On-farm Biosecurity Risk Identification Framework for the Australian layer industry

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A report for Australian Eggs Limited by

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Foreword

This report is designed as a support tool for Australian egg producers when determining biosecurity risks on-farm. Egg producers cannot be expected to adequately undertake an on-farm risk assessment without first understanding what constitutes a risk, and why. Biosecurity helps to protect hens from diseases that may cause morbidity or mortality, but also identifies food safety pathogens that may cause human illness (e.g. *Salmonella*). Minimising the incidence of disease in layers and the presence of human food safety pathogens are critical in maintaining a viable egg business.

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This report is an addition to Australian Eggs Limited's range of peer reviewed research publications and an output of our R&D program, which aims to support improved efficiency, sustainability, product quality, education and technology transfer in the Australian egg industry.

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Printed copies of this report are available for a nominal postage and handling fee, and can be requested by phoning (02) 9409 6999 or emailing research@australianeggs.org.au.

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Dr Greg Underwood is a specialist poultry veterinarian with 25 years' experience in the Australian poultry industry. Greg holds a PhD from the University of Bristol in infectious diseases of poultry, and has an interest in exotic disease outbreak management having served as the Industry Liaison Officer of the 2013 Avian Influenza outbreak in Young, and as a Government officer for the Avian Influenza outbreak in Tamworth, 1997. Greg has held senior executive positions in egg layer and meat breeding companies and vaccine manufacturing companies. Greg has served on the Australian Egg Industry Consultative Committee and is a current member of the AgriFutures Chicken Meat advisory panel, and is a consultant to the Australian poultry industry.

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Abbreviations

AE	Avian Encephalomyelitis
AECL	The Australian Egg Corporation Limited (now Australian Eggs Limited)
AHA	Animal Health Australia
AI	Avian Influenza
EAD	Emergency Animal Disease
EDS	Egg Drop Syndrome
HPAIV	Highly Pathogenic Avian Influenza Virus
IBV	Infectious Bronchitis Virus
ILT	Infectious Laryngotracheitis
MD	Marek's Disease
MDV	Marek's Disease Virus
ND	Newcastle Disease
NDV	Newcastle Disease Virus
vvIBD	very virulent Infectious Bursal Disease
vvIBDV	very virulent Infectious Bursal Disease Virus

1 Introduction

In Australia, the egg industry is an important, intensive animal production system. The industry comprises several large producers, which make up approximately 50% of the national flock numbers, as well as medium sized producers, an increasing number of small niche market segments, and some backyard production. There were 6.2 billion eggs produced in the 2017-18 financial year, which is an average of 16.9m eggs per day. Egg consumption in Australia has risen strongly over the past decade, effectively doubling to 245 eggs per person per year in September 2018, or 4.7 eggs per person per week. This represents a total industry value of $819.6m. Currently, Australia does not import intact shell eggs for human consumption due to biosecurity risks. Imported egg products are either preserved, cooked, pulped, or in powder form (Australia Eggs Ltd, 2018).

There are three egg production systems in Australia: cage, barn, and free range. Organic egg production is a niche segment within free range. Eggs are produced in all states and the Australian Capital Territory, and there are some small free range farms in the Northern Territory. New South Wales/Australian Capital Territory (~32%), Queensland (~28%) and Victoria (~22%) produce most of the overall egg production in Australia, with Western Australia contributing 11%, South Australia 7% and Tasmania less than 0.5% (Australia Eggs Ltd, 2018). There are also several breeding facilities spread throughout these states and territories.

Biosecurity is an integral part of any successful poultry production system. As defined in the National Farm Biosecurity Technical Manual for Egg Production (AHA, 2015), biosecurity refers to those measures taken to prevent or control the introduction and spread of infectious agents to a Flock. Such infectious agents, whether they cause clinical or subclinical disease to hens or human foodborne illness (e.g. *Salmonella*), can significantly reduce the productivity, profitability and long-term financial viability of a poultry operation and potentially the entire industry.

Currently, the level of understanding of biosecurity varies across the industry. However, as this is a technically complex issue with varying risks (and varying understandings of the risks) between farms and other horizontal contacts, an effective management strategy will need to: 1) be a collaborative effort that relies on the development of good relationships between industry, ancillary service providers and government agencies/regulators; 2) be founded on objective information; and 3) involve a system (or systems) to control biosecurity risks on-farm and with associated contacts.

Each producer has a responsibility to identify and address their own biosecurity risks. Due to the complexities associated with biosecurity risk assessment, producers require guidance from experts in this field to ensure they cover the scope (risk identification), impact (risk likelihood and consequence rating), and have insight to control options (risk management). Important factors that can impact on farm biosecurity include:

- layout and boundaries of the Property and Production Area (natural and man-made)
- regional disease challenges
- proximity to other Production Areas with avian and/or porcine species
- proximity to large water bodies
- presence and type of wildlife in the area (especially waterfowl)
- live poultry movement outside the boundary of the Property
- choice and implementation of vaccination and health management programs
- source of water and feed supply
- movement of personnel, contractors, vehicles and equipment, especially their contact with other poultry/poultry products, and
- egg handling and cartage (especially fillers).

Australian Eggs has recently updated and produced the National Farm Biosecurity Technical Manual for Egg Production (AHA, 2015), in conjunction with Animal Health Australia, and facilitates knowledge sharing with other poultry industries as to what constitutes risk on a poultry farm in general. This current report captures the risks laid out in the National Farm Biosecurity Technical Manual for Egg Production and highlights why each is considered a risk – this is essential when explaining concepts and motivating action – and potential options for how these risks could be managed. Each farming operation is different, so the focus of each risk assessment, the level of risk for each site (likelihood and consequence), and the mitigation options require a customised approach for each site and, ideally, involve the key farm stakeholders, especially management, veterinarians and employees.

2 Principles of biosecurity

Biosecurity helps to protect hens from pathogens that may cause diseases that result in morbidity, mortality or reduction in egg production, and also food safety pathogens that may cause human illness (e.g. *Salmonella*). Minimising the incidence of disease in layer hens, and the presence of human food safety pathogens, are critical in maintaining a viable egg business.

2.1 Definitions

This report follows the flow of direct and indirect contacts, or 'risks', from outside the Property to the Flock (Figure 1). The definitions used in this document are aligned with the National Farm Biosecurity Technical Manual (AHA, 2015) and include:

Biosecurity is the principle of prevention and control of the transfer of micro-organisms that can cause disease to humans or animals.

Flock refers to all commercial poultry on the farm, regardless of age or housing environment.

Horizontal contact points include regional and supplier/customer contacts that may be direct or indirect with other poultry or avian pathogens, including: litter source/disposal; new stock; spent hen disposal; transport vehicles; other farms/regional poultry farms.

Production Area refers to the poultry sheds, including range, entry foyer and air intake areas, egg collection, grading and storage areas, feed production and storage areas, dry stores, loading pads and roadways in the immediate vicinity of the poultry houses.

Property refers to the land and buildings within an external perimeter fence that people, livestock and vehicles regularly access, including: the Production Area; dead bird storage; water supply and treatment; equipment storage; on-farm vehicles; manager's residence and staff amenities.

Risk refers to the probability that a procedure, contact, or feature could lead to the transfer of pathogens to the Flock.

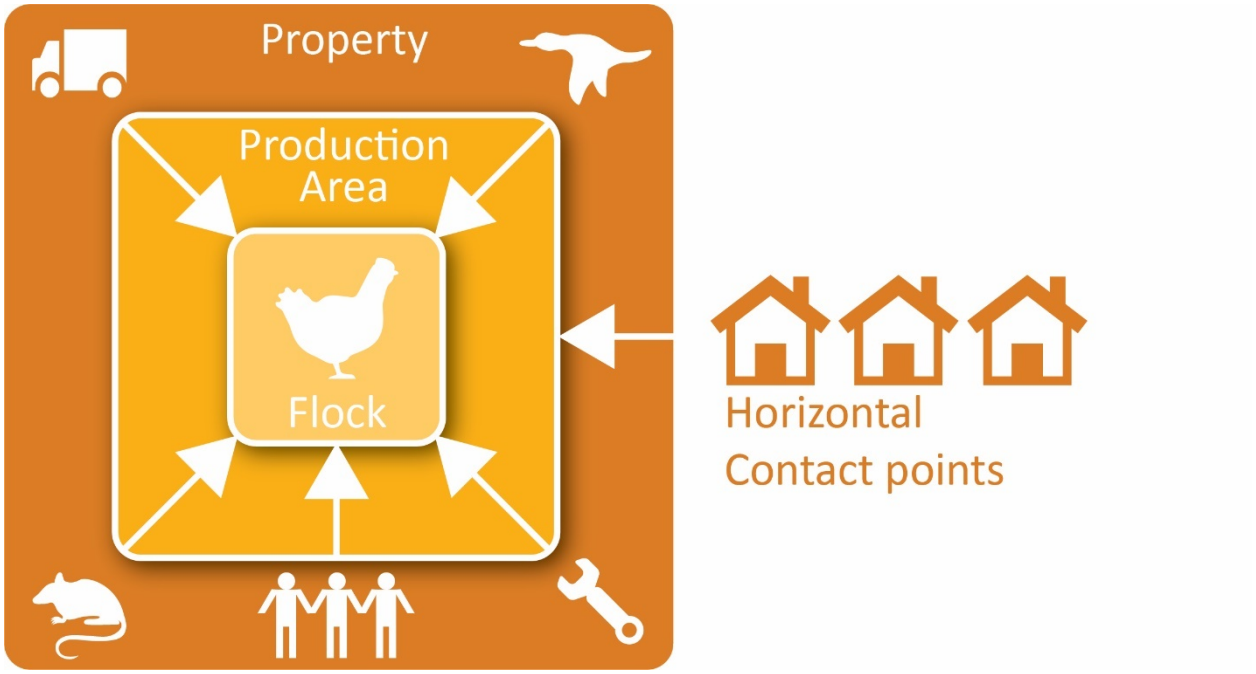

Figure 1 Flow of biosecurity risk to layer hens

2.2 Emergency animal diseases

Emergency Animal Disease (EAD) is a disease that has met one or more of the following criteria:

- It is a known disease that does not occur in endemic form in Australia, including (without limitation) the diseases that are in the national interest to be free of.
- It is a variant form of an endemic disease, which is itself not endemic, caused by a strain or type of the agent, which can be distinguished by appropriate diagnostic methods, and which if established in Australia would have a negative national impact.
- It is a serious infectious disease of unknown or uncertain cause, which may be an entirely new disease based on the evidence available at the time.
- It is a known endemic disease but is occurring in such a fulminant outbreak form (far beyond the severity expected) that an emergency response is required to ensure that there is not a large-scale epidemic of national significance or serious loss of market access.

