3rd Edition

National Guidelines for Beef Cattle Feedlots in Australia

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Foreword

The beef cattle feedlot industry is an important, value-adding component of Australian agriculture, representing a value of production of approximately $2.7 billion whilst employing some 2,000 people directly and almost 7,000 more indirectly.

The Australian cattle feedlot sector evolved due to its ability to consistently meet market requirements in terms of quality and quantity irrespective of Australia's variable seasons. Consumers in both domestic and export markets also actively demand grain-fed beef.

The Australian cattle feedlot industry recognises that it has a social and ethical obligation to customers, communities and government to continually deliver improvements to environmental, animal welfare and food safety practices if it wishes to maintain the confidence of these key stakeholders. From an environmental perspective, the *National Guidelines for Beef Cattle Feedlots in Australia – 3rd Edition* (the *Guidelines*) provide a key mechanism to help deliver such improvements.

The *Guidelines* are designed as a companion document to the *National Beef Cattle Feedlot Environmental Code of Practice* (the *Code of Practice*). The *Code of Practice* is intended to provide nationally consistent requirements under state regulation for lot feeders and administrators regarding the environmentally relevant aspects of the establishment and operation of beef cattle feedlots. In contrast, the *Guidelines* provide 'guidance' on how the *Code of Practice* requirements regarding the establishment and operation of beef cattle feedlots may be achieved.

The industry's quality assurance system, the National Feedlot Accreditation Scheme (NFAS) requires all accredited feedlots to adhere to the *Code of Practice* along with all other relevant environmental, animal welfare and food safety legislation. Under this government and industry managed program, every accredited feedlot is independently audited each year to ensure compliance.

Previous editions of the *Guidelines* were released in 1992 and 1997 under the auspices of the Standing Committee of Agriculture and Resource Management. This third edition of the *Guidelines* has been approved by state and federal governments, the Feedlot Industry Accreditation Committee and the Australian Lot Feeders' Association (ALFA).

I commend these *Guidelines* to those stakeholders with an active interest in the cattle feedlot industry.

Jim Cudmore

ALFA President

Contents

Preface

The Australian beef cattle lot feeding industry considers that the protection of the environment is essential for ecologically and economically sustainable agricultural production. To this end, the industry has been pro-active in seeking to develop and adopt appropriate guidelines and codes of practice for environmental management. This approach has been pivotal in the production of two previous national guidelines and an environmental code of practice.

Previous editions of the *National Guidelines for Beef Cattle Feedlots in Australia* (National Guidelines) were released in 1992 and 1997. These documents were produced under the auspices of the Standing Committee of Agriculture and Resource Management.

In 1998, the Australian Lot Feeders' Association (ALFA) initiated the development of a code of practice for cattle lot feeding in Australia. The *National Beef Cattle Feedlot Environmental Code of Practice – 1st Edition* (Code of Practice) was subsequently published by Meat & Livestock Australia (MLA) in 2000.

Since the publication of these documents, scientific knowledge, technology and community expectations have changed. In 2006, the Feedlot Industry Accreditation Committee (FLIAC) initiated a review and update of the National Guidelines. It soon became apparent that this could not be undertaken in isolation and the Code of Practice was also included in the review and update process.

Both documents have been extensively revised into new editions – the *National Guidelines for Beef Cattle Feedlots in Australia – 3rd Edition* (the *National Guidelines* or the *Guidelines*) and the *National Beef Cattle Feedlot Environmental Code of Practice – 2nd Edition* (the *Code of Practice* or the *Code*). The development of the new editions of these documents was a joint project of Meat & Livestock Australia and the Australian Lot Feeders' Association.

As significant new information becomes available from research and practical experience with feedlot operations, the *National Guidelines* will be periodically refined and updated.

Document scope

These *Guidelines* are designed as a companion document to the *Code of Practice*. The intent of the *Guidelines* is to provide guidance on the means of achieving the requirements specified in the *Code*. They are not intended to represent compulsory standards that must be strictly adhered to in order to comply with the *Code*. The *Guidelines* provide a broad framework of generally acceptable principles for the establishment and operation of feedlots based on the best technical information available at the time of publication. They also provide information on specific topics, particularly where specific guidance might be useful in assisting operators to meet the performance measures.

Compliance with the details of the practices and methods described in the *Guidelines* is not mandatory, and the *Guidelines* do not demonstrate the only means by which compliance with the *Code* might be achieved. There will be other ways of achieving the required outcomes. This is particularly the case as knowledge, management and technology progressively improve over time, allowing us to avoid, or better manage, environmental impacts in the future.

Document structure

This document has the following structure:

- An overview of the feedlot development process, including:
  - major design components of a feedlot
  - key site selection parameters
  - development application and approval process
  - feedlot construction.
- Appendices that provide additional information on specific aspects of feedlot siting and design, including:
  - guidelines for the design of controlled drainage systems in beef cattle feedlots
  - separation distance guidelines
  - clay lining of feedlot pens, pads and drainage system
  - manure and carcass composting
  - effluent and manure utilisation
  - feedlot application documentation
  - a glossary of terms used in this document.

1. A beef cattle feedlot

1.1 Beef feedlot definition

A beef cattle feedlot is a confined yard area with watering and feeding facilities, where cattle are completely hand- or mechanically-fed for the purpose of beef production. This definition includes both covered and uncovered yards.

The above definition does not include the feeding or penning of cattle in the following situations:

- for weaning, dipping or similar husbandry practices
- for milk production
- at a depot operated exclusively for the assembly of cattle for live export
- for drought or emergency feeding purposes
- at a slaughtering facility
- in recognised saleyards.

The feedlot complex includes:

- pens
- handling yards
- drains and ponds
- stock lanes and feed alleys
- manure stockpile and composting pads
- feed mill and feed storage facilities
- stock and vehicle washdown facilities.

The feedlot complex does *not* include manure and effluent utilisation areas.

1.2 Feedlot design components

A number of components are found in most feedlot designs. These are listed in Table 1.1. In some instances, certain activities, such as feed preparation and manure utilisation, may take place entirely off-site. In smaller feedlots, some activities may not be undertaken.

Table 1.1. Common components of a feedlot design

Component	Elements
Livestock management	• production pens • livestock handling facilities • induction facility • cattle lanes • hospital pens • stables
Stock feeding	• feedstuff receival facilities • grain storage • grain processing • silage bunkers • commodity storage • feed mixing • feed delivery • feed bunks
Stock watering	• pumps and pipelines • water storage tanks and dams • reticulation system
Drainage system	• production pens • stock handling facilities • hospital pens • solid waste storage and processing facility • cattle lanes • feed lanes or alleys • runoff catch drains • run-on diversion banks • sedimentation system • holding pond
Manure management	• manure harvesting and transport equipment • stockpile and composting facility • any on-site manure utilisation area
Effluent management	• pumping, irrigation or application equipment • effluent irrigation area • evaporation ponds
Administration and staff	• office • weighbridge • staff amenities • any on-site staff accommodation

Figure 1.1 shows an example of a feedlot site plan, which incorporates many of the elements identified in Table 1.1.

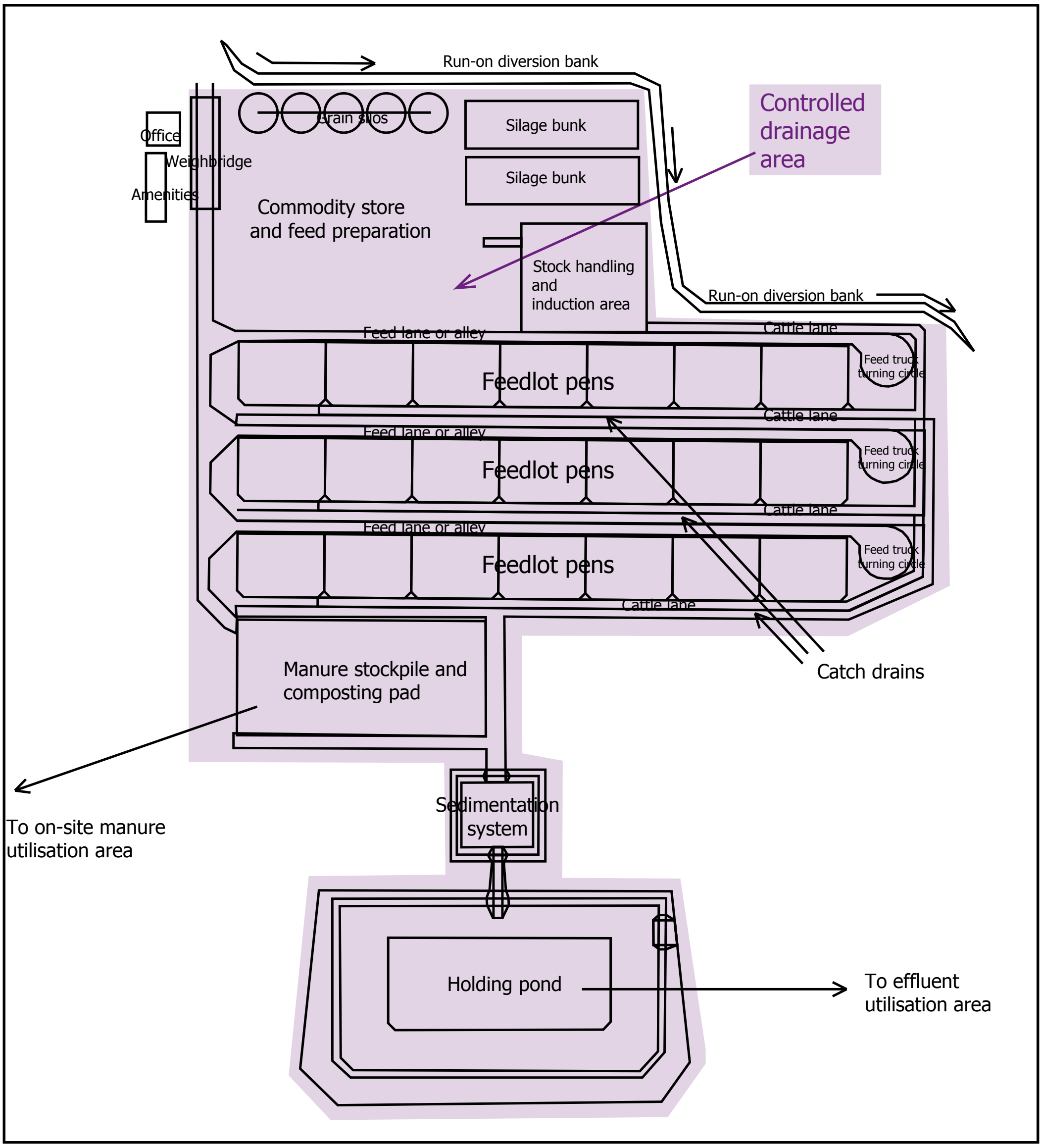


Figure 1.1 An example of a feedlot layout

1.3 Drainage system

1.3.1 Design concept

Central to the design of beef cattle feedlots is the controlled drainage area as identified in Figure 1.1. It is a self-contained catchment surrounding those parts of the feedlot complex from which uncontrolled stormwater runoff would constitute an environmental hazard.

