AUSTRALIAN VETERINARY EMERGENCY PLAN

AUSVETPLAN

Operational manual

Disposal

Version 5.1

AUSVETPLAN is a series of response plans that describe the proposed Australian approach to an emergency animal disease incident. The documents provide guidance based on sound analysis, linking policy, strategies, implementation, coordination and emergency management plans.

National Biosecurity Committee

Disclaimer

Warranty

This manual may contain text under development

In this manual, text in square brackets and greyed out [xxx] indicates that that aspect of the manual remains unresolved or is under development. This text is not part of the official manual. The issues will be further worked on by experts and relevant text included at a future date.

Contact information

If you have any requests or inquiries concerning reproduction and rights, or suggestions or recommendations, you should address these to:

AUSVETPLAN – Animal Health Australia
PO Box 998
Dickson ACT 2602
ausvetplan@animalhealthaustralia.com.au

EMERGENCY ANIMAL DISEASE HOTLINE:
1800 675 888
The Emergency Animal Disease Hotline is a toll-free telephone number that connects callers to the relevant state or territory officer to report concerns about any potential emergency disease situation. Anyone suspecting an emergency disease outbreak should use this number to get immediate advice and assistance.

Approved citation

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- Version 5.0, 2021 (incorporation into the edition 5 format, and minor updates to the information on management of wool)
- Version 5.1, 2026 (major update)

Contents

Tables and Figures

1 Introduction

1.1 This manual

This operational manual on disposal is an integral part of the Australian Veterinary Emergency Plan, or AUSVETPLAN (Edition 5). AUSVETPLAN structures and functions are described in the **AUSVETPLAN *Overview***.

This manual has been produced in accordance with the procedures described in the **AUSVETPLAN *Overview*** and in consultation with the Australian Government, the state and territory governments, and the relevant industries.

1.1.1 Purpose

This manual addresses the matters to be considered when disposing of waste, including animal carcasses and animal products, for disease control purposes. It provides a decision-making framework that allows decisions on disposal methods to be assessed using weighted factors such as current legislation, operator safety, community concern, international acceptance, availability of transport, industry standards, local environment, cost-effectiveness, resource availability and speed of resolution. The importance of each factor will vary with each emergency animal disease (EAD) response. The approach allows logical, defensible and transparent decisions to be made on disposal using one method or a combination of methods.

1.1.2 Scope

This manual only considers EADs that are included in the Government and Livestock Industry Cost Sharing Deed in Respect of Emergency Animal Disease Responses (EAD Response Agreement (EADRA))[1] and for which there are AUSVETPLAN disease-specific response strategies.

Since each event will differ in its extent, the available resources, the risk to operators and the suitability of available disposal methods, this manual does not seek to provide solutions for every eventuality.

In any major animal health emergency, disposal methods may evolve or be superseded by alternative methods as the extent of the response is better understood. The solutions are likely to be a combination of multiple appropriate technologies.

This manual does not include possible avenues of waste minimisation, such as destruction of animals (uninfected or vaccinated) for human consumption, or potential treatment of animal products to render them suitable for human or animal consumption.

[1] https://animalhealthaustralia.com.au/eadra/

1.2 Other documentation

This manual should be read and implemented in conjunction with:

- other AUSVETPLAN documents, including the response strategies, enterprise and management manuals, and any relevant guidance and resource documents. The complete series of manuals is available on the Animal Health Australia website[2]
- relevant nationally agreed standard operating procedures (NASOPs). These procedures complement AUSVETPLAN and describe in detail specific actions undertaken during a response to an incident. NASOPs have been developed for use by jurisdictions during responses to EAD incidents
- relevant jurisdictional or industry policies, response plans, standard operating procedures, safety data sheets and work instructions
- relevant Commonwealth and jurisdictional legislation and legal agreements (such as the EADRA), where applicable.

1.3 Principles

The primary objective of disposal of animal carcasses, animal products, materials and wastes is to prevent the dissemination of infectious agents. For many EADs, stamping out is the primary strategy undertaken in Australia. As defined by the World Organisation for Animal Health (WOAH) stamping out involves the destruction of animals, disposal of contaminated materials and decontamination.

Disposal should be completed as soon as possible after destruction to minimise opportunities for infectious material to disperse. Although rapid disposal is of primary importance, it must be undertaken in a way that does not increase the risk of spread of the disease, or adversely affect the environment or community (see Sections 3.6 and 3.9 respectively).

State and territory legislation relating to environmental protection must be considered. It is highly recommended that jurisdictional environment protection agencies (EPA) are identified and engaged before an EAD event, as part of preparedness activities, to consider environmental aspects of disposal activities. EPAs should be engaged in the planning and implementation of disposal at the time of an EAD event.

Furthermore, as part of preparedness activities, external stakeholders, including local government, transporters and private disposal site operators, should be identified and engaged in the process of identifying potential disposal methods and locations (see Sections 2.2 and 2.4).

When planning and implementing disposal, the protection of public health and worker health and safety must be considered. Where there is relevant public health legislation, the responsible government agencies should be consulted. Risk assessments and the hierarchy of controls should be used to control human health and safety risks. While personal protective equipment is the lowest level of protection and least reliable control, it will have a place in operational activities, especially where management of zoonotic disease agents and fomite spread is required. Disposal site security must be maintained to control work health and safety (WHS) risk and prevent unauthorised access.

[2] https://animalhealthaustralia.com.au/ausvetplan/

2 The decision-making framework

2.1 Introduction

Disposal of animal carcasses, materials and equipment (fomites) used in the husbandry of animals, and products and byproducts created by the enterprises involved is a major challenge in an emergency animal disease (EAD) response. It is often the rate-limiting step of the operational activities of destruction, disposal and decontamination.

To assess and prioritise disposal methods according to their appropriateness, a decision-making framework should include all relevant factors, and be flexible enough to allow modifications for different situations and locations. A range of disposal methods is likely to be needed, especially in long-term, or large-scale responses.

The decision-making framework includes the selection of an expert team to review a particular field situation, following a structured decision-making process, and making recommendations to the controller of the operation (see Figure 2.1). The framework involves consideration of all available disposal methods and the application of the best solution at the local level, while being acceptable in the broader context of an EAD response.

2.2 Planning before responses

Prior planning should be undertaken by animal health authorities, in conjunction with all stakeholders, including agencies responsible for protection of the environment and for public health (where there is relevant legislation), local government, the farming industry, other agencies and service providers (e.g. excavation and transport contractors, and waste disposal operators). This is especially important for enterprises with large numbers of livestock, such as feedlots, piggeries and intensive poultry farms.

Planning before responses, possibly including formal agreements or memorandums of understanding, may provide the opportunity to clarify and resolve areas of concern. Environmental agencies may be able to provide guidance about the appropriate controls and approvals required for different disposal methods. A fast-track or emergency approval process might be available as the basis of agreements or standard operating procedures, to ensure timely approvals under particular circumstances.

Some legislation may provide exemptions, such that, under certain circumstances or under the authority of certain positions, the provisions of an Act do not apply in respect of:

- a particular area of the state or territory, or
- a specified premises, act or thing, or
- premises, acts or things in a specified class or situated in a specified area of the state or territory.

Using a previously unexplored site for disposal is the least preferred option, because it may require a complex assessment that may take some time. If this is to be considered as an option, consideration should be given to working proactively with environmental agencies to identify suitable disposal sites.

2.3 Decision-making process

The disposal of waste, including carcasses, during an EAD outbreak is a critical process that requires careful decision-making.

All wastes need to be considered concurrently. There may be potential for disposal of one waste to complement disposal of another—for example, composting of poultry carcasses and poultry litter.

Figure 2.1, below, outlines the indicative sequence of steps in the decision-making process.

Section 4 of this document outlines the various disposal methods, and Figure 4.1 gives a schematic representation of disposal methods.

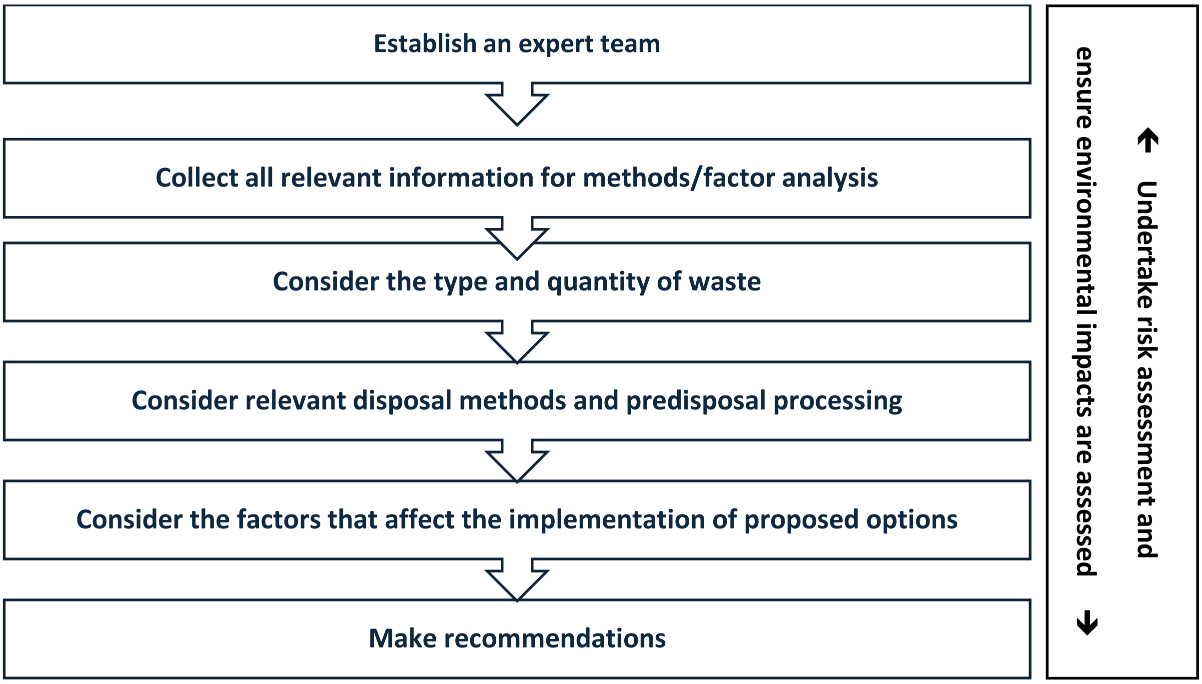

Figure 2.1 — Decision-making process for disposal options

2.4 Establishment of an expert team

An expert team will be established to determine the appropriate methods of disposal, considering a range of factors and making recommendations for disposal method(s) that may be used.

Membership of the expert team will vary with the incident, amount of waste and its location, waste disposal methods available and environmental conditions of the contaminated premises. It is important to keep the focus at the local level. The team needs to be assembled quickly and recommend waste management options as soon as possible. Delays in carcass disposal can result in public health concerns, and increased stress to animal owners and local communities, and may reduce the available disposal methods (e.g. it is difficult to transport autolysed carcasses).

Expert team members may provide expertise across a range of functional areas (see **AUSVETPLAN *Control centres management manual* – Part 2**). Below is a guide to the functions and/or areas of expertise that may be required. In some cases, members may fulfil multiple functions and may serve functions at the state coordination centre or local control centre.

Operations

- LCC Operations Management (chair of the expert team)
- Infected Premises Operations

Planning

- Planning Management
- LCC Response Planning
- LCC Technical Analysis—Epidemiology
- Specialist Advice—Livestock Industry

Liaison

- Emergency Management
- Liaison—Other Agencies
    - environment protection
    - civil engineering
    - human health department
    - local government
        - community
        - transport
        - water authorities
        - lands authorities.

It is important that the membership of this team, the decision-making process followed, and the recommendations made are documented to facilitate transparency in decision making and allow decisions taken to be reviewed later.

2.5 Waste material type and quantity

Waste materials during an EAD response may be diverse and require management through decontamination or disposal. Types of potentially contaminated materials are identified in Appendix 1.

Different disease outbreaks will require different control measures, resulting in different types and amounts of waste. An eradication plan that requires the destruction of all infected and at-risk animals, and the decontamination and disposal of associated materials (such as for foot-and-mouth disease) would produce large amounts of waste in a short time. An outbreak of bovine spongiform encephalopathy, on the other hand, would probably require disposal of fewer carcasses and animal products over a prolonged period. Some intensive industries produce larger quantities of waste products than others.

Many Australian waste management or processing facilities (e.g. renderers, landfills, knackeries, facilities for disposal of liquid waste and hazardous materials) process wastes similar to those that might be generated during an EAD outbreak. These facilities might be able to be used for diseases that do not generate large quantities of materials for immediate disposal. Conversely, in a large outbreak, routine waste disposal techniques might not be able to cope. This applies particularly to the disposal of liquid wastes such as milk.

2.6 Classification of material

EAD waste materials include animal carcasses, animal by-products, bedding, feed, manure, and other contaminated materials that need to be appropriately managed to prevent the spread of EAD agents. The proper classification of EAD waste materials is essential for their safe and effective disposal, as different types of waste may pose different risks to animal health, human health and the environment.

If not undertaken as part of EAD preparedness activities, the expert team, in consultation with relevant authorities, will classify wastes that may arise from the EAD response. A wide range of waste classification systems exist in Australia and vary between states and territories; however, for the purposes of this manual, EAD waste materials can be classified into risk categories.

- **High-risk waste** requires immediate and secure disposal to prevent the spread of the disease. This category includes carcasses of animals that died or were destroyed due to the disease, as well as any materials that came into direct contact with them, such as blood, fluids, tissues, organs, and contaminated equipment.
- **Medium-risk waste** may contain viable pathogens or vectors that could cause infection in susceptible animals or humans. This category includes bedding, feed, manure, litter, and other materials that were exposed to infected animals or their secretions or excretions.
- **Low-risk waste** has a low or negligible chance of containing infectious agents or vectors. This category includes materials that were in the vicinity of infected animals or premises, but did not come into contact with them, such as packaging, paper, plastic, and other general waste.

The classification of waste (as above) will inform the appropriate disposal method as well as any transport arrangements that may be required. Transport of waste material should be in accordance with jurisdictional legislation and relevant codes.

In a declared animal disease emergency, disease control legislation may prevail over other legislation, allowing for a prompt and efficient response. Nonetheless, it is important to consult with government agencies, such as those responsible for environmental legislation, to avoid environmental damage that may need to be managed over many years, and potential litigation relating to non-compliance with legislation.

2.7 Predisposal issues

Carcasses and other items awaiting disposal pose a high risk of pathogen and disease spread. They should be contained to prevent unauthorised access, and to prevent domestic pets, wild animals and birds from moving potentially infectious material. People attempting to gain unauthorised access might include distressed animal owners, animal rights activists, local stakeholders, unauthorised media, disgruntled employees and the curious public. Control of insects and rodents should be considered if there is a risk of passive transmission to nearby susceptible species. If disposal is delayed, carcasses should be thoroughly sprayed with an approved disinfectant (see the **AUSVETPLAN *Operational manual: Decontamination***) and covered, if possible.

The benefits of destroying animals and outrunning disposal capacity (e.g. to prevent pathogen amplification) should be weighed against the consequential disadvantages, such as the need to manage carcasses in an advanced stage of decomposition.

All site hazards, including the exposure of personnel to potential zoonotic agents, must be identified and assessed, and appropriate controls must be implemented, before disposal work begins. Personnel should be fully trained and briefed, including on the nature of the disease and any hygiene requirements.

Overall management of disposal operations is described in the **AUSVETPLAN *Control centres management manual* – Part 1 and Part 2** (in particular, refer to Infected Premises Operations in Part 2).

2.8 Predisposal processing

Predisposal processing of carcasses, animal parts, products and fomites in an EAD response may increase options for their transport and disposal, and could be crucial in determining the most appropriate and cost-effective disposal methods. If the infectivity of material can be reduced or eliminated, less restrictive methods of handling, transport and disposal may be possible. It might also be possible to modify the form of the material to make it easier to handle, make alternative transport methods viable, and possibly speed up the disposal and decomposition process.

Appendix 2 identifies some predisposal processing methods, and their advantages and disadvantages.

Care must be taken to ensure that predisposal processing does not increase the risk of spreading the disease, result in excessive additional costs, or add to work health and safety concerns.

2.9 Decision-making and disposal recommendations

The expert team, using a structured decision-making process, such as the appreciation process or another documented method used in the affected jurisdiction, will consider the relevant factors (see Section 3) and their impact on the relevant disposal methods (see Section 4), to determine a risk-based and ranked list of suitable disposal methods.

A two-dimensional matrix aims to give structure to the expert team's consideration of complex interactions in a way that demonstrates the transparency of the team's decision. The matrix, or another documented method for reaching a decision, allows a variety of different disposal methods to be considered for the existing conditions. This technique uses the weighting of various factors and an assessment of their utility to reach a conclusion on the most suitable of the available disposal methods. If a disposal method is not available for operational or disease management reasons, it is excluded from the process at the outset.

Members of the team work on the matrix together, and the result should be a ranked list of acceptable disposal methods agreed by the majority of the team. This process may be guided by a skilled facilitator, who may be part of the LCC Operations Management function. The ranked list needs to be determined within a short timeframe.

It will probably be necessary to perform this process for different types of waste that have different handling and disease risk characteristics. A 'one size fits all' solution is unlikely.

As with all decisions made in an EAD response, the process by which the recommendation on disposal is decided must be transparent and accountable. To achieve this, a standard format should be followed for submitting the recommendation to the LCC. The recommendation must include a list of the members of the team who completed the process, the ranked list of recommended disposal methods, a list of reference materials used, and a summary of the advantages and disadvantages of each option.

2.10 Media and community engagement

This section should be read in conjunction with the Biosecurity incident public information manual[3], with specific reference to:

- the role of the National Biosecurity Communication and Engagement Network[4]
- the public information function during an EAD response.

It is important to clearly state to the public and media that:

- The disposal methods being used were adopted on the recommendations of an expert panel.
- Disposal arrangements must not impede disease control measures, particularly destruction of infected animals. Delays in disposal will potentially result in spread of the disease which may necessitate the destruction of more animals and/or reduce the disposal methods available, because disposal of decomposing carcasses is difficult.

Communications plans should address the concerns of the community (see Section 3.9 for further details).

[3] https://animalhealthaustralia.com.au/bipim/

[4] https://www.outbreak.gov.au/our-role/response-outbreak/national-biosecurity-communication-engagement-network

3 Factors to be considered

3.1 Introduction

A key principle of disposal is that, where possible, infected materials should be disposed of occur on the infected premises to minimise the risk of spread to other locations. However, a variety of factors will affect the disposal method(s) recommended, as determined through the decision-making process (see Figure 3.1). The relative importance of each factor will depend on the local situation. The epidemiology of the disease may mean that some disposal methods are not appropriate. Most importantly, the disposal methods chosen must prevent the dissemination of EAD agents.

Factors to consider include, in no particular order:

- *disease containment*—the disposal method should effectively contain the disease to prevent further spread.
- *the disease*—the nature of the disease can dictate the disposal method. For example, burning carcasses may be preferred for infectious disease outbreaks such as anthrax
- *public health, including workplace health and safety of operational personnel*—this may include protection of public health from disposal contaminants (e.g. leachate contaminating groundwater) and protection of operational personnel from zoonoses
- *environment*—on-site issues such as the size of the farm, soil type, and level of the water table can inform environmental impacts and mitigation measures to be employed. There is a need to ensure that disposal does not leave the affected producer or community with a long-term or permanent adverse environmental inheritance
- the *proximity of the disposal site* to affected enterprises
- *feasibility* of undertaking disposal, or the disposal option, given local conditions
- *waste transport* requirements, if any
- *animal destruction method*—for example, use of wet foam for destruction of poultry will influence the moisture content of the carcasses to be disposed. Accordingly, this should be considered for burning, composting and other methods where water or moisture may adversely affect the disposal option
- *local conditions*—for example, the depth of the water table, soil type, and bushfire restrictions will influence deep burial and burning or incineration options respectively
- *waste volume*—the number of animals to be disposed can influence the choice of disposal method, including the use of multiple methods. Large volumes may necessitate disposal to licensed landfill sites or bespoke disposal sites
- *regulatory compliance*—disposal methods must comply with local, jurisdictional and national legislation to ensure environmental safety and protection of public health
- *logistics and resources*—the availability of resources, including human, physical and financial resources can influence the choice and efficiency of disposal methods
- *public perception and welfare*—the method and location of disposal should consider owner concerns, public sentiment with respect to visual perception and human health management (e.g. visual and particulate pollution, and adverse psychological impacts)
- *time*—rapid disposal is crucial in an emergency animal disease outbreak to prevent the spread of pathogens. Timely availability of resources, such as information, materials, expertise and equipment, must be considered.

These factors are interrelated and must be balanced to ensure an effective and efficient disposal response to an EAD outbreak. Disposal methods cannot be considered in isolation from factors that may determine or limit the methods available at the time (see Figure 3.1).

Long-term factors, such as the maintenance, monitoring and eventual rehabilitation of disposal sites, must also be considered. The industry involved, and those associated with it, need to be reassured that the disposal process is secure. The public needs to know that food and drinking water, and the environment, remain safe from contamination.

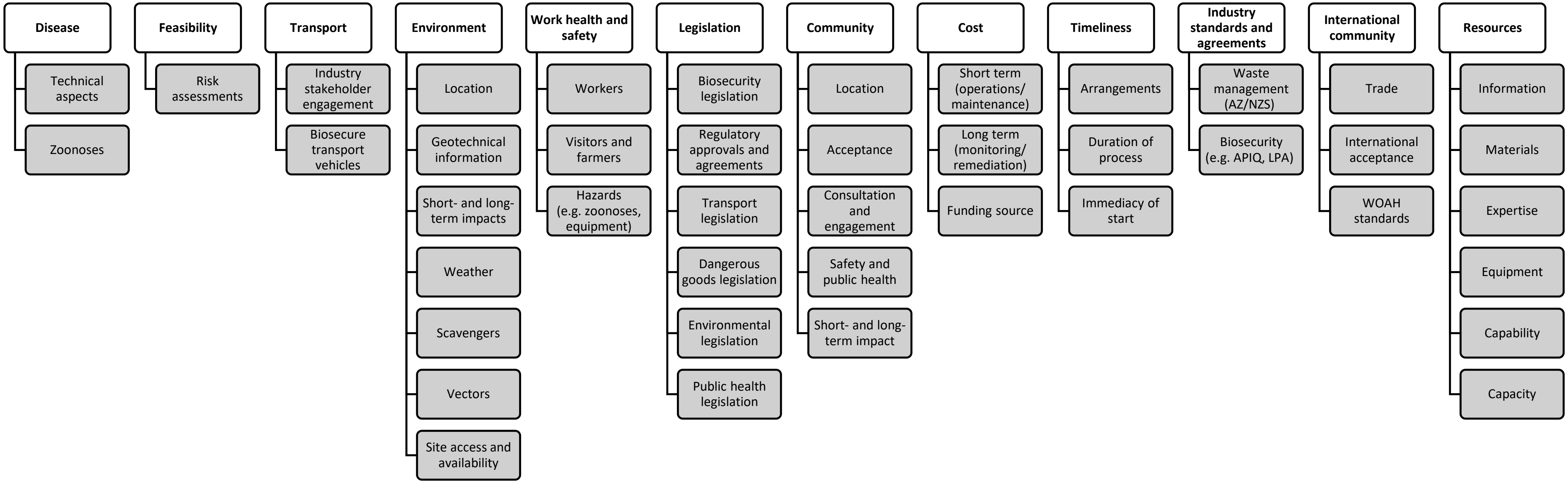

Figure 3.1 — Summary of factors affecting disposal methods

APIQ = Australian Pork Industry Quality Assurance Program; AZ/NZS = joint Australian/New Zealand standards; LPA = Livestock Production Assurance program; WOAH = World Organisation for Animal Health

3.2 The disease

The epidemiology of the EAD agent will determine the suitable transport and disposal methods. To maintain biosecurity, it is essential to understand the mechanisms involved in the transmission of the infective agent. The ability of an agent to remain viable and remain a disease risk following a particular disposal method will determine whether that method can be used, or whether a combination of methods may be required. The document Persistence of disease agents in carcases and animal products (Williams 2017) should be consulted. For the epidemiological characteristics of the EAD, refer to the relevant AUSVETPLAN response strategy.[5]

3.3 Decontamination

To minimise the spread of EAD pathogens from a disposal site, a decontamination area (or areas) will need to be constructed to allow for decontamination of vehicles, personnel and equipment leaving the site. The Infected Premises Operations (IPOPs) team will determine the need for resources such as water, disinfectant, spray units, wastewater management and protective clothing. All personnel involved in this function will need to be trained in biosecurity and decontamination procedures, appropriate use of decontamination chemicals and WHS.