EADs for the poultry industry include avian influenza (AI), very virulent infectious bursal disease (vvIBDV) and Newcastle disease (ND), which can cause devastating impacts to a poultry farming operation and the industry. Occurrence of these diseases is unusual, and can be devastating to a business, region and/or industry.

2.3 Endemic disease

An endemic disease is one that belongs exclusively to, or is confined to, a particular location. In the context of poultry diseases, this means any disease that is known to occur, and recur, in Australian poultry flocks. Endemic disease includes Marek's disease (MD), infectious bronchitis virus (IBV), avian encephalomyelitis (AE), Egg Drop Syndrome (EDS), *Mycoplasma gallisepticum*, infectious laryngotracheitis (ILT), etc. These diseases are more likely to occur on Australian eggs farms and biosecurity should prioritise the exclusion of these diseases. Biosecurity practices that exclude endemic diseases (other than vaccination) are also expected to significantly reduce the risk of emergency disease occurrence.

2.4 Human foodborne illness

A major reputational and public health issue for the egg industry is the presence of *Salmonella* spp. (particularly some *S. Typhimurium* serotypes), which can cause salmonellosis in humans throughout the supply chain. The presence and spread of *Salmonella* depends on numerous variables, so there is no single effective control measure. However, biosecurity practices that reduce the incidence of endemic diseases are also considered to significantly reduce the incidence of foodborne pathogens associated with eggs. While transfer of antimicrobial resistant bacteria is considered a low risk in Australian egg production, it is still important to note the biosecurity principles that can reduce the risk of antimicrobial resistant bacterial transfers.

3 Principles of risk

3.1 Objective of risk identification

This report is designed to help Australian egg producers identify biosecurity risks in their operation, understand why these are biosecurity risks, and provide an indication of how to improve the management associated with the risks. More specifically, this report identifies risks associated with the transfer of disease agents:

- to poultry associated with horizontal contact
- from an infected area to an uninfected area, and
- to humans.

This report provides producers a guide to:

- identifying biosecurity risks
- determining why each is considered a biosecurity risk, and
- some potential options available to reduce each risk.

This document is NOT intended to provide a complete risk assessment and risk control framework, as these are specific to each operation and should not be generalised.

3.2 Industry scope

There are three egg production systems in Australia: cage, barn and free range. Organic egg production is a niche segment within free range. The risks associated with each production system are based on the same premise – minimising the potential for pathogen incursion to the Flock, although prioritisation and management of the risks will vary.

3.3 Pathogen scope

Biosecurity is the prevention and control of the transfer of pathogens that cause disease to humans or animals, and good biosecurity should not discriminate between a human pathogen (e.g. *Salmonella*) and pathogens that cause disease in poultry. Occurrence of any of these pathogens on an egg farm can have serious, negative economic consequences.

Pathogens include:

- viruses, such as endemic (MDV, ILT, EDS, AE, IBV) and emergency (NDV, HPAIV, vvIBDV)
- bacteria that affect poultry (e.g. Mycoplasma, *Pasteurella* and *Campylobacter hepaticus,* the cause of Spotty Liver Disease) and pathogenic bacteria that affect humans (*e.g. Salmonella*)
- protozoa, such as coccidia (e.g. *Eimeria* spp.), and
- internal and external parasites.

3.4 Special considerations for layer industry

While general biosecurity risks for poultry operations apply (in principle) to layer farms, there are some specific considerations for risks that relate to operations that house layer hens:

- most layer farms are multi-age, and some farms have multi-age sheds (particularly cage)
- some layer farms may have rearing and production, grading floor and feed mill on the same

property, are within the same region, or a combination thereof
- movement of the same personnel between different sectors of the farming operation, and
- some layer farms are mixed enterprises, with free range, barn and cage operations.

The site manager (who is often the owner) has ultimate responsibility for the management of all vehicle and personnel access, stock and feed movement, and direct contact of the Property to other enterprises. The manager is also responsible for setting the 'biosecurity culture' for a farming operation, which impacts directly on the attitude of the staff to biosecurity, as well as the attitude of those visiting the farm. The manager is also responsible for monitoring staff and visitor compliance with the biosecurity risk management procedures that are in place.

3.5 Biosecurity risk management (risk vs impact)

This report is designed to inform an on-farm risk assessment for Australian egg producers. Identifying areas of risk is the first step to building a farms' risk management plan. Each hazard (area of risk) that is identified as being relevant to an operation should be assessed for its 'risk' vs 'impact'.

Risk refers to the likelihood that a hazard (or 'area of risk') would cause an 'impact' on production or animal welfare. Procedures, contacts and features that could lead to the transfer of pathogens to the Flock are all areas of risk. However, the likelihood of a risk occurring doesn't necessarily affect the impact that it is going to have on the Flock/production – e.g. there may be a high risk that a subclinical infection will occur, but the impact on the Flock would be minimal. Conversely, there may be a low risk that a foreign pathogen will enter Australia and affect a Flock, but the impact would be disastrous if it occurred.

For example, an identified risk may be 'untreated surface water supplied to the hens'. The 'likelihood' is how likely, or probable, it is that this situation may present a risk to the hens (and by extension, the farm business), and untreated surface water supplied to the hens has a 'high' likelihood of providing pathogen transfer to the hens. The impact, or consequence, of this situation can then be determined based on varying perspectives. The worst-case scenario in this instance is potentially '*transfer of an emergency animal disease to the hens that could lead to complete depopulation of all stock followed by downtime on the farm',* with the most likely scenario being '*lost productivity, markets and increased costs associated with disease investigation, control, and prevention for next flocks'*. How this risk is managed depends on each individual situation and the producer's individual appetite for risk (i.e. how much risk they are willing to operate with). For EAD's, producers have a (legal) responsibility to the egg laying industry to ensure their biosecurity practices are applied and risk minimisation optimised.

4 Resources – technical manuals and posters

Australian Eggs (formerly known as AECL) together with Animal Health Australia has recently published two key documents on biosecurity for the egg industry:

1. *National Farm Biosecurity Technical Manual for Egg Production* (April 2015). This is available at: https://www.farmbiosecurity.com.au/wp-content/uploads/2019/03/National-Farm-Biosecurity-Technical-Manual-for-Egg-Production1.pdf
2. *Code of practice for biosecurity in the egg Industry – Second Edition* (Jan 2015). This is available for download as a PDF at: https://www.australianeggs.org.au/what-we-do/leading-research/biosecurity-in-the-egg-industry/

Other materials include:

- Biosecurity posters (https://www.australianeggs.org.au/what-we-do/leading-research/biosecurity-in-the-egg-industry/)
- *Salmonella* posters (https://www.australianeggs.org.au/what-we-do/leading-research/through-chain-salmonella-risk-identification/)
- Farm biosecurity videos and toolkits (http://www.farmbiosecurity.com.au)
- Australian Eggs Annual Report, 2017. (https://www.australianeggs.org.au/who-we-are/annual-reports/#item-818)

5 The Property – biosecurity risk identification

5.1 Scope and overview

5.1.1 What is the 'Property'?

The Property is the area defined by a boundary that encompasses all buildings that house poultry, farm business buildings (e.g. office), people that come into contact with poultry, water and feed storage, vehicle movement to/from and on/off the farm, equipment storage, cleaning and chemical equipment, out-buildings, and roads that service vehicle movement between buildings.

The Property is the buffer zone that provides a secure perimeter and separates the Production Areas that house poultry from potential incursions and biosecurity breaches. It is the primary control zone for producers to restrict pathogen transfer, prevent disease infection of their flocks and is the buffer zone that keeps unwanted pathogens away from the Production Area and the Flock. The Property should be clearly marked on a map, including all access points, and form part of the site Biosecurity Management Plan. The Property zone should be physically defined by a stock-proof fence, with lockable access gates on all vehicle entry/exit points. There should be signage advising all entering the Property that it is a 'biosecurity area' and that there are strict access controls in place, with contact details on how to reach the manager. There should also be a log book within the Property at the entrance of the Production Area to record entry to the Production Area and other pre-visit movement details, including a quarantine declaration. Some Properties are expansive and may have multiple 'Production Areas', and each of these must be adequately fenced to clearly emphasise production units and the Biosecurity Production Area. Action must also be taken to reduce the biosecurity risk of unwanted animals entering the Production Area (including rodents and wild animals).