It is typically established using a series of:

- catch drains to capture runoff from the feedlot pens and all other surfaces within the feedlot complex, and convey that runoff to a collection and disposal system
- diversion banks or drains placed immediately upslope of the feedlot complex, designed to divert 'clean' or uncontaminated runoff around the feedlot complex.

Depending on the topography and layout of the site, the feedlot may have more than one controlled drainage area.

1.3.2 Pen configuration and drainage

For ease of feeding, stock handling and service delivery, feedlot production pens are normally built in rows. To facilitate drainage, these rows are usually aligned across the slope, with a slight fall to one or both ends of each row to allow drainage.

Normally the configuration of the rows is in one of two basic designs.

These are:

- back-to-back designs
- front-to-back designs.

Back-to-back designs have two parallel rows of pens separated and serviced by a common feed road. This feed road should be located on the higher side or at the 'front' of the pens. Feed bunks or troughs are also normally located along the sides of the pens with frontage to the feed road. Both rows of pens slope away from the feed bunk, towards the 'back' of the pens, where each row may share a common catch drain, with another row of pens. Rather than sharing a common cattle lane (and catch drain), back-to-back designs may have two separate cattle lanes, either side of the catch drain at the back of each row. Each cattle lane then only services a single row of pens on that particular side of the drain. The back-to-back design is probably best suited to sites with a relatively low natural gradient (i.e. <2%).

In general, front-to-back designs are better suited to sites where there is a substantial slope (i.e. >2%). These designs consist of single rows of pens, each serviced by a dedicated feed road (and normally a feed bunk) on the higher side, and a catch drain and cattle lane on the lower side. A typical pen cross section of the two designs is shown in Figure 1.2.

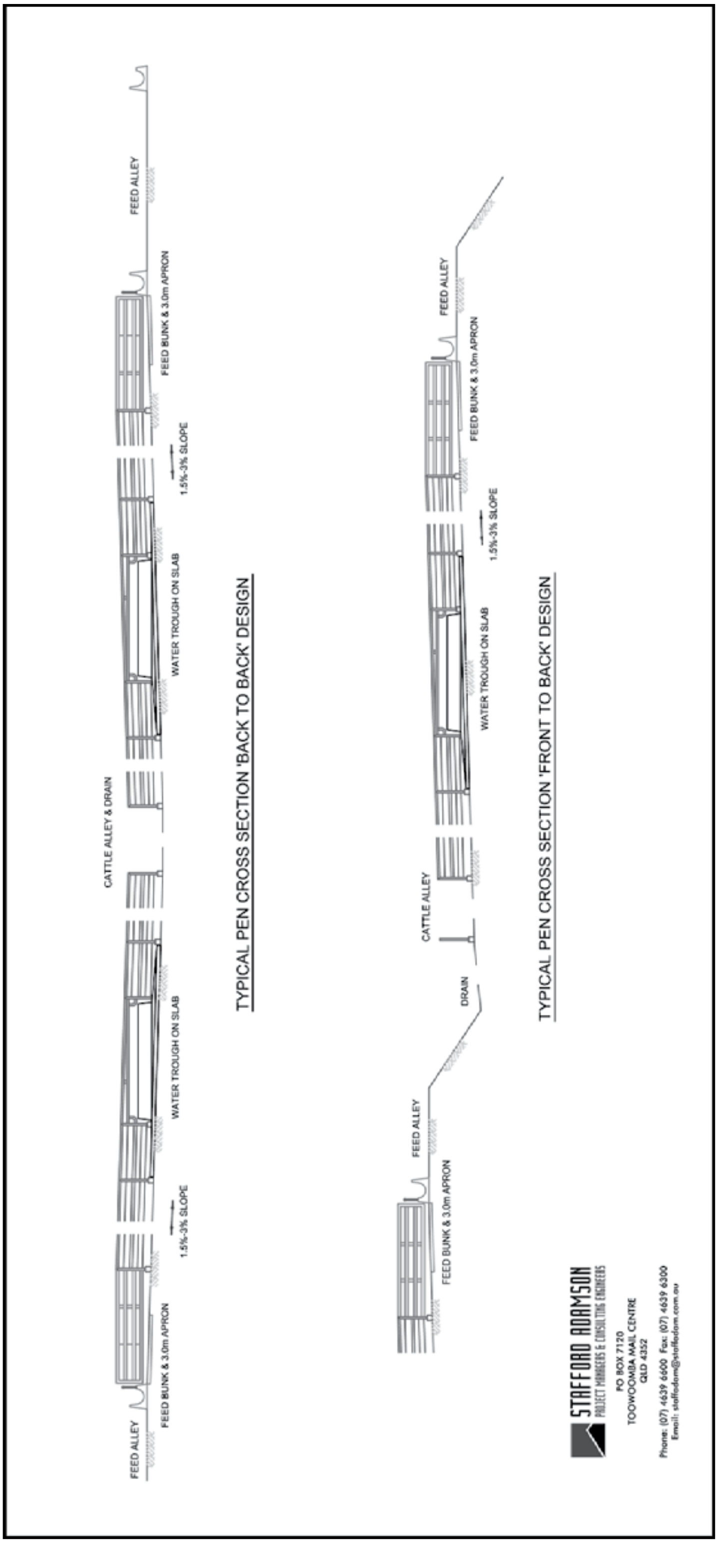


Figure 1.2 Typical pen cross section of back-to-back and front-to-back feedlot designs

In either of the above designs, and except where there is only a single row of pens, the individual catch drains discharge into a larger main drain, located at one end of each row of pens. This main drain conveys the runoff to the sedimentation system, and ultimately the holding pond (refer Figure 1.1). In smaller feedlots, the catch drain may discharge directly into the sedimentation system or a full-length sedimentation terrace may be located directly below a single row of pens.

1.3.3 Sedimentation system

Feedlot sedimentation systems are designed to remove at least 50% of the settleable fraction of the solids entrained in the runoff collected by the feedlot drainage system. Different types of sedimentation systems are in use in Australian feedlots, including ponds, basins and terraces. The sedimentation system will discharge its effluent to a holding pond or ponds. In more complex feedlot designs, where there is a second controlled drainage area (or more), there may be more than one sedimentation system. Sedimentation systems may also be duplicated (in parallel), so that one can be in service while the settled solids in the other are drying, prior to their removal before the system comes back into service.

The objective of the sedimentation (or settling) process is to remove a large proportion of the solids that would otherwise carry-through to the holding pond where they would substantially increase both the organic matter loading and the sludge build-up in the pond. Reducing the organic matter loading rate in the holding pond helps reduce odour emissions. Reducing the rate of sludge deposition increases the interval between the de-sludging operations required to maintain the design storage volume in the holding pond. The design capacity of the sedimentation system will be variable, dependent on climatic region, storm intensity, feedlot size and layout, and determined by the design process set out in Appendix A.

1.3.4 Holding pond

A holding pond is located at the lower end of the controlled drainage area immediately below the sedimentation system. It is designed to capture and store the normal runoff from the controlled drainage area pending the captured effluent being either applied to cropland or evaporated.

Where evaporation is the sole or primary disposal mechanism for effluent (i.e. where captured effluent is not normally applied to crop land), these ponds are typically referred to as evaporation ponds. Appendix A provides more detail on the design and management of holding ponds.

1.3.5 Manure stockpile and composting pad

There is normally a requirement to store feedlot manure after it has been removed (scraped or harvested) from the feedlot production pens, and before it is used, normally by application to cropping land. Sometimes the stockpiled manure is actively composted to enhance its value. Deceased animals may also be composted in the stockpile.

The storage and processing of manure must take place on a specially designed pad located within a feedlot controlled-drainage area or in a controlled drainage area of its own.

1.3.6 Stock handling and induction facility

Stock handling and induction facilities that are used to unload, load, draft, weigh, treat and, in other ways, attend to the needs of the stock must be sited within a controlled drainage area.

1.3.7 Feed storage and preparation areas

Feed storage and preparation areas may also be included in the feedlot controlled-drainage area. Where they are outside of the controlled-drainage area, the facilities may need to be within a separate controlled-drainage area. Storage and handling of materials in the facility must not constitute a hazard to surface or groundwater (e.g. the associated storage and milling and mixing operations should take place entirely within covered areas or sheds not exposed to rainfall runoff).

2. Site selection

2. Key site selection criteria

Selecting the right site for a feedlot can make a large difference to the viability and sustainability of the development.