See the **AUSVETPLAN *Operational manual: Decontamination*** for further information.

3.4 Feasibility

The feasibility of disposal (i.e. whether disposal can be undertaken or not) and disposal options may be constrained by resources or accessibility. For example, animals that are destroyed by aerial culling may be in geographic areas that are inaccessible for disposal at the site of destruction or at an alternative site. In such cases, risk assessments must consider, among other factors provided in this section, environmental impacts, legislative responsibilities and biosecurity considerations and whether natural decomposition processes are sufficient to inactivate pathogens and mitigate spread of the disease.

The risk of adverse natural events, such as flood or fire events, may also influence the feasibility of disposal and must be considered when selecting a method of disposal.

3.5 Transport

See Appendix 1 for a list of potentially contaminated materials that may need to be transported in an EAD response.

An integral part of the decision-making process is assessment of the risks of transporting carcasses or other material to the disposal sites, either within the infected premises or to another location (i.e. approved disposal site). If transportation is needed during an EAD response, the methods and infrastructure used will depend on interrelated factors such as the nature of the disease agent, the urgency of the operation, and the decontamination procedures required. Figure 3.2 shows the transport factors schematically.

[5] https://animalhealthaustralia.com.au/ausvetplan/

Waste management and other transport contractors may have vehicles suitable for the transport of carcasses and contaminated material under acceptable risk management procedures. Some specialised waste contractors are licensed to handle such wastes and are familiar with the WHS concerns — for instance, those already contracted to 'approved arrangements' (formerly Quarantine Approved Premises). It is important that vehicles used to transport carcasses and waste can be sealed and covered appropriately to contain potentially contaminated material (including bodily fluids) during transport. Selection and monitoring of transport operations should ensure that movement of materials provides the appropriate level of risk management.

In a large-scale outbreak, burial, composting or other means of disposal of large numbers of carcasses at a selected site will often require specialised transport by large-capacity transport vehicles that can ensure biosecure transport. Assessing the availability of vehicles of the required type will help to determine if a disposal method is feasible.

Preparedness planning should identify potential disposal sites and potential transport contractors. If material is to be transported, it is important that a comprehensive risk assessment is completed; a biosecurity plan is in place; decontamination procedures are agreed; and appropriate local authorities have been advised of what is proposed, the routes to be taken and the safeguards that are in place before transport commences. As the classification of carcasses and some wastes as 'dangerous goods' may vary by jurisdiction, it is recommended to check if there are specific provisions under the legislation relating to the transport of dangerous goods (e.g. vehicle placard requirements, and dangerous goods transport certification).

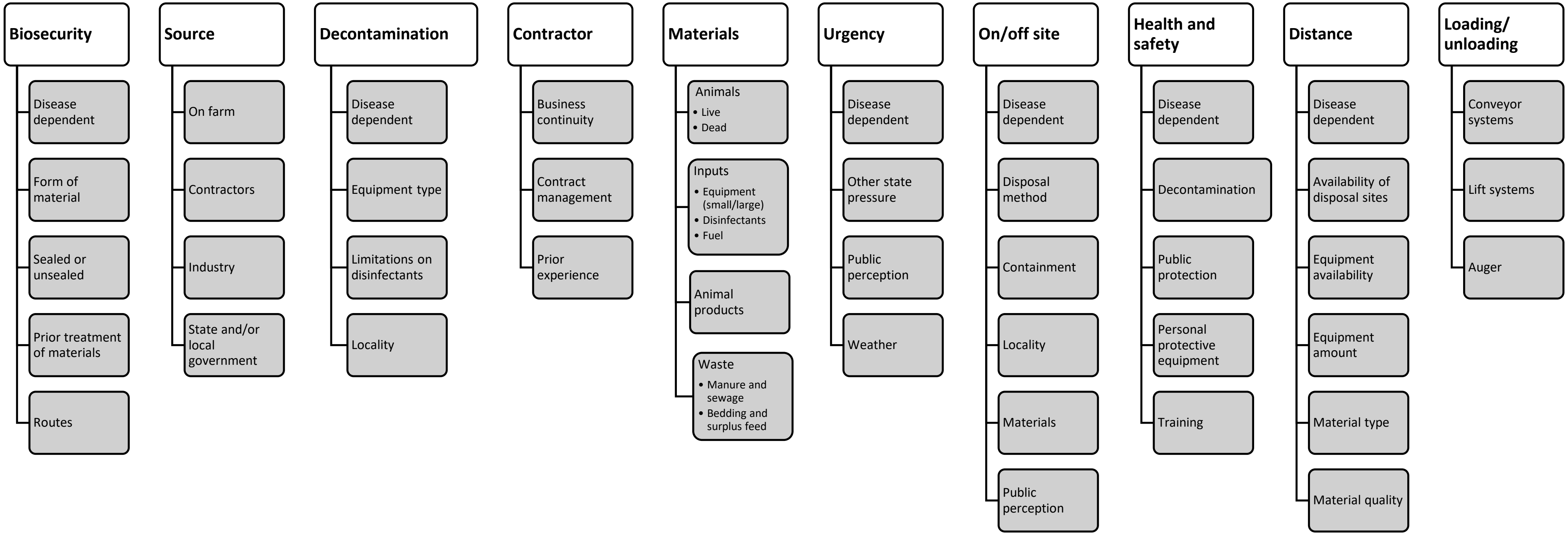

Figure 3.2 — Issues to be considered in deciding options for transport

3.6 Environment

Rapid approval of disposal methods and sites may require pre-approval mechanisms involving agreements with environment protection authorities (EPA) and other agencies. Government agencies responsible for EAD legislation should discuss the range of preferred and possible disposal methods with EPAs and establish a good understanding of the approval processes required for each step in the emergency response.

Formal legal advice may be required to determine whether state and territory environmental legislation or legislation relating to EAD control takes precedence in a jurisdiction. Heritage and cultural aspects, such as heritage-listed and sacred sites, respectively, also need to be considered.

Furthermore, any disposal site should be chosen with careful consideration of its potential impact on the surrounding environment, ecosystems, and wildlife. Locations where the disposal process could disrupt biodiversity, particularly areas home to endangered species or sensitive ecological systems, should be avoided.

EPAs are the regulatory agencies normally responsible for setting standards, risk assessment, design approval, licensing and monitoring of facilities that manage putrescible waste. Their input is essential in preparedness planning before responses and as early as possible in a response, to provide sufficient lead time for key considerations for each site to be determined, and for the adequacy of design and mitigation measures to be assessed. Landfill operators should also be engaged in the planning phase to determine their ability and willingness to receive EAD waste in an outbreak and ability to manage biosecurity and environmental risks.

EPAs may not have considered in detail the types of situations that might arise during EAD outbreaks. Therefore, it is important to work with these agencies, considering current legislation, to evaluate the logistics, approvals and environmental controls required to manage EAD waste within timeframes consistent with EAD response objectives, as provided in AUSVETPLAN response strategies. It is important that the EPAs are actively involved in all planning activities involving disposal. Personnel from EPAs are essential liaisons officers in the expert team in the local control centre and state coordination centre.

Post-disposal monitoring and remediation should also be discussed with EPAs, to determine appropriate responsibilities for waste that has been disposed of. Long term risk management and monitoring costs are likely to be future considerations.

Locations of disposal sites must be comprehensively documented. This includes use of a geographic information system (GIS) mapping tool for potential carcass disposal sites.

3.7 Work health and safety

Worker safety must rank highly when a disposal method is being chosen, and every effort must be made to effectively manage identified risks in compliance with WHS legislation.

Under legislation in all states and territories, all transport and disposal activities to be carried out in the event of an EAD outbreak must be subject to risk assessments before they are undertaken, to ensure the safety of the workers involved.

A preliminary detailed risk assessment of each potential disposal method and work site should be undertaken, with appropriate input from WHS professionals. Appropriate treatment methods should be devised to minimise risks to personnel.

Activities associated with disposal sites have significant safety risks, and the safety of operational personnel is an overriding consideration. The engagement of a WHS officer is a critical component of risk management. Decisions on layout, design, equipment flow and other issues that affect the safety of the site should be made by the Infected Premises Operations team, in consultation with relevant personnel (e.g. contractors), as well as facility management where necessary.

All operations on site should be controlled by Infected Premises Site Supervision personnel or commercial facility personnel. Personnel should be properly trained and briefed before operations begin.

Care must be taken to avoid transmission of zoonotic diseases to those involved in disposal operations.

3.8 Legislative requirements and regulatory approval

Legislation varies between the states and territories, and may also vary according to the location of the outbreak.

A range of legislation, including biosecurity, environmental, human health and transport legislation, may affect the choice of disposal method.

Disposal sites usually require works approval and licensing under environmental legislation. They may be the subject of exemptions if undertaken once an EAD outbreak has been declared. The relative precedence of environmental and EAD legislation should be determined for the jurisdiction in question. Jurisdictional legislation also needs to be examined in terms of its application to the proposed disposal methods — for example, ‘composting’ under the legislation might refer to the production of commercial compost, rather than disposal of waste.

Another issue to consider is that the disposal sites are likely to be considered ‘contaminated sites’ under environmental or other legislation. If so, they require formal reporting, investigation and management (remediation) to address environmental and health risks. This can be a complex and expensive process, involving long-term monitoring of leachate and gas emissions, and possibly other interventions. The use of contaminated sites may be restricted until remediation has been completed.

3.9 Community concerns

Ongoing liaison with the community is an important part of the decision-making process. Potential local community concerns about the disposal method and site will need to be assessed. Ensuring that the local, as well as overall, environmental impacts of a disposal method are minimised should help to reduce community concerns. Proximity of the operation to human habitation (including residential properties, parks, schools etc) and failure to keep the community fully informed may increase concerns. Ongoing liaison with the community is an important part of the decision-making process.

Transport of carcasses and contaminated materials may cause community concern about the potential for spread of infection. Safeguards taken need to be clearly stated. Another specific concern is the potential for the EAD agent to spread by thermal air currents when materials are burned. Studies in the United Kingdom in 2001 showed this to be unlikely for foot-and-mouth disease (Bourne 2001, Gloster et al 2001).

Issues that may affect the community include:

- potential spread of the pathogen to susceptible animals or humans, including the potential spread of a zoonotic disease from improper disposal
- environmental impacts, including:
    - potential generation of odours from carcasses, animal products and animal wastes
    - the potential for leachate to pollute water supplies and soil
    - the potential for air pollution from burning of carcasses and other material, and the resulting impacts on human health (especially for people with respiratory disorders)
- the extent and length of proposed disposal monitoring programs
- use of local resources to the detriment of the local community—for example, use of local fuels; filling of local landfills; and deterioration of facilities, such as roads, due to use of heavy machinery
- use of lands that have heritage or cultural significance
- potential restriction of access to facilities, such as landfill sites
- future plans for the rehabilitation of disposal sites, the time required for rehabilitation and any potential restrictions on the use of the sites
- immediate and longer-term impacts on farming and tourism.

3.10 Cost

It is difficult to fully cost the available disposal methods. In the planning process, consider developing costing models that cover all operational costs and future monitoring costs. Also consider future land use and costs associated with the existence of contaminated sites, reduced land use (e.g. social amenity costs) and land value. Costing models could significantly hasten the estimation of the relative costs of different disposal methods.

Consider the continuing costs of disposal methods that may provide quick solutions but require long-term maintenance, management and monitoring, or extensive remediation work. For example, burial may be quick, but the need for monitoring and potential problems with aquifer contamination may make it less acceptable than composting, which may need longer management but produce a desirable, readily disposable product.

3.11 Timeliness

Usually, a disposal method that neutralises, reduces or eliminates the contaminated material's biosecurity risk as soon as possible is preferable. Some disposal methods may provide quick solutions but may result in a longer duration of biosecurity controls on the premises, a requirement for long-term maintenance, management and monitoring, or extensive remediation work. These aspects need to be considered.

3.12 Industry standards and agreements

Standards vary from industry to industry and may be at national, state/territory or local levels. Understanding and application of such standards and agreements should be considered as part of the disposal decision making.

3.13 International community

Overseas trading partners will decide how soon to resume trade with Australia after an EAD outbreak. To a large extent, their confidence will be determined by Australia's appropriate use of internationally accepted methods of control and eradication, including for disposal. The standards published by the World Organisation for Animal Health (WOAH) are accepted references for the purposes of international trade.

3.14 Resources

The availability of suitable and sufficient financial, and human and physical resources must be considered when assessing disposal methods. This will include approved costs; information, such as weather information and mapping; personnel capacity and capability; equipment, including machinery (on-site, contracted, transport) and safety equipment; and materials, such as fuel sources and appropriate decontaminants.

Resource limits may affect the choice and extent of use of a particular disposal method, and the ability to comply with legislation or biosecurity requirements (see also Section 3.8). Use of some resources, especially if supplies are exhausted, may have a detrimental impact on the environment and the local community.

Personnel engaged in disposal must be competent to perform their functions, which will vary for each disposal method. They may include personnel providing technical advice and support, contractors (for machinery, transport and facilities), site supervisors, safety personnel and field personnel. Given that trained personnel are likely to be a limiting resource in a large outbreak, optimum use should be made of contractors, where possible. All personnel, including contractors, must be provided with appropriate training in biosecurity and safe working practices.

Preparedness planning should identify the types of resources required, potential suppliers and limitations.

4 Methods of disposal

4.1 Introduction

In an EAD response, there may be multiple methods for disposing of carcasses and other items. The most common disposal methods for carcasses and other materials are burial, burning, incineration, rendering and composting (see Figure 4.1). Other disposal methods may be considered if relevant factors and risks are assessed in accordance with the transparent and systematic decision-making process outlined in this manual.

A decision on the most appropriate disposal method, or combination of methods, should be based on the decision-making framework outlined in Section 2. Before work commences, it is important that appropriate advice from a range of stakeholders is sought on all the factors identified in Section 3 as having a potential impact on disposal methods.

The methods used to dispose of animals, animal products and associated wastes during an EAD outbreak must be science based, informed by the requirements of legislation, and consider both immediate needs and future consequences.

Much time can be saved by prior consultation with appropriate authorities, such as environment protection agencies (EPAs), to locate appropriate potential disposal sites and to determine the basic minimum requirements for the various disposal options available.

Predisposal processing treatments may need to be considered before the disposal method is used. These include freezing and storage, grinding, sterilisation (using disinfectants, heat, barriers), and carcass breakdown (see Appendix 2).

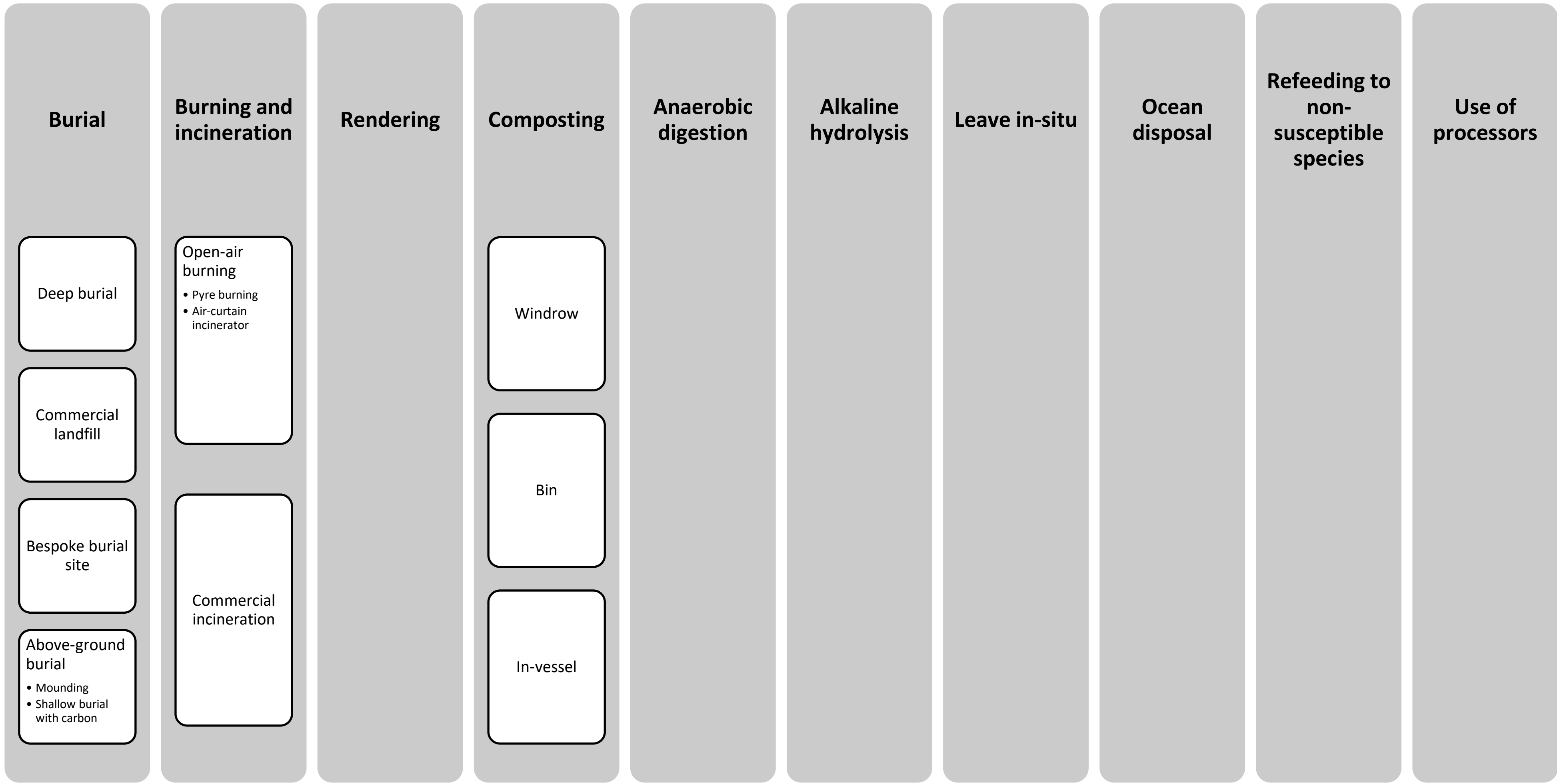

Figure 4.1 — Disposal methods

4.2 Burial

4.2.1 Process overview

Animal carcasses and other contaminated materials (such as litter and manure) can be disposed of by burial at suitable sites.

Burial may incorporate the use of sophisticated byproduct management systems or may be quite basic. The appropriate burial approach is determined based on a range of considerations, as described in Section 4.2.2.

After burial, animal carcasses undergo anaerobic decomposition, gradually breaking down into minerals and organic matter. This process is slow and can span several decades. As part of this decomposition, leachate is produced, and seeps into the soil beneath the burial site, and may eventually reach the groundwater.

Carcasses and other organic material capable of being decomposed by microorganisms are 'putrescible waste'. Licensed landfills are classified according to the materials they are licensed to accept—putrescible waste is one such classification.

During the decomposition of carcasses, methane is produced. This gas can migrate through the soil and infiltrate enclosed spaces like sheds and houses. In such confined areas, it poses an asphyxiation risk or can accumulate to explosive levels if ignited by a spark or flame. Additionally, methane is a greenhouse gas that contributes to global climate change. Despite these hazards, burial has historically been a common method for managing animal mortality and is familiar to most people.

The main categories of burial are described below.

4.2.1.1 Deep burial (trench or pit burial)

Deep burial involves the excavation of a pit or trench into the earth, placing of carcasses and other materials in the pit or trench, and covering the materials (backfilling) with excavated earth or other inert material. Deep burial may be done on the site where animals originate or in another place. Burial on farm is preferred as it has the advantage of avoiding the biosecurity risks associated with the transport of carcasses and other materials. However, environmental conditions and jurisdictional legislation relating to environmental protection may have a significant impact on the ability to bury on farm and these requirements must be considered.

Some jurisdictions may limit the quantity of carcasses that can be buried on a farm or require that only animals from that farm may be buried on it. These restrictions can be addressed by obtaining a waste disposal licence, but granting of a licence is usually conditional on measures to prevent environmental contamination.

The longer-term implications of having a contaminated site on a farm must also be considered, including who bears the cost of remediation and monitoring.

See Appendix 3 for details of burial pit construction.

4.2.1.2 Commercial landfill

Commercial landfills are waste disposal facilities licensed by the EPA or equivalent government agency. The quantity and type of waste they can accept for disposal is specified on the licence and these facilities may pay a per-carcass or per-tonne levy to the licensing authority. Modern facilities have sophisticated management systems for leachate and methane to comply with environmental legislation. These facilities may have sufficient capacity to hold several thousand tonnes of waste. Usually, they have a series of cells, which are systematically filled, then sealed and capped, and subjected to environmental remediation. Some licensed landfills have their own transport vehicles while others use an external transport company.

When planning the disposal of carcasses, it is valuable to consult with managers of licensed landfill sites, the transport companies that service the landfills and the licensing agencies.

4.2.1.3 Bespoke burial site

For large disposal operations, it may be necessary to construct pits suitable for the mass disposal of carcasses. It is important to consult with EPAs to ensure compliance with legislative requirements as far as possible. The timeframe for construction of such facilities may be lengthy, especially if specific components (such as liners) are in short supply. Bespoke disposal pits may be engineered and constructed to operate as an 'approved disposal site'. They have the advantage of being specifically engineered for the purposes of containment of carcasses and other EAD-related waste, and can be located and constructed to protect the environment and human health.

