper, the area of land for spreading and the bulk density of the solids (as per tanker method). Alternatively, you can determine the mass of the solids by weighing the truck or spreader filled with solids then subtracting the net weight of the truck or spreader.

The quantity of solids spread, and the paddock involved, should be recorded each time spreading occurs.

Yield of Plants

It is generally adequate to estimate the nutrients removed from an area by yields and textbook nutrient concentrations of plants.

Measure yield of plants harvested by weighing or by estimating weight from the number of truck-loads removed. For a crop, the yield from an area should be recorded and a yield per hectare calculated (divide the total yield for the paddock (t) by the area of the paddock (ha)). The yield should then be converted to a dry matter yield. As a guide, grain crops have a dry matter content of about 88% and hay has a dry matter content of about 90%. Fresh harvested forage crops vary more.

If you harvest 4 t/ha of barley, the dry matter yield is about 3.5 t/ha ($4 \text{ t/ha} \times 88/100$). From Table 24, a 4 t/ha winter cereal crop removes about 80kg N/ha and 12 kg P/ha. Hence, the 3.5 t/ha crop will remove about 70kg N/ha and 10.5kg P/ha (i.e. $80\text{kg N/ha} \times (3.5\text{t}/4\text{t})$; $12 \text{ kg P/ha} \times (3.5\text{t}/4\text{t})$).

Laboratory determination of the dry matter and plant tissue analysis can more accurately determine the nitrogen and phosphorus concentration of the harvested material. This should only be required in borderline cases, for example where removing sufficient nutrients relies on nutrient uptake greater than would be typically seen for a particular plant species (luxury uptake).

Appendix L. Soil and Water Testing Costs

This appendix comprises a listing of typical tests and some common/approximate costs of their analysis. The need for any testing should be based on environmental risk and is not necessary for all sites. When undertaking any testing it is important to check state legislative requirements and licence conditions.

The following information is only indicative and should be confirmed by contacting the laboratory or by visiting the NATA website: www.nata.com.au. It is recommended that you contact several laboratories prior to submitting samples to confirm that all required analyses are possible. Most laboratories offer a suite of agricultural tests that include typical tests included in soil or water testing for agriculture.

Below are listed some example costings (2017) requested by a range of laboratories.

Water

- Agricultural package** – Total N in water, Ammonia, Nitrate N, Total P, EC, Chloride, Sodium adsorption ratio, Biochemical O₂ demand, Chemical oxygen demand = Approximately \$280.
- Surface water package** – Suspended solids (SS), Total nitrogen (TN) or total Kjeldahl nitrogen (TKN), nitrate-nitrogen (NO₃-N), total phosphorus (TP), ortho-phosphorus (ortho-PO₄P), pH & electrical conductivity (EC) = Approximately \$150.
- Groundwater package** – Total nitrogen (TN) or total Kjeldahl nitrogen (TKN), nitrate-nitrogen (NO₃-N), pH & electrical conductivity (EC) = Approximately \$140.
- Faecal coliforms and ecoli** – Faecal coliforms and Ecoli - Total nitrogen (TN) or total Kjeldahl nitrogen (TKN), ammonia-nitrogen (NH₃N), nitrate-nitrogen (NO₃-N), total phosphorus (TP), ortho-phosphorus (ortho-PO₄P), potassium (K), pH, electrical conductivity (EC) and sodium absorption ratio (SAR) = Approximately \$170.
- Solid by-products** – Total nitrogen (TN) or total Kjeldahl nitrogen (TKN), ammonia-nitrogen (NH₃N), nitrate-nitrogen (NO₃-N), total phosphorus (TP), potassium (K), carbon (C), pH and electrical conductivity (EC) = Approximately \$120.

Soil

- Agricultural soils package 1** – pH, EC, Exchangeable Cations and ECEC plus ESP, Nutrients (TN, TP, TKN, NO₂, NO₃, NH₃ and NO_x) = Approximately \$130.00.
- Agricultural soils package 2** – Includes all of example 1, plus Chloride (1:5), pH (CaCl₂) Colwell P and K, DTPA extractable Fe, Cu, Zn and Mn, Organic Matter and Organic Carbon (by Walkley-Black) = Approximately \$245.00.
- Agricultural soils package 3** – EC, Exchangeable cations, Nitrate N, Organic Matter (by Walkley-Black), P Buffer index, P sorption index, P sorption capacity, pH, Colwell P, Total N, Total P = Approximately \$245.

Other commonly included tests:

- Emerson test** = Approximately \$45.
- Particle size analysis** = Approximately \$75-195 (depending on size and type of test).
- Phosphorus buffer index (PBI)** = Approximately \$20 (\$30 if corrected with Colwell P).

Plants

- Package for plant/manure analysis** – Ammonia, Ash, Chloride, Nitrate N, Total N (Dumas Combustion), Organic Carbon (Ignition), Minerals (Ca, Mg, P, Na) = Approximately \$160.

Laboratories vary widely in their fee structures and costs. Some laboratories have separate charges for sample preparation, while others do not. Some supply quotes including GST, while others exclude GST. It is well worth getting quotes from two to three laboratories. Ask them to provide a quote including the total cost you will be invoiced. If you have specific tests requested by an agronomist or for environmental reporting purposes, it is also important to ask for a specific quote for your needs.

Appendix M. Community Feedback, Complaint Recording and Subjective Monitoring

Table 42 Community Feedback/Complaint Register

Community Feedback/Complaint Register						
Date						
Time						
Details						
Distance and direction to complainant						
Name of person advising of complaint						
Method of complaint delivery						
Name of complainant						
Complainant contact details						
Investigation Details						
Temperature at time of complaint	Cold	Cool	Mild	Warm	Hot	Very hot
Wind strength at time of complaint	Calm	Light	Moderate	Fresh	Strong	Gale
Wind direction at time of complaint						
Person responsible for investigating complaint						
Investigating method						
Findings of investigation						
Action Taken						
Corrective actions						
Communications with complainant						

- **STEP 1:** Using the German VDI 3882 (VDI-RICHTLINIEN, 1993 – see Chapter 4: References) odour intensity scale in Table 44 below, record odour intensity every 30 seconds over a 10 minute period.
- **STEP 2:** Enter the highest intensity level experienced during the 10-minute period into the record below.
- **STEP 3:** When an odour intensity of A-D is experienced, corrective action is required.

Table 44 GERMAN VDI 3882 odour intensity scale

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

Table 45 Odour assessment record

Name	Date	Time	Wind direction	Wind strength	Odour Monitoring Point				
					MP1	MP2	MP3	MP4	MP5

Table 46 Dust assessment record

	Name	Date & time	Wind direction	Wind speed	Dust from poultry farm	
					Absent	Present
MP1						
MP2						
MP3						
MP4						
MP5						