Important aspects which should be considered include:

- prevailing climatic conditions
- suitable site topography that affects building costs and site drainage
- distance to nearest receptors for odour, dust, noise or aesthetic impact
- distance to nearest potable water supplies (i.e. reservoirs, water catchment areas)
- access to construction materials (e.g. clay and gravel)
- absence of archaeological and heritage sites or artefacts
- likely impact on threatened or endangered species or ecological communities
- flood or bushfire risk of the site
- legal and physical access to adequate water
- risk of salinity or groundwater impacts
- risk of impacts on surface water quality
- site access in respect to traffic and road safety
- available land and soil suitability for effluent reuse
- proximity to other feedlots or intensive livestock facilities
- proximity to abattoirs, saleyards and other services
- access to feedstuffs.

2.2 Climate

Climate impacts on a diverse range of issues associated with feedlots. These include:

- heat and cold stress and animal welfare
- stock water requirements
- animal productivity and feed conversion
- odour
- dust
- noise
- feedlot drainage
- waste management and utilisation.

It is possible to avoid some of the above issues, or make acceptable compromises. Climatic issues would preclude a development only in extreme circumstances; however, they are placed at the head of the listed considerations because:

- making provisions for difficult climatic conditions can be costly (financially and in terms of productivity)

- climatic considerations are interrelated with some of the other site selection criteria discussed below.

2.3 Topography

Sites with a natural slope of 2–4% will help minimise the cost of earthworks. The slope must be able to accommodate the fall required within the drainage system; sites with a low gradient can be more difficult (and expensive) to drain.

There should be sufficient depth of soil to accommodate the cut-and-fill and borrowing requirements needed to undertake earthworks during construction. This applies particularly to areas where sedimentation basins and holding ponds might be located.

2.4 Natural environment

2.4.1 Remnant vegetation

Clearing remnant native vegetation is now subject to various controls, and state and local council requirements must be considered before commencing a feedlot development that may involve clearing. Clearing may be possible under certain conditions (e.g. offset plantings); otherwise an alternative site should be sought.

2.4.2 Threatened and endangered species

In order to protect threatened and endangered species, any potential direct or indirect threats from the feedlots must be assessed for the following:

- endangered or threatened ecological communities or ecosystems (e.g. grassy box woodland in the eastern states)
- critical habitat for endangered or vulnerable species (e.g. spotted-tailed quoll)
- wildlife corridors
- Ramsar wetlands
- migratory species.

Some of these matters are covered by both federal and state legislation (e.g. the commonwealth *Environment Protection and Biodiversity Conservation Act 1999* or EPBC Act) under bilateral agreements. This means compliance with federal and state legislation can generally be assessed simultaneously by the relevant state agency.

2.5 Water

2.5.1 Water supply requirements

A feedlot requires a secure water supply. That security must be in both a legal (i.e. a legal right to the required volume) and a physical sense (i.e. the physical ability to pump, store and deliver the required volume of water). In areas where water usage is regulated, this usually requires an industrial or similar high-security water licence, allocation or entitlement.

As a guide, a proposed feedlot would normally need to demonstrate access to approximately 24 ML of high-security water per annum per 1,000 SCU of feedlot capacity. In addition to water for stock, this estimate includes water for the following purposes:

- dust suppression
- feed processing
- cattle wash down
- general cleaning
- staff and office amenities.

Additional water may be required where it is necessary to dilute feedlot effluent before it is applied to waste utilisation areas.

In addition to a legal right to the required water supply, it may be necessary to demonstrate that available infrastructure has the capacity to meet likely water demands, including peak demand in hot weather. An emergency storage or supply is needed in case the normal supply fails (e.g. pump failure, broken mains or loss of a storage tank). As a guide, the emergency supply should be capable of supplying basic water requirements (e.g. domestic and stock water) for at least 48 hours in mid-summer.

The water must be of a suitable quality for stock use. Many feedlots obtain stock drinking water supplies from bores; some feedlots supplement these supplies with surface water pumped from creeks and rivers and dams or collected in ring tanks supplied by harvesting water from overland flows. Bore supplies generally have higher salinity levels than surface water supplies, but may be more reliable.

Quality standards for beef cattle drinking water are outlined in the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000)* (ANZECC and ARMCANZ 2000). They suggest that the maximum total dissolved solids concentration for healthy growth of beef cattle is 4000 mg/L; this is equivalent to an electrical conductivity of 6.25 dS/m.

In addition to the supply for cattle, it is desirable for a feedlot to have a reliable supply of good-quality irrigation water so that crops and pastures in effluent and manure utilisation areas grow vigorously, thereby maximising nutrient uptake and crop yields. Consistently high nutrient uptake by crops minimises the area needed to utilise the nutrients in the effluent and manure. Good-quality irrigation water supplies can also be used to dilute poor-quality effluent, such as effluent with a high concentration of total dissolved solids, to reduce crop foliar damage and soil structural problems.

2.5.2 Protection of water resources

Feedlots are required to demonstrate protection of surface water quality and riverine ecosystems.

In determining water access, developments that alter environmental flow regimes, particularly in regard to the transfer of licences or allocations, should be checked against the regulations and policies of the relevant authorities.

2.5.3 Flooding

Feedlot sites should generally be above a 1-in-100-year average recurrence interval flood height. Sometimes the site can be protected with levees or similar structures, but not if these will affect the hydraulic characteristics of streamflow (in particular flood heights).

Some state and local governments also have guidelines that stipulate that waste utilisation areas need to be above specific flood heights (e.g. Q20 or Q50 floods).

2.6 Soil

2.6.1 Geotechnical qualities

Soil materials for construction purposes may be available on site or borrowed from near-by sites. This applies particularly to clay that might be used as a lining material in feedlot pens, the feedlot drainage system, composting pads and silage bunks.

The suitability of soil for earthworks is assessed on the basis of its geotechnical qualities. These qualities are assessed by testing in a laboratory or (less commonly) in the field. To be useable, these tests must be undertaken in accordance with published standards (e.g. *Australian Standard AS 1289: Methods for testing soils for engineering purposes*). Some soil types, because of their physical and chemical properties, are impermeable *in-situ*, but fail to meet the design standard when measured in the laboratory. Agencies assessing feedlot development applications may request copies of geotechnical laboratory reports confirming the suitability of the materials.

2.6.2 Manure and effluent utilisation areas

The proposed location should have an area or areas suitable for manure and effluent re-use. The re-use area(s) should be good-quality agricultural land, and have:

- a soil without any serious limitations on plant growth (such as plant nutrients and available water capacity)
- an area large enough to sustainably utilise the nutrients likely to be applied
- either be in a climate capable of reliably producing dryland crops, or have reliable access to irrigation. (Note that very large waste utilisation areas may be needed for dryland cropping only.)

It may be possible to use land of lesser quality (i.e. land with some significant limitations) but the constraints will generally need a higher level of management (and monitoring).

Note 1. Grazing removes only small quantities of some nutrients, such as phosphorus, and is therefore generally not a preferred land use for effluent re-use areas.

Note 2. To protect both human and animals from potential pathogen transfer, stock cannot be grazed on pastures for up to three weeks after effluent application.

If manure and compost are used off-site, availability of land for effluent re-use is of less importance. More details on managing the sustainable utilisation of the nutrients in manure and effluent are set out in Appendix E.

2.6.3 Use of good-quality agricultural land

While effluent re-use areas should be good-quality agricultural land, the converse is true for the site of the feedlot complex. The likely effects on good-quality agricultural land should be considered when siting a feedlot.

2.6.4 Salinity and groundwater

The lining of feedlot structures, with clay or liners, will generally result in the feedlot complex posing a minimal risk to landscape salinity or groundwater contamination.

Applying feedlot effluent and manure to land will increase soil salinity, especially in low-rainfall zones, and this will directly or indirectly increase deep drainage and groundwater recharge. Areas that may not be suitable as manure and effluent utilisation areas, or that may require expensive or intensive management and mitigation measures, include the sites with one of more of the following:

- shallow watertables
- existing salinity problems
- very permeable soils.

This is generally more significant in areas where seasonal rainfall is frequently higher than soil evaporation (e.g. winter rainfall areas in southern Australia). Where possible, sites with any of these problems should be avoided.

2.7 Amenity impacts

2.7.1 Community amenity

Community amenity is afforded by maintaining the environmental attributes that contribute to physical or material comfort of community members. Nuisance is caused by the unreasonable loss of amenity. Central to whether loss of amenity is reasonable is the frequency and magnitude of the events that might threaten it. A secondary, but important consideration, is the context in which the threat occurs and the prior experience of those being exposed.

2.7.2 Air quality

Feedlots can be a source of fugitive odour and dust emissions. Emissions are termed 'fugitive' when they are not emitted from a readily controlled point (e.g. a duct, vent, chimney or stack), and are therefore impossible to capture readily.

Once emitted into the atmosphere, the significance of these fugitive emissions (or the likelihood of causing a nuisance) depends largely on the atmospheric dispersion and dilution that takes place between the source of the emission and the potential receptor. For coarser particulate emissions, such as feedlot dust, some degree of settling will occur between the source and the receptor. Vegetation screens can be useful in diminishing the impact of dust and odours.

The amount of dispersion, dilution and settling after emission is a function of distance, and this will vary with the prevailing atmospheric stability. The required distance (or distances) can be determined using:

- fixed separation distances
- odour and particulate dispersion modelling
- variable separation distance formula (where the applicable distance is a function of the scale of the operation, the level of feedlot management applied, the atmospheric conditions commonly experienced at the site, and the nature of the surrounding terrain).

Fixed separation distances are typically absolute minimums, and may not be considered adequate for larger feedlots. Dispersion modelling and variable separation distance formulae have a more robust scientific basis, but require a substantial amount of information in order to estimate and characterise the emissions; it is often not well suited at an investigatory or preliminary stage. In this case, the use of variable separation distance formulae can provide a reasonably conservative guide as to the required separation distances. More details on the methods employed for calculating separation distances are outlined in Appendix B.