Typically, cells are lined with multiple layers to protect against leachate migration and groundwater pollution. The layers may include a thick clay liner and a high-density polyethylene plastic liner. Once a cell is full, it is capped with clay and then covered with a thick layer of topsoil and vegetation. Properly designed cells help minimise environmental impact by containing waste and preventing harmful substances from escaping. The process involves a balance between waste management and environmental protection. As with any site in which large quantities of carcasses are buried, jurisdictions usually have legislative requirements relevant to contaminated sites. These requirements can involve monitoring and remediation over many years.

Post-burial site management and environmental monitoring could be part of the contractual arrangements of managing the EAD-related waste.

Though likely to be costly, for very large operations the use of this bespoke approach may be appropriate.

4.2.1.4 Above-ground burial

Mounding

This method is only likely to be used when disposing of a small number of carcasses and when other environmentally sound animal mortality disposal methods are not available or practical.

Mounding involves placing carcasses on a natural surface of earth and covering them with soil obtained from another source. Low permeability soils such as clay are preferred. Once the mound is complete the soil should not be compacted as this may impede the natural decaying process. Typically, this process takes place on the site where animals originate. There will be byproducts of decomposition to manage, and the method must address environmental, legislative and human health concerns or requirements.

Shallow burial with carbon

Shallow burial with carbon (SBC) is a new technology and information is expected to evolve.

SBC is a hybrid between burial and composting. The method involves a shallow trench excavated into native soil to a depth of 60 cm. A 30 cm layer of carbonaceous material, such as rice hulls, sawdust or straw, is placed in the bottom of the trench followed by a single layer of animal carcasses. The excavated soil is subsequently placed back in the trench, forming a mound on which a vegetative cap is established. Finally, the perimeter of the mound is trenched to prevent the intrusion of surface water into the system. Once the carcasses have decomposed, the disposal site can be levelled and returned to its previous use. In most environments this will take between 9 and 12 months.

Pathogens are inactivated through a combination of heat, pH changes and antagonistic soil microbes. The period in which pathogen elimination occurs may vary depending on the specific disease organism or complex of organisms, soil type, composition and moisture levels. In an SBC trial with pig carcasses infected with African swine fever virus, the virus was found to be completely inactivated in all spleen and bone marrow samples 6 days post burial (Ebling et al 2022, Duc et al 2023).

The SBC method avoids some of the risks associated with deep burial of carcasses and uses less carbon than traditional aerobic composting. SBC may be best suited to on-farm burial of small numbers of carcasses, unless an extensive site is available off-farm to accommodate large numbers of carcasses laid in a single-layer. This method shows promise as plots require minimal ongoing management, and the risk of groundwater contamination is mitigated due to the shallow depth of carcass placement and the inclusion of the absorbent carbonaceous layer.

Refer to Appendix 4 for details on SBC construction.

4.2.2 Considerations

4.2.2.1 Burial trench or pit lining

Unlined burial is usually used when soil types or local geology can manage the risk of leachate leakage, whereas lined burial is used when there are risks of leakage of leachate into subsoil or the watertable that need to be managed.

Lining a burial pit for carcass disposal is typically undertaken to prevent contamination of the surrounding soil and groundwater. Lining is recommended for:

- *environmental protection*—when burying animal carcasses, especially in areas with sensitive ecosystems, near water sources, or where the soil is highly permeable, lining the pit helps prevent leachate from seeping into the soil and reaching groundwater, especially where there is a high watertable.
    - If the burial site has a high watertable, lining the pit helps prevent leachate from contaminating the groundwater. Conversely, an alternate site may be selected.
- *regulatory compliance*—some regions have specific regulations regarding carcass disposal. In such cases, lining the pit may be a legal requirement to ensure proper waste management.

For long-term burial, such as in mass disposal operations, lining provides added protection against leachate migration.

Ultimately, the decision to line a burial pit depends on various factors, including local regulations and considerations described in the following sections.

4.2.2.2 Disease agent

Deep burial is an appropriate disposal method for most EADs. Exceptions are anthrax, for which deep burial is contraindicated because of the persistence of anthrax spores in soil, and transmissible spongiform encephalopathies (TSEs), which require specific heat or chemical treatment to denature prions.

The biosecurity requirements and logistics of transporting carcasses and other materials to a suitable burial site and managing them therein should be carefully considered. Management of zoonotic disease agents will also require consideration of WHS and public health (see Sections 3.7 and 4.2.2.21).

Lime (calcium oxide) has been used for centuries in agriculture as a disinfectant and in burial pits to increase the rate of decomposition of carcasses. It is now known that the disinfectant properties of lime are due to its ability to raise the pH. A pH above 10 will disrupt bacterial cell walls and hydrolyse viral genome nucleotides. Unfortunately, this counteracts the acidification of carcasses that occurs naturally as part of the decomposition process and destroys many disease organisms. In addition, it has been shown that calcium preserves anthrax spores (Himsworth 2008). Hence, the addition of lime to burial pits is not recommended.

4.2.2.3 Volume of material for disposal

The amount of material to be disposed of and the number of locations from which it will be sourced will have an important bearing on which burial method is used. Deep (trench or pit) burial and mounding tend to be used for on-farm burial locations when the amount of material to be disposed of is small and the number of premises is low. Some jurisdictions have weight or volume limits for material for disposal above which the need for EPA approval is triggered. Use of many small burial sites on individual premises may have advantages, rather than bringing material from many sites to one large central burial site that then requires approvals and ongoing management and monitoring. The volume or weight of carcasses and other materials to be buried from one premises may be small enough that approval from an EPA is not needed, although this may severely limit the amount of waste / number of carcasses able to be buried. A disadvantage of multiple small disposal sites compared with a smaller number of mass burial sites is the relatively high resource allocation that may be needed to meet potential remediation, maintenance and monitoring requirements for each site, which may extend over many years.

4.2.2.4 Environment

Environmental implications of all burial categories are potentially serious and are detailed in Section 3.6. Environmental implications of lined pits, although less than for most unlined pits, are not insignificant as the site must be monitored to ensure that the integrity of the liner is maintained.

Environmental implications for an established commercial landfill facility will already be part of the facility's management planning.

Leachate production

Leachate is the liquid that is released during the decomposition of wastes. It has been estimated that 50% of the available fluids will leak out of carcasses within the first week following death, and nearly all fluid will drain from the carcasses in the first 2 months. Following the outbreak of foot-and-mouth disease (FMD) in the United Kingdom (UK) in 2001, it was estimated that 170 litres of fluid was released in the first 2 months by an adult cattle carcass, and 16 litres was released from an adult sheep carcass (UK Environment Agency 2001).

The potential for leachate to cause long-term problems is significant, especially for putrescible mono-fill disposal pits for carcasses. Effective leachate management must be included in early planning, such as by the inclusion of drainage to collection points in pit bases, with inspection points and pump-out wells installed at appropriate locations, depending on pit design.

Leachate can potentially contaminate surface water and groundwater supplies. Advice must be sought from relevant EPAs on the programs required for containment, treatment and monitoring of leachate.

Gas production

Gas production from decomposition within unopened carcasses may result in a considerable increase in the volume of the buried material, to the extent that the surface of the closed pit may rise, and carcasses, leachate or other disposed material may be expelled. WHS and biosecurity considerations may outweigh the benefits of piercing the abdomens/rumens of carcasses to prevent them from bloating and surfacing. Carcasses should not be pierced before transport. A small puncture hole can be made in the abdomen/rumen at the side of the pit before the carcass is placed in the pit. Alternatively, attachments on excavating equipment can be used to puncture carcasses when this is considered necessary. Under no circumstances should personnel enter the pit during filling. Where mass burials occur, the gas trapped under the cover of soil can be vented through pipes for treatment.

4.2.2.5 Location

Approval requirements will vary according to state/territory and local laws. Consultation with jurisdictional environmental and other agencies is therefore essential. Important considerations for selection of burial sites include the criteria addressed below. For each of these criteria, the site may need to be evaluated using further on-site investigation and/or detailed map or soil analysis. It is always preferable to have potential sites evaluated and given EPA approval as part of preparedness activities, rather than seeking approval during an incident.

Notwithstanding the following considerations, lining (see Section 4.2.2.1) of trenches or pits may help mitigate the location and environmental risks associated with burial.

4.2.2.6 Proximity to drinking water supply

It is preferable that the site is not in a designated drinking water catchment area, as defined by jurisdictional water authorities. For example, in Western Australia, such areas are referred to as ‘gazetted public drinking water source’ areas. This will prevent contamination of drinking water supplies by decomposing animal carcasses and other waste.

4.2.2.7 Proximity to human habitation

The proximity of the burial site to human habitation should be subject to risk assessment and jurisdictional guidance.

In general, the site should be away from towns, dwellings and major roads to reduce the risk of undesirable exposure of the public to dust, odour and unsightly activities. Consideration should also be given to mental health aspects of people affected by the disposal location. Convenience of the disposal site to the response should not be at the cost of negative impacts on people's long- term mental health and wellbeing.

4.2.2.8 Soil characteristics

The site should preferably be on soils of low permeability (any soil with significant clay content). Even in clay soils, the bases of pits should be compacted during construction because fissures and porous sandy inclusions are common. Where soils are not of low permeability, efforts should be made to stockpile clay from excavations or obtain clay from nearby sources for use in constructing the pit base.

If there are issues with soil permeability, consideration should be given to lining pits. This reduces the likelihood of contamination of the water table by leachate (see Section 4.2.2.1).

4.2.2.9 Groundwater depth

The seasonal maximum groundwater level at the site should be at least 2 m below the base of the burial pit;[6,7] however, this may vary by jurisdiction. This will also reduce the likelihood of contamination of the watertable by leachate.

4.2.2.10 Proximity to surface water

The site should be away from watercourses, lakes, ponds and so on, to reduce the likelihood of contamination of water systems by leachate and runoff. This includes natural or dammed fresh water, aquaculture ponds, tailings ponds, sewage treatment ponds, reservoirs and water tanks.

Details of distances may be specified by jurisdictional environmental authorities.

4.2.2.11 Proximity to coast

The site should be a sufficient distance from the coast and estuaries to reduce the likelihood of coastal contamination by leachate and to avoid areas that are heavily used for recreation. As well, sandy soils near the coast, being very permeable, are not suitable for the construction of burial pits.

Details of distances may be specified by jurisdictional environmental authorities.

4.2.2.12 Proximity to World Heritage Areas, conservation areas and cultural sites

The burial site should be a sufficient distance from World Heritage Areas, conservation areas and cultural sites to prevent negative impacts on these sites.

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[6] https://epa.tas.gov.au/Documents/Guide%20for%20the%20Burial%20of%20Slaughter%20Waste.pdf
[7] https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/1299603/animal-carcass-disposal.pdf

4.2.2.13 Site accessibility

The site should be accessible to trucks and earthmoving equipment, allowing for easy entry and effective decontamination.

4.2.2.14 Site terrain

The site should preferably be on a slope of less than 6%[8] and should allow digging of 5-metre-deep pits with heavy equipment.

4.2.2.15 Site area

The site should be of sufficient size to accommodate the required burial activity without affecting neighbours.

4.2.2.16 Risk of flooding

The burial pit should not be located in a flood prone area.

4.2.2.17 Remediation (including monitoring)

Remediation requirements for burial and mounding will depend on local environmental regulatory requirements and will be the subject of detailed assessment by the jurisdictional EPA.

Regular inspection of unlined mass burial sites after closure is recommended so that appropriate action can be taken in the event of movement of leachate in the soil profile or other problems. Such inspection will be informed by EPAs and may require drilling and sampling to confirm appropriate management of leachate with dissolution through natural processes. Inspections of lined burial sites after closure may be less frequent than for unlined sites. The objective is to return the site to its original condition. Advice on any requirements for an ongoing environmental monitoring program for burial sites will need to be obtained from the relevant EPA during the planning and implementation stages.

Remediation requirements will already be part of any commercial landfill facility's management planning. However, a decision to accept large, atypical volumes of livestock carcasses would have implications for the landfill, and advice should be obtained from the licensing authority (normally EPA).

Monitoring equipment is imperative for the long-term surveillance of burial sites to ensure environmental safety. Such equipment could include devices for groundwater assessment, soil testing, and gas detection (to monitor emissions), and geographic information system (GIS) technology, to monitor burial sites over time. Engaging with environmental monitoring services could offer access to specialised expertise and advanced equipment for comprehensive site assessment.

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[8] https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/1299603/animal-carcass-disposal.pdf

4.2.2.18 Time

Trench and pit burial, mounding and shallow burial with carbon (SBC) are the least time-consuming burial methods when small numbers of infected premises are involved. After site environmental risks have been considered, operations are more time-efficient because of lower resource needs, including reduced need for transport if carcasses are being buried on site.

For mass burial, selection of a site that is not currently used for that purpose will likely involve delays before burial activities can take place. Depending on the weather and seasonal conditions, there is a practical limit on how long animal carcasses and other materials can be left before being transported to an approved and constructed burial facility. This imposes limits on the usefulness of a large-scale, approved site for disposing of animals destroyed early in an emergency response. Well-planned prior agreements with environmental agencies can reduce the approval time, to allow deep burial to occur within practical timeframes.

Lining or partial lining (i.e. lining of only the base, side or cap) of pits and use of absorbent layers may help to control the generation, release and degradation of leachate that may affect groundwater resources. It may allow use of sites where subsoil structure or deep groundwater has not been fully evaluated. This may reduce the time between site identification and use, if materials such as clay or synthetic materials to line the pit can be sourced promptly. In most cases, significant time is needed to obtain synthetic materials to line burial pits.

Using a commercial landfill facility will have significant time advantages because approvals, construction, access and security facilities are already in place, albeit there may be a need to modify licence conditions or undertake works to address biosecurity risks. Resources such as power, water, lighting and on-site machinery are often also available. Environmental risk management measures will usually already have been carried out. It will be important however to determine the willingness, capacity and volume thresholds with landfill operators beforehand. Landfill operators may limit the volumes of material they are willing to receive if these may significantly reduce their operational longevity, as was evidenced in the UK in 2001 (Scudamore et al 2002). Operators may seek guidance on the implementation of biosecurity and WHS measures to manage risks associated with a possible EAD outbreak or public health issue relating to their activities. There may also be public resistance to the use of landfills if there is a perceived risk to the lifespan of these facilities.

Methods to mitigate leachate issues include using clay from excavations or nearby sources to put in place a compacted and channelled clay base, use of high-density polyethylene (HDPE) liners, and placement of absorbent layers of wood chips or hay (see Section 4.2.1).

4.2.2.19 Cost

Trench burial, mounding and shallow burial with carbon (SBC) will generally require less infrastructure and personnel, and will therefore have lower costs than other disposal methods. The cost of excavation, access and security will need to be included.

For unlined mass burial, there are two main cost categories to be considered:

- immediate costs including site evaluation, provision of access, construction of facilities and security, carcass transport and site burial work
- longer-term costs of rehabilitation of the site including monitoring movement of leachate in the soil profile, and monitoring for contamination of water or other sensitive environmental assets.

For lined mass burial, the cost of establishing a site, time, approval process from the environmental regulator and the longer-term costs of rehabilitation of the site, including monitoring, need to be considered. There may be a much lower likelihood of movement of leachate from the mass burial site, and therefore a reduced need for monitoring of the site and surrounds. However, the cost of facilities to manage and treat leachate will need to be added.

The cost of using a commercial landfill facility can usually be established quickly, thus avoiding complex costings of unbuilt and unapproved sites. However, use of a commercial landfill facility may require variations to licence conditions and potentially also new works (e.g. to open up a new cell dedicated to carcasses, development of additional entry and exit points, creation of dedicated internal roadways, and/or establishment of places for vehicle decontamination).

Economic modelling of all cost issues, including transport, site costs and ongoing monitoring costs, will inform decisions about the most suitable burial method(s).

4.2.2.20 Resourcing

The following important issues relating to resource requirements are common to all categories of burial.

Supervision

The burial site will be managed by Infected Premises Operations personnel, who are responsible for all activities being carried out at the burial site. All personnel on the site must have been inducted. Burial activities may carry significant safety risks, so WHS considerations and controls should be implemented and supervised.

When using a commercial landfill facility, the existing site workforce is usually available and familiar with working on the site. Personnel will need to be trained in biosecurity procedures, including safety procedures, by Infected Premises Security (IPS) personnel. IPS personnel retain responsibility for biosecurity procedures.

Burial works

For non-commercial sites, the activities of pit construction and burial works can be conducted by contractors. The expert team (see Section 2.4) can decide the specifications of the contract, and site supervisors can directly supervise the contractors. In most cases, contractors will arrange their own resources and include the supply of these in the contract price.

For lined burial, sourcing of a suitable pit liner and equipment to install it and manage leachate and gas production are the main additional activities required before burial works commence.

When using a commercial landfill facility, burial works will usually be conducted by employees of the existing facility on a contract basis. The specifications of the contract will be decided by the expert team. The facility will normally have, or have access to, its own resources; however, biosecurity may require oversight by response personnel.

Site security (people and uncontrolled animals)

For on-site burial, security preventing unauthorised persons accessing the burial site is normally the same as for the premises (e.g. infected premises or dangerous contact premises). Additional biosecurity measures to minimise scavenger access, such as animal security fencing, wild/feral animal baiting, trapping, and gas guns, should form part of disposal site planning as appropriate.

For large burial sites, whether on-site or off-site (e.g. an approved disposal site), perimeter security of the site may be considered along with scavenger management strategies.

When using an existing commercial landfill facility, some base level of security will exist for the facility. This may need to be increased, in consultation with the facility's management. Existing measures for the exclusion of scavenging animals and birds may need to be strengthened.

4.2.2.21 Work health and safety

Personnel should have access to rescue equipment for use if a person falls into the pit or the pit wall collapses.

4.2.3 Advantages and disadvantages of burial

Burial category	Advantages	Disadvantages
All categories	Allows disposal of any number of animals of all species Can be initiated relatively quickly if the site has prior approval Continuous process that minimises exposure times Depending on the location, may be less visible than other disposal methods International acceptance Allows disposal of other materials Minimises odour risk Approval process may be simpler if only low numbers of carcasses require disposal	Potential risk to groundwater Requires suitable geology and land area Likely to require ongoing site monitoring for several years or decades Requires biosecure transport of materials to the disposal location, whether on-site or off-site WHS risks for large operations (large equipment required) Leachate and gas need to be managed Potential local community concerns May affect future use and rehabilitation of the site Requires timely availability and acceptable cost of suitable equipment Not suitable for urban areas or near human habitation (unless it is a commercial landfill facility) (see also Section 4.2.2.7)
Pit or trench burial on-site	Can be initiated relatively quickly on the site where animals are destroyed Relatively low equipment requirements Volume or weight of carcasses and other materials to be buried from one premises may be small enough that EPA approval is not needed Usually there are fewer WHS risks because of the size of the operation and equipment used	If many premises are involved, many suitable sites will be required Number of carcasses able to be disposed of is lower than for mass burial method
Commercial landfill	Sites may already be licensed to accept putrescible waste (e.g. carcasses) On-site facilities (power, water, machinery, personnel, security, decontamination facilities) are already in place Environmental protection measures are already designed and implemented (e.g. infrastructure to treat leachate and gas) WHS protocols and security arrangements are already in place These facilities are licensed by EPAs and already have an investment in compliance with regulatory requirements (such as control of environmental risks and nuisances to the community)	Sites may not be in a suitable location to minimise risks associated with transport of infected carcasses and other materials Sites may not have capacity for burial of large volumes of animal carcasses and other materials May exhaust a local resource (i.e. shorten the operating lifespan of the landfill facility) Potentially high cost
Greenfield burial site (unlined)	Can be initiated relatively quickly if the site has prior approval Can be undertaken on suitable land close to the animals requiring disposal May be able to be used for large numbers of carcasses (tens of thousands)	Requires careful management of WHS risks for large operations with significant equipment May be difficult to engage specialised engineering and waste treatment personnel in a timely manner

Burial category	Advantages	Disadvantages
Greenfield burial site (lined)	Less strict requirements for suitable impermeable soils Lower environmental risks from leachate leaking from the lined burial pit May be able to be used for large numbers of carcasses (tens of thousands)	Suitable lining material may be difficult to source and requires specialist engineers to install Requires careful management of WHS risks for large operations with substantial equipment Sourcing lining materials can lead to disposal delays May be difficult to engage specialised engineering and waste treatment personnel in a timely manner
Mounding	Can be initiated relatively quickly on the site where animals are destroyed Relatively low equipment requirements Volume or weight of carcasses and other materials to be buried from one premises may be small enough that EPA approval is not needed Carcasses and other materials can be disposed of rapidly Usually there are fewer WHS risks because of the size of the operation and equipment used	If many properties are involved, many suitable sites will be required Fluids from decomposition will need to be managed Higher risk of serious odour issues if carcasses and other materials are not covered effectively May, depending on volume and type of material to be disposed, require large amounts of soil to cover material May not effectively inactivate pathogens which may have implications for proof of freedom
Shallow burial with carbon	Can be initiated relatively quickly on the site where animals are destroyed Carcasses and other materials can be disposed of rapidly Requires less machinery and time than for deep burial Leachate will be less of an issue due to shallow depth of burial and absorbent carbonaceous layer Burial area can eventually be returned to its original land use	Further research is required to determine effectiveness against a range of viral and bacterial pathogens and suitability under Australian conditions May require a relatively large spatial footprint for large numbers of animals

EPA = environmental protection agency; SBC = shallow burial with carbon; WHS = work health and safety

4.3 Burning and incineration

Burning and incineration are both thermal treatment processes that convert materials into ash, gas and heat through combustion. The terms are often used interchangeably but refer to separate processes.

In the context of carcass disposal and AUSVETPLAN, ‘burning’ is used as a more generic term but refers to a process that relies on combustible materials to generate sufficient heat to reduce carcasses to ash. Incineration achieves a higher heat than just burning as it uses a purpose-built chamber (an incinerator) to achieve temperatures between 800 °C and 1200 °C to accelerate the process.

The main driver for selecting one process over the other is the pathogen and its resistance to heat treatments. Other factors include the volume of carcasses requiring disposal, the availability of an incinerator and relevant environmental considerations.

Incineration is considered a more efficient way to dispose of waste. Compared with burning, incineration achieves higher temperatures, reduces the volume of waste produced by up to 90% and produces fewer emissions.

Burning carcasses may, however, be more feasible in areas where incinerators are not operational, for smaller waste amounts or where combustible materials are readily available.

4.3.1 Process overview

4.3.1.1 Open-air burning

Open-air burning involves the burning of carcasses or other materials in an open setting (outdoors), using combustible materials as a primary fuel source. Gelled fuel or other accelerants such as straw and kindling can be used to help initiate the combustion process. It may be carried out on-site or off-site with the pyres above ground or in trenches.

This category includes pyre burning, air-curtain incineration and small mobile gas-fired incinerators. Gas-fired mobile incinerators are not readily available in Australia and have limited throughput capacity; they are not addressed further in this manual.

