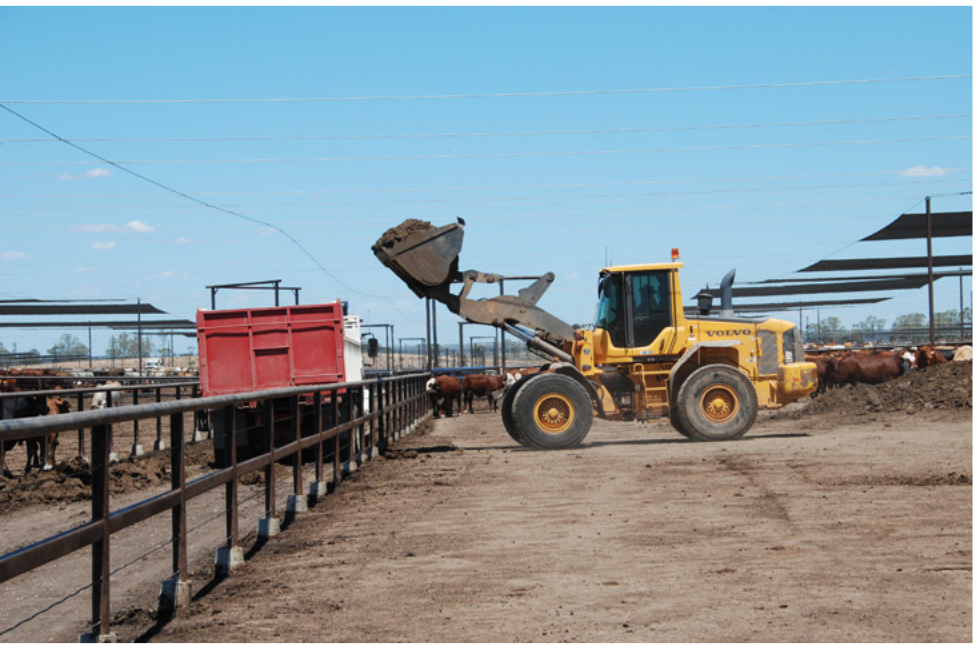


BEEF CATTLE FEEDLOTS: WASTE MANAGEMENT AND UTILISATION

1. Solid wastes

CONTENTS

The pen area must be cleaned regularly for odour and dust control, worker safety and efficient cattle performance.

Wet, muddy pens do not provide pleasant conditions for workers or cattle.

Manure interface layer over compacted gravel base

Introduction

The main waste product of a beef cattle feedlot is manure. To maintain good conditions for workers and cattle and to ensure sound environmental performance, manure must be removed from feedlot pens regularly. Some feedlots use bedding and this, along with small amounts of spoilt feed thrown into the pen during bunk cleaning, is removed with manure during pen cleaning. Thus manure handling becomes a major ongoing part of feedlot management. Spoilt silage and mill run, mortalities, and sometimes boiler ash, are other solid wastes that may also need to be managed.

Pen cleaning

Pens must be cleaned regularly to

- optimise cattle performance and welfare
- present animals for pre-slaughter inspection in a clean condition
- provide a safe work environment for staff (particularly pen riders)
- mimimise odour levels
- minimise dust during hot, dry conditions
- promote good pen drainage
- promote good integrity of the pen surface
- minimise costs of pen maintenance.

Frequent, regular pen cleaning reduces the average depth of manure over the pens, promoting more rapid pen drying. Odour emissions from wet feedlot manure can be 50–100 times higher than from dry manure and the odour is more offensive. Even a small area of wet manure, such as a pothole, can be a significant source of odour. Regular pen inspection allows low spots to be identified early and repaired.

Muddy, odorous conditions do not provide a pleasant, safe working environment for pen riders and others working within the feedlot.

Weight gains can be reduced by 30–40% and feed conversion rates increased by 20–35% when cattle are kept on deep manure. Wet, muddy conditions also adversely affect animal health, with increased incidence of foot problems such as foot abscesses.

The manure pad

As manure deposited on the floor of feedlot pens dries and is compacted by the action of cattle hooves, it typically forms layers. The lowest layer may be an ‘interface’ layer – a compacted, moist plastic mixture of manure and soil – which has low permeability and can reduce nutrient leaching through the feedlot pen. If there is no interface layer, the manure layer overlies the feedlot base directly as a moist and plastic layer, sometimes with a crust on the surface.