2.7.3 Noise

Ambient noise levels in rural areas are often very low (<30 dB), particularly at night-time. Thus, any new, unusual or particularly loud noise is likely to be noticed, and could become a nuisance – more so than if the same noise occurred in a busy urban environment.

Factors affecting the amount of noise reaching a receptor include:

- the nature of the surrounding terrain
- the atmospheric conditions
- the frequency and tonal qualities of the noise.

In beef cattle feedlots, common sources of noise emissions include:

- stock handling activities (e.g. loading, unloading, moving, drafting)
- vehicle movements (including feed trucks and stock transports)
- feed milling and handling
- other plant and equipment.

For the ‘normal’ noise emissions from the feedlot complex, the separation distances typically required to mitigate air quality impacts (refer Appendix B) afford similar protection from noise impacts. Exceptions to this may include:

- less common or intermittent noises (e.g. noise from construction activities)
- frequent or unusual night-time activities (e.g. night-time milling and mixing of feed)
- traffic noise along roadways servicing the feedlot.

Confining noisier activities to daytime and, where otherwise unavoidable, evenings, will normally minimise the risk of serious noise impacts. However, in instances such as the loading or unloading of cattle in summer (particularly where daylight saving applies), animal welfare considerations may preclude confining operations to these times.

When considering the design capacity of the feed mill and mixing facilities, it is desirable to have a capacity that avoids having to operate routinely at night.

2.7.4 Visual amenity

In designing and siting a feedlot, its visual impact should be considered, with any advantage being taken of natural screening provided by topography or vegetation. Highly visible sites should be avoided but, if unavoidable, buffers of trees or earth mounds can be placed between the site and nearby vantage points.

As with noise complaints, the separation distances required to address air quality impacts often provide for significant mitigation of visual impacts at nearby residences or townships, particularly in low-relief terrain. The maintenance of the feedlot and its associated infrastructure in a clean and tidy condition will generally assist in the management of the visual impact of the facility.

2.8 Roads and traffic

When selecting a feedlot site, the following impacts of traffic should be considered:

- road infrastructure
- traffic noise
- road safety.

Local and state governments generally have criteria by which they judge the significance of an impact on the road network. Typically these will involve a threshold increase in road traffic volumes or pavement loads that correspond to what would otherwise be expected with the 'normal' growth in the Australian economy (e.g. the average percent increase in national GDP).

National and state standards apply to road design in Australia. These standards cover a diverse range of matters, not the least of which is road safety.

Owing to the volume of heavy transport they can generate, feedlot developments may require the upgrade of roads and bridges to comply with the standards. Common requirements include the need for all-weather access and the upgrading of turnoffs and road junctions servicing a development, particularly on major roads where the higher traffic volumes trigger the need to install slip and turning lanes.

Because of the low ambient noise levels in rural areas (particularly at night), traffic noise may be a specific consideration, and noise-related conditions, such as curfews on traffic movements or having designated access routes, may be applied.

Proponents are encouraged to consult with the responsible authority early in the planning stages to identify any standards and road requirements, identify whether the proposal needs to be referred to a roads authority, and the arrangements for upgrading public roads.

2.9 Archaeological and heritage issues

Impacts on Aboriginal, European and natural heritage need to be considered during the assessment process for a feedlot development. Most state governments maintain registers of known sites, and these should be consulted before selecting a development site. Notwithstanding the status of a property in these registers, it is still possible that a detailed site assessment will be required for development approval or consent. Proponents are encouraged to consult with the responsible authority early in the planning stages to identify any requirements.

2.10 Development planning considerations

Some form of local or regional development plan is likely to exist in most parts of Australia. These plans normally include:

- some form of control on the types of developments allowed
- details of the level of planning and regulatory scrutiny applied
- provision for public comment on significant developments.

While these plans often preclude some types of development in particular areas, some states identify areas where certain types of development, such as feedlots, are encouraged.

2.10.1 Local plans

These plans are normally made and administered by a local government authority (e.g. a shire or local council). Typically these local plans establish zones, or similarly designated areas, where certain types of development are allowable after some relatively basic considerations; others require more intensive scrutiny and consideration (i.e. impact assessment).

Where local government areas encompass rural areas, there will normally be a rural or agricultural zoning which allows most traditional agricultural activities (e.g. cropping or grazing) with few, if any, approval requirements. Often, feedlot developments are allowable in these rural areas or zones after some form of impact assessment. However, where the dominant landuse is horticultural (such as orchards or vineyards frequented by tourists) a feedlot development may be a prohibited development (i.e. not allowable even with impact assessment).

Copies of local plans are usually available for perusal or purchase at the offices of local government authorities. Increasingly, these documents are freely available on the Internet.

Note that these plans are subject to frequent revision, and because a previous development was allowed does not mean a new one will be.

2.10.2 Regional plans

Regional plans are normally a ‘big picture’ version of local plans. They are an increasing common strategic planning instrument, particularly where sensitive areas, such as riverine wetlands, overlap a number of local government areas.

It is common for local plans to be drafted to accommodate the requirements of any regional plan, and consequently compliance with a local plan will provide compliance with the regional plan. However, some local plans pre-date regional ones and there may be some specific requirements, additional to those of the local plan, which need to be addressed. Local government planning departments can advise.

2.10.3 Catchment management plans

In some states, catchment management plans have a formal status in legislation and regulation. Like regional plans, catchment management plans usually cover a number of local government areas, and their requirements may already be reflected in the respective local government plans. However, catchment management plans are generally a newer form of planning and their requirements may not always be addressed by local plans. Anyone considering developing a feedlot should check whether a catchment management plan exists, and what its official status is.

2.11 Other considerations

2.11.1 Access to building materials

Check the on-site availability or ready off-site access to the following:

- suitable clay for lining feedlot pens, ponds, drains, composting pads
- suitable gravel for feedlot pens, drains, composting pads, roads, cattle lanes and hard stand areas
- suitable materials for road base and sub-grade
- concrete aggregate (if mixing on-site) or ready-mixed concrete.

Clay pits and quarries, for even moderately sized feedlots, may themselves require a development approval and licence and, as a result, an environmental impact assessment or similar report.

2.11.2 Labour availability

Feedlots can have a significant requirement for labour. In larger operations, where these requirements cannot be met by family or staff residing on-site, proximity to towns and a ready source of employees may be a significant consideration in determining the scale and location of the proposed development.

2.11.3 Development staging

The staging of feedlot developments is quite common. Staging a development can help establish that:

- the predicted impacts of the final development are reliable
- the impacts are capable of being properly managed
- the success in managing the impacts can be reliably monitored.

This can be advantageous to both the developer and the regulatory agencies.

3. Development applications and approvals

3.1 Background

In Australia, a feedlot development normally has to undergo some type of regulatory or planning assessment before it is legal to begin construction. The local government authority or the responsible state government agency or department (typically the department of agriculture or environment protection agency) must be consulted. There can be serious implications if development starts without appropriate authorisation.

The assessment process will involve making a formal application. During the assessment, the application may be referred to local government and various state or territory government departments, agencies and authorities. In some cases, the development may need to be referred to commonwealth departments and agencies. For simplicity, these governmental bodies are generically referred to as agencies in this document.

Note that it is typically a requirement that the public be made aware of the proposed development, and that they be allowed to make submissions or responses in favour or against the proposed development.

The result of the assessment process is normally some form of notification that the development might proceed. The notification might be called development approval, development consent, planning permission, or one of a range of similar terms that all imply that the operator is legally authorised to undertake the development. These authorisations will be referred to generically as approvals in this document.

Often the development will require other specific licences, approvals or authorities to undertake the main activity (e.g. a cattle feedlot environmental licence or authority), or ancillary activities (e.g. approvals or licences for water allocations, land clearing, feed milling, composting). In many cases, the application for, and granting of, the necessary licences, authorities or approvals is integrated into the main development approval process; however, this is not always the case and separate applications may be required for certain activities. Development approval may only provide for the activity to take place, and building permits or construction certificates may be necessary before construction can start.

The number and nature of the differences between the various local and state government agencies described above preclude a comprehensive review of the requirements in every state and territory in this document. However, Figure 3.2 illustrates the steps that are likely to be found in the approval process in most states and territories. It will be necessary to check with the development assessment manager (typically the local council), or licensing authority, for the actual process applicable to your development.

3.2 The approval process

3.2.1 Project conception and planning

This section details the steps that need to be considered before submitting a development proposal, but not all may be necessary, particularly for smaller developments.

The objective of this planning phase is to gain a realistic appreciation of:

- the strengths and limitations of both the selected site and the proposed development
- what the various agencies responsible for assessing the application are likely to require in regard to information about the proposal
- the time lines over which the approval process might happen
- the likely costs of the application process
- the likelihood of the development application ultimately being successful.

The initial proposal is likely to be considerably less costly and time consuming if it addresses all of the possible requirements, rather than continually having to make amendments once the formal assessment process has begun.

The development of a feedlot might best be advanced by a series of steps (Figure 3.1).

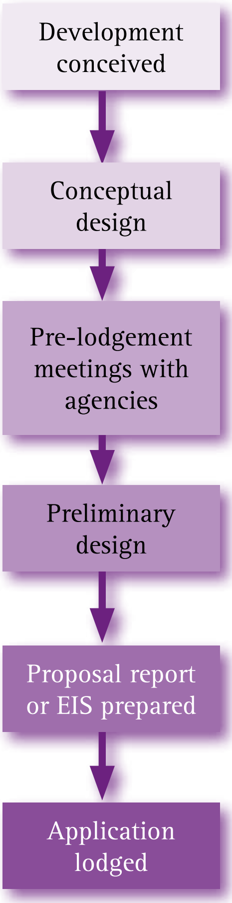


Figure 3.1

1. Consider a range of potential sites and operational scales.
2. Draft some sketch plans for various sites and designs which consider the strengths and weaknesses of each (i.e. try not to make some preconceived design fit a site).
3. Refine the designs and eliminate less favourable ones to arrive at a conceptual design that provides for both optimum productivity and financial and environmental performance.
4. Develop a conceptual design accompanied by a project description sufficient to allow others to provide advice.
5. Organise an on-site meeting with relevant regulatory agencies to get their input on likely issues which might need to be addressed in the development application and to provide suggestions regarding refinement of the design (note there may be a formal requirement for a pre-lodgement or planning focus meeting in some states).
6. Refine and develop more detailed plans that are sufficient to allow those responsible to assess the proposal.
7. Where necessary, prepare a proposal report or environmental impact statement, which is typically required to:
   - identify the proponent
   - identify and describe the site
   - identify likely environmental impacts
   - describe how the impacts will be managed
   - show how the success of the proposed mitigation measures will be monitored.
8. Complete the necessary application forms required to accompany the plans and report, determine the required fees, and submit the application and fees.

