



SUMMARY HANDBOOK

WASTE AND BY-PRODUCT
STRATEGIES



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About the Authors

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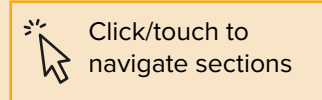
Eugene works as an agricultural/environmental engineering consultant. He has spent the last 30 years working predominantly on environmental and resource management issues related to agricultural and agro-industrial industries, with a particular focus on the intensive animal industries. Primary work areas include development of environmental and planning guidelines, extension guidelines, life cycle assessment (LCA), including carbon and water footprinting, development and planning applications for industry, environmental management systems, nutrient and manure management, odour measurement and assessment, anaerobic digestion (including biogas capture and use), and supplying expert advice.

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Purpose

This handbook is designed to assist egg producers and facility managers to identify, assess and implement strategies to beneficially use or convert by-products into alternative revenue streams.

Industry can use this handbook to understand the opportunities and factors that determine the viability of managing, utilising, or converting by-products, contributing to closed-loop production and/or circular economy principles.



Producers should refer to the **Optimising waste and by-product utilisation and conversion to value streams manual** for information on how to implement/conduct the strategies and outlines potential barriers to adoption (e.g. capital requirements, scale) to ensure that industry has access to precompetitive information to prioritise targeted investment.

The strategies and technologies are outlined in order of preference against the waste hierarchy. This follows an avoid, reduce, reuse, recycle approach. Producers should consider this idealised hierarchy in light of their own farm, including their own waste and by-product volumes and other factors (e.g. labour availability, proximity to neighbours), to identify their best options for waste and by-product utilisation. Fundamentally, the most preferred option to manage a given by-product may differ from farm to farm.

State and Territory regulations may also be a barrier to by-product use, and requirements can vary significantly between jurisdictions. Regulations should be reviewed before implementing by-product management or utilisation strategies.





Developing a waste and by-product management strategy

Developing an effective waste and by-product management plan for a farm requires undertaking the following steps, the first of which is to audit the types and volumes/weights produced on your farm.





- Step 1:**
Populate egg farm waste and by-product audit template for your farm for a given period (e.g. one year). Note that not every waste and by-product listed below may be generated on your farm. Equally, you may generate other waste and by-products on your farm that are not listed below. You should add these under the 'other' categories.

A hard copy version of the template is available in APPENDIX 1 – FARM WASTE and BY-PRODUCT audit.

Guidance on how to estimate some volumes/weights are provided in the notes sections of the farm waste audit template.

- Step 2:**
Understand the total quantities of waste and by-products produced on your farm. This involves quantifying the amount of each type of waste and by-product produced. This will identify the amount of each waste or by-product stream. This will allow you to focus on the most important (i.e. largest) residue streams. You may choose to focus on developing strategies to reduce or better manage your largest sources of waste and by-products.

- Step 3:**
Compare the waste and by-product volumes produced on your farm with the industry averages reported in Appendix 2 - Industry Baseline in the **Optimising waste and by-product utilisation and conversion to value streams manual** per one thousand birds housed and eggs graded. This will demonstrate how your farm differs from average industry values, i.e. it will show if/where you produce less or more waste and by-products than what the industry does on average. You may choose to focus on developing strategies to reduce or better manage the waste and by-products that you produce more of on average than does the rest of the industry.

*Note that not all waste types were disaggregated or trackable at the industry level in the baseline assessment (in Appendix 2 - Industry Baseline in the **Optimising waste and by-product utilisation and conversion to value streams manual**). In future, as more farms begin auditing and tracking waste and by-products, it may be possible to update/expand on the industry baseline.*

- Step 4:**
Familiarise yourself with the principles of waste and by-product management (Section 4). This is an important step in identifying the 'best'

strategies and technologies for each waste and by-product stream. As you are doing this, identify any waste or by-product management practices that currently fall into the 'least preferred' category, e.g. anything that goes to landfill or even burial. You may choose to focus on developing strategies to avoid this altogether or to at least reduce the volumes going to landfill or burial as a first step.