5.1.2 What are 'Property' biosecurity risks?

Property biosecurity risks are those that are related to the movement of pathogens from outside the Property onto the Property, either carried on/in vehicles, wild animals, personnel and equipment.

There are many options available for managing the transfer of pathogens onto a Property, although not all may be practical or viable for each operation. For example, a vehicle and/or wheel wash could be located at the primary access point with appropriate disinfectants, fresh clean water, washing equipment and drainage, but may not be feasible on smaller Properties.

Pre-visit requirements should be established by the manager, which are to be abided by all personnel and visitors entering the Property to limit the potential transfer of pathogens onto the Property via clothes, hair, boots, vehicles and equipment, etc.

A manager should question whether a person really needs to enter the farm, and if so, they must determine what risks they pose to the site, and any proactive measurements required. These requirements could include clean boots, or property-only boots to be worn while on-site, clean clothes and/or disposable coveralls to be worn, and where to store items such as mobile phones and other personal items (that may not be allowed to be brought onto the farm). Other options include methods to disinfect equipment or sanitise personal items.

Pre-visit quarantine is a pre-determined period of time that a person who has been in contact with other poultry, avian species, poultry product (eggs, abattoir and poultry waste) must wait before being permitted entry to the Property. This may also extend to include other livestock, which may contain

pathogens that can be transferred to poultry. This principle should also be applied to equipment and vehicles that enter the property.

The severity of biosecurity risks to a Property may change over time, so potential risks should be identified and assessed for varying management options as new information becomes available, or the risk becomes more likely (e.g. a disease outbreak on neighbouring farms).

5.2 Biosecurity risk identification Section 1 – the Property

Table 1 Areas of risk identified on a Property

Area of risk identified	Why is there a risk?	Features of the risk
Farm Biosecurity Plans	Each farm should have a Biosecurity Plan, developed and maintained by management, to clearly define zones and procedures for all staff to prevent, or reduce, a biosecurity incident.	If operations and procedures are not clearly defined, and staff are not properly trained in these procedures, there is a higher risk that a biosecurity incident will occur due to human error.
Proximity to water bodies that may house waterfowl	Surface water, including rivers, creeks and dams are the natural reservoirs of critically important avian pathogens, such as AI virus, and can be frequented by waterfowl. If unsecure water is used in the Production Area for drinking, cooling, and amenity use, this could introduce significant avian pathogens.	The ability to control waterfowl on larger dams or rivers has limitations, and thus the water should be considered as having a high risk of contamination at any time. Waterfowl may frequent the Property range and amenity contact areas, which will increase the risk of pathogen transfer. The size and location of water bodies has a direct impact on the number and types of waterfowl that may enter and reside on the Property (even puddles on the range or around the perimeter of sheds can pose a risk). The green vegetation around surface water or around the perimeter of the sheds and range can act as an attractant for waterfowl, particularly during dry periods. Water is a critical resource on farms, however, it should not be situated near the sheds or within the Production Area unless mandated by planning and environmental authorities. Seasonal flooding may inundate low-lying areas adjacent to sheds and maintain water for longer periods, which may attract waterfowl.
Terrain	Respiratory pathogens can travel further along valleys than over ridgeways, which increases the risk of airborne transmission along a valley. Flooding or pooling of water increases the risk of contaminated water coming into contact with the poultry.	The terrain surrounding a Property can influence the prevailing wind direction and likelihood of water pooling in the Production (and/or Range) Areas and can therefore increase the risk of airborne pathogen transmission down a valley, compared to over a ridge or via direct contact in infected water.
Climate	Climate can increase the risk of greater pathogen transfer via wind and water (e.g. flooding).	Airborne pathogen survival rates are directly correlated with the transmission distance and increase the risk of pathogen transfer between farms. There is a known correlation between prevailing winds and the risk of pathogen transfer due to cool/moist or dry climates.
Vegetation	Vegetation can be a refuge for wildlife that can be carriers of pathogens and potentially increase the risk of disease transmission to the Flock. Vegetation may also impact on wind movement, which can increase the risk of pathogen transfer between neighbouring Properties.	Wild birds and animals will nest and live in vegetation and there are many examples of them transferring pathogens to poultry. Waterfowl tend to land on open water and congregate. They then venture up the banks to graze on grass and are attracted to the vegetated and green grass range of poultry farms, and are considered to have contributed to AI outbreaks in the past.

Area of risk identified	Why is there a risk?	Features of the risk
Geography	Wild birds can be carriers of pathogens, such as AI. The risk of AI has been linked to wild-waterfowl movements and indirect or direct horizontal contact with commercial poultry.	Farms in certain locations should be aware that they may be at greater risk of EAD incursion due to the geographical location of the farm in relation to waterfowl populations. For example, the area from South-East Queensland to Victoria is seen as a part of Australia at higher risk due to waterfowl breeding season, climate and waterfowl movements. Fortunately, waterfowl movement monitoring studies have shown that Australia is not influenced by international migrating of waterfowl that are high risk species (Order Anseriformes). The endemic populations of these waterfowl have very low infection rates with endemic-type influenza viruses. Other species that migrate internationally, such as waders (Order Charadriiformes), are considered low risk species. Biosecurity risks are therefore much greater with larger water bodies that attract waterfowl on, or near, the Property, and not migratory paths.
Proximity to roadways	Regarding the transport of poultry along a roadway, open vehicles may allow feathers, dust, faecal material and pathogens to potentially disseminate into the immediate environment, posing a pathogen transfer risk directly related to the proximity of a poultry farm to the roadway.	Not all pathogens transmit well via wind. Pathogen transfer risk is directly related to the size of the populations, in terms of both the source of the pathogen and the susceptible flock. The larger the population, the greater the concentration of material released. A truck carrying a load of poultry moving along a roadway that passes a farm situated close to the road increases several potential risks. Firstly, if the farm has a large population of poultry that has an airborne pathogen (e.g. Mycoplasma) and the truck is carrying day-old chicks from the hatchery, or pullets from the rearing farm to a layer farm, the birds on the truck could become infected. Alternatively, if the truck is carrying a relatively small number of spent hens to processing and these are infected with a respiratory pathogen, they could transmit to poultry that is housed on a farm in close proximity to the road. Pathogens emitted from moving vehicles generally survive shorter periods in the day time compared to night due to ultraviolet light during daylight hours.
Vehicles: General	Any vehicles entering a Property may have unknowingly been in contact with pathogens on another farm, which can potentially transmit disease between farms. When there is direct or indirect contact of vehicles entering the Property with unknown pathogens during a disease outbreak, quarantine restrictions may be imposed on the farm and, depending on the pathogen, potential depopulation of the Flock can occur, which could have a catastrophic impact on business.	Pathogens, such as bacteria, viruses and insects, have been shown to travel from one farm/site to another on vehicles. Examples include: AI transmission via waste disposal, egg transport and dead bird pick-up vehicles; and Infectious Laryngotracheitis transfer via feed transport and spent hen pick-up vehicles. Vehicles entering the site that may move between other properties and carry pathogens include feed transport, gas, litter, chick supply, pullet supply, spent hen removal, egg transport, dead hen removal, manure removal, litter supply and removal, packaging and other suppliers. Both the outside and inside of a vehicle represent a risk of pathogen transfer. It is difficult to effectively disinfect the inside of a vehicle, however, vehicle footwells should be kept cleaned and the cabin should be free of insects when moving between farms. For most farms, it is not practical to effectively wash and

Area of risk identified	Why is there a risk?	Features of the risk
		disinfect the outside of larger vehicles, although this should be managed according to frequency of visitation and risk.
Vehicles: Stock Placement	The hatchery and hatchery vehicles can be a potential contact point with other farms, particularly if using a transport contractor that works across multiple poultry industries.	Hatchery vehicles may have been to another farm prior to delivery, and potentially had direct contact with another vehicle where chicks may be transferred. Thus, the hatchery vehicle can be a source of pathogen transfer.
Vehicles: Stock Transfer Crates	Pullet transfer crates come into direct contact with the Flock and can be one of the greatest risks for pathogen transfer to a poultry farm.	Pullet transfer is often performed by contractors who visit multiple farms. Pullet transport crates may not have been cleaned properly after being used to move hens on another farm. The vehicles and transfer crates can be a source of pathogen transfer and need to be thoroughly cleaned and disinfected prior to loading with stock and transporting to, and entering, the Property.
Vehicles: Stock Depopulation Crates	Vehicles and crates used for transporting spent hens to the abattoir (or elsewhere) will have been in contact with other poultry, including spent hens from other farms and could have, therefore, been in contact with pathogens or external parasites, such as red mites.	Modules with crates are usually unloaded and taken into sheds or positioned immediately within the vicinity of the shed to load hens. If not adequately cleaned and disinfected, these can transfer organisms onto the Property. The highest risk situation is considered to be if some hens remain in the shed (partial depopulation), which could allow any pathogen introduced to amplify and spread across the Property. This risk is considered higher within multi-age sheds.
Vehicles: Egg Transport	Transport vehicles often travel between multiple farms, and carry eggs and fillers between Properties, all of which can harbour pathogens. The truck, eggs and egg fillers and pallets represent a high risk of pathogen transfer to the Property.	Eggs are often packed in egg fillers onto pallets on trucks, which may be unloaded within the Production Area if there is a need to retrieve packaging or trolleys from further up the trailer. This movement may transfer pathogens to the Property. Due to the time it can take before a pathogen causes disease, every horizontal contact should be treated as potentially contaminated and controls put in place to minimise the risk of pathogen transfer. For example, AI virus transfer is suspected to occur by an egg transport vehicle that stopped to collect eggs from one farm before picking up eggs from another, prior to the first farm becoming aware that it was infected with AI. Eggs, egg fillers and pallets returning from farms may transfer pathogens to the grading floor and should be quarantined and washed/disinfected when possible.
People movement	People can carry pathogens on their clothing, on their hands and in their hair, and even in their upper respiratory tract.	Movement of people in and out of the Property can transfer pathogens and so biosecurity programs should target all areas of personnel movement on and off the Property.
People movement: Staff	Staff are the most frequent form of human contact on the Property. Staff can move frequently between flocks of different age, health status, and farming system (cage and free range), which represents a significant risk of pathogen transfer.	From a positive perspective, staff tend not to visit other Properties, but rather travel between their home and work. Therefore, the highest risks are staff who have independent contact outside of work with other avian species or pigs, or who visit other egg production Properties. Staff returning from high-risk, overseas