3.2.2 Lodging the development application

Lodgement of the development application initiates the formal (and normally time-limited) stages of the approval process. Limits typically apply to the time frames in which those responsible for assessing the application need to provide responses or decisions. The application may well lapse if the applicant does not undertake any required steps within specified time frames, and a new development application may be required to restart the process.

In most states, there is now some form of integrated application whereby an application for development approval also provides for concurrent or joint applications to be made for most or all other necessary licences, consents and/or permits. However, additional licences or applications may still be required before the development can take place (e.g. a separate quarry licence may be required if it is proposed to quarry gravel on the site for use in construction). A separate application for building approval or a building certificate may also need to be lodged once the development application is approved (i.e. development approval may not automatically provide building approval).

Building approvals typically require more detailed design information and plans – those plans lodged with a development application may need only to be sufficient to establish that it is feasible and practicable to undertake the proposed development on a particular site. This more detailed design should be a refinement or specification of the approved design, and should not include any significant changes which could require a reassessment of the development application. If in doubt about the significance of any changes, it is best to consult with the consent authority and responsible agencies.

For most small feedlots, the local government authority for the area will be responsible for managing the assessment process, and ultimately for deciding on the approval of the application and any conditions that will apply. However in some instances, particularly very large feedlots (which are likely to have a significant regional impact), the state department of planning will manage the assessment process, and the relevant state government minister is likely to be responsible for the approval of the development.

Besides providing a proposal report or environmental impact statement with the development application, some form of application or assessment fee (or fees) is required. The application fee may include the first year's licence fee for the feedlot. These fees and charges can be substantial, and should be provided for when preparing budgets. Details of likely fees and charges are normally available from the relevant agencies or their websites.

3.2.3. Information and referral stage

After lodging the development application, those responsible for making a decision on its approval will check to see if they have received sufficient information. Figure 3.2 shows the processes applied in most states or local government areas. Most of these stages are time-bound, and responses must be provided within a certain period.

After the application is lodged, the following steps may occur:

1. The application is checked before being accepted to ensure it is complete and meets requirements.
2. The application is referred to any other agencies responsible for assessing parts of the proposal. (Note that this may be done by the assessment manager or consent authority, but in some states the applicant is supplied with a list of agencies and it is their responsibility to forward copies of the application and proposal report to these agencies.)
3. Those responsible for assessing the application review it to determine if there is enough information to make a decision.
4. If there is not adequate information, the applicant is requested to provide it.
5. Having obtained all the information, the agencies assess the proposal against the legislation regulation, codes and policies that they administer, before providing advice to the assessment manager regarding its acceptability, and any conditions that should apply.
6. At or about the same time as the agencies are assessing the proposal, there is normally a requirement to advertise in the local press and to inform neighbours that the application is being made (the actual notification requirements and timing vary significantly from state to state).
7. The assessment manager or consent authority then considers all the recommendations from the various agencies, their own staff, and any public submissions; and provides advice to the decision maker on whether the application should be approved. (Note that sometimes the consent authority has to accept a recommendation from an agency not to approve a development, but can make a final decision either way if the referral agencies recommend approving the development.)

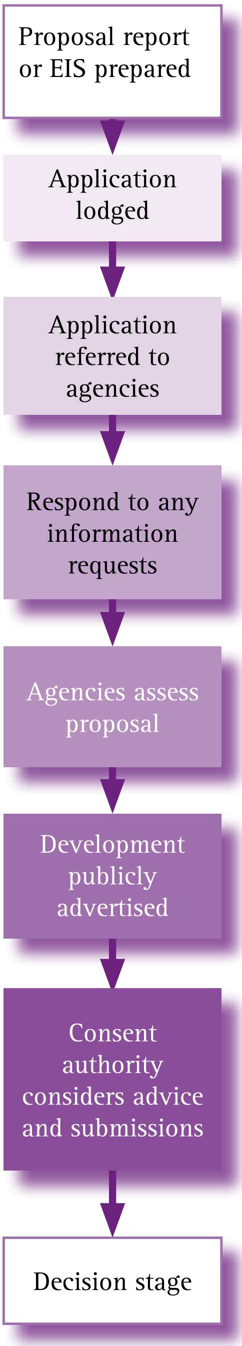


Figure 3.2

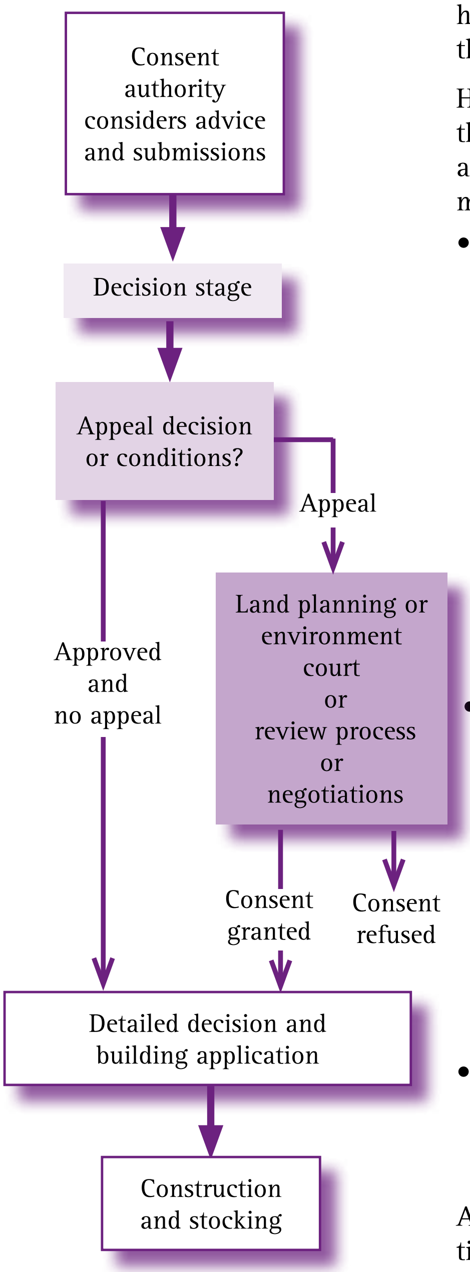


Figure 3.3

3.2.4 The decision stage

The section provides a broad view of what might happen once a decision to approve or not approve the development is made.

Having considered all the submissions and reports, the assessment manager or consent authority makes a decision from which a number of different paths might flow. These include:

- If the application is approved, and the applicant accepts any conditions imposed, the applicant:
  - a) waits a statutory period in which any submitters (from the information and referral stage) may appeal the decision
  - b) undertakes any necessary detailed design work
  - c) applies for any building approvals, construction certificates or additional licences and permits
  - d) engages any outside contractors
  - e) starts construction work.
- If the application is not approved, or the applicant considers the conditions imposed are unreasonable, the applicant may:
  - a) lodge a legal challenge through the court system
  - b) refer the decision to a review panel or similar process (not available in all states) or enter into a formal negotiation process to resolve any dispute (not available in all states).
- In the event that a submitter initiates an appeal against the approval – which they normally have a legal right to do – the applicant must then decide whether to respond or not.

A legal challenge is likely to be expensive and time-consuming, and the risks and benefits should be thoroughly evaluated before proceeding.

Regardless of the form of the approval process, it is a lengthy one, and realistic time lines and budgets need to be planned for. In general, the choice of a suitable site will result in less risk of the application being refused, less onerous consent conditions and a faster approval process.

4. Feedlot construction

4.1 Complying with approval conditions

4.1.1 Design modifications

Even in the best designed and planned facilities, it is common to have to make some modification to the design or management systems of the proposed feedlot. This modification must not result in a non-compliance with any development consent or licence condition; if it does, a formal approval must be obtained. Consultation with the relevant authorities will enable them to determine the significance of the modifications and what level of additional assessment might be required.

Where it is less obvious whether the changes will affect compliance, it is necessary to consider whether the modification will substantially alter the impact of the development (e.g. change the nature or volume of emissions, or reduce the available separation distances).

4.1.2 Staging

Where a staged development has been proposed, with a timetable for each stage, it is usually necessary to comply with that timetable.

Development approvals normally include 'sunset clauses'. If a stage is not completed within the specified time frame, the approval either lapses or the development is limited to the existing stage of development. Further development would typically require a new application (and a new impact assessment).

Where it can be demonstrated that there were justifiable or extenuating circumstances, the responsible agencies may be able to make some modifications to staging timetables, but these are unlikely to allow a delay of more than 12 or 18 months at the most. Gaining such modifications normally involves making formal representation to the administering authority before the approval lapses. Applications made after the approval has lapsed may not be accepted.

Note that undertaking a development faster than a timetable may also have repercussions. Certain performance criteria often have to be met once a stage is complete and before the next stage can commence (e.g. a specified area be developed for effluent irrigation, or existing pens be upgraded by the completion of a certain stage).

4.1.3 Notification of authorities

At the completion of construction, there is normally a requirement to notify authorities, to submit information (e.g. compaction test results) or to have an inspection, before the feedlot can commence operations. Failure to do so may breach licence or consent conditions, and expose the applicant to prosecution. The development consent or licence conditions should be read carefully and understood to avoid such problems.