The thickness of the manure layer depends upon the manure deposition rate, the pen cleaning frequency, weather conditions and other factors. Under dry conditions, about 20 mm of manure accumulates across the pens after 25 days, gradually increasing to about 30 mm after 75 days and to around 35 mm after 100 days. When the dry compact manure pack is moistened by rainfall, it may double in depth.

Principles of pen cleaning

Feedlot pens should be cleaned at least every 13 weeks. Ideally, pen cleaning should occur when the manure is moist (but not wet). Moist manure is more easily removed in a good even cut for a smooth pen surface. However, pens should be cleaned regularly even when conditions are not ideal.

If a manure–soil interface layer will be retained, it is necessary to determine the depth of manure covering it. In moist manure, a screwdriver pushed into the pad will encounter increased resistance at the interface layer. The difference is less distinct if the manure is hard and dry and it may be necessary to dig into the pad to confirm the depth to interface.

The depth of manure and its moisture content will vary over the pen; for example, manure will accumulate and may be wetter under shade. During cleaning, care needs to be taken to prevent machinery from cutting too deep in different parts of the pen. If the manure is too hard, pen cleaning can be deferred until the manure moisture content increases.

Because of climatic conditions some feedlots do clean all manure from the feedlot floor. But this may include large amounts of soil or rock resulting in more material for processing, including manure screening. It may also increase pen maintenance needs and result in more wear and tear on manure handling equipment.

Attention to detail during pen cleaning is important to control odour since even small areas of wet manure can emit significant odour. Every time pens are cleaned, manure that has accumulated under fencelines, along the sides of feedbunks and water troughs and along aprons should also be removed. Cleaning under the bottom fenceline more frequently will also promote good pen drainage and fly control.

Manure can be temporarily mounded in the pens before stockpiling and composting, but never in drains or cattle alleys.

Temporary mounding of manure in the pen may increase management flexibility because

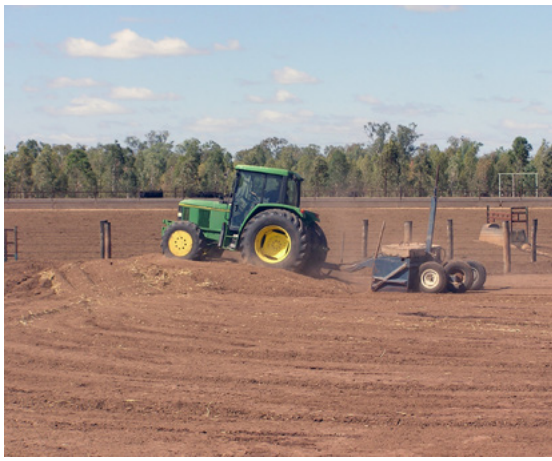
- decomposition reduces the mass of manure to be removed from the pen
- pens can be cleaned as required and more regularly
- the manure mound can be removed from the pen at a convenient time.

Mounds should be removed when conditions allow but also when

- they become too high for machinery to practically and safely drive over them
- they become a hazard to the welfare of cattle
- they begin to disintegrate under dry conditions
- manure haulage equipment becomes available.

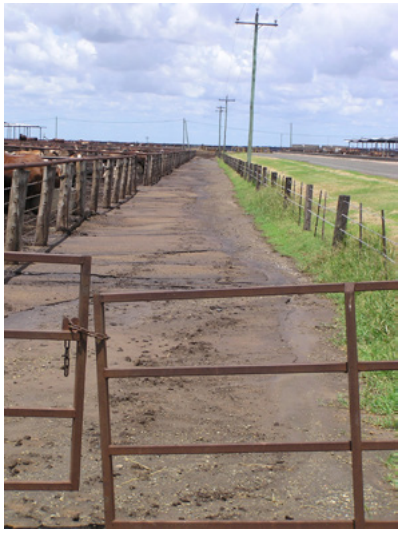
To form stable mounds, the manure needs to be moist enough to be well compacted so that it can support the weight of cattle and also to exclude air. Mounds should be shaped so they shed runoff and located so as not to interfere with pen drainage. In unshaded pens, they should be situated in the centre of the pen with their long axis running down the slope. In pens with shade over the centre or top third of the pen, they should be located downslope of the shade structure.

A feedlot pen that has been cleaned to a smooth gravel base.