Pyre burning

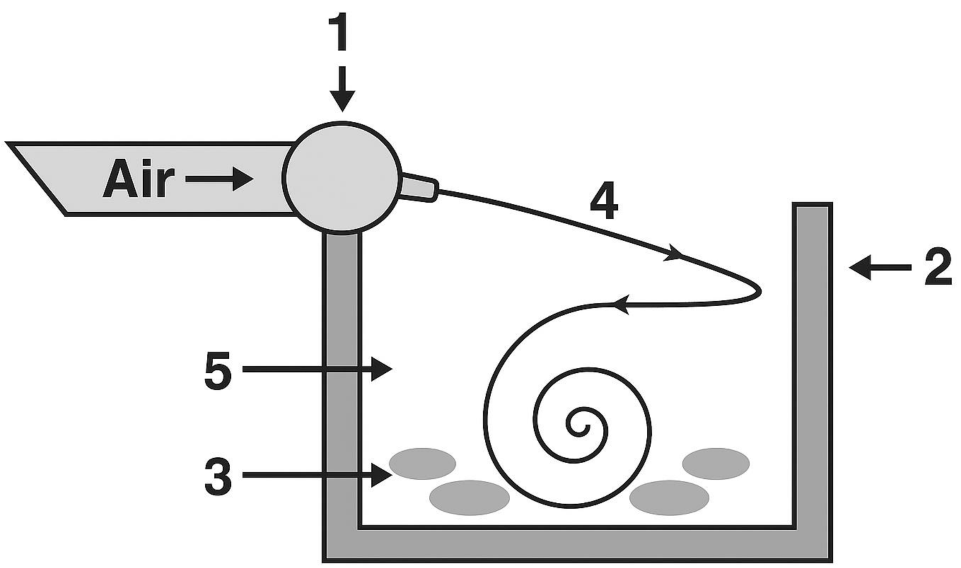
Pyre burning involves burning carcasses on pyres constructed of solid fuels such as dry wood and/or coal briquettes. The carcasses are placed on top of the solid fuel, ensuring that there is sufficient airflow around them for efficient combustion. The pyre design and the quality of the solid fuel used will determine the efficiency of combustion. Generally, the more efficient combustion, the less smoke generated and the greater the temperature achieved. For further details on how to construct a pyre, refer to Appendix 5.

Air-curtain incinerator

Use of air-curtain incinerators (Figure 4.2) involves burning materials in either an earthen pit (pit burner) or a metal refractory box (firebox) using fan-forced air. A machine forces a mass of air across the length of the pit or box, creating a turbulent environment that greatly enhances burning. The angle of the airflow results in a curtain of air acting as a top for the burner and provides oxygen, which results in a more complete burn. Unburned particles are trapped under the curtain of air in the high-temperature zone, where temperatures can reach 1000 °C (1832 °F).

When operating an air-curtain incinerator, solid fuel (e.g. dry wood) is loaded by an excavator into the receptacle to establish a base fire. Once the base fire is established, the solid waste (e.g. carcasses) can be loaded onto the fire. This process can be monitored by observing the volume of smoke leaving the receptacle and adjusting the fuel-to-waste ratio accordingly.

Availability of air-curtain incinerators varies by jurisdiction.



1. Air-curtain manifold and nozzles direct high-velocity airflow into refractory lined firebox or earthen pit
2. Refractory lined wall (firebox) or earthen wall (pit burner)
3. Material to be burned
4. Initial airflow forms a high-velocity ‘curtain’ over the fire
5. Continued airflow oxygenates the fire, keeping temperatures high. Higher temperatures provide a cleaner and more complete burn.

Figure 4.2 — Theory of air-curtain incineration

Adapted from: Air Burners Inc (www.airburners.com)

4.3.1.2 Commercial incineration

Commercial incineration (fixed facility incineration) involves the combustion of waste materials in contained and usually highly controlled chambers, which are typically fuelled by natural gas. This is considered an efficient and safe method of disposing of contaminated waste. This category includes large-scale energy-from-waste (EfW) incinerators, waste incineration plants, pet crematoriums, small on-farm incinerators and power plants.

EfW, also referred to as waste-to-energy (WtE), incinerators are used in Europe — noting land burial of carcasses is banned in the European Union (Vithanage at al 2021) — and North America to generate electricity by burning waste. Such facilities are being built in Victoria and Western Australia but have not yet been commissioned. In New South Wales, four precincts are zoned for future EfW operations, with one commercial EfW facility currently in the proposal stage (GHD 2023).

EfW facilities may have the capacity to process a large volume of waste (one Western Australian facility is planned to process up to 460,000 tonnes of waste per year). They generate valuable outputs including electricity and construction materials from the residual ash. The license conditions of the EfW facilities in Western Australia currently prohibit the processing of carcasses and medical wastes. The possibility of allowing carcass disposal in an EAD response is under discussion with the licensing authority. The potential carcass-processing capacity at an EfW facility under Australian operating conditions is not yet well understood.

Waste incineration plants are usually located in populated centres and are primarily designed to handle smaller quantities of material (e.g. medical waste, quarantine waste and deceased pets) than EfW incinerators. The facilities are usually well set up to transport, store and handle hazardous biological materials in a safe manner. The capacity and willingness for such facilities to process animal carcasses during an EAD response may be limited due to their size.

Incinerators, like other waste disposal facilities, are licensed and regulated by EPAs. They are designed to operate at high temperatures and technology is employed to avoid airborne pollution.

4.3.2 Considerations

4.3.2.1 Disease agent

Bacteria (including spore-forming bacteria), viruses, fungi and parasites should not survive any form of burning. However, prions, the disease agents responsible for TSEs — such as scrapie, bovine spongiform encephalopathy (BSE) and chronic wasting disease of cervids — are more durable and will survive temperatures up to 850 °C. TSE experts agree that open-air burning should not be considered a legitimate disposal option for TSE agents (SSC 2003). However, because commercial incineration is highly controlled, the required 850 °C is obtainable. Use of air-curtain incinerators can also achieve the required temperature, but the temperature can depend on the efficiency of the system, and the temperature is not typically measured and therefore cannot be guaranteed.

The biosecurity requirements and logistics of transporting carcasses and other materials to a suitable burning or incineration site and managing them therein should be carefully considered. Management of zoonotic disease agents will also require consideration of WHS and risk mitigation to public health (see Sections 3.7 and 4.3.2.13).

4.3.2.2 Volume and type of material for disposal

The volume of material for disposal may directly affect the method of disposal. Because burning is a more resource-intensive method with regard to labour and other inputs than some other disposal methods, it may not be suitable for EAD responses involving large volumes of material. This will not be the case where there is a disease imperative for burning carcasses (e.g. anthrax).

The low throughput of an air-curtain incinerator must be considered as part of the disposal plan. Air-curtain incinerators may only be appropriate for specific diseases (e.g. anthrax) or when small numbers of carcasses need disposal. For larger-scale mass disposal, a combination of disposal methods, which may include air-curtain incinerators, may be required.

The throughput and capacity of pyre burning will depend on the material to be burned (e.g. species and volume of carcasses), availability of fuel, the fuel type, land/space available to undertake the burning, maintenance of the pyre and accessibility.

4.3.2.3 Nature of carcass material

Animal carcasses with higher fat percentages, such as pigs, will burn more readily due to their composition (NABC 2004). Sheep in full wool may be difficult to burn due to the fire-retardant properties of wool covering the carcasses (Kastner & Phebus 2004).

4.3.2.4 Location

Factors affecting where a burning operation can proceed will depend on the type of waste materials and the chosen method.

Approval requirements will vary according to state/territory or local laws and any fire restrictions in place. Consultation with jurisdictional environmental and other agencies is therefore essential. Important considerations for selection of burning sites include the criteria addressed below. For each of these criteria, the site may need to be evaluated using further on-site investigation, weather and climatic condition analysis, and even soil analysis (e.g. to avoid peat fires).

4.3.2.5 Fuel

Dry wood

Dry wood is critical to the success of pyre burning and is required for the initiation of air-curtain incineration, ensuring rapid and cleaner combustion. Dry hardwood has a moisture content of 20–30%.[9]

Gelled fuel

Gelled fuel — a combination of a powdered aluminium soap and a hydrocarbon — is a fuel source that has been trialled for burning carcasses in Australia. Gelled fuel is routinely used by fire agencies in aerial drip-torch operations for prescribed burning (e.g. hazard reduction burning). More recent liquid gelling products appear to be more operator-friendly than previous solid powder gelling agents.

[9] https://era.daf.qld.gov.au/id/eprint/3138/2/PN01.1307_Drying_best_practice_part1_2003WEB%5b1%5d-sec.pdf

Findings from Australian trials (Worsfold & King 2006) indicate that gelled fuel is more appropriate as a secondary fuel source during initiation of a timber pyre burn than as a standalone primary fuel source. Gelled fuel is not as volatile as straight hydrocarbon products (e.g. petrol and diesel) and has a more sustained burn time, making it particularly useful for starting long timber pyres.

4.3.2.6 Open-air burning

Proximity to neighbours

Depending on the size of the operation and the materials to be disposed of, burning can affect surrounding neighbours and roads. Adverse community impacts, including to human health, can result from the presence of smoke and odours, and reduced visual amenity. Impacts can be reduced through appropriate selection of the site (on-site or off-site), good design and management of pyres or pits, and effective communication with neighbours and property owners.

Availability of fuel

A suitable and cost-effective supply of solid, liquid or gas fuel is required. Other disposal options should be considered if fuel is severely limiting, unless there is a disease imperative (e.g. anthrax).

Fire risk

Personnel should ensure that all possible controls are implemented to reduce the risk of fire spread (e.g. adequate cleared area, adequate supervision, presence of firefighting capability, fire permits, notification of burn times, suitable soil type for ground/pit-based burning).

Infrastructure

Identification of underground and above-ground utilities should be part of any initial property risk assessment.

Site access

Good access is required to deploy machinery to supply fuel, construct the pyre or pit, maintain the fire, dispose of ashes and facilitate the movement of firefighting equipment.

Impacted businesses and tourism

Planning should include assessment of the risks the burning operation and smoke pose to surrounding businesses. Viticulture is particularly sensitive to smoke tainting of grape crops at certain stages of production. Tourism operators in both the immediate area and within the jurisdiction more broadly may suffer if highly visible pyre burning is employed. This occurred in the UK, where the cost of the 2001 FMD disease outbreak to the tourism industry was estimated to be similar to the outbreak cost to the agricultural industry (Thompson et al 2002).

Community

Animal burning for disposal purposes should balance the need for effective and timely disposal of animal carcasses, the need to minimise environmental and human health impacts, and the need to meet community expectations and legal requirements. This, in turn, helps obtain community support for the response or, at least, minimises community objections.

Consideration may be given to undertaking open-air burning at night to lessen the visibility of burning and smoke production.

4.3.2.7 Commercial incineration

Availability

Commercial facilities may not be available in some areas or may not accept EAD-related waste materials.

Transport

Biosecure transport methods will be required to enable access to the site for personnel and materials.

4.3.2.8 Environment

Effects on air quality

The nature of emissions from open-air burning depends on many factors, including fuel types and efficiency of combustion. Risks associated with open-air burning were the subject of studies during the FMD outbreak in the UK in 2001. The fear of dioxins and smoke inhalation, along with the generally poor public perception of pyres, eventually led to discontinuation of the use of mass burn sites in the UK. However, pollution levels never exceeded levels in other urban parts of the UK, did not violate air quality regulations and were deemed not to have unduly affected public health (NABC 2004). Properly operated commercial and air-curtain burning methods pose fewer pollution concerns than pyre burning (Ford 2003).

Groundwater pollution

Open-air burning can pose risks to groundwater, although this is usually only if liquid fuels are used for initiating burns.

Soil and food pollution

Dioxins and polychlorinated biphenyls (PCBs) are known to emanate from pyres. During the UK FMD outbreak in 2001, the UK Food Standards Agency confirmed that levels of these two pollutants, with a few exceptions, were within the normal range throughout the campaign and 'that no significant harm was expected from food produced near pyres' (Cumbria Foot and Mouth Disease Inquiry Panel 2002).

Peat fires

Peat fires are a type of wildfire that occur in natural areas made up of partially decayed vegetation or organic matter. They are characterised by their slow, low-temperature, flameless burning of porous fuels.[10] In peatlands, peat fires can burn undetected for months or years.[11]

Peat fires pose significant environmental, economic and ecological threats, including air pollution, property damage, destruction of animal habitats and air pollution.

Soil analysis prior to commencing surface or pit burning should be undertaken to avoid accidental ignition of peat.

Climatic conditions

Significant rainfall events can limit combustion efficiency, while some environmental conditions (e.g. heat and wind) may favour fire escape. Fire bans may preclude the use of burning as a disposal method.

Responsibility for environmental controls

[10] https://www.iawfonline.org/article/the-long-slow-burn-of-smouldering-peat-mega-fires/
[11] https://environxsolutions.com/peat-fires/

For commercial incineration facilities, environmental considerations (air, water, soil and food) will be accounted for by the facility operator.

For other burning operations, the responsibility for environmental controls will rest with the jurisdictional response agency undertaking the EAD response operation.

4.3.2.9 Monitoring and remediation

The monitoring and remediation requirements for burning will vary according to the method used. The main environmental impacts are relatively short term and largely relate to air quality and the potential for fire escape. The necessity to monitor air quality and provide site remediation should be negotiated with jurisdictional environmental agencies.

Where open-air burning is used, the main focus should be on efficient combustion and returning the burn site to a reasonable condition. Burying of ashes on-site or disposal to landfill off-site, followed by clean-up using machinery, should facilitate this process. An advantage of pit burning using an air-curtain incinerator is that the ashes are already buried, and only backfilling is required.

Typically, additional monitoring and site remediation are not required for commercial incineration methods.

4.3.2.10 Time

Factors that affect the time taken to prepare for, and complete, burning or incineration of carcasses and contaminated materials include the:

- method used
- design and capacity of the method
- proximity of the waste materials to the site (i.e. on- or off-site)
- quality and availability of solid and liquid fuels
- number and class of animals requiring disposal
- experience and availability of personnel
- type and availability of machinery
- weather conditions.

Experience from Victorian anthrax responses indicates that around 20–24 hours is required to completely burn an average bovine carcass (or small numbers of carcasses), depending on the quality of the pyre construction and how actively the carcass is managed (i.e. agitated). Poorly constructed pyres or pyres comprising low-quality solid fuel can significantly increase the burn time (e.g. to 3–4 days). This is in contrast to air-curtain incineration in a pit using dry wood — once set up and fully functional, this system can incinerate a whole bovine carcass in 90 minutes. During the FMD outbreak in the UK in 2001, 15 bovine carcasses were able to be incinerated using an air-curtain incinerator in an 8-hour period using wood as a primary fuel source.[12]

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[12] https://airburners.com/wp-content/uploads/2017/10/bre_defra_report_b2.pdf

Commercial incineration plants can vary greatly in their capacity (tonnes per hour). They may be immediately available because there are no set-up requirements.

4.3.2.11 Cost

The costs of open-air burning and commercial incineration can be highly variable. Costs involved in open-air burning include the supply and transport of solid and liquid fuels, contracting of machinery and personnel, disposal of the remaining ash and any decontamination requirements.

The costs of commercial incineration may include:

- handling, transporting and treating the waste
- decontaminating the facility, equipment and personnel
- disposing of ash
- fixed costs associated with operating the facility.

4.3.2.12 Resource requirements

Resources required will vary with the method used and the location of the operation.

Open air-burning

Fuel

Solid or liquid fuels are required for open-air burning. Dry hardwood (20–30% moisture) is the preferred solid fuel, especially for large pyres and air-curtain burning operations. Other solid fuels such as coal briquettes can be used, but briquettes produce larger amounts of smoke because there is limited airspace between the briquettes. Briquettes can be burned more efficiently in an air-curtain incineration operation, particularly in conjunction with wood.

Machinery

The quantity and type of machinery will depend on the tasks to be undertaken. For safety reasons, when using an air-curtain incinerator, solid fuel should be loaded into the pit or box using an excavator.

Personnel

The number of personnel required will be dictated by the size of the operation. Personnel should receive a site induction and have the required level of biosecurity training and skills for their function.

Wherever possible, machinery rather than manual handling should be used.

Commercial incinerators

Machinery

The quantity and type of machinery will depend on the tasks to be undertaken and the facility being used. All machinery and equipment that have been in contact with contaminated materials must be decontaminated before they are returned to normal operations.

Personnel

The number of personnel required will be dictated by the facility being used. Access to the facility may be restricted to authorised personnel. Personnel should receive a site induction and have the required level of biosecurity training and skills for their function.

4.3.2.13 Health and safety considerations

Health and safety considerations include:

- public perception of health risks associated with open-air burning (e.g. dioxins, particulate matter)
- fire-retardant outerwear and respiratory protection against fumes
- weather conditions that increase the likelihood of fire spreading
- handling of combustible materials (e.g. liquid fuels)
- existing standards for managing waste at commercial incineration facilities.

4.3.3 Advantages and disadvantages of burning

Burning category	Advantages	Disadvantages
Open-air burning (pyre)	Low-technology option Can be initiated relatively quickly Can be used where the watertable is high or where soil types preclude burial Should destroy all pathogens, except prions Requires only short-term monitoring Can accommodate all classes of animals and animal products	Can be time consuming and labour intensive to construct Requires large volumes of solid fuel Cost of solid fuels can be considerable Can take considerable time to consume whole carcasses High fire risk at certain times of the year Public perception of poor environmental outcome and disease spread risks Ash will require disposal Short-term effect on air quality (smoke, smell) Combustion efficiency can be affected by climatic conditions (e.g. rain) Requires continual operation to maintain burning
Open-air incineration (air-curtain incinerator)	Can be initiated relatively quickly (if machine available) Machines are portable Efficient combustion achieves high temperatures and minimal smoke Should destroy all pathogens, except prions (unless operated at >850 °C) Requires only short-term site monitoring Burn site can be easily and quickly rehabilitated Lower fire risk than pyres due to better containment Better fuel economy than pyres Can be used where the watertable is high Can accommodate all classes of animals	Limited availability and expense of purpose-built machines Requires suitable geology to construct the pit (not required for fireboxes) Requires specialist operators to manage the site Requires significant site controls to monitor personnel safety Requires active monitoring during operation Requires large volumes of solid fuel Cost of solid fuels can be considerable Can handle only limited volume of materials Public perception of poor environmental outcome and disease spread risks
Commercial incineration	Should destroy all pathogens, including prions Highly efficient and controlled combustion achieves high temperatures Can be initiated relatively quickly (if close to origin of wastes) Environmental monitoring is managed by commercial operator Better pollution controls than other burning methods Management of materials by contractors is usually biosecure and safe to the operator No requirements for site remediation or monitoring Located in industrial zones away from livestock and residential areas	Capacity of facilities varies — some are limited in their throughput or capacity to handle large animals Carcasses and materials need to be transported to the site May be difficult to engage specialist operators to manage the site in a timely manner Limited locations and numbers of suitable facilities (which may affect transport costs) Conditions of licenses may preclude processing of carcasses May require pre-planning arrangements for access to a facility, or access may take some time to arrange Incinerator loading mechanisms (e.g. conveyor belts) may not be suitable for animal carcasses or easily decontaminated Limited capacity as the carcasses are almost a contaminant to the end product, depending on fat content

4.4 Rendering

4.4.1 Process overview

'Rendering is the industrial process of heat treating and physical transformation of animal co-products destroying pathogens, removing moisture, separating solids and lipids or fats/oils to produce valuable animal protein meal or processed animal protein, and rendered animal fat/oil'.[13] Rendering systems use various methods, such as wet, dry, batch, continuous, press dewatering and wet pressure rendering (Auvermann et al 2004). Co-products of the rendering process include meal (meat, feather etc), fuel, methane and fertiliser.

In Australia, the rendering industry operates in a highly regulated environment with stringent requirements to establish and maintain hygienic rendering practices. Accredited rendering plants are required to adhere to Australian Standard AS5008 Hygienic Rendering of Animal Products, with additional accreditation available to enable processing plants to access diverse, high-value export markets. The stringent hygiene requirements for processing, which aim to assure food safety, should also assist in maintaining biosecurity when rendering is used to dispose of carcasses in an EAD response.

The Australian Renderers Association (ARA) should be consulted to determine the location of facilities, their capacity and the species they can accept,[14,15] and to confirm that the facility will accept diseased carcasses and animal products.

4.4.2 Considerations

4.4.2.1 Disease agent

When considering rendering as a disposal option during an EAD response, the capacity of the rendering process to effectively inactivate the causative organism must be determined. Treatment parameters (heat, pressure, time) may vary from facility to facility, and some facilities may not accept EAD-contaminated carcasses. Others may be unwilling to process carcasses during a response if there is an associated risk to their accreditation and commercial contracts. Useful references include AUSVETPLAN response strategies[16] and the document ***Persistence of disease agents in carcases and animal products*** (Williams 2017).

4.4.2.2 Volume and type of material for disposal

The volume of material and species of animal[17] able to be disposed of through rendering will vary between facilities.

Whole carcass rendering may not be possible, or may require a change in rendering processes (e.g. preprocessing such as dismembering, carcass grinding, changes to heat, pressure or time). Some rendering facilities may only be able to process certain species, for reasons relating to infrastructure or conditions of their licence.

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[13] https://www.ausrenderers.com.au/en/what-is-rendering/

[14] https://www.ausrenderers.com.au/en/about-us/

[15] https://www.ausrenderers.com.au/en/member-directory/ specifies the type of rendering facility. This site allows filtering on the type of species that can be handled.

[16] https://animalhealthaustralia.com.au/ausvetplan/

[17] https://www.ausrenderers.com.au/en/member-directory/ specifies the type of rendering facility. This site allows filtering on the type of species that can be handled.

4.4.2.3 Location

As at May 2024, 56 of the 77 member organisations of the Australian Renderers' Association are described as 'integrated renderers' (i.e. associated with an abattoir or group of abattoirs). The proximity of the rendering facility to the affected premises and the possibility of accessing it must be evaluated.

Rendering facilities that are associated with industries or located in areas that are not affected by an EAD outbreak may not be available for disposal of carcasses from an area under EAD-related restrictions.

4.4.2.4 Environmental implications

Industry standards provide guidelines for best-practice containment and treatment of the products of rendering. Commercial operators have licences from environmental agencies that cover these aspects. The environmental implications of disposal of EAD-contaminated carcasses must be considered.

4.4.2.5 Monitoring and remediation requirements

Not applicable.

4.4.2.6 Time

The capacity and infrastructure of the facility will determine the time taken to dispose of the volume of waste, including carcasses. In a large EAD response, the availability and capacity of rendering need to be carefully assessed to ensure disposal within reasonable timeframes. Freezing or chilling of materials may allow disposal over a longer timeframe, but will increase costs (Pluimers et al 1999) and may increase the risk of dissemination of disease as a result of increased handling requirements. See also Section 4.4.2.2.

4.4.2.7 Cost

Variable costs include collection and transport of materials, storage fees, labour requirements, sanitation (Auvermann et al 2004) and decontamination.

A significant percentage of rendered animal products is exported. In 2015–16, an ARA survey showed that about 50% of mammalian protein meals, 52% of poultry and feather meals, and 73% of animal fats were exported that year.[18]

Response costs may increase if markets cannot be found for the safe end products of rendering or if additional disposal is required.