4.2 Managing construction-related environmental impacts

4.2.1 Erosion and sedimentation control

Authorities will usually require an erosion and sedimentation plan to be prepared and implemented prior to construction. This plan may require the installation of control measures such as sedimentation basins, silt traps and silt fences.

Those agencies responsible for assessing the erosion and sedimentation control plan will often have guidelines and design criteria that need to be applied in the design and placement of these control structures. However by building the actual feedlot sedimentation system first, and diverting all runoff from upslope construction areas through this structure, it is often possible to satisfy erosion and sedimentation control requirements for the construction phase with a minimum of additional control measures.

4.2.2 Traffic

Feedlot construction activities will increase the amount of traffic and alter the time of peak movements. Care is necessary to ensure the changes do not cause a nuisance. This particularly applies where longer hours might be being worked to hasten construction activities.

4.2.3 Amenity impacts

Construction activities, particularly those that generate noise, dust or light, need to be managed so they do not cause a nuisance. This applies in particular where working hours are longer than normal.

4.2.4 Dangerous and hazardous goods

During construction, the temporary nature of many operations and the high level of activity can pose a greater than normal risk in the storage and handling of dangerous and hazardous goods on the site. Fuels, oils, explosives and similar materials must be safely and securely stored and managed. Even temporary storage facilities must comply with relevant Australian Standards, regulations, guidelines and codes.

4.2.5 Bio-security

While the risk may be small, it is also advisable to ensure that any materials (e.g. clay or gravel) brought onto the site is not contaminated in any way. An area of concern, which in some areas is subject to controls, is the risk of weed seeds being carried onto or off the site on construction equipment. In many areas, publicly accessible washdown facilities are available for machinery moving between sites.

4.2.6 Other permits and approvals

There may be other permits or approvals required during the construction phase. This applies in particular where mining gravel or clay on-site may trigger a requirement for a separate quarry or gravel pit licence and approval.

4.3 References

ANZECC and ARMCANZ (2000), '*Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000)*', National Water Quality Management Paper No 4, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

Appendix A. – Design of controlled drainage systems

Preamble

Australian feedlots typically consist of open-air pens in which the cattle are housed for the period that they are on feed. As the pens in these feedlots are uncovered, water will run off during and immediately following substantial rainfall. Light or low-intensity falls may produce no runoff.

Feedlot cattle, like grazed cattle, excrete a substantial quantity of water each day in the dung and urine (collectively termed manure in the context of a feedlot). At the stocking densities typically used in feedlots, the moisture in manure is normally lost to the atmosphere through evaporation. In dry weather, there is normally little, if any, direct runoff from the feedlot pens. Despite this, residual manure moisture influences the hydrological characteristics of the surface of the feedlot pen, and the surface condition of the pen can affect the chemical and physical characteristics of stormwater runoff from the pens.

Other intermittent feedlot activities, such as cleaning water troughs, washing cattle and cleaning of handling yards and trucks, will also generate small, but often significant, quantities of wastewater, and this needs to be managed. Some stormwater will also run off paved and grassed areas in and around the feedlot pens.

Both the organic and the mineralised manure constituents normally present in the runoff from the pen and other wastewater pose a significant environmental hazard if that material is released, uncontrolled, into the general environment. A central concept in feedlot hydrology is that the feedlot, and any associated infrastructure from which runoff might pose a pollution hazard, is to be located within a small

Covered feedlots

There has been increasing interest in building covered or partially-covered feedlot pens. This has come mainly from southern Australia where sites with substantial winter-dominant rainfall and/or extreme winter and summer temperatures may be better served by covered pens.

Fully-covered feedlot pens will generate little direct stormwater runoff. However, substantial runoff is generated from the roofs themselves, as well as from ancillary areas such as feed preparation areas, roads, and stock loading areas. While this stormwater runoff may be less contaminated than that from an open lot, it must still be captured, and stored safely on site, and disposed of appropriately afterwards.

While some of the structures described in the following sections may not apply to covered feedlots, the fundamental design principles do. Thus any drains, sedimentation systems and holding ponds will still need to comply with the same design criteria or performance standards. Importantly, additional planning and building requirements may apply to covered feedlot developments.

artificial catchment, generally termed a controlled drainage area or CDA. This catchment is closed, and should not discharge runoff into the external environment under normal circumstances[1].

The following section describes the various elements of a feedlot controlled drainage system, and provides some commonly accepted (but not exclusive) design methodologies.

Drainage system

Water is a valuable resource, and efforts should be made to ensure that:

- pollution of the resource is avoided
- no water is taken unnecessarily from natural systems when capturing any polluted or potentially polluted runoff
- water is used efficiently.

A controlled drainage area should capture and contain only the runoff that is necessary to maintain the environmental values of this resource. In practice, this means that the controlled drainage system should not capture what is effectively ‘clean’ stormwater runoff.

To achieve the above, controlled drainage areas are typically established using a series of:

- diversion banks or drains placed immediately upslope of the feedlot complex[2]; these are designed to divert ‘clean’ or uncontaminated upslope runoff (sometimes termed ‘run-on’) around the feedlot complex
- catch drains to capture runoff from the feedlot pens and all other surfaces within the feedlot complex, and ultimately convey that runoff to a holding pond.

To ensure that pens drain quickly after rainfall, but that runoff is not so rapid that it scours excessive amounts of manure from the pen surface, the downslope gradient in all new feedlot pens should be between 2.5 and 4%. As a result of some earlier design standards, some existing feedlots do have greater or lesser pen slopes. Cross-slope gradients should be less than 1% to minimise pen-to-pen drainage.

Since the main purpose of the drainage system within a controlled drainage area is to convey the runoff from rainfall, its design has to consider the probability of the rainfall events that the system might be required to handle.

[1] Since the intensity, frequency and duration of rainfall events are probabilistic variables, it is not possible to design a controlled drainage area that will never discharge into the external environment, but rather, it should only discharge under exceptional circumstances at what has been determined to be an acceptable design frequency (e.g. average recurrence intervals of 10, 20 or 50 years).

[2] Where feedlots are built close to the crest of a hill or ridge, and there will be no runoff from upslope, it is possible to have a controlled drainage area without any diversion banks or drains.

As an example, Figure A.1 shows the frequency distribution of daily rainfall at one location. The pattern will be the same at any location; except that the size of the rainfall events (mm/day) on the *x*-axis will vary between locations.

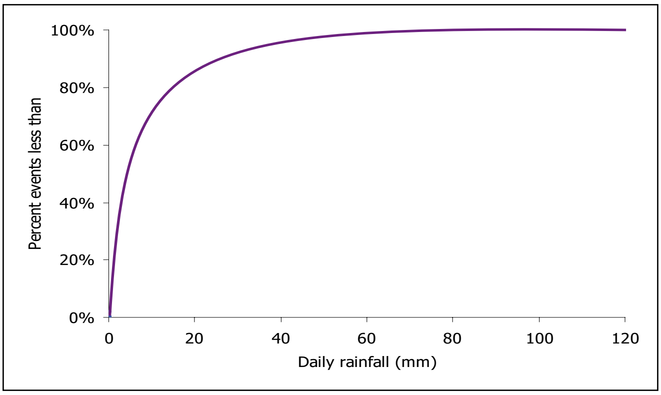


Figure A.1 Frequency distribution of rainfall (based on 120 years of daily data from one location).

Figure A.1 shows that relatively small rainfall events are very common, with 50% of daily rainfalls being of 5 mm or less. Even 90% of rainfalls are less than 25 mm. Falls larger than these become increasingly rare, with daily totals of greater than 100 mm occurring on only 0.2% of occasions. The important point is that the curve never reaches the 100% limit. In the 120-year dataset used to generate Figure A.1, 152 mm was the highest daily rainfall recorded. The curve indicates that 152 mm will inevitably be exceeded at some time in the future, but very infrequently.

It is not possible to design a runoff control structure that will handle every future rainfall event. Drainage systems are designed to cater only for rainfall events of specific frequencies and durations. These frequencies are typically expressed in terms of an average recurrence interval (ARI)[3], which is the average interval between two events of a specific size. Importantly, the interval between two such consecutive events may be greater or less than the average interval; but over the long term the average interval between events will approach the ARI. Commonly used ARIs are 10 and 20 years, the value chosen depending on the assessed consequences of overtopping of the designed structure. For catch and main drains, a 20-year ARI generally applies and is used in these Guidelines.

To minimise the settling of solids conveyed in the runoff, the flow velocity in both the catch and main drains should be greater than 0.5 m/s, but not so fast as to cause scouring of the drain. Where high velocities (i.e. generally >1.5 m/s) are unavoidable, the drain should be lined with an appropriate, durable liner (e.g. compacted gravel, masonry or concrete). Drop structures or energy dissipaters may be installed to reduce the slope and flow velocities in a drain, without having to line the entire length.

[3] The other term used in hydrological design is annual exceedance probability (AEP). This is the probability of exceeding a specific level of rainfall within a period of one year. The terms ARI and AEP are not synonymous or interchangeable.

Generally, vegetation should not be allowed to grow in either catch or main drains, even though it may reduce flow velocities. Vegetation in the drain:

- alters the flow characteristics (e.g. impeding flows, or increasing the hydraulic head and the likelihood of drains overtopping)
- increases sedimentation within the drains
- may be killed in any parts of the drain exposed to extended flows (e.g. during lengthy, low intensity rainfall events).

Where main drains need to be vegetated, low-growing stoloniferous grasses should be used, and should be kept short by regular mowing. Ideally, a concrete or masonry-lined, low-flow channel should be used within the vegetated main drain to overcome some of the problems described above.