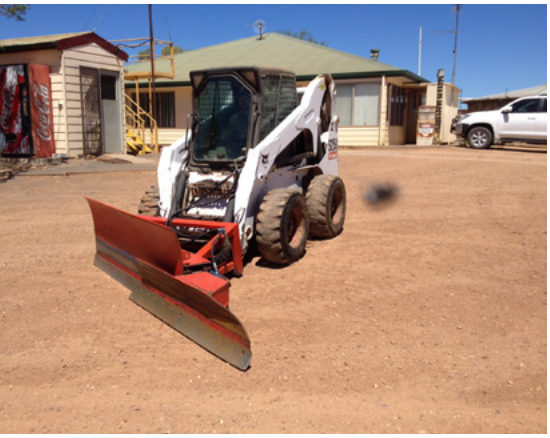


Manure being mounded with a box scraper.

Manure that accumulates under fence lines needs to be removed as it impedes drainage and provides a habitat for flies to breed.



Drains below the pens direct runoff to the holding pond and need to be kept clean.



Slider blade for removing manure from under fencelines, along aprons, around shade posts, and from drains and lanes

Wheel loader removing scraped and mounded manure from pen.

Drains below the feedlot pens (which often also act as cattle lanes) are used to catch rainfall runoff and direct it to a holding pond generally via a sedimentation basin, tank or terrace. Drains need to be kept free of sediment build-up to maintain maximum flow capacity. Where drains are vegetated, the grass should be kept short by regular mowing.

Sedimentation facilities are designed to remove at least 50% of the settleable solids in the runoff, and should be cleaned out when they are dry to maintain removal capacity. This will reduce the amount of organic matter entering the holding pond and hence the potential odour emission rate. Weirs also need to be cleaned when deposited sediment is sufficiently dry. In wetter climates, having two sedimentation facilities in parallel allows one to be dried and cleaned while the other is in operation.

Manure entering the holding pond is broken down by microbial action, but some undegradable material is deposited as sludge on the floor of the pond. Holding ponds need to be cleaned when the required water storage capacity is compromised (e.g. less than 80% available), typically every 5 to 20 years depending on the initial size of the pond and the efficiency of the sedimentation system.

Pen cleaning equipment

Equipment that can be used for pen cleaning includes

- *Tractor-drawn box scrapers* – box scrapers are widely used in medium to large feedlots in conjunction with wheel loaders. These scrapers provide good depth control, a smooth pen finish, a single manure removal and mounding operation and a fast rate of manure removal. However, they are less effective in wet conditions when an excavator may need to be used instead.
- *Wheel loaders* – wheel loaders are widely used in medium and large feedlots for removing mounded manure from the pen. While they can also be used to quickly clean the pens, they often produce a rough surface finish and may damage the interface layer. Buckets should be fitted with small teeth to minimise damage to the pen surface.
- *Excavators* – excavators can efficiently remove manure, particularly under wet conditions, but need to be used carefully as it can be difficult to achieve good depth control and a smooth finish. They are efficient at transferring mounded manure into trucks.
- *Skid-steer bobcats* – bobcats can be used to tidy up small areas.
- *Under-fence pushers* – mounted on tractors, front-end loaders or bobcats, under-fence pushers are commonly used for removing manure from under fencelines, around shade posts and water troughs; and manure and spilt feed from feed bunk aprons.
- *Slider blade* – mounted on a skid steer bobcat, the slider blade can be used in place of an under-fence pusher but can also clean drains and lanes.
- *Graders* – graders are suitable only for cleaning large pens; they provide good depth control and a smooth finish.

Manure collection and handling is a significant component of the feedlot budget. Different manure removal technologies offer different efficiencies in time and energy, but the most efficient systems may conflict with retaining an interface layer and maintaining an even pen surface.

For example, tractor-drawn box scrapers which provide good depth control and a smooth finish could have a capacity of 45–50 t/hr, compared to 80 t/hr for the wheel loaders which may produce a rough surface finish and damage the interface layer. The manure harvested with a wheel loader is likely to contain extra soil and rock, and this will increase the mass of material for transportation and processing.

Local climate conditions can also interfere with the retention of an interface layer and equipment used as illustrated in examples below.

Manure being removed by a under-fence pusher mounted on a bobcat.