Area of risk identified	Why is there a risk?	Features of the risk
		countries and/or experiencing gastrointestinal signs on return to Australia are considered a high risk.
People movement: Visitors (including delivery truck drivers, suppliers and other visitors)	Visitor footwear and clothing can carry pathogens onto the Property. Even if visitors stay outside the Production Area, there is still a risk of pathogen transfer to farm staff, which could lead to infection of the Flock.	Visitors who are suffering from gastroenteritis, human influenza, or who have recently travelled internationally can transfer pathogens onto the Property. They may also not have the same understanding of biosecurity as staff and are less likely to be aware of the risk they pose to the Property. For example, delivery vehicle drivers usually move from farm-to-farm within each day and must leave their vehicle to connect delivery tubing between the truck and the silo, or truck and tank. Drivers tend not to change boots or put on external clothing when they enter the Property, and the silos/tanks are invariably situated immediately adjacent to the Production Area. Farm staff who venture into the delivery zone can create a contact point for pathogen transfer, so it is vital that there are controls around delivery vehicle driver movements before coming to, and entering, the Property.
People Movement: Suppliers, service personnel and customers	Product suppliers can have contact points with other poultry producers and represent a biosecurity risk. Examples include the feed supplier, waste disposal, suppliers of egg handling equipment, auditors, regulators and veterinary health services.	Suppliers and customers represent a risk of farm-to-farm pathogen transfer. Contact with these companies, organisations and individuals should be appropriately managed to reduce the risk of pathogen transfer to the Production Area.
People Movement: Sales representatives	Sales personnel move from farm to farm and usually meet on-site, which could cause pathogen transmission between farms.	Sales representatives are focused on meeting as many customers as possible, as efficiently as possible.
People movement: Personnel and visitors travel to high risk areas overseas	Staff or visitors returning from holidays or even transiting in countries or regions known to be dealing with disease outbreaks (e.g. South-East Asia) can develop gastroenteritis and potentially transfer these pathogens, or other specific poultry pathogens, to the Flock.	Parts of Asia have a high risk of exposure to food pathogens such as *Salmonella* Enteritidis, organisms with antibiotic resistance and virulent AI viruses. There is a risk that other travellers with whom personnel or visitors have come into contact may transfer pathogens, which may potentially transfer to the layers through other contact points, such as in the grading floor or liquid egg processing area. This is a known pathway for disease outbreaks.
Signage	Clear signage is required to ensure procedure compliance by all personnel and visitors.	Without clearly outlined procedures, staff and visitors may decide on their own actions to take in a given situation, which can increase the risk of pathogen transfer between flocks. Correct signage demonstrates the importance of biosecurity on the Property, and guides visitors to be cautious about what they do, where they go, and to raise concerns with management in order to help reduce risks.
On-site feed manufacturing	When feed is manufactured on the Property, there are multiple contact points (direct contact or indirect contact through pathways, such as aerosolisation) that could lead to pathogen transfer to the Property. Contact points can be associated with grain, other raw material and other horizontal contacts. There are also risks pertaining to storage	Some raw materials can increase risk when brought on-site, as they may be contaminated with pathogens, such as *Salmonella.*

Area of risk identified	Why is there a risk?	Features of the risk
	areas that attract wildlife, rodents and invertebrates (insects) that may transfer pathogens to the Property and/or act as a reservoir of pathogens.	When finished feed is sold to a third party, there is increased contact with other poultry and livestock farms that could return pathogens to the Property if vehicles and personnel movements are not securely managed. Grain stores/spillage can attract wild birds and rodents if not properly managed, which can increase the risk of pathogen levels in the environment. These pathogens could potentially transfer around the Property, including to the Production Area, on personnel or equipment, and could even contaminate feed supplied to the Flock.
Tools and equipment	Tools and equipment can be contaminated with pathogens via direct or indirect contact with fomites, air, or insects, which can then be transferred to the Property if not effectively cleaned and disinfected prior to entry.	Equipment that comes into contact directly or indirectly with poultry can transfer pathogens between farms. A good example is using the same bucket and hopper to load fresh shavings into a rearing shed that was also used to remove litter on another Property. Litter removal equipment can be difficult to clean, so a focused effort and good equipment must be used to complete this task effectively. Equipment used to cull spent hens may be transferred between farms and should be cleaned effectively before allowing entry, even if going onto a Property where the hens are to be depopulated. Tradespersons' tools can transmit pathogens between farms and should be addressed at the farm gate prior to entry onto the Property.
Supplies	Some materials cannot be effectively disinfected, such as cardboard fillers and wooden pallets. These can become contaminated at one farm, moved between farms, and taken onto the Property, which represents a high risk of pathogen transfer.	Materials sourced directly from another farm represent a high risk of pathogen transfer.
On-site composting	Wastes, such as dead hens and used litter, can harbour pathogens. Composting these wastes on-farm can attract rodents, insects and wildlife, and cause pathogen transfer throughout the Property if not properly managed.	Composting takes time to complete efficiently and reduce the risk of pathogens, however, it can be an effective way to reduce risks if managed appropriately, otherwise composting can present a greater risk than the original dead hens/used litter.
Egg fillers	Egg fillers, dividers and pallets can be a primary source of pathogen and parasite transfer between Properties. This can happen directly when fillers are repeatedly used, or indirectly when new fillers are transported between multiple farms on the same delivery equipment and vehicle.	Different types and uses of egg fillers represent different risks for a commercial layer operation. The highest risks are associated with reused cardboard fillers. The lowest risk is with new cardboard, or colour-coded washed and disinfected reusable plastic fillers. Farms should work toward reducing and managing this risk wherever possible, as there have been many examples of pathogen transfers associated with filler reuse between farms.
Grading eggs from other Properties	Handling eggs from other farms represents a risk of introducing pathogens to a Production Area.	Eggs, fillers and pallets represent an ideal pathway for pathogen transfer between farms. When eggs are transferred from one farm to another for grading, there is an inherent risk of pathogen transfer between farms.

Area of risk identified	Why is there a risk?	Features of the risk
B-Grade eggs and waste disposal from packing and grading floors	Eggs are a horizontal contact with Liquid Egg Processing (LEP) processing plants and waste, which includes reject eggs, eggshell and yolk debris and egg handling disposables that are potentially contaminated material. These are high-risk biosecurity contact points and can lead to pathogen transfer to the Property if not managed carefully.	LEP plants take B-Grade eggs that are deemed not suitable as A-Grade shell eggs. This may include shell quality problems, dirties, cracked, smalls or eggs from high-risk, *Salmonella* positive flocks. Commercial disposal of waste or on-site disposal in approved landfills are horizontal contact points that create a risk of cross-contamination. These contact points require a barrier between the Property and the waste removal.
Proximity to other farms	Apart from movement of pathogens on vehicles, personnel and equipment, pathogens can transmit between sites within a region due to the movement of rodents, insects, dust/fomites and by airborne means.	Pathogens can transmit from different types of farms, particularly chicken to chicken, but also other types of avian species, such as ratites. Pathogens can also be transferred from other animal species. For example, the same *Pasteurella* type has been isolated from dead pigs and dead chickens on adjacent farms. Transfer can be via horizontal contact from airborne spread, surface water run-off, or rodents and insects between adjacent properties. It is difficult to control airborne pathogen transfer from nearby poultry farms. Rodents represent a risk of pathogen transfer between properties, particularly during crop harvest and the onset of cooler weather. Greater buffer distances reduce the risk of rodents or insects entering the Property carrying pathogens from another farm, or dust transferring pathogens between Properties.
Pest activity: wild bird, rodent, wild animal and insect movement	Wild birds, rodents, wildlife (e.g. kangaroos), and vermin (e.g. foxes, cats and wild pigs), can be a source of pathogens, such as *Salmonella* spp. Foxes are not considered a high risk of pathogen transfer, although their presence can lead to mortalities by primary intervention and smothers, or secondary flight and fright behaviour. These stresses can evoke diseases such as spotty liver disease.	Poultry farms represent a highly attractive environment for rodents, wildlife and other vermin due to the presence of open water, grass, exposed feed/grain around silos, and manure. Poor Property design, such as long grass, open water, open shelters/sheds, lack of fencing, on-farm manure storage, together with a lack of grounds maintenance, encourages pest activity in larger numbers.
Other livestock/animals	Livestock, such as sheep and cattle, can be a source of pathogens (e.g. *Salmonella*). This risk can also apply to domesticated animals, and those housed on-site as protection for the hens.	Livestock tend to gather on the pedestrian paths, roads and around buildings and their faeces can easily contaminate personnel, vehicles and equipment that enter the Property and its perimeter.
Record keeping	Accurate record keeping is essential for highly effective biosecurity risk management.	Without accurate record keeping of all production parameters, people, vehicle and equipment movements, it may not be possible to determine when a problem arises, if procedures are being followed, or to identify key risk areas. Record keeping also helps to protect operations by providing active biosecurity risk management.
Training	Without training it is difficult to ensure standardisation of procedures, and this can increase biosecurity risks.	Training is the best way to standardise procedures and provide staff with accountability for biosecurity risk management on the Property.