- Step 5:**
For your priority waste and by-product streams, review current practices and the options available (strategies and technologies) to manage these. A list of available options is outlined in management and processing options (Section 5), with hyperlinks to the relevant section in this handbook where the strategy, process management, and any pros and cons are outlined. For each section (i.e. each major by-product or waste stream), the options are presented from the theoretically most preferred to the least preferred, based on the principles of waste and by-product management (Section 4). The best options for your farm, however, will depend on the scale of your farm, the capital available for investment, the amount of labour and land available, proximity to sensitive receptors, intended use, etc.

- Step 6:**
Implement selected strategies and technologies on your farm/ continue to assess whether there is scope to improve your existing implementation of selected strategies and technologies. This process may include periodic re-evaluation as to whether variations or upgrades could (financially) or should (reduction in environmental risks) be made to your existing operations/facilities, e.g. if managing mortalities in mostly static piles with temporary walls, is there sufficient capital to justify upgrading to a permanent (e.g. timber walled, roofed) facility, reducing the risk of runoff, etc.

- Step 7:**
Repeat the audit in future (e.g. in another year) to track how waste and by-product volumes have changed since your baseline/previous audit. This will demonstrate whether new priority streams have emerged (e.g. an increase in volume since the baseline/previous year) and whether a change in management practices is needed or is now feasible for particular streams.



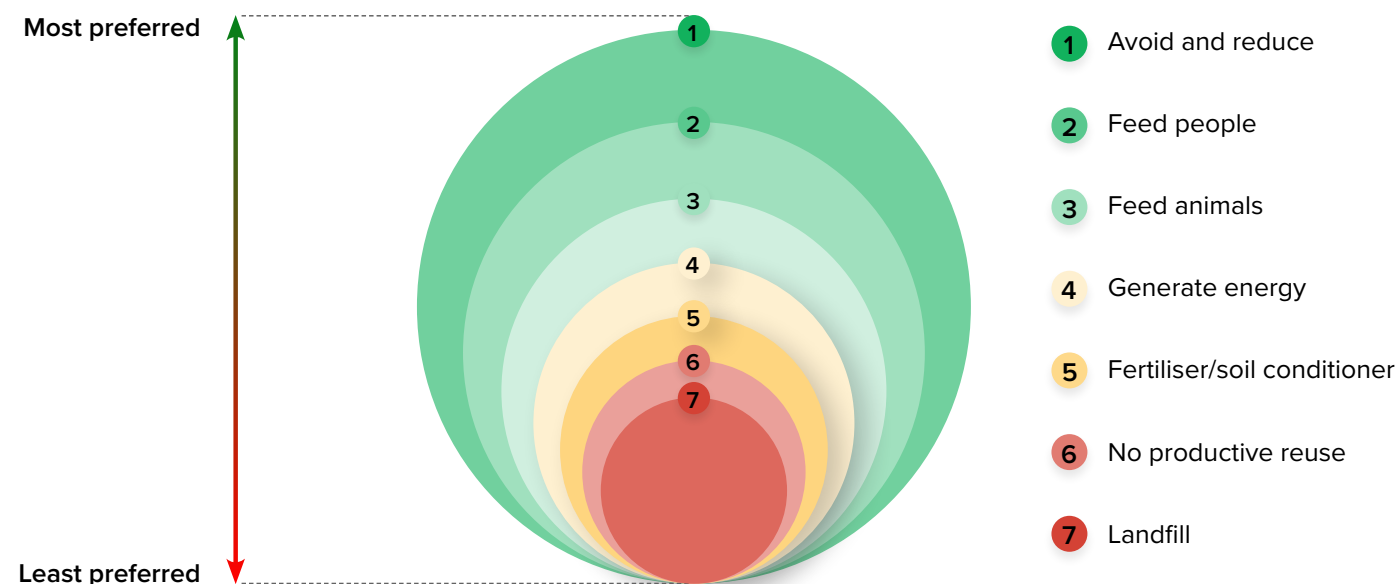
Principles of waste and by-product management

After conducting a waste and by-product audit for your farm, the next stage in developing your management plan is to understand the general principles of waste management so that you can identify preferred technologies and strategies.