Upslope diversion drains also need to provide non-scouring flow velocities. They should be able to safely disperse flows at their discharge points so that the discharge does not contribute to downslope erosion, and does not cause any other significant changes in flow characteristics in stream catchments. This is particularly important where there are other structures (e.g. contour banks, dams, culverts, table drains) nearby and lower in the catchment.

While it is preferable for diversion drains to be vegetated, the vegetation should be kept short by regular mowing or grazing to ensure that flow velocities are within design values.

To minimise the risk of groundwater pollution, the feedlot drainage system must be lined with a low-permeability clay or other suitable compactable soil or durable synthetic liner. Clay liners should be of sufficient thickness and layered to ensure that their integrity is not compromised. Repair or replacement of the liner may be necessary from time-to-time due to wear and tear associated with drain-cleaning operations. To protect liners during cleaning operations, they may have to be overlaid with a suitably durable material such as compacted gravel.

Design standard

- Drains are designed such that they can safely carry the peak flow rates resulting from a design storm event with an ARI of 20 years.
- The duration of the design storm should be taken as being equal to the time taken for water to flow from the most remote point of the catchment to the catchment outlet.
- Flow rates in drains during the 20-year ARI design storm should be greater than 0.5 m/s, but at the same time be non-scouring.
- Catch and main drains should be underlain by at least 300 mm of clay or other suitable compactable soil or a synthetic liner able to provide a design permeability of $<1 \times 10^{-9}$ m/s (~0.1 mm/d).

An acceptable design method

Drains should be designed to carry the peak flow rate resulting from a 20-year ARI design storm. The duration of the design storm should be taken as being equal to the time of concentration of the catchment area. This is the time taken for water to flow from the most remote point of the catchment to the catchment outlet. After this time, runoff from the entire catchment area is contributing to flow at the catchment outlet.

Several methods are acceptable for determining the time of concentration[4] of a small catchment. Some of these are detailed in Pilgrim and Cordery (1993) and Pilgrim and Doran (2001).

One of the more widely accepted methods of estimating time of concentration uses the Bransby Williams Formula, which is given by:

$$t_c = \frac{58 \times L}{A^{0.1} \times S_e^{0.2}}$$

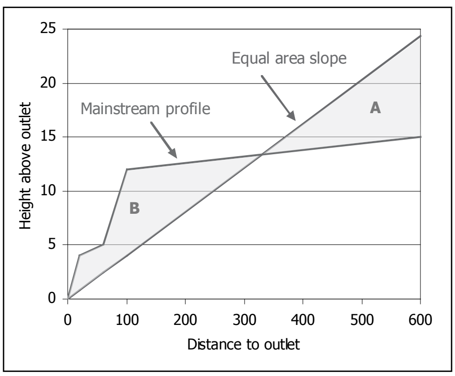
where:

t_c = time of concentration (min)
L = mainstream length (km)
A = area of catchment (km^2)
S_e = equal area slope[5] (m/km)

Having established the time of concentration of the catchment, it is then possible to determine the intensity of a 20-year ARI design storm at the development site. This design storm would have a duration equivalent to the time of concentration of the catchment.

[4] The *time of concentration* (t_c) is the time taken for rain that has fallen in the farthermost part of a catchment to flow to the discharge point. Thus after t_c, the whole of the catchment is contributing to the discharge and the *peak flow* (Q) will only occur after this time.

[5] This equal area slope is the slope of a line drawn through both the catchment outlet and the mainstream profile, such that the line subtends equal areas above and below the mainstream profile (i.e. area 'A' = area 'B' in the example below).



The generally accepted method for determining the design storm intensity is that provided by Canterford et al. (2001) in *Australian Rainfall and Runoff*. Tabulated intensity-frequency-duration (IFD) values are available for major population centres in Australia. Other software is also available that will calculate values for sites away from major towns and cities.

While other more complex methods are available, it is recommended that the rational method be used to estimate the peak flow rate for feedlot drains. This is a relatively simple method which is widely used in the field of water engineering.

The formula for the rational method is given by:

$$Q = \frac{C \times I \times A}{360}$$

where:

Q = peak flow rate (m^3/s)
C = runoff coefficient
I = rainfall intensity of 20-year ARI design storm (mm/hr)
A = catchment area (ha)

Some suggested ranges for the runoff coefficient, *C*, in the rational method (and which are applicable to the expected range of rainfall intensities for a feedlot catchment), are given in Table A.1. The first four catchment types apply to areas upslope of diversion banks and drains (i.e. outside of the controlled drainage area). The lower values for each of these four catchment types should be applied to low-relief catchments that are dominated by overland flow or contour drains, and to catchments having deep sandy soils with high infiltration rates. The higher values for each of the catchment types should be applied to high-relief terrain that has well-defined watercourses, minimal surface storage, and rocky, clayey or other poorly absorbent soil; and/or catchments with scant ground cover. Intermediate values should be applied where intermediate conditions exist. A value of 0.8 can be applied to most feedlot complexes where there are only small areas of grass or other vegetation in the catchment.

Table A.1 Suggested ranges for the value of the runoff coefficient in the Rational Method formula (adapted from Cordery, 2001)

Catchment type	Range
Forest	0.1–0.6
Pasture/grassland	0.1–0.6
Cultivation	0.3–0.8
Roads	0.9
Residential/industrial	0.4–0.8
Feedlot complex	≥0.8

The diversion and catch drains in feedlots usually have either trapezoidal or vee-shaped cross-sections.

These two cross-sectional designs are illustrated in the figures below where:

d	= flow depth (m)
W	= drain bed width (m)
z_1 and z_2	= drain batters (1 vertical to z horizontal)

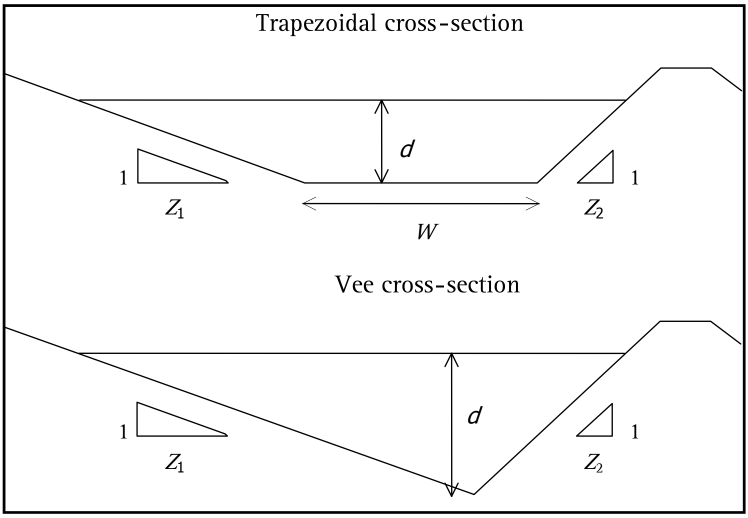


Figure A.2 Typical profiles of feedlot drains

The empirical Manning formula can be used to estimate flow rates and velocities in drains. This formula can be expressed as:

$$\bar{U} = \frac{R^{2/3} \times S^{1/2}}{n}$$

or

$$Q = \frac{A^{5/3} \times S^{1/2}}{P^{2/3} \times n}$$

where:

$\bar{U}$ = mean flow velocity (m/s) in drain
R = hydraulic radius (m)
S = drain bed slope (m/m)
n = Manning roughness coefficient
Q = flow rate (m^3/s)
A = cross-sectional area of flow (m^2)
P = wetted perimeter (m)

Some suggested values for the Manning roughness coefficient are given in Table A.2.

Table A.2. Values for Manning roughness coefficient n (source O'Loughlin & Robinson, 2001)

Surface type	Value range
Concrete box sections	0.011–0.012
Concrete lined (smooth)	0.012–0.015
Concrete lined (rough)	0.013–0.018
Rip-rap lined	0.025–0.030
Gravel lined	0.020–0.030
Earthen (bare)	0.018–0.025
Poorly grassed earthen	0.025–0.035
Short grassed earthen	0.030–0.035
Long grass earthen	0.035–0.050

The hydraulic radius (R) of the flow in a drain is given by:

$$R = \frac{A}{P}$$

The cross-sectional area (A) of the flow in a drain can be determined using the equation given by:

$$A = W \times d + d^2 \times \frac{(z_1 + z_2)}{2}$$

Similarly, the wetted perimeter (P) can be determined using an equation given by:

$$P = W + d \times \left[(1 + z_1^2)^{0.5} + (1 + z_2^2)^{0.5}\right]$$

In V-drains, the value for the drain bed width (W) in the above equations is zero.

The required flow velocities can be calculated from the above equations using:

- the 20-year ARI design storm flow rate (Q)
- various candidate values for channel depth and side batters (for either trapezoidal or vee drains).

The side batters on drains should in general be no steeper than 1:2.

Excessive flow velocities can cause scouring of drains, particularly of earthen drains. Some suggested maximum flow velocities in earthen channels, with various types of vegetative cover, are provided in Table A.3. Where soils are dispersive or easily eroded, values less than those shown should be adopted. However, as flow velocity values of less than 0.5 m/s are likely to result in excessive sedimentation in feedlot catch and main drains, readily-erodible soils should be either dressed with non-dispersive soils or lined (e.g. compacted gravel, concrete, or masonry).

Table A.3 Recommended maximum flow velocities in earthen channels

Soil cover	Flow velocity (m/s)
Couch and similar low-growing stoloniferous grasses	1.5
Mid-height, mat-forming grasses	1.4
Native and other culmiferous grasses	1.2
Lucerne	1.2
Annual weeds	0.8
Coarse gravel	1.3–1.8
Bare, consolidated, stiff sandy clay	1.3–1.5
Bare, consolidated, coarse sand	0.5–0.7
Bare, consolidated, fine sand	0.2–0.5

All feedlot drains and embankments should have a crest height, following post-construction consolidation, at least 0.15 m above the design flow depth in a 20-year ARI design storm. To accommodate this freeboard, and to allow for variations in embankment height, soil type and construction method, it may be advisable to build embankments 25–40% higher than the estimated requirement. In catch drains, the freeboard may be provided within the adjoining cattle lane or pen. In this situation, it may not be necessary to allow for settling due to soil compaction during construction.