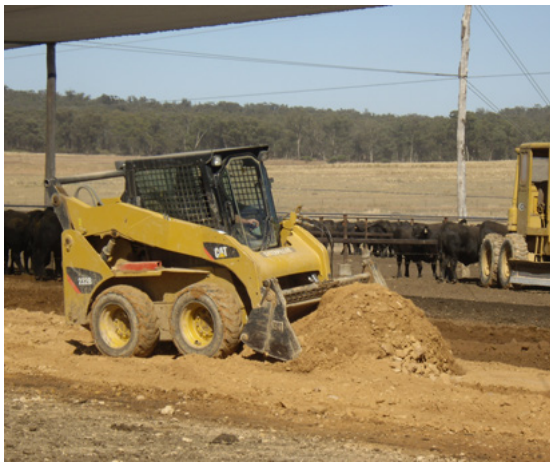
CASE STUDIES

Cleaning in summer-dominant rainfall areas

The Queensland climate allows for year-round pen cleaning, manure mounding and retention of an interface layer. In a Queensland feedlot, pen cleaning was done every six to eight weeks. First, an under-fence pusher removed manure from under the fences, then a box scraper was used in a circular motion then diagonally to scrape the manure into a mound in the centre of the pen. The mound was retained for 12–18 months during which decomposition reduced its bulk by 20–30%. The manure was then collected by contractors using a front-end loader to break the mound and load the manure into trucks, resulting in little idling time. This simple system was time and cost efficient (Reeves 2007).

Cleaning in winter-dominant rainfall areas

Wet winters provide challenging conditions for pen cleaning. A New South Wales feedlot was cleaning its pens every eight to ten weeks. As the frequent wet conditions were not conducive to the formation of an interface layer, manure was harvested down to the gravel base using skid-steer equipment. An excavator cleaned the aprons and under fences, a front-end loader removed and mounded the manure and another front-end loader filled two trucks parked below the pens (Reeves 2007).



The pen surface needs maintenance to retain a smooth slope. Areas under shade tend to stay moist and may need more frequent attention.

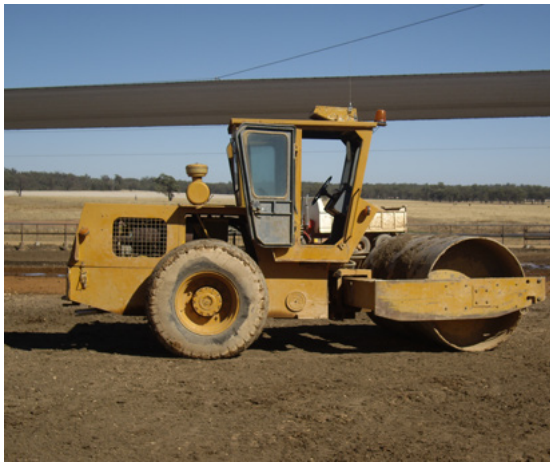
Once the pens are clean, routine maintenance such as patching potholes can be carried out.

Manure removed from pens is usually transported by truck to a stockpiling or composting area, allowing manure spreading to occur at the most suitable time and independently of the pen cleaning and manure collection process. Efficiency of manure removal is improved by

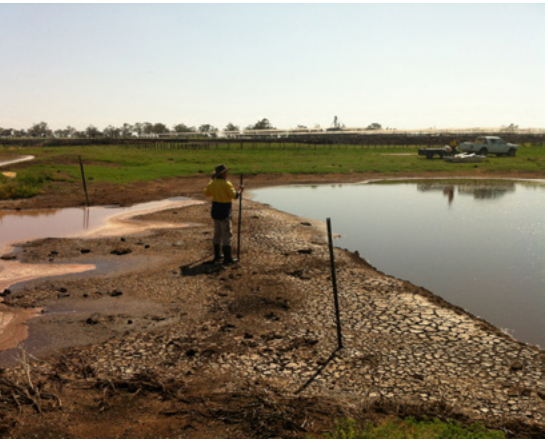
- minimising idling time during truck loading
- using larger capacity trucks
- loading the trucks in the pen rather than having to transport the manure to the truck. If this is not possible, locate the truck in the stock lane or drain below the pen so that feeding is not disrupted.