A hierarchy of the most preferred to least preferred waste and by-product management options for the egg industry is provided in **Figure 1**. If you keep in mind the general principles of waste and by-product management (avoid, reduce, reuse, recycle), it should be relatively straightforward to identify appropriate strategies and technologies, resulting in improved (more preferred) waste and by-product management outcomes.

Figure 1: Waste and by-product management hierarchy for egg production

Source: Adapted from US EPA (2023)



Not every option in **Figure 1** will be available or practically applicable to every waste or by-product produced on your farm, e.g. spent hens cannot be 'avoided' and plastic wrap cannot 'feed people or animals'.

Improvements in production efficiency (e.g. reduced mortality, increased eggs per hen per year, improved FCR) will generally reduce most waste and by-product volumes on-farm. Conducting regular audits will allow you to track this change over time on both a whole of farm (total) and intensity basis (per 1,000 birds housed, etc.).



Management and processing options

A list of management and processing technologies for each category of by-product or waste is shown in **Table 1**. More detailed descriptions and assessments are set out for each of these categories in Sections 6 to 13 of the **Optimising waste and by-product utilisation and conversion to value streams manual** found on the **Australian Eggs Website**.

Suitability for small-medium and large farms are colour-coded: green means the option is available and generally suited to a given farm size, orange means it may be feasible, red means it is not feasible, and blue means it is a 'blue-sky' option, i.e. could potentially become available in the future.

Table 1: Options available (or potentially available) to manage egg farm by-products and waste

Options	Suitable for small-medium farms	Suitable for large farms	Capital and operating cost	Labour requirement	Used/treated productively on-farm?
Manure and spent litter					
On-site land application	●	●	Low	Moderate	✓ Yes
Stockpiling (covered)	●	●	Low, Scalable	Low	✓ Yes
Stockpiling (uncovered)	●	●	Low	Low	✓ Yes
Windrow composting	●	●	Low, Scalable	Scalable	✓ Yes
Passive aeration	●	●	Low, Scalable	Scalable	✓ Yes
Forced aeration	●	●	High	Scalable	✓ Yes
Value adding to compost	●	●	Moderate	Scalable	✓ Yes
Advanced options – Anaerobic digestion	●	●	Very high	Variable	✓ Yes
Advanced options – Pelletisation	●	●	Moderate–High	Moderate–High	✓ Yes
Advanced options – Combustion	●	●	Very high	Moderate	✓ Yes
Selling off-farm direct from sheds* - dependant on state requirements	●	●	Low	Low	✗ No
Centralised organic fertiliser production	●	●	Low	Low	✗ No
Feedstock for insects	●	●	Moderate–High	Moderate	○ Maybe

* Not suitable due to biosecurity and bird health risks.

● available ● may be feasible ● not feasible ● available in the future



Options	Suitable for small-medium farms	Suitable for large farms	Capital and operating cost	Labour requirement	Used/treated productively on-farm?
Spent hens and off-sex chicks					
Meat processing	●	●	Low	Low	⊗ No
Rendering	●	●	Low	Low	⊗ No
Windrow composting	●	●	Low, Scalable	Scalable	✓ Yes
Bays and piles	●	●	Scalable	Scalable	✓ Yes
Advanced options – Anaerobic digestion, drying	●	●	Very high	Variable	✓ Yes
Selling off-farm to local markets*	●	●	Low	Low	⊗ No
In-ovo technology	Hatcheries only		High	Unknown	● N/A
Dedicated spent hen processors	●	●	Low	Low	⊗ No
Maceration/grinding	●	●	Unknown	Moderate	✓ Yes (could be composted)
Burial	●	●	Low	Low	⊗ No
Landfill	●	●	Low	Low	⊗ No
Day-to-day mortalities					
Windrow composting	●	●	Low	Low	✓ Yes
Small bin composting	●	●	Low	Low	✓ Yes
Bay and pile composting	●	●	Scalable	Scalable	✓ Yes
Rotary drum processing	●	●	Moderate	Scalable/variable depending on design	✓ Yes
Commercial providers	●	●	Moderate	Low	⊗ No
On-farm incineration**	●	●	Moderate–High	Moderate	⊗ No
Burial	●	●	Low	Low	⊗ No
Landfill	●	●	Low	Low	⊗ No

* Not suitable due to biosecurity and bird health risks.