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7 The Production Area – biosecurity risk identification

7.1 Scope and overview

7.1.1 What is 'the Production Area'?

The Production Area encompasses all buildings that house poultry, any range areas that poultry directly access, egg grading areas connected directly to the poultry sheds, personnel areas that directly come into contact with poultry, water and feed storage areas that directly connect to the shed. This includes ventilation, shed entry points that have contact with personnel, vehicles and equipment. It may also include an on-site feed mill for smaller operations.

Controlling biosecurity risks at the boundary of a Production Area constitutes the most critically important biosecurity protection zone that a manager and farm staff should prioritise. The Production Area zone should be clearly marked on a site map, including all shed and range access points, and be clearly presented in the site's Biosecurity Management Plan. The Production Area should be physically defined by control access doors/gates that can be locked. The Production Area and Property boundary may be the same in some instances, however, where possible, there should be a separate perimeter fence that restricts movement and clearly defines the Property boundary, including all aspects of the Production Area.

7.1.2 What are 'Production Area' biosecurity risks?

The Production Area is the control point for personnel, equipment, vehicle, water, feed, bedding and air supplied directly to the Flock.

While the biosecurity control procedures at the Property level are designed to minimise the transfer of pathogens onto the farm, there are additional risks that occur in the Production Area. These risks include: on-site exposure to wild birds; on-site flocks of different age; rodents; other wild animals (that can carry *Salmonella*); or a truck driver who has delivered to another farm on the same day. Management of the risks in the Production Area is secondary to risks associated with direct contact with the Flock. The key to efficiently managing the biosecurity risks of the Production Area is to build biosecurity into the farm design and Standard Operating Procedures (SOPs).

The manager should adopt a risk assessment-based approach to evaluating any new risk or change in status before allowing the process to progress, especially if that process involves people, vehicles, or equipment entering the Production Area, as this is the final control point before direct contact with the Flock.

As with Property risks, some options for the management of Production Area risks may be more viable than others, which depends on farm and manager-specific characteristics. The viability of managing a risk should not undermine the seriousness of that risk.

7.2 Biosecurity risk identification Section 2 – the Production Area

Table 2 Areas of risk identified in the Production Area

Area of risk identified	Why is there a risk?	Features of the risk
Vehicles: General	Vehicles that enter the Production Area can carry pathogens on their wheels, on and under the vehicle, within the truck body, and within the driver's cabin.	Vehicles entering the Production Area should be screened and controlled to prevent the transfer of pathogens onto the site.
Vehicles: Egg transport	Egg transport vehicles can enter the Production Area and may drop off eggs or packaging from another farm, which can increase the risk of transferring pathogens between farms.	Egg transport vehicles and personnel are a key risk for poultry farms, as they come into direct contact with the packing floor or cool room in the Production Area. This can be an indirect source of pathogens to the Flock, with the precise transmission method involving multiple horizontal contacts. A good example is one Australian AI outbreak, whereby the only contact between the first infected premises and second farm site was an egg transport vehicle. The vehicle unloaded pallets containing egg fillers into the Production Area of one farm, and then loaded eggs from the Production Area of the second farm.
Vehicles: Feed delivery	Feed delivery vehicles will enter a Production Area, after having previously visited multiple farms that day. The farm silos are usually situated immediately adjacent to the sheds, which can contaminate the outside of the feed delivery vehicle with pathogen-laden dust. If not cleaned effectively, the vehicle can then transfer pathogens between sites.	By nature of their function, feed vehicles work in close proximity to the sheds that house the Flocks. They can become contaminated by dust leaving the shed, particularly in open-sided sheds on warm days or when the vehicle is parked adjacent the exhaust fans (common in mechanically-ventilated sheds). Blower feed delivery trucks can have a higher risk of contamination as they draw air from the immediate environment to pressurise the feed transport pods and push the feed into the silo.
People movement: Visitors	People that come into the Production Area site who have been in direct contact with another farm, hatchery, processing plant or higher risk areas can carry pathogens on their hands, feet, clothing, in their hair, and even in their upper respiratory tract. People returning from overseas can fall ill from, and carry, enteric pathogens, such as *Salmonella* Enteritidis. Visitors can also carry AI viruses on their clothes or footwear, which can be transferred to the stock directly or indirectly.	Pathogens are more likely to be transferred and infect a Flock if visitors enter the Production Area and have direct contact with the Flock. If the Production Area is not clearly defined, visitors can may be able to enter the Production Area with ease, as this is where farm staff/management are likely situated.
People movement: Staff	Staff are the most frequent visitors to a Property and its Production Area. Staff also move frequently between Flocks of different age, health status, and farming system (cage and free range), which increases the risk of pathogen transfer.	When staff are allowed to wear the same clothes and footwear from home to work, they represent a risk of transferring pathogens directly into the Production Area.
Egg belts and egg conveyors	Cloth egg belts and egg conveyors/anacondas represent high risk areas for pathogen retention and transfer (especially *Salmonella*).	Egg belts and conveyors/anacondas can be difficult to clean and can create a shed-to-shed transfer of pathogens on the Property. These need to be managed, especially where eggs can break, as egg yolk is a particularly good growth medium for bacteria such as *Salmonella*.

Area of risk identified	Why is there a risk?	Features of the risk
Range area (free range flocks)	The range area is both a direct and indirect contact point with wild birds, vermin and rodents. This is a potential transmission route for high-risk pathogens (such as AI virus) to commercial poultry operations. There can also be contact between hens in adjacent sheds through the mesh fencing. It is not feasible to control faecal-oral endemic pathogens in the soil outside the range.	Range areas may attract aggregates of wild birds, particularly waterfowl that can transfer poultry pathogens.
Equipment	Any equipment entering the Production Area can readily transfer pathogens into the Flock if it has been in contact with another farm prior to arrival and not cleaned and disinfected effectively.	Equipment can be difficult to effectively clean and disinfect due to odd shapes, vulnerable components and 'hard to reach' places. There may also be difficulty with electrical components that cannot be easily pressure-washed or cleaned. Examples include tools, trailers and smaller vehicles (such as bobcats and pallet jacks used for litter removal and egg handling, respectively). All equipment that enters the Production Area increases the risk of pathogen transfer.
Suppliers – other materials	Other materials, such as netting, wooden pallets and shavings, may need to enter the Production Area. These materials cannot be effectively decontaminated and increase the risk of pathogen transfer into the Production Area.	Materials from suppliers can be contaminated with pathogens, parasites and insects and are very difficult to clean, increasing the risk of transferring them to the Production Area. They may also be unloaded onto a contaminated surface that inadvertently transfers the pathogens back into the Production Area.
Waste disposal (manure/ dead birds)	Contractors who collect and transport farm waste can inadvertently transmit pathogens between sites. Waste disposal and storage in the Production Area can attract wildlife (birds, rodents and vermin), which can introduce pathogens to the Production Area.	When waste is disposed of on-farm, vehicles, people and equipment passing between the farm and the disposal site can transmit pathogens from the disposal site back to the Production Area. In one AI outbreak, it was highly suspected that the virus was transmitted from one infected premises to a second farm via dead birds that were collected by a waste vehicle that tipped the waste bin at the Property perimeter, which was closely adjacent the Production Area.
Other waste disposal	Contact with skip-bin disposal has been associated with pathogen transfer between Properties.	All waste disposal creates a potential contact point with other Properties, both prior to and after collection from the Property. Waste disposal is therefore a key risk that must be managed. Examples of these wastes include non-organic (such as plastics, used fillers and pallets), and organic (such as reject eggs and spilt feed).
Water bodies or surface water (e.g. dams, ponds, rivers and creeks)	Open water bodies in the Production Area will attract waterfowl and provide an environment for pathogen contamination and transfer. Waterfowl have been known to carry pathogens that can result in emergency and endemic disease outbreaks such as AI, and EDS, respectively.	Waterfowl tend to land on open waterways and may then venture toward the range area and sheds in the Production Area. Larger water bodies also attract larger numbers of waterfowl and encourage breeding, which increases the risk of pathogen transmission.
Vegetation around sheds	Vegetation around sheds and in range areas needs to be managed as it can encourage wild birds and other wildlife into the Production Area, which increases the risk of contact and pathogen transmission.	Vegetation around sheds can also encourage wildlife, such as foxes and rodents, that can carry pathogens into the Production Area and create secondary losses due to smothers and secondary stress-related disease.