4.4.2.8 Resource requirements

The primary resource required for rendering is the facility itself. Given that the premises is established and operating to industry standards, further resources would be directed towards managing the risk of EAD spread and satisfying any additional licensing requirements. This may include additional biosecurity

[18] https://www.ausrenderers.com.au/wp-content/uploads/2023/09/ARA-Rendering-Fact-Book.pdf

controls such as on-site vehicle traffic management, vehicle and personnel decontamination facilities and equipment and a supervisory function.

If a renderer is assisting during an EAD response, the potential impact on day-to-day business operations should also be considered. Waste normally processed by the facility may require disposal via another waste management stream.

Further to this, rendering is a 'just-in-time' industry, meaning that onsite storage capacity is often limited to 1½ days of rendered product.

4.4.2.9 End of use product

Permitted use or disposal requirements of the end product may vary across jurisdictions according to EPA regulations or case-by-case determinations.

4.4.3 Advantages and disadvantages of rendering

Advantages	Disadvantages
Existing, purpose-built facilities are available Facilities and processes should already meet regulated and industry standards Provides biological containment Produces low-risk products (e.g. fertiliser, fuel, methane, fats) Destroys most pathogens (except prions) Product is easier to handle and dispose of through volume and moisture reduction	Operators may be reluctant to accept responsibility for carcass disposal in an EAD response Capacity of rendering and availability (including location) of facilities may be limiting in a large EAD response Complexities associated with decontamination of the facility Response cost is higher if there is no available or accessible market for the final product or if the product requires disposal (e.g. burial)

4.5 Composting

Composting and pasteurisation using the composting method are proven and effective methods for inactivating pathogens, including those associated with most emergency animal diseases.

The terms composting and pasteurisation should not be used interchangeably, as they are distinct processes that produce different end products. Compost is an organic product that has undergone controlled aerobic and thermophilic biological transformation through the composting process to achieve pasteurisation, reduce phytotoxic compounds, and achieve specified levels of stability and maturity.

Pasteurisation on the other hand is a process whereby organic materials are treated to sufficiently high temperatures for sufficient time to significantly reduce or eliminate plant and animal pathogens and plant propagules. The pasteurised material may, however, be immature and continue to be biologically active.

While both processes are effective methods of pathogen elimination, there are implications for how the end products of each process may be reused.

Composting is a natural biochemical decomposition process that predominantly takes place under aerobic conditions. Composting progresses through phases which should be monitored and controlled so that the compost mixture, moisture, oxygen and temperature are managed to achieve the desired outcome. If properly constructed, the first phase (mesophilic phase) is characterised by a rapid increase in temperature as soluble and readily degradable compounds are broken down. The second phase (thermophilic phase) begins several days later as temperatures rise above 45 °C when more complex carbon sources are broken down. This phase is characterised by temperatures between 45 °C and 70 °C and may last for several days or months depending on the primary materials used in the compost. It is during this phase that pasteurisation of the composting material occurs. After this high-temperature phase, the compost begins to cool down (cooling phase) until it reaches ambient temperature as the compost matures (maturation phase) and turns into a consistent dark brown to black material called humus.

Animal mortality composting follows the same process. Carcasses and other organic wastes are placed onto a bed of carbon and covered with a mixture of co-composting materials (e.g. manure and bulk carbon sources). This material is then covered with an outer layer of clean carbon which acts as both a biofilter to reduce odours and a separation layer between infectious materials in the core of the compost and the environment. As this material heats up and enters the thermophilic phase most pathogenic organisms are destroyed and carcass tissues and co-composting materials are digested and decomposed. Note that some pathogens, such as prions, are not inactivated by composting, while others, such as some spore-forming bacteria, may survive the process, albeit at lower levels (Huang et al 2007).

Successful carcass composting requires an appropriate mixture or ratio of carbon (bulking agent and microbial energy source) to nitrogen (from manure and carcasses), together with oxygen, and moisture levels around 40–50%. When managed correctly, composting will remain in an aerobic state which reduces odours and maintains high temperatures and carcass decomposition. If moisture levels are too high, or the compost pile is too dense, anaerobic conditions may become prevalent, which may lead to odour. In contrast, if moisture levels are too low, the thermophilic bacteria may become dormant and compost temperatures will fall. It is important therefore to actively monitor and manage compost to ensure conditions are maintained to ensure pathogens are eliminated and, if desired, the compost progresses to maturity.

4.5.1 Process overview (animal mortality composting)

Effective mortality composting requires active monitoring and management. It should be undertaken by personnel with the required technical knowledge and experience to ensure conditions are met and maintained for pasteurisation and, if required, the production of stable and mature compost.

Mortality composting is generally conducted in several steps to break down the carcasses and inactivate the disease agent. In the first step, the compost piles are set up as described above and left undisturbed to heat up and achieve consistent temperatures above 55 °C. Soft tissues decompose and bones are partially softened. Depending on the type and volume of carcasses, the material may remain undisturbed for two, three or several weeks. Following sufficient time to ensure partial decomposition and after achieving temperatures greater than 55 °C for a minimum of three consecutive days, the compost is usually then moved, turned or mixed to begin subsequent steps of the process, during which the remaining materials break down further. Depending on the composting method used (windrow, bin or in-vessel), the material may be mixed or turned several more times. Composting is complete when the requirements for pasteurisation are met and the compost becomes stable and mature during a curing or storage phase (Keener et al 2006, Wilkinson 2006).

Composting temperatures may rise to levels which begin to compromise beneficial thermophilic bacteria. Generally, temperatures above 70 °C will begin to inactivate the beneficial bacteria required to maintain temperatures required for pasteurisation. Compost piles should be turned when temperatures exceed 65 °C or when they drop below 45 °C, unless compost has reached the cooling and maturation stage. Moisture levels must be monitored and maintained at an optimal level of 40–50%; too little moisture (below about 30%) will reduce microbial activity, while too much may create anaerobic conditions (Wilkinson et al 2014, EPA Victoria 2017, EPA Victoria 2022).

If undertaken correctly, composting results in the elimination of odours, the destruction of most pathogens (see Appendix 6) and weed seeds, soft tissue decomposition, and the partial softening of bones. Compost piles containing carcasses typically heat up relatively quickly (2–8 days) but will require different treatment times depending on the size and bulk of carcasses undergoing composting. Small carcasses (e.g. poultry) will generally take shorter periods to decompose and degrade (6–8 weeks) compared to larger carcasses (e.g. pigs and cattle) which may take several months to fully breakdown, depending on conditions, materials and management. As composting progresses, the compost piles will begin to slump or shrink as carcasses decompose. Any cracks or openings created as the piles begin to slump must be covered with additional carbon to prevent the exposure of potentially infectious material to the environment.

Subsequent stages of composting are comprised of mixing and turning the piles. The number of turns may vary depending on the composting system used. Windrow compost piles are typically turned and mixed five times while bin composting usually requires a minimum of three turns. In-vessel composting systems may be similarly turned as for windrow composting or might undergo constant slow turning in continuous composting systems where feedstock is gradually added at one end and pasteurised material exits the other end.

Guidelines for mortality composting in Australia are based on Australian Standard AS4454-2012 Composts, soil conditions and mulches (currently under review). For windrow composting of ‘higher risk materials’, which includes animal waste and carcasses, AS4454-2012 requires that the core temperature of the compost be maintained at or above 55 °C for 15 days or longer with a minimum of five turns. This is to ensure that all areas of the compost are subject to at least 55 °C for a minimum of three consecutive days between each turn during the treatment period.

In the final stages following the required number of turns and pasteurisation, continued turning and aeration are no longer required. This stage can be undertaken after the EAD response is concluded, as long as the appropriate conditions for pasteurisation have been achieved. During this period, a series of slow-rate reactions, such as the breakdown of lignin and polymerisation of the compost occur at temperatures below 41 °C, and moisture levels decrease. At the end of the curing phase, internal temperatures within the compost pile will reach ambient temperatures. The material bulk density is reduced by 25–40%, the finished product appears dark brown to black and it is free of unpleasant odours (USDA APHIS 2024).

Pasteurisation may suffice for the purpose of infected waste treatment and disposal but should not be confused with the production of a stable and mature compost product. Compost maturation, in which the material becomes less biologically active as it matures, may take several more months following pasteurisation. Product that still retains some pungency is not stable or mature and may not meet criteria for unrestricted use. However, provided it has met minimum quality standards for pathogen and vector reductions, together with acceptable physicochemical characteristics, the compost may be used for land application in rural areas, away from sensitive receptors, where its higher nitrogen value would be valued by farmers.

For poultry, the first stages of mortality composting can be completed in-shed if feasible. After forming compost rows in the sheds, the material is generally left undisturbed for 14 days, during which the material will be subjected to temperatures above 55 °C for a minimum of three consecutive days. The material is then mixed and turned, and composted for a further 14-day period. This will be sufficient to eliminate or significantly reduce most pathogens associated with EAD responses in poultry (Malone et al 2004) The material can then be safely removed from the sheds to continue the composting process elsewhere on the infected premises or, if permitted, offsite. Pasteurised or semipasteurised composted material is safe to transport if it is covered and appropriate vehicle decontamination steps are taken (Malone et al 2004).

The initial stage of composting — to the pasteurisation stage — may also be integrated into a disposal plan. Pasteurisation allows for the inactivation of pathogens and addresses the infectious risk of the product in the short term, which might then allow transport of the product to other locations such as a landfill or an approved compost facility. This strategy could be useful when needing to depopulate large numbers of animals in a short period when the onsite disposal locations are not appropriate for longer-term composting but could be used for short-term pasteurisation.

Commercial composting facilities operate in most Australian jurisdictions but may not be licensed to accept EAD materials for composting or have the required capacity.

It may also be necessary to secure compost sites against access by vermin, feral animals and native wildlife. Compost trials undertaken in Australia have not found evidence of feral animal interference with carcass compost piles. However, in areas with high feral animal numbers, measures may be required to secure compost sites from access by feral animals. The erection of temporary fencing or use of electric fencing may be used in these circumstances.

4.5.1.1 Composting methods

Composting may be carried out on-site or at another appropriate location (e.g. commercial composting facility) if approved by the relevant environmental regulator. There are three general methods of carcass composting:

- *Windrow* — a long, narrow pile of carcasses and/or other organic, biodegradable matter is encased in uncontaminated co-composting material. The large, exposed surface area encourages passive aeration. Dimensions can be adapted to any size and number of carcasses. Windrows may be constructed inside sheds (e.g. poultry sheds and eco-shelters) where compost is protected from rain, thereby allowing for greater moisture control, and where carbon material is already present (e.g. poultry litter or straw/sawdust). It can also be constructed outdoors in long rows and be used to compost large numbers of birds, including turkeys.

- *Bin* — an enclosure with at least three sides on a hard stand is used to contain compost materials, which may be covered by a roof. As in windrow composting, roofing or other covering provides the advantage of being able to control moisture within the compost pile. Hay bales may offer a temporary option. Bins are usually used to compost small and medium-sized carcasses for practical reasons. As a general guide, 10 m3 of bin space is required for every 1,000 kg of carcasses (NABC 2004).
- *In-vessel* — composting material is enclosed in a sealed chamber or vessel, enabling better control of environmental parameters such as temperature and aeration. Examples are (1) agricultural bags (ag-bags), (2) commercial housed composting facilities, (3) mobile biocontainers with ventilation systems, air filters and airlock compartments, and (4) rotary composters.

4.5.2 Considerations

4.5.2.1 Disease agent

Composting is a well-established method of pathogen reduction. It destroys nearly all pathogenic viruses, bacteria, fungi, protozoa (including cysts) and helminth ova. Exceptions are some endospore-forming bacteria (e.g. *Clostridium difficile*) (Usui et al 2017) and prions.

Australian research has shown that Newcastle disease (ND) virus strain V4 in inoculated poultry carcasses was inactivated during composting after 1 day of exposure to temperatures above 45 °C (Wilkinson et al 2014). This finding is supported by other published studies showing that both avian influenza and ND viruses are quickly inactivated when composting temperatures reach 40–50 °C (Guan et al 2009).

High pathogenicity avian influenza (HPAI) can be inactivated rapidly within compost material at a mesophilic temperature of 35 °C (Elving et al 2012; Figueroa et al 2021). The temperatures achieved in composting processes are between 55 °C and 65 °C, which would be effective in inactivating HPAI viruses from infected tissues (Senne et al 1994), as well as ND, infectious bursal disease virus (Murphy 1990), and bacterial and fungal pathogens (Conner et al 1991, Figueroa et al 2021). For inactivating avian influenza, the United States Department of Agriculture requires a temperature of 55 °C to be maintained for 72 consecutive hours during both of two 14-day phases separated by turning the piles (USDA APHIS 2024) (see also Appendix 6).

Most researchers believe that when the overall compost temperature reaches 55–60 °C, it should remain at this temperature for 1–2 weeks. For more confidence on pathogenic bacterial inactivation, the core temperature of carcass composting should reach 65 °C and remain at this level for one to two days. That is, the compost pile could be turned or displaced with minimal risk of spreading pathogenic bacteria when these time and temperature criteria have been achieved. Furthermore, if the compost pile temperature exceeds 65 °C for more than 2 days, it should be turned and aerated to prevent thermal inactivation of beneficial microorganisms (NABC 2004).

4.5.2.2 Volume and type of material

The volume and type of material (carcasses and other contaminated material such as animal waste and litter) that can be disposed of will be affected by the availability of suitable areas for composting, access to water and the ability to source appropriate co composting materials.

4.5.2.3 Location

Composting can be completed either inside or outside. In-shed and in-vessel composting provide security and protection from wind, rain and scavengers. The logistics of in-shed composting will vary from situation to situation. Older sheds with pillars or with little floor-to-ceiling clearance may prove to be more difficult, since manoeuvrability is restricted, and composting piles will need to be constructed between the pillars.

Composting outside in windrows or bins requires land with an adequate slope to facilitate proper drainage and prevent water pooling, all-weather access and security from people and scavengers.

Commercial operators may not be available in rural or remote areas.

4.5.2.4 Environmental implications

Odour

When conducted properly, composting should not result in excessive odour. Peak odour emissions occur during the turning of composting piles, although these are usually short lived when turned piles are re-covered with new co-composting material. The generation of odour reflects inadequate composting, involving factors such as excessive moisture, carbon : nitrogen (C : N) imbalance, anaerobic conditions, lack of appropriate coverage of carcasses, and long periods at low temperature (EPA 2022).

Groundwater pollution

Composting should not result in pollution of groundwater, provided that the depth of the base layer is sufficient. Any leakage of fluids from piles should be immediately attended to by the addition of more absorbent co-compost material. Care should be taken not to overwater compost piles. The preventive infrastructure can include bunding and interception drains around the perimeter of the processing and storage areas, and wastewater storage tanks or ponds to prevent groundwater pollution (EPA 2017). It is better to err on the side of caution and have a drier mix than an overly wet one.

Jurisdictional composting requirements in respect to drainage and site location may vary according to EPA specifications.

Soil contamination

The top layer of soil under the piles may contain higher nutrient concentrations than surrounding areas, where the compost base layer has not absorbed all fluids from piles. This is typically highly localised and is usually restricted to the top 10–20 cm soil layer.

Climatic conditions

Significant rainfall events can affect outdoor composting systems and contribute to environmental risks. Additional co-compost material or a cover (e.g. silage covers) may be needed to prevent excessive rain damage.

Composting in cold climates may increase the time taken to reach suitable temperatures.

4.5.2.5 Monitoring and remediation requirements

Monitoring is mainly required during the composting process itself, and includes monitoring of compost temperatures, leachate and odour. Piles must also be monitored for any cracks or openings in the surface of the pile, as the pile typically slumps as carcasses or other materials break down; any cracks or exposed infected material will need to be covered with clean carbon as soon as possible. Inspections for any scavenger activity may also be required and, if appropriate, measures taken to prevent scavenger access to any infectious materials (in the core of the compost piles).

Monitoring of mature compost piles, or sites where composting has been conducted, is not normally required after the composting process has been completed.

4.5.2.6 Use of final product

Acceptable uses for the final compost product may vary across jurisdictions according to EPA regulations. The finished product may need to be tested for nutrient composition, physical and chemical contaminants and microbiological indicator species.

The finished product can be recycled, stored or added to the land as a soil amendment. Jurisdictional legislation may affect the final use of the product. A risk assessment on a case-by-case basis will inform the use of the finished product. Consideration may also be given to testing the microbiological status of the product before it is released for use.

AS4454-2012 is a voluntary quality standard and recommends microbiological testing of final compost. Jurisdictions tend to adopt this guidance as requirements in relation to the sale of compost.

4.5.2.7 Time

Composting can be immediately set up on-site if adequate co-composting material is available. Off-site composting at a commercial facility usually requires more organisation but may reduce the quarantine period on an infected premises.

The time to completion of composting varies with the size of the animals, the co compost material and management of the pile (e.g. turning, mixing and watering) (Wilkinson 2006). Composting may take longer than other disposal methods, especially with large carcasses, which may affect release from biosecurity controls and quarantine (if conducted onsite) (Bonhotal et al 2022, Bendfeldt et al 2005).

Animal carcasses can be composted whole or, to speed the process, can be ground and mixed with carbon material (e.g. poultry litter, small grain hulls, sawdust, woodchip, ground cornstalks, ground straw) (USDA APHIS 2024). Generally, the larger the carcass, the longer it will take to compost. Keener et al (2000) concluded that decomposition times are largely a function of carcass mass, and reported weight-based prediction equations for the duration of the primary and secondary phases of composting, as well as windrow height and base measurements for optimal performance.

The first stage of composting is usually complete within about 1–2 weeks for poultry, and up to 12 weeks for larger carcasses. The second stage takes an additional 3 weeks for poultry and up to about 8 months for larger animals (but this will vary). Composting in sheds will affect the period for which the facilities will be out of production (CFSPH & USDA 2012). To increase decomposition speed, carcasses may require mechanical turning several times to encourage aeration and speed up the decomposition process. However, infected carcasses should initially be turned minimally to avoid dispersing pathogens (USDA APHIS 2024).

Pretreatment of carcasses (e.g. by grinding) will reduce compost times and co-compost material volumes, but may increase biosecurity risks. Similarly, the grinding of carcasses may be undertaken following pasteurisation, thereby managing the infectivity risk while allowing for more rapid subsequent decomposition.

4.5.2.8 Cost

The cost of a composting operation can be highly variable. Costs include the supply and transport of co-composting material, contracting of machinery and personnel, and disposal of the end product. The composted end product can be spread on farm as a soil improver; however, in some jurisdictions this material will be considered putrescible waste and its burial triggers ongoing site management costs. Costs will be subject to availability of resources and location of operations. Commercial operators (where available) may be a less costly option.

4.5.2.9 Resource requirements

Co-compost material

Mortality composting involves additional challenges compared with conventional composting. This involves maintaining control over more than 20 factors, including carbon : nitrogen (C : N) ratio, moisture, porosity, temperature and oxygen (Keener et al 2000). Ranges for optimal composting include 25 : 1 to 30 : 1 C : N (w/w), 50–60% water, 35–45% porosity and >10% oxygen concentration (Costa and Akdeniz 2019, Keener et al 2000, Doklovic 2022, Oshins et al 2022).

Most animal carcasses contain high enough nitrogen levels to supply the composting process. Bulking agents are an important source of carbon, provide the moisture, provide — through their physical (particle size) and chemical composition — the space required for aeration, trap odours and gases, and absorb leachate. Therefore, choice of bulking agent should be based on factors that include availability, cost and suitability to achieve carcass composting.

Manure is readily available on intensive livestock farms; however, because of differences in species farmed and effluent treatment and management, the available product may range in consistency from liquids to sludges of varying viscosities to solid material. Manure may also be used in conjunction with a high-carbon bulking agent at an appropriate ratio (1 : 1) (USDA Composting Technical Committee 2016). Many factors can affect the chemical and nutrient composition of animal manure, including the animal species and classes of animals, diet, environmental factors, water used in flushing /cleaning, and storage time of the manure (Dadrasnia et al 2021). Manure management may also alter the C : N ratio if manure piles are used for carcass mortality composting.

The ratio of bulking agent to carcasses should result in a bulk density of final compost mixture that does not exceed 600 kg/m3. As a general rule, the weight of compost mixture in a 19 L bucket should not be more than 11.4 kg; otherwise, the compost mixture will be too compact and lack adequate airspace. For a list of co-compost materials readily available in Australia refer to Appendix 7.

As with other disposal methods, jurisdictions will require compliance with their respective legislation. Requirements may include that:

- composting be done on an impervious surface (such as concrete or compacted soil)
- compost that is pasteurised but not ‘finished’ as per AS4454-2012 and may be considered putrescible waste can only be transported off the farm to a licensed waste disposal site.

Sourcing and delivery of co-composting material may be difficult, particularly in remote areas.

Equipment

Composting requires sufficient and suitably sized earthmoving equipment that has adequate reach to safely build piles or load bins. Equipment is also required when piles are turned or moved.

Stainless steel compost temperature probes or data loggers are required to monitor composting on a regular basis, especially during the first stage of composting. Probes and data loggers should be calibrated before use.

Personnel

Skilled operators of earthmoving equipment are essential. Personnel experienced in the composting process — for example, in routine mortality composting (e.g. farm managers) — would be an advantage. Personnel should be trained in biosecurity procedures to prevent the spread of pathogens.

4.5.3 Advantages and disadvantages of composting

Advantages	Disadvantages
Low-technology disposal method Can be done either on-site or off-site (on-site avoids risks associated with transport of carcasses) Can be used where a high watertable or unsuitable soil types preclude other disposal methods Inhouse composting may be available to some commercial entities Commercial operators are available Destroys all pathogens except endospore-forming bacteria (e.g. anthrax) and prions (e.g. BSE) Can be initiated immediately if adequate co-composting material is available Recycles carcasses and results in a saleable product (subject to acceptable use) Can take all livestock, suitable fomites and some industry products Does not require long-term monitoring or remediation Promotes an environmentally responsible image	May require a large area (in particular, for the construction of windrows) May require a large supply of co-composting material and/or water Possibility of localised odour and soil contamination if poorly managed Requires daily control and monitoring during initial stages Biosecurity risk if required temperatures are not achieved May take longer than other disposal methods, especially with large carcasses, which may affect release of quarantine (if conducted onsite) Efficiency may be affected by adverse climatic conditions Limited experience in mass mortalities of large carcasses No data for composting of livestock with heavy fleece Potential local community resistance Transport required for offsite or commercial composting Access to experienced commercial composters may require pre-planning or additional time and cost to arrange; however, the confidence of the pasteurisation process and the deactivation of the disease agent may be higher May require final product testing to release compost commercially Disease agents such as those causing BSE and some pathogenic spore bacteria may not be completely inactivated by pile temperature

4.6 Anaerobic digestion

Anaerobic digestion is a process through which bacteria break down organic matter in the absence of oxygen. For industrial purposes, anaerobic digestion is used to process a range of waste materials including animal manure, wastewater biosolids and food wastes to produce reusable end products.

The number of anaerobic digestors used to process specific waste materials in Australia is increasing, including those used to process municipal sewage sludge and waste and abattoir wastewater (ReNu Energy 2017).

Anaerobic digestion facilities are increasingly being built on large farms to convert animal effluent to biogas (methane), which is then used for heating and/or electricity generation. Similar facilities could be used in the event of an EAD outbreak for the disposal of effluent and carcasses (NABC 2004).