** Depending on jurisdiction, it may be possible to land apply ash, but most beneficial nutrients will have been destroyed.

● available ● may be feasible ● not feasible ● available in the future



Options	Suitable for small-medium farms	Suitable for large farms	Capital and operating cost	Labour requirement	Used/treated productively on-farm?
Wastewater					
Hot water heaters	●	●	Moderate–High	Low	✓ Yes
Reverse osmosis	●	●	Moderate–High	Low	✓ Yes
Filtration	●	●	Moderate–High	Low	✓ Yes
Evaporation	●	●	Low	Low	✗ No
Composting	●	●	Scalable	Scalable	✓ Yes
Irrigation	●	●	Low	Low	✓ Yes
Release to sewer	●	●	Low	Low	✗ No
Shells and broken eggs					
Animal feed	●	●	Low	Low	✓ Yes
Separation	●	●	Moderate	Moderate	○ Maybe
Co-composting	●	●	Scalable	Scalable	✓ Yes
Other uses	●	●	Variable	Variable	ⓘ Variable
Burial	●	●	Low	Low	✗ No
Landfill	●	●	Low	Low	✗ No
Waste (plastic, cardboard, other solid waste)					
Avoid/reduce	●	●	Variable	Variable	● N/A
Reuse/recycle	●	●	Variable	Variable	✓ Yes
Digestion	●	●	Very high	Moderate	✓ Yes
Composting	●	●	Scalable	Scalable	✓ Yes
Burning	●	●	Low	Low	✗ No
Landfill	●	●	Low	Low	✗ No

● available ● may be feasible ● not feasible ● available in the future

Options at a glance

Table 2 provides a high-level summary of the options available to producers to manage or utilise by-products. For each by-product stream, the options are split into those that are proven and relatively common in the egg industry and those that are technically feasible but are not commonly used for various reasons. The options for each by-product stream are arranged in order of most to least preferred, as outlined in the waste hierarchy diagram in **Figure 2**. Green indicates no significant issues/barriers to adoption or implementation, orange flags that there are several potential issues that must be addressed/considered if producers wish to implement the option, and red indicates prohibitive issues which make the option not viable.

Table 2: Summary dashboards of options available for egg farm by-products, in order of most to least preferred

Manure and spent litter

Option available		Producer benefits	Producer negatives
Spread on-farm direct from shed	✓	Uses by-product on-farm as fertiliser / soil conditioner. Limits handling and management. Lowest greenhouse gas emissions of the on-farm strategies.	By-product is not sold (does not become a revenue stream). Environmental risks to be managed.
Covered stockpiling	✓	By-product can be used on-farm as fertiliser / soil conditioner at appropriate time. Low labour and handling requirements. Relatively low greenhouse gas emissions produced.	Environmental and biosecurity risks to be managed. Ammonia losses during stockpiling.
Uncovered stockpiling	✓	By-product can be used on-farm as fertiliser / soil conditioner at appropriate time. Low labour and handling requirements. Generates relatively low greenhouse gas emissions.	Loses more nitrogen (ammonia) than covered stockpiling. Generates more greenhouse gas emissions and odour than covered stockpiling. Environmental and biosecurity risks to be managed.
Windrow composting	✓	The composting process, if done correctly, eliminates most / all pathogens, reducing biosecurity risks. Creates stable product that can be <u>stockpiled</u> and used on-farm as fertiliser / soil conditioner or sold.	Potentially high nitrogen losses during composting process (high greenhouse gas emissions). Environmental and biosecurity risks <u>reduced through composting process, but residual risks</u> to be managed. Additional land, labour and possibly machinery required. Mixing of manure with dry, coarse, carbon-rich bulking material is usually required to facilitate composting process. Regulatory uncertainty when compost is sold.
Bay and pile composting	!		
Passively aerated static pile composting	!		
Selling off-farm direct from sheds*- dependant on state requirements.	✓	Removes labour and handling burden. Shifts greenhouse gas emissions associated with use from on-farm to off-farm.	Not used beneficially on-farm. Biosecurity risks (transport) to be managed. Demand and returns may vary seasonally.