Area of risk identified	Why is there a risk?	Features of the risk
Domestic livestock	Domestic livestock can be infected with pathogens such as *Salmonella*. If allowed into the Production Area, their faeces can collect on wheels and/or footwear and be carried into sheds.	Domestic livestock allowed access to the Production Area tend to congregate around the sheds and walkways, soiling them with faeces. Soiled roadways and pedestrian access paths can result in people, vehicles and wild animals/rodents transferring pathogens onto the Production Area.
Feed spills	Feed spilled during unloading or system break-down will attract wild birds and wildlife, which can introduce pathogens to the Production Area and increase the risk of pathogen transfer into the sheds to the Flock.	Feed spillage is a common occurrence after feed delivery and should be managed appropriately to prevent encouragement of wild birds and wildlife into the Production Area.
Pests: Rodents and other vermin	Rodents, foxes, rabbits, cats, kangaroos, reptiles and even wild pigs can carry pathogens into the Production Area that can infect the Flock.	Rodents and other vermin are attracted to poultry farms as they provide a good source of food, shelter and warmth.
Pests: Wild birds	Wild birds can carry pathogens, parasites and external parasites, which can infect poultry. They represent a high risk of infection and increase the risk of pathogen transfer into the Production Area.	Wild birds can include waterfowl and non-waterfowl species. Wild birds do not usually enter sheds via pop-holes on free range farms, as they are more likely to fly into open barn doors at the end of the shed, or holes along the eaves of the shed or foyer doors (if left open). They should not be allowed to enter sheds and should also be prevented from entering shed foyer areas, packing/grading floor areas, and machinery/storage sheds in the Production Area. Waterfowl tend to land on water bodies and then walk across the ground toward the Production Area.
Pests: Insects	Insects (such as flies) can transfer pathogens into the Production Area and infect the Flock.	Manure can provide an ideal breeding environment for insects, particularly in the summer months. Flies have been shown to transmit both viral and bacterial pathogens over long distances. It is imperative that insects are managed as part of the farm's Biosecurity Management Plan.

8 The Flock – biosecurity risk identification

8.1 Scope and overview

8.1.1 What is 'the Flock'?

The Flock includes all poultry in the Production Area, regardless of age, housing or breed.

Controlling biosecurity risks at the Flock level is the last line of defence against a pathogen infecting a Flock. Once an infectious agent enters the Production Area, it may transmit through the Flock (depending on the immune status of the Flock). Pathogens have evolved to transmit easily between birds, therefore, large numbers of hens on a farm will lead to a rapid transmission through the Flock.

8.1.2 What are 'Flock' biosecurity risks?

Biosecurity risks at the Flock level are those that are posed by the transfer of pathogens between birds and by direct contact with people, rodents, wild animals and equipment, etc., which may be carrying pathogens that can infect the hens (and cause disease in the hens or humans).

It is normal for layer operations to have multi-age sites. The Flock should be managed according to age and disease status with personnel, equipment and vehicle movement from youngest/healthiest to oldest/infected. The transmission rate will depend upon the nature of transmission, that is to say, faecal-oral transmission will spread faster in a floor-based shed compared to a cage shed, and respiratory infections will transmit faster in a cage shed with higher density and wind speed than a barn shed, and much faster than faecal-oral transmission. Contact transmission organisms spread slowest (e.g. red mites).

The Flock's susceptibility to disease agents can be significantly reduced by vaccination and husbandry management. Once the biosecurity risks have been identified at the Production Area level, the same risks must be also considered at the Flock level but expanded to consider risks associated with housing and type of production. Production Area and Flock level risks are closely related and should be managed simultaneously. For example, on a free range farm it may be difficult to stop wild birds flying over the range areas, or perching on the roof or in trees planted specifically in the range for cover, however, the manager can keep the grass low to maximise sunlight penetration to ground level, ensure there are no open water bodies in the range area or nearby to the Property perimeter that would attract waterfowl, and can have good perimeter fences and tidy shed areas with effective rodent control programs to make the site less attractive to wild birds and keep rodents numbers to a minimum. Following this, direct engagement of the risk to the Flock will be subsequently minimised.

Flock vaccination is a critical part of the Biosecurity Management Plan as it provides an immunity barrier that effectively increases the number of pathogen particles required to cause disease infection. It also slows the levels of pathogens shed by the poultry, and therefore decreases the risk of the pathogen spreading in the Flock. Vaccines can help to reduce the risk of the occurrence and spread of disease in layer flocks. Most of the vaccines available provide good disease control in layers in Australia. Care and planning must be taken when considering which vaccines should be used, and how they are administered, to ensure the vaccination program is as effective as possible. Other Flock treatments for health and pathogen control include medications such as anticoccidials, anthelmintics for internal parasites, and insecticides for external parasite control.

8.2 Biosecurity risk identification Section 3 – the Flock

Table 3 Areas of risk identified in the Flock

Area of risk identified	Why is there a risk?	Features of the risk
Shed entry process	The greatest risk of pathogen exposure to the Flock is when people and equipment enter the shed.	People can inadvertently carry pathogens on their clothing, hands, person or footwear. Equipment and packaging can be contaminated with pathogens, which can infect the Flock either directly if it comes into contact with hens (e.g. catching frames, buckets, weigh cells), or indirectly if it comes into contact with something that ultimately comes into contact with the layers (e.g. feed conveyor).
Chick boxes and trolleys	Chick boxes, trolleys and dollies may be contaminated from the hatchery or another farm and could transmit pathogens into the Flock during chick placement.	Contamination of trolley and dolly castors is inevitable during unloading. Chick crates can come into contact with the inside of sheds, and in floor-based rearing it could mean they become soiled with litter. Sometimes smaller deliveries and reloading of creates can be made to multiple farms by the one vehicle, which is a potential for contamination of the remaining chicks.
Chick health: Vertical transmission	Day-old chicks can carry pathogens passed on from the source breeder flock or hatchery, which can infect the rest of the Flock.	Some pathogens are vertically transmitted (i.e. from the parent to the chick during development in the egg) from the breeder flock, such as Mycoplasma and Egg Drop Syndrome. Some pathogens are transmitted on the surface of eggs during incubation and transfer to the chicks on hatching.
Vehicles: Pullet placement/ transfer	Transport cages and vehicles cycle between farms and represent a risk for pathogen transfer if not cleaned effectively, as they have direct contact with the Flock.	Pullet movement is often carried out by contractors. Vehicles and equipment are moved between multiple rearing and production farms, carrying hens with differing health status. The trolleys can then be taken into sheds that also have a different health status (e.g. a fully cleaned out single-aged shed versus a multi-age shed).
Vehicles: Depopulation	Modules and crates used to transport spent layers to the processing plant can carry pathogens into the shed and infect the Flock, which is a higher risk in multi-age sheds where not all the hens will be removed.	Spent layer hens are most likely to carry pathogens that could be transferred during depopulation. Equipment and staff used to transfer these hens to slaughter can become contaminated.

Area of risk identified	Why is there a risk?	Features of the risk
Horizontal contact transfer from other Flocks (e.g. multi-age sheds)	Any Flock on a multi-age farm has a high risk of infection and pathogen transmission to other Flocks on the farm. Older layers have a higher chance of carrying pathogens and transmitting these to younger hens when introduced to the shed.	The risk of pathogen retention in multi-age sheds is considered substantially higher than single-aged sheds. Where hens are maintained in the sheds on an ongoing basis it is difficult to effectively clean the sheds, which retain pathogens, creating a unique environment where multiple pathogens could be present in a single shed. When pullets are placed into a multi-age shed they are exposed to endemic pathogens soon after placement. This is a period of high physiological stress, as the Flock comes into lay and birds need to keep gaining body weight for consistent production of eggs and maintenance of shell quality. The impact of the pathogen infection cycle can therefore be worse in multi-age sheds compared to single age sheds.
People movement: Staff	Personnel can carry pathogens on their clothing, hands, hair, shoes and even in their nostrils, which can infect a Flock.	Staff are often required to work between multiple sheds on a site, or even between multiple farm sites on a single day, e.g. rearing and production units or free range and cage production units. Time constraints on farm staff may result in shortcuts being taken, coupled with the difficulty of sourcing high quality farm staff in rural areas.
People movement: Visitors and contractors who visit other farms	Contractor teams move between farms and they can carry pathogens on their clothing, footwear, person, vehicles and equipment.	Working between multiple farms on a single, or consecutive days, increases the risk of pathogen transfer. Often personnel in vaccination crews and depopulation crews do not have vast knowledge of biosecurity or pathogen transfer. Equipment used by contractors may be used on multiple farms or between Flocks, without adequate cleaning and disinfection, which has been the cause of disease outbreaks on several farms.
Range area for free range Flocks	The outside of the shed is not a controlled space, so layers with access to a range can come in contact with wild birds, vermin, and external parasites, both directly and indirectly, which increases the risk of pathogen transfer to the Flock.	The range area can be attractive for wild birds, vermin (rodents and wildlife) and insects. These animals can travel large distances and carry pathogens that could infect the Flock either directly if they inhabit the range, or indirectly if they pass faeces in the range.
Pest control: rodents	Rodents will live and breed within poultry sheds, which increases the risk of pathogen transfer between batches, Flocks or sheds.	Rodents feed on eggs, dead hens, poultry feed and other shed wastes, so they can become infected with pathogens (such as *Salmonella*) and transfer disease between Flocks after depopulation/re-stocking, or between sheds. Research conducted in the United States on *Salmonella* has demonstrated that rodents