4.6.1 Process overview

Anaerobic digestion takes place in sealed vessels called reactors, which can be designed and constructed in various shapes and sizes specific to the site and feedstock conditions; these include a covered anaerobic lagoon, plug flow digestors and complete mix digester tanks. These reactors contain complex microbial communities that break down (or digest) the waste and produce biogas and digestate (the solid and liquid material end products of the anaerobic digestion process) which is discharged from the digester and can be used for a range of purposes, including fertiliser, soil amendments and animal bedding (USEPA 2024). The end use of these products is regulated by the EPA in each jurisdiction.

The process of anaerobic digestion involves the use of a mixed bacterial ecosystem, without oxygen, to transform organic material into methane, carbon dioxide and a sludge. Initially, hydrolysis breaks down lipids, polysaccharides, proteins and nucleic acids into fatty acids, monosaccharides, amino acids, and purines and pyrimidines. Acetogenic bacteria convert these to organic acids, carbon dioxide and hydrogen. The organic acids are then converted to methane and carbon dioxide. A balance between the various microbial populations must be maintained during this process.

High temperatures are required to ensure thermophilic anaerobic digestion, which can help to inactivate pathogens (Franke-Whittle & Insam 2013, Jiang et al 2020). The treatment time depends on the process temperature and ranges from 1 day at 55 °C to 5 days at 50 °C (EPA NSW 2000).

The combination of pasteurisation and anaerobic digestion can provide a comprehensive solution for managing effluent and blood during an EAD outbreak (Sahlström 2003). By first pasteurising these materials to inactivate pathogens, the biosecurity risks associated with subsequent anaerobic digestion are greatly reduced. The pasteurised materials can then be fed into an anaerobic digester (Franke-Whittle & Insam 2013), where they will be further stabilised and converted into biogas and digestate. This integrated approach can help to minimise the volume of waste requiring final disposal, while also generating useful byproducts and reducing the environmental impact of the outbreak response.

4.6.2 Considerations

4.6.2.1 Disease agent

Pathogen containment and destruction require careful consideration. Thermophilic organisms can be used in the digestion process to achieve temperatures of around 55 °C. An additional heating step can be included after the digestion is complete to inactivate pathogenic organisms that survive the digestion process (NABC 2004). This process is not suitable for destruction of anthrax spores or prions.

4.6.2.2 Volume and type of material

The use of anaerobic digestors in Australian livestock industries has, to date, been limited to the processing of effluent and abattoir wastewater, so in an EAD response the process may be best suited to disposal of biomass other than whole carcasses to align with operators' experience and the microbial balance.

Input material fed into a digester cannot be significantly increased or suddenly changed; the microbial population requires a transition period. This may limit the immediate usefulness of this method for processing large volumes of biowaste in a response, particularly if use of digestors were to be expanded to include processing of carcasses.

Carcasses have a higher nitrogen content than most wastes. The resulting ammonia levels can inhibit the digestion process, and this limits the loading rate for anaerobic digesters that are treating carcass wastes. It is estimated that digesters can handle 3.6 kg of meat per cubic metre of digester capacity per day (NABC 2004).

It is necessary to reduce the size of the carcasses for better heat transfer before the initial sterilisation phase. The recommended maximum particle size diameter in a biodigester is 5 cm, which permits good heat transfer for sterilisation of the carcasses and biodigestion. It is estimated that, for a digestor with a capacity of 195,000 m3, suitably primed for a daily loading of 0.8 kg volatile solids/m3, the sterilised pieces of 1,000 cattle (equivalent to 700,000 kg of beef) could be added to the digestor each day (NABC 2004).

4.6.2.3 Location

Only existing operating facilities could be used because of the time required to set up a facility, and the complexity of the facility and the process. Large-scale pig and poultry operations may have such facilities. Materials for disposal would need to be transferred to the facility, and in doing so may result in a premises classification change.

4.6.2.4 Environmental implications

This process results in the formation of fertiliser and methane, both of which can be recycled or used. Anaerobic digesters should already have the necessary environmental approvals.

4.6.2.5 Monitoring and remediation requirements

The process requires continuous monitoring for optimum processing.

4.6.2.6 Time

It takes 4–6 months to construct and start up the digester, so existing facilities would need to be used.

4.6.2.7 Cost

The construction, start-up and operation costs of the facilities are high. Use of thermophilic bacteria in the digestion process would increase the cost, as would the need for a final heating process for the resultant sludge.

4.6.2.8 Resource requirements

The process requires the construction of a digester at a considerable cost, or the use of an existing facility. Larger carcasses would need to be broken down before being placed in the digester. Optimum particle size is 5 cm diameter or less. This could result in a large labour requirement.

Digesters require water and electricity for operation. An external heating coil may be required to maintain optimum temperature.

4.6.3 Advantages and disadvantages of anaerobic digestion

Advantages	Disadvantages
Produces fertiliser Eliminates most pathogens (except anthrax and prions)	Requires construction of expensive, large-scale facilities or use of pre-existing facilities, which are currently limited in number Requires storage of methane Requires treatment and management of sludge before use as fertiliser Requires electricity and water supply Not suitable for spore-forming bacterial or prion diseases

4.7 Other methods of disposal

4.7.1 Alkaline hydrolysis

Alkaline hydrolysis uses heat, pressure and an alkaline solution (sodium or potassium hydroxide) to dissolve and sterilise biological materials. It involves the hydrolysis of materials (proteins, nucleic acids, carbohydrates, lipids etc) into a sterile aqueous solution of small peptides, amino acids, sugars and soaps. Heat is applied to significantly accelerate the process.

Alkaline hydrolysis is effective against all known pathogens (including prions). However, because of its high capital expense and relatively small throughput, its application is generally confined to specialised operations (e.g. research facilities, laboratories). At this time, there are no alkaline hydrolysis facilities in Australia that could process large numbers of carcasses and animal products in an EAD response.

4.7.2 Leave in situ ('destroy and let lie')

'Destroy and let lie' could be considered for use in areas that have populations of unmusterable livestock or feral animals or that have inaccessible or remote terrain that makes other disposal methods impractical. The method involves leaving destroyed animals in situ; as rigor mortis progresses, the changes in temperature and pH within the carcass reduce viability of some EAD agents.

Use of this method may be considered following risk assessment, which should include the potential for disease spread by scavenging species and the potential for pathogen spread to susceptible animal populations.

Trials in Queensland have been conducted under different environmental conditions (summer and winter) and with various species of animals. Although preliminary results to date indicate that this could be a viable technique for an extensive emergency response, further investigation in a variety of climate areas will be needed before the method can be adopted routinely. Future research is also required on specific pathogens of concern and the conditions under which they are inactivated.

4.7.3 Ocean disposal

Ocean disposal of animal carcasses may be considered during an EAD incursion under two circumstances:

- To manage animals in transit via ship rejected by an importing country where all other options have been exhausted.
- To dispose of large volumes of carcasses within Australia, however this should only be considered as an extreme last resort.

There are international conventions in force that define the conditions to be met for disposal at sea. They include MARPOL, the International Convention for the Prevention of Pollution from Ships, the United Nations Convention on the Law of the Sea, the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (also known as the London Convention or the Marine Dumping Convention), and the 1996 London Protocol to the Dumping Convention. Australia is a signatory to these conventions and protocols.

In Australia, MARPOL is given effect domestically through the Protection of the Sea *(Prevention of Pollution from Ships) Act 1983* and the *Navigation Act 2012*. Section (8) subsection (3) outlines exemptions for the dumping of animal carcasses into the sea as follows:

> Animal carcasses may only be discharged into the sea when:
> - the ship is not in a MARPOL designated special area
> - the ship is en route and the discharge is as far as possible from the nearest land
> - the carcass has been slit or cut so that its thoracic and abdominal cavities are opened or passed through a comminuter, grinder, hogger, mincer or similar equipment, and
> - the discharge is undertaken in accordance with section 2.12 of the 2017 Guidelines.[19]

To consider ocean disposal further the following issues need consideration:

- The above legislation is applicable only to ships enroute. For disposal of carcasses not en route (i.e. carcasses on land) further consideration would be required to navigate applicable legislation.
- Ocean disposal would not be appropriate for animals infected with an EAD due to either the risk of spread or unknown or unintended consequences to marine life.
- Ocean disposal would need to have industry, stakeholder and community support. Public opinion on disposal at sea will be a major factor in decision making

Use of ocean disposal would require a well-informed and robustly constructed communications plan, and a comprehensive public education campaign.

Effects on markets and international support would need to be carefully assessed. Although Australia may have a legitimate need to use disposal at sea, it would need to take into consideration the opinions of other jurisdictions, especially trading partners.

The method would need to be thoroughly discussed and agreed with all stakeholders, including maritime authorities, ahead of time. It is unlikely to be an option in an emergency without prior discussion and consensus.

From a regulatory perspective, ocean disposal is likely to be an option of last resort.

4.7.4 Refeeding to non-susceptible species

Refeeding is the use of whole or cut-up carcasses to feed to other species. It has been used in the past for feeding of animals bred for the fur trade, in hunt kennels, and for feeding of zoo collections and farmed reptiles (crocodiles). It should be noted that reptiles eat less in cooler months, and reptile farms are restricted to northern Australia.

Under Australian legislation (including legislation relating to swill feeding and restricted animal material), it is illegal to feed animal tissue to mammals, to prevent transmission of EADs.

This method would require the collection and transport of carcasses under biosecure means to the feeding point, storage of carcasses at the feeding point, and decontamination of transport, equipment and other contaminated items. Some form of preprocessing of carcasses (grinding, breaking down) may be required.

[19] Annex—2017 Guidelines for the Implementation of MARPOL Annex V, https://imorules.com/GUID-CB6D7E4B-AF97-40B7-A588-AE605DCDF5C4.html

Although refeeding is a low-technology solution, it is associated with some risk of diseases crossing between species. For example, high pathogenicity avian influenza has infected zoo tigers that were fed infected chicken carcasses and cats consuming infected wild birds. Avian influenza H5N1 (clade 2.3.4.4b) has caused unprecedented spillover detections and deaths in a wide range of terrestrial and marine mammals feeding on infected wild birds or via environmental contamination from infected animals. BSE has infected zoo cats fed cattle carcasses. African horse sickness has infected dogs fed raw infected horsemeat. Refeeding is unlikely to provide a disposal option for large numbers of carcasses and, given the risk of unexpected cross-species spillover infection, it may be prudent to limit refeeding of carcasses in an EAD response.

4.7.5 Use of processors

In an EAD response, processing establishments may be used in the destruction of animals and/or the disposal of animals, animal products and animal waste (e.g. manure).

If processing establishments are to be used as a disposal mechanism, the processing establishment must operate in a biosecure manner and have processes in place to ensure people and equipment are operating effectively to manage EAD agent spread risk.

Abattoirs may destroy animals and facilitate transport of carcasses and animal products to an alternate site for disposal and/or for EAD agent inactivation. For example, some abattoirs may use rendering facilities which are within the premises on which animals are destroyed, or the rendering establishment may be external and used to process/dispose of abattoir waste.

Disposal arrangements with processing establishments may be determined, in consultation with processors, before (preferably), during, or following an EAD response.

5 Items requiring special consideration

All contaminated and potentially contaminated carcasses, animal products, materials and wastes should be disposed of by one of the methods outlined in Section 4. However, specific disposal considerations apply to the materials listed below.

5.1 Milk and other dairy products

Disposal of milk products presents difficulties. Milk is a powerful pollutant, with a biological oxygen demand (BOD) index rating of 30,000. It has a significantly higher BOD index rating than raw sewage (300 BOD), hence milk contamination of waterways must be avoided. Large volumes are often involved, with ongoing production continuing to generate additional milk until rapid dry-off or destruction can be completed. Storage capacity on farm is frequently limited to 24–48 hours, depending on the property and seasonal variations in production volume.

It is essential that milk be treated to inactivate the emergency animal disease (EAD) agent before disposal (see the **AUSVETPLAN *Operational manual: Decontamination***). This includes large volumes of contaminated milk in dairy farm vats, at dairy factories or in tankers. Treatment of milk may further complicate disposal through the persistence of chemical disinfection agents or coagulation of the milk, which can occur when some disinfectants, such as citric acid, are used.

Sometimes a combination of methods may be used to dispose of milk. For example, in the Netherlands during the outbreak of foot-and-mouth disease (FMD) in 2001, milk from infected farms was acidified with citric acid to pH <5, rendered and then incinerated. Milk from vaccinated farms was subjected to high-temperature, short-duration pasteurisation treatment, and then heated again until a negative reaction to the peroxidase test was obtained. It was then converted to powdered milk at a designated factory (De Klerk 2002).

Any milk disposal method should be used in conjunction with rapid drying off or destruction of cattle (e.g. on infected premises).

5.1.1 Feeding to animals

Feeding milk to EAD susceptible species is a high-risk disposal option as it may increase the overall number of infected animals, which is counterproductive to the EAD response.

Prior to feeding milk to livestock as a method of disposal, reference should be made to the appropriate AUSVETPLAN disease strategy and jurisdictional legislation.

Not all milk will be accounted for utilising this method, but it may be useful to reduce the total volume that requires disposal through other means. People should avoid unprotected exposures to unpasteurized (raw) milk, especially where there is the potential for zoonoses.

5.1.2 Spraying onto pastures after inactivation of pathogen

Milk should be treated on farm to inactivate the EAD agent — for example, with citric acid in the case of FMD virus — and then diluted. The application of diluted milk should be limited to no more than 50,000 L/ha of pasture (i.e. 5 L/m^2 of land). Milk must not be permitted to enter waterways or run off the property.

To prevent generation of odours, it is recommended to use a dilution ratio of 10 : 1 water : milk. Lower dilution ratios may be used to a minimum of 1 : 1 water : milk, but this will increase the risk of odour generation and undesirable changes to soil nutrient levels.

After application, it is advisable to flush the irrigated area with fresh water to rinse milk residues from foliage.

The soil in major dairy districts is supersaturated by natural rainfall for periods of the year. The requirements to dilute milk with water and rinse pastures following application may limit the use of this disposal method. Other factors to consider are available irrigation infrastructure or spreading tankers, and the suitable paddock area available. Studies have not considered the effect of disinfectants on pastures, and many disinfectant processes result in milk coagulation which poses challenges to land spreading through infrastructure or tankers.

Approval from the local or regional environment protection agency is required prior to spraying milk onto pastures.

5.1.3 Composting

A few milk processing plants may already use composting for disposal of dilute dairy waste. The feasibility of composting is limited by the high fat content of milk, which may reduce the effectiveness of composting and result in odour. The high fat content could also produce potentially phytotoxic compost if oxygen levels are not sufficient during composting, resulting in the formation of organic acids such as lactic and acetic acids. As well, the high moisture content and large volumes of milk lead to problems with transport, storage, mixing with co-composting materials and control of leachate. The feasibility of composting could be increased by first reducing the moisture content of dairy wastes — by water extraction or conversion to milk powder — followed by storage and subsequent composting of the waste (see also Section 5.1.6).

5.1.4 Burial

Milk can be buried in trenches and other carcass disposal pits, given that livestock may be culled and require disposal. However, milk is very difficult to bury because the casein component combines with clay in soils to form a colloidal barrier that prevents absorption of the fluid fraction. This results in difficulties with sealing a pit that contains both carcasses and milk.

5.1.5 Commercial waste disposal (landfill)

Some commercial landfill sites refuse to accept milk for deep burial because the high moisture content of milk generates large quantities of leachate.

5.1.6 Treatment and processing options

Processing of milk into milk powder for storage and subsequent disposal has limited applicability because processing plants for spray drying seldom have spare capacity. Commercial plants that process milk from low-risk premises for sale may not accept milk from higher-risk premises unless contracted. A milk powder plant that is not operating at the time (because of loss of export markets) could be contracted solely to process milk from higher-risk premises, with subsequent disposal of the powder in landfill, by burial or by incineration. Memorandums of understanding may be considered for this purpose.

5.1.7 Use of central effluent wastewater disposal sites

The use of larger central sites where milk can be stored, treated and disposed of safely — for example, a retired water authority sewage treatment facility — should be considered. However, such a site may not be available during an outbreak.

5.1.8 Use of tallow recyclers

Use of tallow recyclers is limited, as they may only accept high-quality fats.

5.1.9 Use of on-farm effluent ponds

Milk products are difficult to dispose of in effluent disposal systems because the fats in milk block screens and interfere with the aerobic digestion process.

The use of on-farm effluent ponds for disposal can overwhelm the function of the pond due to the high BOD of milk. Should this occur, remedial treatments to restore aerobic decomposition may be required over several months, delaying the recovery and return to operation of the farm. Milk should not be added to enclosed effluent storage facilities, as mixing milk and effluent can produce lethal or explosive gases.

However, with caution, on-farm effluent ponds can be utilised as a very short-term disposal solution if required. Data from DairyNZ (2024) has shown that two-pond effluent systems properly designed to New Zealand standards can cope with the addition of milk from a maximum of four consecutive milkings. Specific values within the Australian system guidelines are not available.

If milk is redirected into the effluent system, it should be effectively and rapidly diluted and can then be disinfected or managed alongside the effluent (see Section 5.3).

5.2 Hatching eggs and hatchery waste

Prior to disposal of hatching eggs and day-old chicks into burial pits, all embryonated eggs and day-old chicks must be destroyed (see **AUSVETPLAN *Operational manual: Destruction of animals***). Assistance should be sought from the poultry industry for the use of suitable equipment and guidance on its use.

5.3 Effluent

During an EAD outbreak, the management of effluent from infected premises, particularly intensive piggeries, feedlots and abattoirs, is crucial to prevent the further spread of the disease (FAO 2010). Special attention should be given to the collection, treatment and disposal of these materials. Consideration should be given to the use of closed systems for effluent collection to minimise the risk of environmental contamination (FAO 2010). Where possible, onsite treatment methods, such as pasteurisation or thermophilic anaerobic digestion, should be employed at temperatures suitable to inactivate pathogens before disposal (Franke-Whittle & Insam 2013).

Appendix 8 provides an overview of effluent systems and principles.

5.3.1 Effluent management during an EAD response

Effluent management during disease control activities can include treating existing effluent ponds and systems and managing the increased use of large volumes of disinfectants, cleaning materials and rinse water required for effective decontamination.

In the case of contagious diseases, existing effluent ponds and their contents may pose additional risks and require treatment by disinfectants or pH modifiers (acids and alkalis) to reduce the risk.

The cost of different disinfectants and pH modifiers varies considerably. Cost will be an important consideration when deciding which disinfectant or pH modifiers to use. The effect of disinfectants and pH modifiers on equipment needs to be considered, including whether the systems and equipment in use can withstand exposure to such chemicals.

Effluent produced through decontamination processes containing disinfectants and cleaning material should not be mixed with the normal effluent in effluent ponds because it will disrupt the bacterial and phytoplankton population and retard the treatment process. Where possible, effluent containing disinfectants and cleaning chemicals should be collected and stored separately. It may need to be treated and then disposed of by another method (e.g. burial, spraying on pasture, capping and closure of the pond, or off-site disposal).

Where existing effluent systems are not able to be used or there are no effluent systems on a premises, advance planning is required for other mechanisms to store effluent resulting from disease control measures. Planning should include risk assessment and documentation, locations and long-term considerations.

Effluent management efforts may require feral or wild animal management processes to prevent the further spread of disease.

5.3.2 Dairy processing facilities

Effluent (such as washing water) from dairy processing facilities presents special problems because of its volume. Chemical treatment of large volumes of effluent may render it unacceptable to a sewage disposal unit, but 0.2% citric acid should cause no problems for waste treatment. The danger of disease spread from effluent is greatly reduced by dilution, and the free use of more water than normal in the usual cleaning processes will further reduce the danger.

Where effluent is normally used for irrigating pastures, the pastures should not be grazed for at least 2 weeks after irrigation (or for the period given in the relevant AUSVETPLAN response strategy[20]). Rennet, casein, whey and other wastes must not be sprayed over pastures, discharged into drains or fed to animals, unless treated with disinfectant as for milk.

5.3.3 Dairy farms

Effluent systems for modern milking sheds often reuse the water for cleaning yards. The large volumes of waste from wash-down and sanitisation of equipment require special attention because they are difficult to contain and decontaminate.

Dairy farms often have well-developed effluent management systems in place. During disease control activities, the effluent, disinfectants and wash water should, if possible, be directed to a separate effluent pond, as discussed in Section 5.3.1. Disposal of milk in effluent systems should be minimised because of its high BOD and the precipitation of fats (for more detail see Section 5.1).

5.3.4 Piggeries

Intensive piggeries will have well-developed effluent management plans for normal operations. The principles of effluent management described above also apply to intensive piggeries.

5.3.5 Beef cattle feedlots

Beef cattle feedlots will have well-developed effluent management and drainage systems consisting of sedimentation systems and holding ponds. The National Guidelines for Beef Cattle Feedlots in Australia[21] provide guidance for feedlot operators to meet their requirements under the National Feedlot Accreditation Scheme.

These systems bund the feedlot, including feedlot pens, and protect the surrounding environment from runoff during rain events through controlled draining areas while containing and directing effluent generated from the feedlot pens into a dedicated effluent system.

Feedlot pens are cleaned out on a regular basis with a majority of manure being stockpiled and composted for other applications. Effluent contains traces of manure and urine, and may include other bodily fluids, and water used during pen and trough cleaning.

Beef feedlots may vary in effluent pond treatment and disposal based on their business models however some feedlots that have surrounding paddocks may utilise treated effluent on contiguous or surrounding pastures.

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[20] https://animalhealthaustralia.com.au/ausvetplan/

[21] https://futurebeef.com.au/wp-content/uploads/National-guidelines-for-beef-cattle-feedlots-in-Australia-third-edition.pdf

5.4 Manure and litter

Small amounts of solid manure may be disposed of by burial or incineration.

Composting is an effective way to deal with both manure and litter waste. Material can be composted inside sheds or otherwise on-site, eliminating the risk of spreading the EAD agent during transport. Composting off-site — for example, at a commercial compost facility — is also an option.

Manure must be removed by biosecure transport methods. If litter is to be removed, it may be necessary to moisten the surface to reduce dust.

Manure can be stored in piles or windrows (with no co-compost material) for a period that is sufficient to destroy the EAD agent. The pile is covered to protect it from the weather and birds, and the temperature is monitored frequently to demonstrate that the pile has reached a sufficient temperature for the period required to inactivate the EAD agent. For example, avian influenza was inactivated in field chicken manure in 6 days at 15–20 °C (Lu et al 2003, Guan et al 2009). This method is usually conducted on farm and requires few resources. Consideration should be given to testing the disease status of the product before it is released for use (Lu et al 2003), noting that pathogen detection does not equate with pathogen viability.

5.5 Wool and mohair

Disposal of wool and mohair would only occur where no other practical risk mitigation factors are available (e.g. where decontamination of wool is impractical or ineffective).

If disposal is the only option, burial or high-temperature incineration appear to be the only effective methods.

For large volumes of wool that may be involved in an EAD response, incineration might be logistically very difficult to achieve in a timely and efficient manner. Wool does not burn easily, and this creates a significant challenge for this form of disposal.