* Not suitable due to biosecurity and bird health risks.

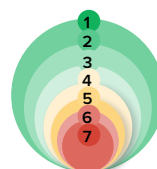
Viability:



No significant issues/barriers



Several potential issues that must be addressed/considered



Waste hierarchy tier:

1 Avoid and reduce

2 Feed people

3 Feed animals

4 Generate energy

5 Fertiliser/soil conditioner

6 No productive reuse

7 Landfill



Spent hens

Option available			Producer benefits	Producer negatives
Meat processing	✓	2 Feed people	By-product is beneficially reused in the wider economy. Removes by-product from farm.	Little/no financial return. Limited access to markets at present. Biosecurity risks to be managed.
Rendering	✓	3 Feed animals	By-product is beneficially reused in the wider economy. Removes by-product from farm.	Little/no financial return. Limited plants accept spent hens (access may be closed in event of disease outbreaks). Biosecurity risks to be managed.
Windrow composting	✓	5 Fertiliser/soil conditioner	See above for 'manure composting'.	On-farm euthanasia required. See above for 'manure composting'.
Bay and pile composting	!			
Passively aerated static pile composting	!			

Shells and broken eggs

Option available			Producer benefits	Producer negatives
Animal feed	✓	3 Feed animals	Beneficially reuses by-product off-farm. Removes management off-farm. Avoids landfill or burial.	By-product not used beneficially on-farm. Biosecurity risk to be managed (transport). Limited customers and may be regulatory barriers.
Co-composting	✓	5 Fertiliser/soil conditioner	Beneficially reuses by-product on-farm as a fertiliser /oil conditioner.	Requires existing on-farm composting activity. Could be difficult to mix evenly and to produce uniform product.
Separation	!	! Variable	Variety of possible beneficial end-uses/markets.	Additional infrastructure and energy (and possibly labour) required. May be limited markets nearby.
Burial	✓	6 No productive reuse	Low-cost disposal method.	No beneficial reuse.
Landfill	✓		Removes management off-farm.	No beneficial reuse.

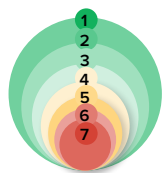
Viability:



No significant issues/barriers



Several potential issues that must be addressed/considered



Waste hierarchy tier:

1 Avoid and reduce

2 Feed people

3 Feed animals

4 Generate energy

5 Fertiliser/soil conditioner

6 No productive reuse

7 Landfill



Day-to-day mortalities

Option available			Producer benefits	Producer negatives
Windrow composting	✓	5 Fertiliser/soil conditioner	See above for 'manure composting'.	See above for 'manure composting'.
Bay and pile composting	!			
Small bin composting	✓		See above for 'manure composting' Suitable for very small farms.	See above for 'manure composting'.
Rotary drum composting	!		See above for 'manure composting' End-product can be land applied on-farm or further composted for sale.	See above for 'manure composting' May require further composting (e.g., windrow) to produce stabilised product.
Collection in aerated bins (pre-composting)	!	5 Fertiliser/soil conditioner**	By-product goes to productive use elsewhere in the economy. Reduced biosecurity risk (relative to other composting systems). Low land and labour requirement.	By-product not used beneficially on-farm. Producer pays for use and collection of bin.
On-farm incineration*	!	6 No productive reuse	Low biosecurity risk if performed properly. Low noise. Different sized systems available.	Expensive to perform properly. On-site storage required. Limited beneficial properties in the ash. Ash may be difficult to use or dispose of or use.
Landfill	!	7 Landfill	Removes management off-farm.	No beneficial reuse of by-product. On-site storage required. Biosecurity risk to be managed (contractor transport). Producer pays for disposal.