Area of risk identified	Why is there a risk?	Features of the risk
		are the primary source of *Salmonella* on commercial poultry farms. Although *Salmonella* are asymptomatic in layer hens, they are a food safety risk through internal contamination of the egg.
Pest control: flies and external parasites	External parasites, such as red mites, can dwell inside nest boxes, cages, and even the shed walls and floors, leading to reinfestation of subsequent Flocks. Litter beetles can also live inside the litter of floor-based sheds (free range and rearing) and inside the walls of the sheds, which can pass pathogens between batches within the one shed.	Mites are considered a pest, particularly red mites, lice and northern fowl mites, which may consume blood from chickens making them anaemic, causing skin irritation, and reducing productivity. Litter beetles have been shown to carry many different bacterial and viral diseases, and are a source of pathogen transmission between Flocks and sheds on a Property. Diseases include *Salmonella*, *Campylobacter* and other avian pathogens.
Ineffective cleaning of internal shed equipment (e.g. cages, feeders, drinkers, egg belts and furnishings)	Transfer of pathogens between Flocks and batches.	High bacterial loads, including *Salmonella* and some viruses, can remain on equipment that was in contact with the previous Flock of layers.
Shed cleaning and disinfection	Inadequate shed cleaning and disinfection between Flocks increases the risk of pathogen transfer to the new Flock, and sets the general culture of biosecurity on that Property at a lower standard than other poultry production units.	Effective shed cleaning and disinfection is an essential part of removing pathogens, rodents, insects and other organics that can be transferred to the new flock and increase risk of disease exposure. This is limited capacity for effective shed cleaning and disinfection in multi-age sheds.
Drinking water	Untreated drinking water from surface water or rain water capture represents a high biosecurity risk when it is supplied directly to the Flock. Any pathogens present in the water can infect the Flock, and serious pathogens, like AI, are readily transmitted via contaminated drinking water.	Poor quality drinking water is an ideal medium for pathogen survival. If contamination is resultant of the source (e.g. surface water from a dam or river), or during storage (e.g. open tank), then the pathogens can survive through the system and infect the Flock. Endemic pathogens, like EDS, can transmit from waterfowl through contaminated drinking water, and cause egg production drop and shell quality problems. EADs can also be transferred through water used for drinking or cooling.
Feed	Feed represents a high biosecurity risk, as it can harbour pathogens and is supplied directly to the Flock.	Raw materials represent a high risk of pathogen entry to the Flock, especially *Salmonella*. Contamination of feed ingredients or spoiling of finished feed can occur if not stored correctly. Mash feed is a higher risk than pelleted/crumbles, as there is no heating process during manufacture that can remove enteric organisms.
Cooling system	Cool cell pads can be difficult to treat effectively between and within batches, which can be a source of pathogens to the Flock. The water used for cooling can carry pathogens and infect the Flock if untreated prior to reticulation.	Cellulose pads are generally 150mm thick and have angled channels that make cleaning and disinfecting very difficult. They can retain dust that contains pathogens and can infect Flocks.

Area of risk identified	Why is there a risk?	Features of the risk
		The water reticulated over the cool cell pads can be contaminated with pathogens, which can be drawn into the shed and infect the Flock.
Dirt floors	Pathogens can survive in dirt floors, shed walls, and even the range area outside free range sheds.	Certain pathogens associated with free range Flocks include fowl cholera, coccidiosis and spotty liver. These pathogens can survive in the litter and earth floors, both inside and outside the shed, and infect new Flocks after placement. Birds can dig in range areas and leave pits that can retain water after rainfall and are difficult to clean.
Dead hen collection and storage	Dead hens may contain pathogens that can be transferred to the Flock. The people and equipment used to collect dead hens can also become contaminated with pathogens.	Collection, removal, transport, storage and disposal of dead hens is a key focus point for managing biosecurity and preventing transfer to the Flock on poultry farms.
Dead hen disposal	Dead hens are a source of pathogens and should be removed from the Flock regularly. Contact with on-site and off-site disposal systems is also a primary source of pathogen transfer and should be managed appropriately.	Contractors who collect and transport farm waste can inadvertently transmit pathogens between sites, which can increase the risk of transfer to Flocks. When on-farm waste disposal is used, the vehicles, people and equipment passing between the farm and the disposal site can transmit pathogens to the Flock if effective biosecurity procedures are not followed.
Waste disposal: manure removal	Contact between manure collection systems and disposal outlets via people, vehicles and machinery can cause pathogen transfer to the Flock.	Litter can be contaminated with faeces that carry pathogens (respiratory and enteric), which can infect other Flocks through contact with disposal vehicles, equipment and personnel.
Waste disposal: litter removal	Used litter can carry enteric pathogens, such as bacteria (*Salmonella* and Spotty Liver), viruses, parasites (coccidiosis and worms) and insects (flies, litter beetles and larvae).	Litter disposal is a high-risk biosecurity practice as it is a primary form of pathogen transfer. If litter is not completely removed prior to shed disinfection, the people and equipment involved can transfer pathogens to other Flocks on the Property.
Nest box management and cleaning	Nest boxes and pads have direct contact with the layers and can be a source of pathogen transfer, especially *Salmonella*. If they are not kept clean, nest boxes can also harbour parasites, such as mites.	Effective cleaning of nest boxes and nest pads is imperative between batches to ensure no pathogens and parasites are transferred to new Flocks.
Choice of disinfectant	The correct disinfectant types must be used to control high-risk pathogens.	The use of an incorrect disinfectant can result in inadequate removal of pathogens from the shed and equipment inside the shed, which can result in the transfer of pathogens between Flocks. This is particularly important if a diseased Flock has just been removed from the shed.
Disinfection use	Application rates, volumes applied, and order of application can impact on the effectiveness of disinfectants.	Product use, including dilution, application rates, and combinations of products, can be ineffective if not conducted in accordance with the manufacturer's recommendations.

Area of risk identified	Why is there a risk?	Features of the risk
Investigating Flock mortality or drops in production	Elevated mortality, clinical signs in birds, reduced egg production, or reduced shell quality are all signs that there could be an infectious disease in the Flock.	Delays in investigating Flock health issues can lead to rapid escalation and transfer to other Flocks on the Property, or even other farms in the area, which amplifies the biosecurity risk. Clinical signs, such as respiratory or enteric disease, mortality, low egg production or quality problems should be investigated promptly by management and an experienced avian veterinarian. Clinical signs of disease can indicate that there is a problem in the Flock, which will make the primary management goal to contain the problem to the affected shed and prevent further transmission.

9 References

AHA (2015). "National Farm Biosecurity Technical Manual for Egg Production ". Animal Health Australia, Canberra, Australia.

Andino, A., and Hanning, I. (2015). Salmonella enterica: survival, colonization, and virulence differences among serovars. *The Scientific World Journal* 2015.

Animal and Plant Health Inspection Service (2015a). "Prevent Avian Influenza at Your Farm Improve Your Biosecurity with Simple Wildlife Management Practices." U.S. Department of Agriculture, USA.

Animal and Plant Health Inspection Service (2015b). "Risk that Poultry Feed made with Corn, Potentially Contaminated with Eurasian North American Lineage H5N2 HPAI Virus from Wild Migratory Birds, Results in Exposure of Susceptible Commercial Poultry." United States Department of Agriculture, Colorado, USA.

Australian Eggs Ltd (2018). "Annual Report; 2017/2018", Sydney, NSW.

BC Poultry Association Biosecurity Committee (2006). "BC Poultry Biosecurity Reference Guide." BC Poultry Association, , British Columbia.

Boseret, G., Losson, B., Mainil, J. G., Thiry, E., and Saegerman, C. (2013). Zoonoses in pet birds: review and perspectives. *Veterinary Research* 44, 36.

Burns, T., Guerin, M., Kelton, D., Ribble, C., and Stephen, C. (2011). On-farm Study of Human Contact Networks to Document Potential Pathways for Avian Influenza Transmission between Commercial Poultry Farms in Ontario, Canada. *Transboundary and emerging diseases* 58, 510-518.

Cappucci Jr, D., Johnson, D., Brugh, M., Smith, T., Jackson, C., Pearson, J., and Senne, D. (1985). Isolation of avian influenza virus (subtype H5N2) from chicken eggs during a natural outbreak. *Avian Diseases*, 1195-1200.

Chaudhry, M., Rashid, H. B., Thrusfield, M., Welburn, S., and Bronsvoort, B. M. (2015). A case-control study to identify risk factors associated with avian influenza subtype H9N2 on commercial poultry farms in Pakistan. *PloS one* 10, e0119019.

Chumpolbanchorn, K., Suemanotham, N., Siripara, N., Puyati, B., and Chaichoune, K. (2006). The effect of temperature and UV light on infectivity of avian influenza virus (H5N1, Thai field strain) in chicken fecal manure.

Conan, A., Goutard, F. L., Sorn, S., and Vong, S. (2012). Biosecurity measures for backyard poultry in developing countries: a systematic review. *BMC veterinary research* 8, 240.

Couteaudier, M., and Denesvre, C. (2014). Marek's disease virus and skin interactions. *Veterinary research* 45, 36.

Dent, J. E., Kiss, I. Z., Kao, R. R., and Arnold, M. (2011). The potential spread of highly pathogenic avian influenza virus via dynamic contacts between poultry premises in Great Britain. *BMC veterinary research* 7, 59.