Waste from wool scouring may require further treatment to mitigate the risk of disease transmission. Such assessments should be undertaken on a case-by-case basis by liaising with the scouring plant manager and the planning function within the state coordination centre.

5.6 Semen and ova

If genetic material is stored on infected premises or dangerous contact premises, its existence should be brought to the attention of the controller of the local control centre (LCC), who will determine if it constitutes a risk and must be destroyed. Because of the potential value of such material, no action should be taken to dispose of it without the express authorisation of the LCC Controller (see the **AUSVETPLAN *Enterprise manual: Artificial breeding centres***).

5.7 Laboratory wastes

For the disposal of laboratory wastes, see also the **AUSVETPLAN *Management manual: Laboratory preparedness***.

Laboratory waste includes materials that have been exposed to EAD agents or other pathogens. This includes personal protective equipment, sampling equipment and sample containers.

The **AUSVETPLAN *Operational manual: Decontamination*** outlines the general principles of decontamination for EAD agents. Joint Australian and New Zealand Standard AS/NZS2243.3:2022 (Safety in laboratories, Part 3: Microbiological safety and containment) describes preferred decontamination and disposal methods for laboratories that handle potentially infective materials.

All waste produced from an EAD response must be decontaminated or treated appropriately. In many cases, this may require sterilisation or incineration. If adequate equipment, such as an autoclave or incinerator is not available at the facility, plans and risk assessments should be in place for transporting waste material to a suitable facility. Any transport must comply with the requirements of relevant regulatory bodies and AS/NZS 2243.3:2022.

Practical considerations for disposal of contaminated material includes the following:

- Steps should be taken to undertake disposal on a regular basis to avoid large buildup of laboratory waste.
- Where possible, animal tissues should be bagged and incinerated on-site. Other laboratory waste should be placed in autoclave bags and disposed of after autoclaving.
- Laboratories without on-site access to an autoclave and/or incinerator should double bag and seal all contaminated waste at the site of handling, and thoroughly disinfect the external surface of the bags before transferring them securely for safe off-site autoclaving and/or incineration.
- If transferring off site for disposal, dispose of material as close to the laboratory as possible to minimise transport distances and associated transport risks.

Appendix 1 Types of potentially contaminated materials

The jurisdictional environment protection agency should be consulted as early as possible in an emergency animal disease (EAD) response to provide accurate advice and assistance in the disposal of all waste materials. Agencies can provide extensive legislative and practical advice on waste disposal options for specific materials, and are best placed to expedite disposal processes and to secure waste levy waivers where possible.

Table A1.1 — Types of potentially contaminated material

Material	Description	Comments
Acidic and basic (alkaline) solutions	Prepared solutions for treating contaminated material	• May require neutralising before transport and disposal • Depending on the containers they are held in, the preferred option is to decontaminate and leave on-site
Acids and bases in solid form	Solid form of acids and bases before preparation	• Refer to SDS for information on work health and safety, storage, handling and disposal options • Depending on the containers they are held in, the preferred option is to decontaminate and leave on-site
Air filters and residues from air filters	Derived from equipment, including large machinery, involved in disposal and decontamination activities	• Consign to licensed hazardous waste disposal agent, or treat. Treatment will depend on the infective agent. Biosecurity of transporting contaminated materials needs to be subjected to risk assessment • The preferred option is to decontaminate and leave on-site
Animal carcasses (infected)	Assumes animals were destroyed recently to prevent loss of significant quantities of fluid. May need to consider carcasses removed to knackeries or at abattoirs	• Can be very difficult to handle • Decomposition occurs quickly, within hours of destruction (faster in summer than in winter) • Ruminants (cattle, sheep, goats etc) begin to expand rapidly after death because of gases trapped in the rumen. Nonruminants (e.g. horses) pose a similar but lesser problem • Odours can cause significant public concern and may affect the willingness of workers to deal with carcasses • Leakage of materials must be avoided. Suitable liners that fit transport vehicles and can withstand loading of animal carcasses without puncturing may be required. Alternatively, leakproof vehicles can be used
Animal fluids (rumen fluid, blood etc)	Largely viscous fluid	• Similar problems to animal carcasses
Animal viscera, meat and bone (infected)	Mixture of fluid and semi-processed animal parts	• Similar problems to animal carcasses
Ash/remnants after burning	Remains of the funeral pyre, which may contain some incompletely burned animal material, bones etc	• Bury
Bedding and litter (contaminated)	Used or unused bedding and litter that may be contaminated with the disease agent	• Conduct risk assessment of biosecurity of transporting contaminated materials • Quantity of material may be substantial • Material may be in a solid, semisolid or liquid form • May be suitable for other concurrent disposal/decontamination uses (e.g. composting)

Material	Description	Comments
Blood and bone products	Processed material that has already been put on market shelves or is destined for the market	• Risk assessment may be required to determine infectivity likelihood • Subject to risk assessment, used material may require treatment to ensure that infectivity is eliminated • Subject to risk assessment, procedures for recall, treatment and disposal may need to be put in place
Chemical containers	Disinfectants etc come in a variety of container shapes and sizes. There will be large numbers of these containers	• Check SDS for instructions on handling and storage • Container label should identify contents and appropriate disposal method • Washings from containers should be disposed of in an environmentally sound manner • The preferred option is to decontaminate and leave on-site
Clinical and related wastes (including sharps)	A complex mix of material containing potentially infectious materials, sharps etc	• Conduct risk assessment of biosecurity of transporting contaminated materials • Dispose of in usual way, ensuring use of biohazard disposal containers
Clothing and footwear — disposable (contaminated)	Single use or single-premises use; used in destruction, transportation, decontamination and disposal stages of EAD response	• System for appropriate treatment and packing is needed before disposal
Compost	Some intensive enterprises (e.g. poultry units, feedlots) compost bedding, litter and carcasses. May be in large volumes	• Manage process and site as per standard operating procedures • Monitor compost windrow conditions and infectivity • Ownership of compost end products needs to be established at start of process • Potential markets and users need to be identified
Detergents and surface-active agents (diluted and undiluted)	Used in normal clean-down operations (refer to SDS for active ingredients)	• Refer to SDS and use appropriate method of disposal • If the product has remained in packaging, the preferred option is to decontaminate and leave on-site or reuse the product
Disinfectant mats	Carpet and other types of matting used on roadways and at entrances for disinfecting car tyres	• Usually limited numbers • Disposal at local landfill site is probably acceptable, but check state/territory regulations • Depending on the material it may be possible to decontaminate and retain the mat
Disinfectant wash-down water Portable shower waste	Water that may contain acids, bases, oxidising agents, detergents and surface-active agents, along with low levels of soil etc	• Contain wastewater in a suitable vessel (e.g. sump) and treat with suitable disinfectant to eliminate infectivity • Containment, treatment and disposal of wastes must be included in any EAD response program
Effluent — animal	From saleyards, abattoirs, intensive agriculture operations etc	• Biologically highly active • May be in significant volumes • May be able to be disposed of to liquid waste facilities or sewerage systems, but further research is needed • May require treatment with disinfectants or other chemicals that modify pH, resulting in deactivation of microflora that normally aid decomposition • Solids from effluent may be suitable for composting
Eggs, egg pulp	May be on farm; in transit; or in packaging plants, bakeries, supermarkets etc	• Procedures for recall, treatment and disposal may need to be put in place • May require refrigeration until disposed of

Material	Description	Comments
Equipment	Equipment considered not worth keeping once contaminated (e.g. personal protective equipment, including respirators and boots)	• May be possible to consign to licensed hazardous waste disposal operation or bury at a licensed landfill site
Feed (animal) — hay, lucerne, grain etc (potentially contaminated)	Suspected or confirmed infective	• Treatment will vary with material and EAD agent
Filter cake	From sewage treatment	• See Effluent — animal
Fire debris and fire wash waters	Water used to wash fire area, or rainfall on fire area	• Conduct risk assessment to determine infectivity • Ensure that water does not run into groundwater drains
First-aid wastes	Bandages, bandaids, slings etc used to treat personnel	• Consign to licensed hazardous waste disposal operation
Food — unprocessed, or partially or fully processed (potentially contaminated)	May be on farm; in transit; or at abattoirs, milk processing factories, pet food manufacturers, supermarkets etc	• May require refrigeration until disposed of • Leakage must be avoided
Food and drink packaging	Used on infected premises	• See Food
Food packaging	Recalled produce (e.g. milk cartons, meat wrappings, egg cartons)	• See Food
Grease-trap waste	As part of sewage or waste-stream processing	• Bury or incinerate
Hatchery waste — eggs	May require maceration before disposal	• May require pretreatment before disposal, depending on EAD agent
Hides, and partially or fully processed leather	Located on farm, in abattoirs and further down the process line	• Conduct risk assessment to determine infectivity • Disposal as for carcasses
Construction and associated materials	Building materials, wood, panelling, asbestos etc used in construction	• May need to be deconstructed to allow for disposal • May require specialist disposal operations (e.g. for asbestos) • The preferred option is to decontaminate buildings/building materials and leave in situ • The disposal of materials such as asbestos is not the responsibility of the EAD response unless they seriously compromise the work health and safety of responders
Laboratory animal specimen waste	Specimens taken from infected and suspect animals for analysis	• Volumes will probably be greater than under normal operations • Continue to use normal disposal routes
Liners for trucks used to transport infected animal carcasses	Liners will probably require frequent replacement, so quantities of used and contaminated liners will become a disposal problem	• May require pretreatment before disposal, depending on EAD agent
Manure	On farms, on land, in sheds, in saleyards, in abattoirs etc	• Similar issues to filter cake • May be able to be composted or beneficially used, depending on EAD agent

Material	Description	Comments
Meat — unprocessed or partially or fully processed (potentially contaminated)	May be on farm; in transit; or at abattoirs, knackeries, pet food manufacturers, supermarkets etc	• Procedures for recall, treatment and disposal may need to be put in place • May require refrigeration until disposal • Leakage must be avoided
Milk and dairy products — unprocessed, or partially or fully processed (potentially contaminated)	May be on farm; in transit; or at milk processing factories, supermarkets etc	• Conduct risk assessments to determine infectivity or other risks • Procedures for recall, treatment and disposal may need to be put in place • May be treated to eliminate infectivity (treatment is essential if the material is known to be infective) • May require refrigeration until disposal • Leakage and aerosols must be avoided
Miscellaneous items from disposal operations not listed elsewhere	All other waste not listed separately. May include equipment/housing materials that cannot be effectively decontaminated	• Conduct risk assessments to determine infectivity or other risks
Office wastes	Some office wastes may be confidential and will need to be secured at all times	• Use usual recycling, reuse and disposal methods unless contaminated
Oil/hydrocarbon and water mixtures or emulsions	May be in chemicals used to treat infected animals and materials etc	• Treat and/or dispose of in appropriate and environmentally safe manner
Oxidising agents (diluted)	Products such as peroxymonosulfate compounds prepared for treating infected/contaminated material	• If used in decontaminating equipment, ensure that all equipment is adequately rinsed, and washings are collected and appropriately treated before disposal
Pesticides — unused remnants	Incidental use of chemicals required	• Follow procedures in SDS or on container label • Follow relevant guidelines for disposal • Use only in accordance with label
Pharmaceuticals, drugs and medicines (surplus to use, out of 'use by' date, residual etc)	Includes drugs used to euthanase infected, suspect or dangerous contact animals	• Follow appropriate normal procedures for treatment and disposal
Post-decomposition products	Safe byproduct of a chemical, anaerobic or aerobic disposal process	• May be a commercial product or require burying • Arrange suitable market • Ownership of compost end products needs to be established at start of process
Seeds and grain	Principally found on farm, possibly contaminated	• Disinfect in sealed containers
Semen and ova (infected)	Origin must be traced by following document trail from infected premises	• May need disinfection before disposal • Conduct risk assessment to determine exposure and/or infectivity
Sewage sludge or residues	Mainly saleyards, abattoirs and intensive operations (e.g. dairies, feedlots)	• See Filter cake
Soil contaminated with disinfectants, detergents etc	Soil contaminated with chemical spillage from treatment or disinfection areas	• Check SDS for information on constituents and safety information

Material	Description	Comments
Soil contaminated as a result of the destruction process	Contaminated byproduct of the destruction process	• May require decontamination and/or disposal, depending on the EAD agent
Tallow	Found principally in abattoirs and tanneries	• Conduct risk assessments to determine infectivity or other risks • Bury or incinerate • Consider suitable market
Tannery wastes, including leather dust, ash sludges and flours	Specialised industry	• Wastes may require neutralising
Truck wash-down containing faeces, body fluids etc	Will be an infectious material	• See Effluent
Vaccines (partially used or out of date), empty containers, administrative equipment	May be on farms, at control centres or at central storage sites	• Need to adhere to manufacturers' and licensing authority guidelines • May need decontamination before disposal • Bury or incinerate
Waste derived from processing contaminated food	Byproducts derived from processing of animal carcasses etc	• May follow similar disposal path to food, effluent or filter cake
Wool scouring wastes	At fellmongers, abattoirs etc	• Most organisms are unlikely to survive this treatment. Any treatment will depend on the EAD agent involved • Determine whether treatment of products and perception of continued infectivity allow for economic use of products after treatment
Wool, cashmere, mohair, feathers, deer velvet	On farm; at fellmongers, abattoirs, wool processing industries, stockpiles etc	• Determine whether treatment of products and perception of continued infectivity allow for economic use of products after treatment

EAD = emergency animal disease; SDS = safety data sheet

Note: Each product will need to be classified according to local legislation relevant to waste disposal.

Appendix 2 Predisposal processing options

Some disposal options can be considered as predisposal processing methods themselves, in that they reduce or destroy pathogens, reduce moisture content, or reduce total mass before final disposal is completed using another method. Examples are composting followed by incineration, and rendering followed by burial.

Table A2.1 — Predisposal processing methods

Treatment	Principle	Advantages	Disadvantages
Chemical sterilisation / decontamination	Many AUSVETPLAN decontamination procedures are based on use of chemicals for sterilisation or decontamination. The chemicals used vary for each disease. They range from agents that simply change pH, such as citric acid and sodium hydroxide, to more powerful oxidising agents, such as peroxymonosulfate compounds	• Procedures for chemical disinfection are well documented and understood	• WHS concerns • Environmental concerns • Chemical needs to come in contact with organism to be effective
Heat sterilisation / decontamination	Heat sterilisation, including pasteurisation, is a well-recognised method of destroying pathogens. It can use direct sunlight, gas and electrical heating elements. Covering materials with black plastic in summer may raise temperature to required levels	• Uses existing technology • Available throughout Australia • Can be used immediately	• Not suitable for some materials • Rendering capacity is limited • Requires monitoring to ensure required temperature is achieved throughout the material being treated
Maceration / grinding	Maceration of carcasses and other materials will generally reduce their volume, and possibly make them easier to handle and speed the rate of decomposition/disposal	• Ease of handling resultant material • Different types of vehicles can be used to transport the material (e.g. tankers, concrete trucks) • Allows improved mixing of disinfectant products (adjuvants) with material • Increases speed of decomposition/disposal (by composting/fermenting) • Increases range of possible disposal options • Large units can handle about 15 tonne/hour	• Increased production of aerosols • Need for additional equipment • WHS concerns • Difficulty decontaminating equipment • Adverse owner and public perceptions • Bulking agent needs to be added to absorb liquid released from carcasses at grinding • Large labour requirement

Treatment	Principle	Advantages	Disadvantages
Combined steam sterilisation and maceration	Sterilisation combined with maceration involves steam sterilising the waste and then grinding it for delivery to landfill or composting	• Steam sterilisation will remove most infective agents • Waste produced can be buried in landfill site that accepts uninfected putrescible waste • A portable unit can be taken on farm • Suitable for treating small ruminant and poultry carcasses • Ease of handling resultant material • Different types of vehicles can be used to transport the material (e.g. tankers, concrete trucks) • Increases speed of decomposition/disposal (by composting/fermenting) • Increases range of possible disposal options	• Capacity is too small for large numbers of large ruminants and horses • Requires monitoring of final product • Not suitable for anthrax or TSEs • Requires skilled labour • High cost of equipment • Adverse owner and public perceptions • Bulking agent needs to be added to absorb liquid released from carcasses at grinding
Chilling / freezing	Chilling has been used in Europe as an emergency measure to hold carcasses for later disposal. Opportunities could arise if chilling facilities at an abattoir become available because the abattoir is itself caught up in the EAD outbreak. Chilling also needs to be considered as an option for animal products to be disposed of later	• Quick response to a medium-scale incident • Freezers are generally easy to build. Some mobile freezers may be available from the game meat industry. Refrigerated containers may be used for short-term storage • Offers time to consider future action • Could handle carcasses and byproducts	• Expensive to source and maintain • High electricity costs • Potential impact on future trading of enterprises involved • Difficult to handle whole carcasses • Rehabilitation of chiller equipment required • Freezer trucks will not freeze material not already frozen (designed to hold items that have already been frozen to – 20 °C) • May not be enough refrigerated containers available in a large outbreak

Treatment	Principle	Advantages	Disadvantages
Time treatment	Many pathogens responsible for causing EAD emergencies survive for only limited periods in the environment (refer to relevant AUSVETPLAN response strategy), particularly if conditions are hot and dry. If it is known that a pathogen will deteriorate and disappear over time, it may be more appropriate to do nothing other than restrict access to the area and wait. This is an option for remote and feral animal populations that can be isolated by distance	• No chemicals used • Minimal labour requirements • Low cost • Waste classification changes from hazardous to a lesser category • No transport requirements	• Public perception may be negative • Some organisms may not disappear as quickly as predicted • Inability to use the property during the waiting period • Potential impact on trade • Inability to restrict access by feral animals
Carcass breakdown (skinning, evisceration and quartering)	Some disposal options (e.g. rendering) require that carcasses and materials are broken down before they can be disposed of effectively. This could include: • skinning • eviscerating • quartering or chunking • prebreaking or grinding • slashing • removing limbs (disarticulation)	• Reduces total volume of material for disposal • Speeds up decomposition or composting	• Increases biosecurity risks • Increases WHS concerns • Increases resource and time requirements • Requires specific and specialised skills
Lactic acid fermentation	Lactic acid fermentation should be viewed as a means to preserve carcasses until they can be disposed of. The low pH prevents undesirable degradation processes. Carcasses are ground to fine particles, mixed with a fermentable carbohydrate source and culture inoculant, and then added to a fermentation container	• Decontaminates carcasses • Possibility of recycling into a feed • Allows storage of carcass material • Potentially mobile process • Minimal environmental impacts	• Not all pathogens are destroyed • Risk of contamination from grinding due to aerosols • Corrosion of containers • Need carbohydrate source and culture of *Lactobacillus acidophilus* • Capacity may be limited

EAD = emergency animal disease; TSE = transmissible spongiform encephalopathy; WHS = work health and safety

Appendix 3 Burial pit construction

Activities on burial sites have significant safety risks, and the safety of operational personnel is an overriding consideration. The engagement of an officer trained in work health and safety (WHS) is a critical component of risk management. Decisions on layout, design, equipment flow and other issues that affect the safety of the site should be made by the Infected Premises Operations function, in consultation with the contractors on the site, as well as facility management when commercial landfills are used. If the EAD is a zoonosis (e.g. avian influenza, anthrax or Hendra virus), additional WHS measures may need to be taken to prevent infection of burial site workers.

Other issues to consider include the hygiene of the personnel working on the site, the availability of rescue equipment if a person falls into the pit or if the pit wall collapses, and protection from noise and dust. All operations should be controlled by Infected Premises Site Supervisory personnel or commercial facility personnel. Personnel should be properly trained and briefed before operations begin. Biosecurity for the site remains the responsibility of Infected Premises Security personnel.

Earthmoving equipment

The preferred equipment for digging the burial pit will depend on the design of the pit. Excavators are the most efficient equipment for construction of long, deep, vertically sided pits, and allow the easy storage of topsoil separately from subsoil. If required, the equipment can also be used to fill the pit with carcasses or other materials, and to close it without disturbing the contents. Excavators may be fitted with a hammer attachment for rock work.

Loaders, bulldozers, road graders and backhoes (for small jobs) may be used if excavators are not available.

Excavators and backhoes remain in a fixed position while digging, and therefore move soil faster, with less cost and less damage to the site surrounding the pit. The other types of equipment move across the site during work.

Burial pit construction

The expert team should select the pit design. Construction of the pit and whether it needs to be lined will rely on advice from engineers and representatives from environment protection agencies.

Soils should be stable enough to withstand the weight of equipment used to construct and fill the pit. If necessary, surface runoff should be prevented from entering the pit by the construction of diversion banks. Similar banks should be constructed to prevent any liquids escaping from the burial site. Fencing may be necessary to exclude animals and people until the site is safe for use.

Straight-sided (trench) pit dimensions

The following guidelines may help in determining the pit volume required for straight-sided pits (from FAO 2020).

The base of the pit must be at the required level (at least 2 m) above the watertable.

The volume required will depend on the size of the animals. As a guide, use the information below; then modify the volume using observed dimensions occupied by the first carcasses deposited in the pit:

- 1.5 m^3 per mature cow
- 0.3 m^3 per mature pig or sheep
- 0.005 m^3 per grown broiler/commercial layer (200 birds/m^3)
- 2 m required depth of soil to cover carcasses.

The number of cattle or sheep that can be accommodated per linear metre of a pit 3 m wide and 5 m deep filled with carcasses to within 2 m of ground level (see Figure A3.1) can be calculated as shown below.

First, calculate the volume of pit available for burial per linear metre of the pit (the effective volume):

- Effective volume = width x depth of carcasses x length
  = 3.0 m x 3.0 m x 1.0 m
  = 9.0 m^3

Then divide by the volume required per animal:

- 9.0/1.5 = 6 cattle
- 9.0/0.3 = 30 sheep

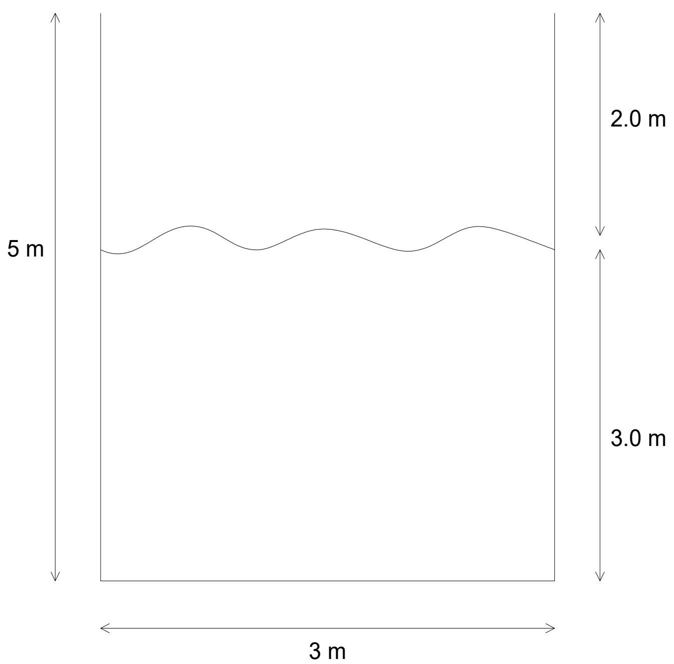

Figure A3.1 — Example of the dimensions of a straight-sided pit

Battered pit dimension

To overcome the WHS issues associated with straight-sided pits in some locations, such as collapsing walls and environmental concerns about uncontained leachate, it may be necessary to use a pit with outwardly sloping (battered) sides to prevent collapse and allow for impervious liners to contain leachate. There must also be enough cover to prevent carcasses from surfacing.