Wastewater

Option available			Producer benefits	Producer negatives
Irrigation	✓	5 Fertiliser/soil conditioner	Beneficially reuses by-product on-farm. Reduces need for water extraction from environment.	Pre-treatment may be required. Irrigation opportunity and infrastructure required, including dam and pipes from processing facility. Environmental and biosecurity risks to be managed.
Using water for Compost production	✓		Beneficially reuses by-product on-farm. Reduces need for water extraction from environment.	Water needs to be moved from processing to composting site. Pre-treatment may be required. Environmental risks to be managed.
Evaporation	✓	6 No productive reuse	Low labour and handling requirement.	No beneficial reuse. Land required.
Release to sewer	✓		Removes management off-farm.	No beneficial reuse.

* Depending on jurisdiction, it may be possible to land apply ash, but most beneficial nutrients will have been destroyed.

** Secondary to on-farm process

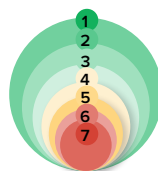
Viability:



No significant issues/barriers



Several potential issues that must be addressed/considered



Waste hierarchy tier:

- 1 Avoid and reduce
- 2 Feed people
- 3 Feed animals
- 4 Generate energy
- 5 Fertiliser/soil conditioner
- 6 No productive reuse
- 7 Landfill



Table 3 describes the options available to producers to manage waste streams generated on-farm. The columns (avoid/reduce through to landfill/burial) are arranged in order of most to least preferable options, as outlined in the waste hierarchy in **Figure 2**. Green means it is an option, orange means producers should investigate whether it is an option, and red means it is not an option.

Table 3: Summary of options available for waste streams on egg farms, in order of most to least preferred

Waste	Avoid/reduce	Reuse/recycle	Digestion	Composting	Burning	Landfill/Burial
Baling twine	●	●	●	●	●	●
Bale netting/wrap	●	●	●	●	●	●
Cardboard	●	●	●	●	●	●
Chemicals	●	●	●	●	●	●
Conveyor belting	●	●	●	●	●	●
Disposable PPE	●	●	●	●	●	●
Drums	●	●	●	●	●	●
Dust	●	●	●	●	●	●
Feed and fertiliser bags	●	●	●	●	●	●
Fencing materials	●	●	●	●	●	●
Floor eggs	●	●	●	●	●	●
IBCs	●	●	●	●	●	●
Medication waste (e.g., syringes, vaccination bottles)	●	●	●	●	●	●
Old machinery	●	●	●	●	●	●
Pallets	●	●	●	●	●	●
Pallet wrap	●	●	●	●	●	●
Plastics	●	●	●	●	●	●
Shed infrastructure (broken lights etc)	●	●	●	●	●	●
Silage cover	●	●	●	●	●	●
Tyres	●	●	●	●	●	●
Waste feed	●	●	●	●	●	●

● It is an option

● Producers should investigate whether it is an option

● Not an option



Appendix 1 – Farm waste and by-product audit

Table 4: Farm by-product audit template

Table 4. Farm by-product audit template

		Inventory data					
Parameter	Units	Your farm	Cage	Cage-free (barn)	Free range	Rearing	Explanatory notes (as required)
Farm by-products							
Daily mortalities	tonnes						Multiply the number of birds placed (e.g. 100,000) by the average mortality rate for the flock (e.g. 3%) and the average weight of the birds (e.g. 2 kg for layers), and then divide by 1,000 to convert to tonnes. EXAMPLE: (100,000 birds x 3% mortality x 2 kg/mortality)/1,000 = 6 tonnes
Manure/spent litter	tonnes						
Spent hens	tonnes						
Wastewater	kL						
Grading by-products							
Broken/cracked eggs	tonnes						Multiply the number of eggs packed/graded (e.g. 30 million) by the average loss rate (e.g. 2%) and then multiply that by the average weight per egg in kilograms (e.g. 60 grams/1,000), then divide by 1,000 to convert to tonnes. EXAMPLE: (30,000,000 eggs x 2% loss x 60 g/1,000)/1,000 = 36 tonnes Multiply the number of eggs broken on site (e.g. 2 million) by the average weight per egg in kilograms (e.g. 60 grams/1,000) and then multiply by 14% (roughly 14% of the mass of a whole egg is the shell), and then divide by 1,000 to convert to tonnes. EXAMPLE: (2,000,000 eggs x 60 g/1,000 / 14%)/1,000 = 16.8 tonnes
Shells	tonnes						
Wastewater	kL						