Cleaning drains, sedimentation systems and ponds

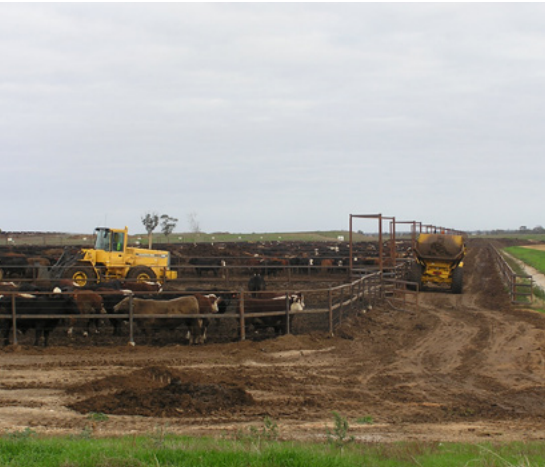
Drains and sedimentation basins can be cleaned with a box scraper, bowl scraper, grader, front-end loader (in smaller systems) or with an excavator working either from the bank (depending on basin width) or within the system under reasonably dry conditions. Sedimentation tanks can be cleaned using an excavator.



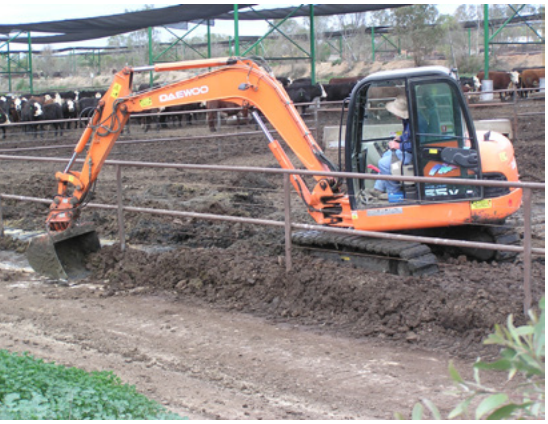
Newly placed gravel under shade being compacted with roller.



Solids that accumulate in the holding pond over time need to be removed eventually.



Front-end loader taking manure to an articulated dump truck during pen cleaning operations.



Excavator being used to clean manure from behind and underneath a fence above a drain.

Options for desludging ponds include

- *Dragline* – produces semi-solid sludge that is difficult to manage. This material should be stored separately from other manure or spread directly.
- *Agitator and pump* – the effluent is agitated to re-suspend the sludge which is then extracted with a chopper or propeller pump for irrigation with a system capable of handling the solids.
- *Excavator* – great care has to be taken to avoid damage to the pond lining.

Some effluent should be left in the bottom of the pond after cleaning to protect the liner and maintain a bacterial population ready to digest the organic matter in the next inflow.

Pen manure

Physical properties of pen manure

The physical properties of pad manure vary with depth: see Table 1.1. Manure consists of moisture and dry matter (DM) or total solids (TS). The organic fraction of the TS, or volatile solids (VS), breaks down over time reducing the total mass of manure solids. The remaining material, fixed solids (FS), is inorganic material that cannot be broken down. The longer manure is stored on the pad, the more VS breakdown occurs.

- about 80% of the TS in excreted manure is VS that is quickly broken down on the pad. Some 60–70% of VS is removed after 20 days, 70% after 35 days and 75% after 80–100 days. (Davis et al. 2010).
- the VS/TS ratio of harvested manure (at pen cleaning) averages 0.64.

This large, rapid loss of VS has significant implications for manure storage and management, greenhouse gas (GHG) emissions and for any advanced treatment technologies described in Appendix 5.

Table 1.1 Typical characteristics of pen manure (Davis et al. 2010)

Manure zone	Moisture content (%)	Fixed solids (%)	Volatile solids (%)
Loose surface layer	22	28	73
Moist loosely-compacted layer	40	33	67
Moist interface layer	22	74	27

The bulk density of pen manure affects the volume of material for removal from the pens. Factors influencing this bulk density include the manure moisture content, manure age, and the amount of soil and rock that is harvested with the manure.

The bulk density of manure on the pad can range from 430 to 1,000 kg/m^3 or even higher for manure containing more soil or rock.