Relevant information is as follows:

- 1.5 m^3 per cow
- 0.3 m^3 per pig or sheep
- 5 m minimum depth of pit
- 2 m required depth of soil to cover carcasses.

The number of cattle and sheep that can be accommodated per linear metre of a pit 3 m wide at the base, 5 m wide at the top of the carcasses, and 5 m deep, filled with carcasses to within 2 m of ground level (see Figure A3.2) can be calculated as follows.

Because the width changes from the top to the bottom of a battered pit, the average width must be used to calculate the volume of the pit. That is:

- Volume of a pit = mean width x vertical height x length

Therefore, first calculate the mean width of the effective volume:

- Width at base of pit: 3 m
- Width at top of carcasses: 5 m
- Mean width: 4 m

Then calculate the effective volume:

- Effective volume = mean width (of effective volume) x (vertical height of carcasses) x length

  = 4 m x (5 – 2) m x 1 m

  = 12 m^3

Then divide by the volume required per animal. For example:

- 12/1.5 = 8 cattle
- 12/0.3 = 40 sheep

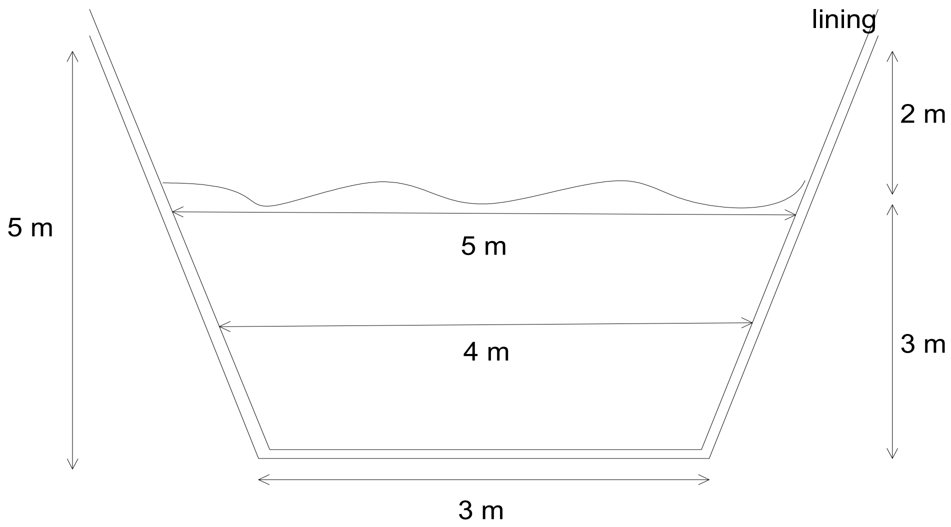

Figure A3.2 — Example of the dimensions of a battered burial pit

Appendix 4 Shallow burial with carbon

The key steps to shallow burial with carbon are as outlined below.

Site selection

- Not prone to flooding or in a low-lying area
- At least 2m separation between the bottom of the trench and groundwater table
- At least 100m from bores, springs and surface water bodies
- Avoid heavy clay and highly permeable sandy soils.

Trench preparation

- Dig a 60 cm deep trench of sufficient width and length to accommodate the number and size of animals requiring disposal.

  Note: if the trench is less than 60 cm deep there may not be enough soil to completely cover the carcasses. If the trench is too deep (>60 cm) decomposition will be slowed.
- Stockpile the excavated soil at the edge of the trench.
- Place 30 cm of carbonaceous material in the bottom of the trench. The carbon material should have a high carbon-to-nitrogen ratio such as wood chips, bark mulch, sawdust, chopped hay or straw, silage, or animal bedding with minimal manure.
- Place the carcasses on the carbon base on their sides in a single layer as close together as possible, preferably facing the same direction. Ensure the legs and heads can be adequately covered with soil.
- For pigs weighing more than 120 kg and for ruminants, consider opening the abdominal cavity or puncturing the rumen to limit carcass expansion.
- Return the excavated soil to the trench to form a minimum 30 cm thick mounded cover over the carcasses to prevent water from pooling on the mound and to promote drainage. Ensure that the entire trench is filled in and graded to avoid pooling. If the site has a slope, install a bund at the upper end of the site to divert surface water away from the mounds. Alternatively, install a perimeter trench.
- Seed the mound with a regionally and seasonally appropriate grass seed mix.

Maintenance

- Inspect the mounds weekly for the first month and then monthly thereafter, or immediately after extreme weather events to assess:
  - cracks in the soil cover or evidence of animal burrowing
  - poor vegetative cover
  - excessive water ponding.
- Correct any issues identified, for example:
  - add soil, if needed, to fill cracks and areas where animals may have burrowed
  - reseed if vegetation is poor
  - consider regrading around the mounds to promote drainage if ponding is severe.
- One year after construction of the mounds, verify the carcasses are fully decomposed by uncovering a small area of the mound to be sure no tissue remains on the bones. If soft tissue remains, recover exposed area and monitor monthly until all tissue is degraded. Small pieces of hide on long bones are acceptable.

Site restoration

- Regrade the mounds to original topography.
- If any bones are exposed after grading, they should be covered, or collected and disposed of in accordance with state and local regulations.
- Return area to its original use.

For images, and more detail, refer to the United States Department of Agriculture *Guidelines for the emergency use of above ground burial to manage catastrophic livestock mortality*.[22]

[22] https://www.aphis.usda.gov/sites/default/files/agb-emergency-policy.pdf

Appendix 5 Pyre construction

When constructing a pyre, it is important to maximise the airflow from wind. Typically, pyres are rectangular in shape, with the long edge at 90 degrees to the direction of the prevailing wind. When timber is used as a solid fuel source, the bottom row should be parallel to the wind, with a gap between the lengths equivalent to the diameter of the timber pieces. The second layer should be placed at 90 degrees to the first layer, again with a gap between lengths. This cross-hatching should continue until the desired height is achieved. Larger-diameter timber should be used at the base of the pyre and smaller timber towards the top. Additional trenching underneath the pyre may improve airflow but is not necessary if the pyre is constructed in the above manner.

Other primary fuel sources (e.g. coal briquettes) can be used to supplement some of the timber; however, too large a quantity will reduce the overall airflow and produce more smoke. One layer in the middle of the pyre will be effective.

Straw or hay should only be used as a fire starter, not in the main body of the pyre. Bales should be opened and spread along the windward side of the pyre.

Experience has demonstrated that a single bovine carcass (around 500 kg) can be completely consumed using 1.5 tonne of dry timber (20–30% moisture) (Worsfold & King 2006). For multiple carcasses, the amount of timber can be reduced to around 1.0 tonne per adult bovine. Carcasses are layered onto the pyre, preferably on their backs. Because the rear ends of bovine carcasses are usually the hardest to consume, alternating carcasses head to tail can even out the burn. Carcasses should only be stacked one row high and should have sufficient air space around them (Figure A5.1). The number of carcasses per pyre should be limited to a manageable level. Restricting airflow around the carcasses will reduce the efficiency of combustion and produce more smoke. Excavators are preferable for laying carcasses, but front-end loaders and chains can be used. There is no need to cut extensor tendons before burning.

Liquid fuels are required to start burning a pyre; the volume required depends on the size. For safety reasons, diesel is the preferred liquid fuel. When lighting, ignition points should be prepared at suitable intervals along the length of the pyre. These may consist of rags soaked in hydrocarbon (i.e. diesel fuel). Alternatively, gelled fuel[23] can be used to initiate large pyres — it can provide a more sustained burn time and is not as volatile as liquid fuel.

The pyre should be monitored for unstable carcasses and adjusted only when safe to proceed. A well-constructed large pyre should consume carcasses within 24–48 hours. The remaining ash should be disposed of by burial.

[23] Gelled fuel is the product that results from mixing a liquid or solid gelling agent with a hydrocarbon.

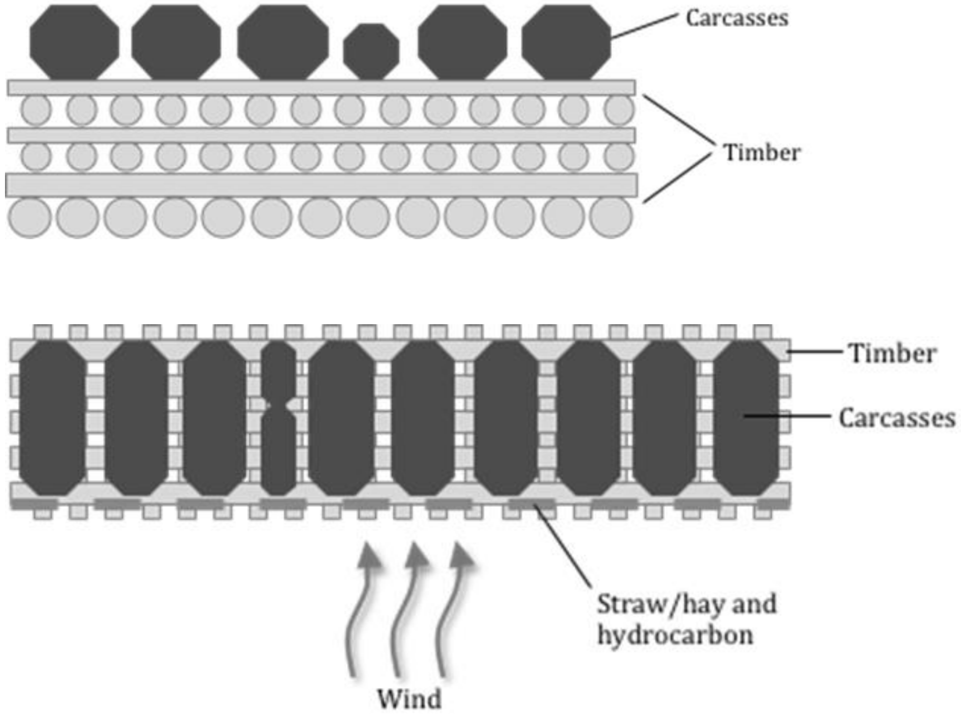

Figure A5.1 — Example of construction of a pyre: side (top) and aerial views (bottom)

Appendix 6 Composting times and temperatures for EAD agent inactivation

Table A6.1 is an indicative guide to the composting times and temperatures required to ensure inactivation of various emergency animal disease (EAD) agents.

Table A6.1 — Composting times and temperatures

EAD agent	Temperature	Time	Reference
Avian influenza			
Poultry carcasses	≥ 55°C	3 days above 55°C, then turn pile and achieve a further 3 days above 55°C.	USDA-APHIS 2024
Poultry manure/feed/litter	≥ 55°C	3 days	Elving et al 2012
Poultry manure	42°C to 67°C	24 hours	Elving et al 2012
Newcastle disease	≥ 55°C	3 days	Guan et al 2009
	> 60°C	3 days	Eid et al 2023
Foot and mouth disease - pigs	50°C to 70°C	10 days to 21 days	Guan et al 2010
African swine fever - pigs	≥ 55°C	5 days	Gabbert et al 2023
	54°C at the top and 65°C at the core	3 days	Hutchinson et al 2023
Foot-and-mouth disease **Avian influenza**	Internal compost pile ≥ 56°C	10 to 14 days	USDA APHIS 2024
Most viruses inactivated	55°C	3 days (AS4454 and EPAs require 5 turns and 15 days >55°C)	Berge et al 2009

Appendix 7 Carbon content of bulking agents for carcass composting

Table A7.1 is an indicative guide to the carbon content of bulking agent accessible in Australia that can be used for carcass composting (Mukhtar et al 2004, Hoyle 2013).

Note: The destruction method may affect the volume of bulking agent required (e.g. destruction methods using high water content may require more bulking agents).

Table A7.1 — Carbon content of composting bulking agents

Bulking agent	C : N ratio	Porosity	Management notes
Saw dust or wood shavings	200–700 : 1	Good	Carbon percentage and moisture content decreases with age Particle size would determine whether or not to add another bulking agent for aeration or turn the pile intermittently
Wood chips (up to 2.5 cm pieces)	40–100 : 1	Good	Carbon percentage and moisture content decreases with age; carbon percentage varies across species of wood Aged products may require additional water to be added to increase moisture content Particles should not exceed 2.5 cm
Bark	100–300 : 1	Very good	Carbon percentage and moisture content decreases with age; carbon percentage varies across species of wood Particles should not exceed 2.5 cm
Green waste (up to 2.5 cm pieces)	20–60 : 1	Good	Carbon percentage and moisture content decreases with age Particles should not exceed 2.5 cm
Grass clippings	15–25 : 1	Poor	Requires to be blended with another bulking agent with high carbon and good or very good porosity due to density Pre-drying may be required to reduce moisture content
Dried hay or straw	40–100 : 1	Good	Carbon percentage and moisture content decreases with age Rough chopped for best results
Lucerne and legume hay	17 : 1	Good	Requires blending with another bulking agent with high carbon and good or very good porosity
Oaten hay	30 : 1	Good	Carbon percentage and moisture content decreases with age Rough chopped for best results Requires blending with another bulking agent with high carbon and good or very good porosity
Canola	51 : 1	Good	Carbon percentage and moisture content decreases with age Rough chopped for best results

Bulking agent	C : N ratio	Porosity	Management notes
Crop stubble (wheat, oat, barley, sorghum stalks) (up to 2.5 cm pieces)	40–120 : 1	Good	Carbon percentage and moisture content decreases with age Rough chopped to reduce stalk sizes to under 2.5 cm for best results
Horse manure	25 : 1	Good	Requires blending with another bulking agent with high carbon and good or very good porosity
Spent horse bedding (shavings, discarded hay, waste)	42–46 : 1	Good	Manure : hay : bedding ratio would determine whether or not to add another bulking agent to increase carbon content or aeration capability
Cattle manure (dry)	17 : 1	Poor	Requires blending with another dry matter bulking agent with high carbon and good or very good porosity
Cattle manure (liquid)	8–13 : 1	Poor	Requires blending with another bulking agent with high carbon and good or very good porosity
Poultry manure and litter	13–30 : 1	Medium	Requires blending with another bulking agent with high carbon and good or very good porosity
Poultry manure	5 : 1	Poor	Requires blending with another bulking agent with high carbon and good or very good porosity
Pig manure	5–7 : 1	Poor	Requires blending with another bulking agent with high carbon and good or very good porosity
Newspaper	170–800 : 1	Medium to poor	Requires blending with another bulking agent to assist with moisture and porosity
Rice hulls	85 : 1[a]	Good[b]	

a C : N ratio from Thiyageshwari et al 2018.
b Porosity from Hutchinson et al 2023.

Appendix 8 Overview of effluent systems

Terminology

Collectively, urine and dung are called excreta. Excreta is typically mixed with wash water produced by cleaning yards; with wash water, chemicals and residual milk from cleaning equipment; with waste feed or bedding material; and occasionally with rainwater. The resulting liquid is usually referred to as effluent (or dairy shed effluent or wastewater).

Excreta that dries before being collected (e.g. by scraping from feed pads or loafing yards) and is handled as a semisolid or solid is called manure. Manure can also contain waste feed or bedding material, and soil removed by scraping nonconcrete areas.

Effluent systems and principles

Once considered purely as a useless byproduct or waste, and a potential environmental pollutant, effluent is now considered a valuable nutrient and water resource if it is properly managed, and if environmental risks are identified and addressed.

Most agricultural activity involving farm animals will produce some level of effluent, which is managed during usual activities. Dairy farms and intensive operations (e.g. feedlots, pigs and poultry) produce the largest amounts of effluent.

There are two major types of effluent management systems: continuous application systems, and treatment and storage systems (effluent ponds).

Continuous application systems

Continuous application systems are not designed to treat effluent and have limited storage capacity. Consequently, they rely on regular collection and application of effluent, usually twice daily. The effluent is generally collected in a concrete sump and applied directly to pasture as raw (untreated) effluent.

The main types of continuous application systems are:

- sump and gravity flow (generally through a movable hose)
- sump, pump and movable sprinkler
- sump and effluent tanker.

To protect pumps and prevent pipe blockages, each of these systems needs a stone trap, screen or trafficable solids trap to remove coarse solids and foreign material from the effluent stream before it enters the sump.

Provision should be made to store the effluent during extended periods of wet weather when spray irrigation of effluent should not take place (to avoid pollution of rivers and creeks from the runoff). Application of effluent to pastures by a spray irrigator requires regular manual or automatic shifting of the irrigator to avoid excessive application, so that the soil is not overloaded and the pasture is palatable to cows at the next grazing.

Single or multiple effluent ponds

From an environmental perspective, effluent ponds are generally preferable to continuous application systems in drier areas.

On dairy farms, these systems employ one or more ponds (generally one or two) to treat the daily inflow of effluent from the milking shed and yards, and to store both the liquid effluent and solids (sludge) that settle out of the effluent. Pond systems can also collect, treat and store runoff from concrete and earth yards, and, in some cases, feed pads and regularly used laneways. The liquid effluent is stored until it is either irrigated onto crop or pasture, or recycled for yard flushing purposes.

Ponds may be constructed in series to treat and store effluent. The first pond in such a series is generally referred to as the primary pond and the second pond as the secondary pond. The quality of the treated effluent in the final pond generally improves as the number of ponds in the effluent management system increases.

Sludge accumulates in the primary pond and is removed at regular intervals. Primary ponds are commonly designed to store 1–10 years of accumulated sludge. The sludge storage capacity generally depends on the intended method of sludge removal. For example, if a farmer wishes to employ a contractor with an excavator to remove the sludge, they may prefer to limit desludging operations to a frequency of once every 10 years. Alternatively, if the farmer has ready access to a vacuum tanker, they may choose to pump out and apply the sludge as a fertiliser much more frequently, perhaps annually.

Regardless of the number of ponds in the effluent management system, the following three storage/treatment volume components must be provided:

- active treatment volume to maintain the necessary bacterial population to treat and break down the organic matter in the effluent stream
- sludge storage volume to store the solids that settle out of the effluent during treatment
- wet weather storage volume to store liquid effluent during periods when the land is too wet for effluent irrigation, or until the timing of effluent irrigation suits other farm management considerations.

In a single-pond system, each of these three treatment/storage volumes must be provided in the primary pond (see Figure A8.1). In a double-pond system, the active treatment volume and sludge storage volume must be provided in the primary pond, and the wet weather storage volume in the secondary pond (see Figure A8.2).

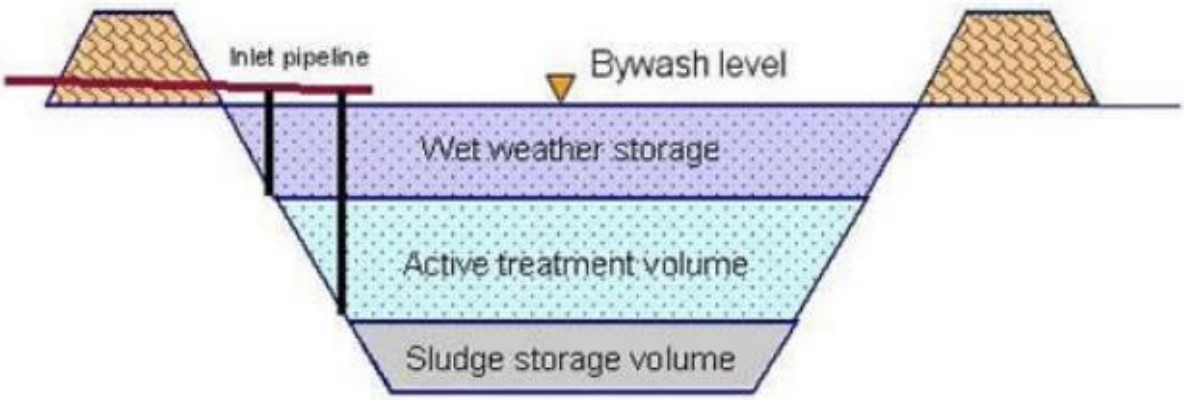

Figure A8.1 — Cross-section of single effluent pond, showing treatment volumes

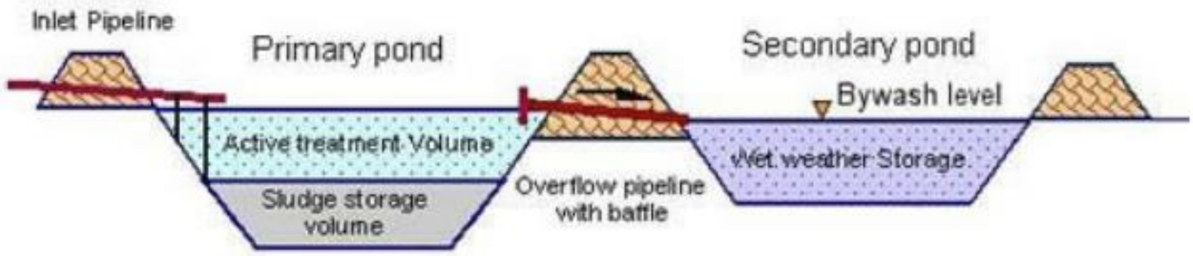

Figure A8.2 — Cross-section of double effluent pond, showing location of storage volumes in each pond

Effluent ponds should have sufficient wet weather storage capacity to limit effluent spills (overtopping) to a frequency not exceeding once every 10 years, except in sensitive environmental areas, where less frequent overtopping may be desirable. Effluent ponds should not generally be located close to watercourses. However, if this is unavoidable, additional wet weather storage capacity may be required to further limit effluent spills.

The 'treatment' of the effluent consists of allowing solids to settle to the bottom of the pond as sludge. Both sludge and liquids become a medium for the growth of bacteria that occur normally in faecal matter or the environment. These bacteria may be aerobic, anaerobic or both (facultative). The bacteria and phytoplankton break down the remaining organic compounds in the effluent and produce either methane and carbon dioxide (anaerobic) or water and carbon dioxide (aerobic) as byproducts. The remaining effluent contains simpler organic nutrients and minerals that are more suitable for applying to pasture.

Glossary

Terms and definitions

Standard AUSVETPLAN terms

For definitions of standard AUSVETPLAN terms, see the **AUSVETPLAN *Glossary***.

Manual-specific terms

Term	Definition
Leachate	Body fluids generated during the decomposition process of carcasses.
Pasteurisation (in the context of composting)	The temperature and time required to inactivate the emergency animal disease (EAD) pathogen.
Putrescible waste	Solid wastes that contain organic matter capable of being decomposed by microorganisms.

Abbreviations

Standard AUSVETPLAN abbreviations

For standard AUSVETPLAN abbreviations, see the **AUSVETPLAN *Glossary***.

Manual-specific abbreviations

Abbreviation	Full title
AI	avian influenza
BOD	biological oxygen demand
BSE	bovine spongiform encephalopathy
EfW	energy-from-waste
FMD	foot-and-mouth disease
IPOP	infected premises operations
TSE	transmissible spongiform encephalopathy
WHS	work health and safety

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