Table 5: Farm waste audit template

		Inventory data	
Parameter	Units (If blank, enter your own unit)	Your farm	Explanatory notes (as required)
Inorganic waste			
Cardboard			
Soft plastic			
Hard plastic			
Total plastic		0.00	Sum the two lines above.
IBCs	No.		
Drums, e.g. 44-gallon	No.		
Chemical containers/bottles	No.		
Conveyor belting	m		
Lights	No.		
Feed bags	No.		
Fertiliser bags	No.		
Vaccination bottles	No.		
Used syringes	No.		
Bale or silage wrap	m		
Bale netting	m		
Poultry netting	m		



		Inventory data	
Parameter	Units (If blank, enter your own unit)	Your farm	Explanatory notes (as required)
Tractor tyres	No.		
Car tyres	No.		
Old machinery	No.		
Fence posts	No.		
Pallets	No.		
PPE (e.g. disposable overalls)			
Broken feed chain	m		
Broken drinker line	m		
Other			
Other			
Other			
Organic waste			
Waste feed	kg		
Dust	kg		
Baited/trapped rodents	No.		
Other			
Other			
Other			



Disclaimer

Scope of the document

Facilities to which this manual applies

The handbook details a couple of relevant strategies and technologies, their methods, and any key considerations (scale, labour, capital investment) to assist producers and facility managers with identifying, implementing, or further improving by-product management and utilisation.

While the document focuses on layer farms, the principles outlined may equally apply to breeder farms and standalone rearing farms. This is designed for the Australian egg industry only, i.e. may not be applicable to meat chicken farms (breeder or grower), or other species such as ducks, quails, or ratites (flightless birds).

The principles outlined in this document are applicable to both small and large enterprises. Where feasibility or ease of practical implementation may vary between facilities based on scale, efforts have been made to flag this. The strategies and technologies described in

this document are not exhaustive and do not preclude producers using alternative means to manage or utilise by-products.

Content is not legal advice

While this document was developed with reference to State (all references to 'State Government' contained in this handbook include 'Territory Government') regulatory frameworks, it is not a guide to regulatory compliance. This handbook does not claim that its recommendations meet regulatory requirements, it only advises on important issues to address when processing and using industry by-products. It is recommended that producers and end-users review their State or Territory's requirements for by-product regulations.

Guidance does not preclude alternative practices

The information in this handbook is based on current information, knowledge and practices that can be used as a reference standard. Future research and

innovation may identify new strategies and best practice methods for waste and by-product utilisation and conversion to value-add these materials. The handbook aims to provide industry with the necessary information to take a risk-based approach to utilisation. Where potential solutions and strategies have been identified, there may be alternatives (and alternative methods) not covered here that also achieve the desired outcome.

Guidance is subject to other requirements

Egg industry facilities are subject to other requirements including biosecurity, animal welfare, food safety, and labelling standards. Any changes to these standards can have flow-on effects with respect to waste and by-product generation, management and utilisation and must be considered.

Site specific considerations must be accounted for when determining the on-farm viability and feasibility of the

strategies outlined in this document. The benefit-cost analysis is done at a high level only, and includes capital (including infrastructure, equipment) and operating (labour, fuel, energy) costs, and benefits (e.g. revenue from product sales, avoided energy costs).

Biosecurity considerations for by-product management and utilisation

It is important to consider all factors that may affect the biosecurity of the production area, including by-product management, handling, and use. Producers should consult the relevant biosecurity requirements and guidelines directly and in full.



For more information please
contact the Australian Eggs offices:
(02) 9409 6999 or
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