Department of Environment and Primary Industries (2006). "Biosecurity Guidelines for Poultry Producers." The Australian Government, Melbourne, Victoria.

England, J. J. (2002). Biosecurity: safeguarding your veterinarian: client: patient relationship. *The Veterinary clinics of North America. Food animal practice* 18, 373-8, v.

Food, and Drug Administration, H. (2009). Prevention of Salmonella enteritidis in shell eggs during production, storage, and transportation. Final rule. *Federal register* 74, 33029.

Gilbert, M., Chaitaweesub, P., Parakamawongsa, T., Premashthira, S., Tiensin, T., Kalpravidh, W., Wagner, H., and Slingenbergh, J. (2006). Free-grazing ducks and highly pathogenic avian influenza, Thailand. *Emerging infectious diseases* 12, 227.

Hakim, H., Thammakarn, C., Suguro, A., Ishida, Y., Kawamura, A., Tamura, M., Satoh, K., Tsujimura, M., Hasegawa, T., and Takehara, K. (2014). Evaluation of sprayed hypochlorous acid solutions for their virucidal activity against avian influenza virus through in vitro experiments. *Journal of Veterinary Medical Science*, 14-0413.

Hulse-Post, D., Sturm-Ramirez, K., Humberd, J., Seiler, P., Govorkova, E., Krauss, S., Scholtissek, C., Puthavathana, P., Buranathai, C., and Nguyen, T. (2005). Role of domestic ducks in the propagation and biological evolution of highly pathogenic H5N1 influenza viruses in Asia. *Proceedings of the National Academy of Sciences* 102, 10682-10687.

Jonges, M., Van Leuken, J., Wouters, I., Koch, G., Meijer, A., and Koopmans, M. (2015). Wind-mediated spread of low-pathogenic avian influenza virus into the environment during outbreaks at commercial poultry farms. *PLoS One* 10, e0125401.

Kang, Y., Li, Y., Yuan, R., Li, X., Sun, M., Wang, Z., Feng, M., Jiao, P., and Ren, T. (2014). Phylogenetic relationships and pathogenicity variation of two Newcastle disease viruses isolated from domestic ducks in Southern China. *Virology journal* 11, 147.

Kassaify, Z. G., El Hakim, R. G., Rayya, E. G., Shaib, H. A., and Barbour, E. K. (2007). Preliminary study on the efficacy and safety of eight individual and blended disinfectants against poultry and dairy indicator organisms. *Veterinaria italiana* 43, 821-830.

Klaassen, M., Hoye, B. J., and Roshier, D. A. (2011). Identifying crucial gaps in our knowledge of the life-history of avian influenza viruses–an Australian perspective. *Emu* 111, 103-112.

Kung, N. Y., Morris, R. S., Perkins, N. R., Sims, L. D., Ellis, T. M., Bissett, L., Chow, M., Shortridge, K. F., Guan, Y., and Peiris, M. J. (2007). Risk for infection with highly pathogenic influenza A virus (H5N1) in chickens, Hong Kong, 2002. *Emerging infectious diseases* 13, 412.

Leibler, J. H., Carone, M., and Silbergeld, E. K. (2010). Contribution of company affiliation and social contacts to risk estimates of between-farm transmission of avian influenza. *PLoS One* 5, e9888.

Malladi, S., Weaver, J. T., Clouse, T. L., Bjork, K. E., and Trampel, D. W. (2011). Moving-average trigger for early detection of rapidly increasing mortality in caged table-egg layers. *Avian diseases* 55, 603-610.

Organization, W. H. (2002). "Risk assessments of Salmonella in eggs and broiler chickens," Food & Agriculture Org.

Racicot, M., Venne, D., Durivage, A., and Vaillancourt, J.-P. (2011). Description of 44 biosecurity errors while entering and exiting poultry barns based on video surveillance in Quebec, Canada. *Preventive veterinary medicine* 100, 193-199.

Reperant, L., Rimmelzwaan, G., and Kuiken, T. (2009). Avian influenza viruses in mammals. *Revue scientifique et technique* 28, 137.

Rossi, G., Smith, R. L., Pongolini, S., and Bolzoni, L. (2017). Modelling farm-to-farm disease transmission through personnel movements: from visits to contacts, and back. *Scientific Reports* 7, 2375.

Scott, A. B., Singh, M., Toribio, J.-A., Hernandez-Jover, M., Barnes, B., Glass, K., Moloney, B., Lee, A., and Groves, P. (2017). Comparisons of management practices and farm design on Australian commercial layer and meat chicken farms: Cage, barn and free range. *PloS one* 12, e0188505.

Scott, P. (2015). "Development and Extension of Industry Best Practice for On-Farm Euthanasia of Spent Layer Hens." Poultry CRC, Armidale, NSW.

Scott, P., and Ahern, T. (2009). National Water Biosecurity Manual-Poultry Production. *Department of Agriculture, Fisheries and Forestry and Scolexia Animal and Avian Health Consultancy. Commonwealth of Australia, Canberra*.

Seedorf, J., and Schmidt, R.-G. (2017). The simulated air flow pattern around a moving animal transport vehicle as the basis for a prospective biosecurity risk assessment. *Heliyon* 3, e00358.

Shahid, M. A., Abubakar, M., Hameed, S., and Hassan, S. (2009). Avian influenza virus (H 5 N 1); effects of physico-chemical factors on its survival. *Virology Journal* 6, 38.

Shriner, S. A., VanDalen, K. K., Mooers, N. L., Ellis, J. W., Sullivan, H. J., Root, J. J., Pelzel, A. M., and Franklin, A. B. (2012). Low-pathogenic avian influenza viruses in wild house mice. *PLoS One* 7, e39206.

Si, Y., de Boer, W. F., and Gong, P. (2013). Different environmental drivers of highly pathogenic avian influenza H5N1 outbreaks in poultry and wild birds. *PloS one* 8, e53362.

Siembieda, J., Johnson, C. K., Boyce, W., Sandrock, C., and Cardona, C. (2008). Risk for avian influenza virus exposure at human–wildlife interface. *Emerging infectious diseases* 14, 1151.

Spackman, E., Gelb, J., Preskenis, L. A., Ladman, B. S., Pope, C. R., Pantin-Jackwood, M. J., and Mckinley, E. T. (2010). The pathogenesis of low pathogenicity H7 avian influenza viruses in chickens, ducks and turkeys. *Virology journal* 7, 331.

Ssematimba, A., Hagenaars, T. J., and De Jong, M. C. (2012). Modelling the wind-borne spread of highly pathogenic avian influenza virus between farms. *PLoS One* 7, e31114.

The Center for Food Security and Public Health (2015). "Poultry biosecurity officer information manual." The University of Minnesota, USA.

Thomas, M., Bouma, A., Ekker, H., Fonken, A., Stegeman, J., and Nielen, M. (2005). Risk factors for the introduction of high pathogenicity Avian Influenza virus into poultry farms during the epidemic in the Netherlands in 2003. *Preventive veterinary medicine* 69, 1-11.

Tiwari, A., Patnayak, D. P., Chander, Y., Parsad, M., and Goyal, S. M. (2006). Survival of two avian respiratory viruses on porous and nonporous surfaces. *Avian diseases* 50, 284-287.

Tracey, J. P., Woods, R., Roshier, D., West, P., and Saunders, G. R. (2004). The role of wild birds in the transmission of avian influenza for Australia: an ecological perspective. *Emu* 104, 109-124.

Van Kerkhove, M. D., Mumford, E., Mounts, A. W., Bresee, J., Ly, S., Bridges, C. B., and Otte, J. (2011). Highly pathogenic avian influenza (H5N1): pathways of exposure at the animal-human interface, a systematic review. *PloS one* 6, e14582.

Vijaykrishna, D., Deng, Y.-M., Su, Y. C., Fourment, M., Iannello, P., Arzey, G. G., Hansbro, P. M., Arzey, K. E., Kirkland, P. D., and Warner, S. (2013). The recent establishment of North American H10 lineage influenza viruses in Australian wild waterfowl and the evolution of Australian avian influenza viruses. *Journal of virology*, JVI. 03437-12.

Ward, M. P., Maftei, D., Apostu, C., and Suru, A. (2008). Environmental and anthropogenic risk factors for highly pathogenic avian influenza subtype H5N1 outbreaks in Romania, 2005− 2006. *Veterinary research communications* 32, 627-634.

Washington State Department of Agriculture "Avian Health Program." Washington State Department of Agriculture,, Washington State, USA.

Wierup, M., Wahlström, H., Lahti, E., Eriksson, H., Jansson, D. S., Odelros, Å., and Ernholm, L. (2017). Occurrence of Salmonella spp.: a comparison between indoor and outdoor housing of broilers and laying hens. *Acta Veterinaria Scandinavica* 59, 13.

Woźniakowski, G., and Samorek-Salamonowicz, E. (2014). Direct detection of Marek's disease virus in poultry dust by loop-mediated isothermal amplification. *Archives of virology* 159, 3083-3087.

Zellen, G., Weber, L., and Martin, S. (1984). Infectious laryngotracheitis in the Niagara Peninsula: a case control study. *The Canadian Veterinary Journal* 25, 75.

Zou, S., Guo, J., Gao, R., Dong, L., Zhou, J., Zhang, Y., Dong, J., Bo, H., Qin, K., and Shu, Y. (2013). Inactivation of the novel avian influenza A (H7N9) virus under physical conditions or chemical agents treatment. *Virology journal* 10, 289.