Quantity of pen manure harvested

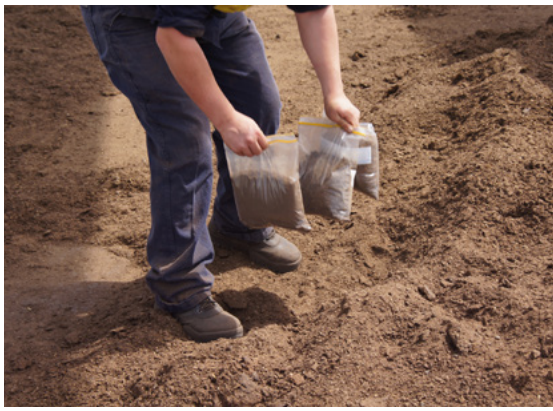
For many years, the pen cleaning manure removal rate for Australian feedlots was widely quoted to be 1 tonne TS/head/year but some Australian lot feeders have suggested that the real number could be half of this. Calculations of the TS excreted per standard cattle unit (SCU)

and decomposition losses suggest that the harvested yield of manure could be as low as 400–420 kg TS/SCU/year.

However, results differ for feedlots that do not retain an interface layer and clean their pens down to the gravel base. These feedlots could be harvesting around 2,000 kg TS/SCU/year made up of manure plus large amounts of gravel, rock or soil.

If bedding is used, this will also be harvested with the manure cleaned from the pens. Wood chips degrade much more slowly than manure so most of the incoming bedding mass will be removed with the manure.

Note: one SCU is equivalent to an animal weighing 600 kg. Scaling factors allow cattle of lower weight to be expressed as SCUs.



Manure samples can be analysed to determine volatile solid content.

Quantity of manure removed

Keeping interface layer

With manure production of 400 kgof TS/SCU/yr and assuming the manure has a bulk density of 650 kg/m^3 and a moisture content of 33%, some 600 kg manure/SCU or 0.9 m^3/SCU of manure would be harvested annually. A full 200 SCU pen cleaned every 13 weeks would yield about 47 m^3 at each pen cleaning.

Scraping to base

With manure production of 2000 kg of TS/SCU/yr and assuming a manure bulk density of 800 kg/m^3 and moisture content of 25% (due to gravel content), some 2700 kg/ SCU or 3.3 m^3/SCU capacity of manure would be harvested annually.

A full 200 SCU pen cleaned every 13 weeks could yield about 170 m^3 at each pen cleaning, but this would greatly depend on how much pen foundation material is harvested.

Nitrogen losses are higher under moist conditions.

Composition of pen manure

Pen manure is a rich source of nutrients and organic matter that has potential for utilisation on agricultural land. However, it may also include contaminants that need to be considered in its management. This section provides quantitative data on the composition of pen manure.

The amount of nitrogen (N), phosphorus (P) and potassium (K) in pen manure depends on the composition of the manure excreted by the cattle, but also on climate, pad conditions, pen cleaning practices and the use of dietary or pad additives that reduce volatilisation losses.

The nutrient content of excreted manure is influenced by the class of cattle, their diet, their feed intake and other factors. Gaseous losses of N as ammonia occur rapidly and about 60-70% of the initial N can be lost. This N loss contributes to GHG emissions and also reduces the future fertiliser value of the manure. While some P and K is removed with the manure in runoff and deposited in the holding pond, these minerals are not lost as gas.

A summary of analyses of Australian feedlot pen manure, aged manure and compost manure is shown in *Section 2. Solid waste storage and processing.*

The weight of manure harvested is greatly affected by its gravel and stone content.

Freshly excreted manure has a high volatile solids and moisture content.

Spoilt feed can be processed with manure.

Ash produced by a coal-fired boiler.

A range of pathogens can be found in feedlot pen manure and very low concentrations of parasiticides and steroids may also be present. Further details are provided in *Appendix 2: Managing human exposure to contaminants.*

Weed seeds may also be introduced through feedstuffs and bedding.

Significant quantities of gravel from the pen foundations and wood chips or other bedding materials may also be included with the manure.

Other wastes

Solid wastes may include spoilt silage and mill run, mortalities and boiler ash.

Spoilt silage and mill run

Well-run feedlots generate only small amounts of spoilt silage and mill run. This waste is usually taken directly to the manure stockpiling or composting area for management.

Mortalities

The average mortality rate in Australian feedlots is generally consistent and low (less than 1%). Management options for feedlot mortalities include

- composting
- burial
- incineration
- rendering.

Most large Australian feedlots compost their mortalities because this yields a usable product. Guidelines for composting mortalities are provided in *Section 2. Solid waste storage and processing.*

Boiler ash

Ash is produced by feedlots with coal-fired boilers for their steam-flaking plants. Ash can be stockpiled for future use in maintaining pen floors and roads.

Further reading

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The amounts of nutrients excreted in manure are influenced by the diet.