Alternative design methods

Any alternative methods used for drain design should be in accordance with approaches recommended in Pilgrim (2001).

Performance indicators

Satisfactory performance occurs when:

- drains have sufficient capacity so that they do not overtop in 'normal' circumstances
- feedlot catch drain and main drain performance is not impeded by excessive sedimentation or tall vegetation
- significant scouring of drains does not occur (within design limits)
- vegetated waterways are kept mown or lightly grazed.

Monitoring requirements

- Visual monitoring of sediment depth and vegetation height.
- Visual monitoring of scouring and damage to liners during cleaning operations.
- Quarterly inspections of embankments, with particular note of any potential structural problems (e.g. cracking or slumping of banks and batters) that might affect the integrity of the structure – noting the date of inspections and any significant outcomes of that inspection.
- Records to be kept of the date of cleaning operations and of any repairs and maintenance.

Sedimentation system

Design concept

A substantial quantity of organic matter may be carried in stormwater runoff from feedlot pens, especially during high-intensity rainfall. This organic matter is mainly derived from the manure on the surface of the feedlot pens. If all the solids contained in the runoff were to enter the feedlot holding pond, highly undesirable effects would include:

- rapid siltation of the holding pond, possibly causing the pond to overtop at an unacceptable frequency
- excessive loads of organic matter entering the holding pond resulting in higher odour emissions over a longer period.

To avoid these effects, as much as possible of the entrained solids should be settled out before the runoff enters the holding pond. Settling is normally achieved by using some form of sedimentation system (different local terminologies may be used) to reduce the flow rate of the runoff to the point where the entrained solids can settle out. The best results come by reducing the flow velocity as close as possible to the point where the main drain enters the sedimentation system. This may require a specially designed energy-dissipating inlet structure or drop structure.

Under Australian conditions, Lott (1994) and Lott and Skerman (1995) showed that a flow velocity of 0.005 m/s could settle out more than 50% of settleable solids in feedlot runoff. Flow velocities much lower than 0.005 m/s gave only marginal improvements in settling efficiency, and could not be justified.

Sedimentation systems currently used in Australia feedlots are:

- terraces
- basins
- ponds.

Sedimentation terraces are typically long shallow free-draining structures. They are often used in small feedlots located on gently sloping terrain, or in series in larger feedlots located on very flat sites where the limited slope precludes the construction of 'normal' sedimentation basins. After a rainfall event, sediment is deposited in a sedimentation terrace in a relatively thin layer which dries rapidly and can be removed soon after any inflow.

Sedimentation basins are wider, shorter and deeper than terraces, but are still relatively shallow free-draining structures. The maximum depth at the design flow rate should be one metre or less. As with terraces, settled solids should be deposited as a relatively thin layer which dries rapidly. Drying should be rapid enough to allow settled material to be removed within days (rather than weeks or months) of a major inflow event.

Sedimentation ponds are designed not to be free draining. They are usually deeper, shorter and wider than basins, and are intended to store settled solids for lengthy periods (e.g. 3–5 years) before cleaning. To accommodate such infrequent cleaning, ponds are normally substantially deeper than one metre. Ponds may not dry out between rainfall events and thus may generate more odour than basins or terraces. The use of sedimentation ponds should be restricted to feedlots remote from sensitive receptors.

Control weirs should be fitted to all sedimentation terraces, basins and ponds to control discharge.

To minimise the risk of groundwater pollution, the sedimentation system should be fitted with a clay or durable synthetic liner. Although clay liners should be thick so they are not damaged in cleaning operations, they may have to be repaired from time-to-time due to normal wear and tear.

Design standard

- Sedimentation systems should be designed to cater for the peak flow from a design storm having an ARI of 20 years, when applying runoff coefficients of:
  - 0.8 for pens, manure stockpiles or composting pads
  - 0.8 for roadways, drains and other 'hard surfaces'
  - 0.4 for grassed or vegetated areas and other 'soft' areas.
- The maximum flow velocity in the sedimentation system is 0.005 m/s.
- Flow from the sedimentation system should be regulated by a control weir.
- A minimum freeboard of 0.9 m should be provided between the weir crest and the crest of the sedimentation system embankment. The control weir should be capable of discharging the peak flow from a 50-year ARI design storm without the system embankment overtopping.
- Sedimentation basins and terraces should be free-draining down to bed level, and have a bed slope of at least 0.1% towards the control weir to facilitate that drainage.
- The sedimentation system should be underlain by at least 300 mm clay or other suitable compactable soil or by a synthetic liner able to provide a design permeability of $<1 \times 10^{-9}$ m/s (~0.1 mm/d).

An acceptable design method

The required volumetric design capacity of the sedimentation system can be determined using the following formula:

$$V_p = Q_p \times L/W \times \frac{\lambda}{v}$$

where:
Vp = required sedimentation system volumes (m^3)
Qp = peak flow rate (m^3/s) for a 20-year ARI design storm[6]
L/W = length to width or aspect ratio of the system (refer Table A.4)
λ = a scaling factor (refer Table A.4)
v = design flow velocity (m/s)
= 0.005 m/s or less

The normal range of values for the aspect ratio (*L*/*W*) and scaling factor (λ) are provided in Table A.4. The aspect ratios provided are typical values. Values outside of the ranges shown may require more detailed hydrological design being provided to regulatory authorities to demonstrate that they comply with the design criteria. The scaling factors are based on cleaning frequencies that might be expected for each type of sedimentation system. For sedimentation terraces and basins, the deposited material should be cleaned out as soon as possible after a significant amount of material has been deposited in the system. Cleaning frequencies in sedimentation ponds should be such that built-up sludge never approaches the full storage level.

Table A.4 Typical values for the aspect ratio and scaling factors for various types of sedimentation systems

Sedimentation system	L/W	λ
Terrace	8–10	1.0
Basin	2–3	2.5
Pond	2–3	6.0

Alternative design methods

Where alternative sedimentation system designs are proposed, the performance of the design and system configuration may be established using the method described by Lott and Skerman (1995).

Performance indicators

Satisfactory performance is indicated when:

- holding ponds[7] require desludging only every few years (assuming desludging occurs when sludge takes up a maximum 10% of the design capacity of the pond)
- sedimentation terraces and basins drain freely after inflow events (i.e. within days in warm dry weather)
- sedimentation terraces and basins are cleaned of solids as soon as practicable after significant build-up of material occurs.

Sedimentation ponds should be cleaned of solids before sludge takes up 60% of the total design capacity of the pond.

Monitoring requirements

- Visual monitoring of sediment depth in terraces and basins following rainfall events to determine the depth of deposited material and the rapidity with which it dries.

[6] Qp is calculated using the same formulae as used for the drain calculations, except when the catchment involved is all of the controlled drainage area upstream of the sedimentation system weir.

[7] Build up of sludge in holding ponds is indicative of compromised performance in the sedimentation system.

- Visual monitoring of damage to, and condition of, the lining material during cleaning operations.
- Quarterly inspection of sedimentation system embankments with particular note of any potential structural problems (e.g. cracking or slumping) that might affect the integrity of the structure—noting the date of inspections and any significant outcomes of that inspection.
- Records to be kept of dates of cleaning operations and of any repairs and maintenance.

Holding ponds

Design concept

Stormwater runoff from the controlled-drainage area of a feedlot is normally characterised by high concentrations of organic matter. Even though it has passed through a sedimentation system, it still contains substantial levels of organic matter, nutrients and salts. This runoff should not be allowed to flow, uncontrolled, into the external environment.

Feedlot holding ponds are intended to store stormwater runoff until the captured wastewater is either:

- applied to cropland, or
- evaporated.

The storage capacity of the holding pond needs to be large enough that it can safely store the captured wastewater, without spilling at an unacceptable frequency.

The frequency criteria generally applied to feedlot holding ponds are:

- for a holding pond from which wastewater is routinely removed for land application, the spill frequency should not exceed an average of one spill in 10 years (i.e. notionally able to retain runoff in a 90th percentile wet year)
- for a holding pond where evaporation is the sole means of wastewater abstraction, the spill frequency should not exceed an average of one spill in 20 years (i.e. notionally able to retain runoff in a 95th percentile wet year).

The application of holding pond effluent to land, where it is sustainably utilised by crops and soil, is generally the preferred form of feedlot wastewater management. Sometimes (e.g. in arid areas, without access to other irrigation water and where cropping is not sustainable), evaporation of the captured runoff is acceptable; however, it will still be necessary to show the regulatory authorities that the saline residue remaining after evaporation can be safely utilised or disposed of.

Capture of runoff in holding ponds allows the microbial degradation of much of the organic matter that remains after the sedimentation system. Due to the substantial 'slug' loads these periodic inflows provide, this biological degradation is almost entirely anaerobic. Where the design volume of a holding pond has been determined on the basis of a small-catchment hydrological balance, and some form of sedimentation system is also in place, the inflows from even major storm events should produce acceptable levels of odour emissions (Casey et al., 1997). Thus, more elaborate wastewater treatment would not appear warranted.

Because of solids in the runoff entering the holding pond and the substantial biological activity in the pond, sludge will progressively build up. This sludge consists mainly of salts with low solubility, microbiological detritus and heavier components of the influent organic matter. This material will have to be removed before it fills too much of the capacity of the holding pond. Because of the variability in rainfall, cleaning intervals for holding ponds cannot generally be specified, but should be in the order of years, rather than months. Nevertheless, it is advisable to clean the pond whenever it is dry – even if the volume of sludge is relatively small.

To avoid contamination of groundwater, the holding pond should be lined with clay or a durable, low-permeability synthetic liner to minimise seepage. Clay liners should be a minimum of 300 mm thick and placed to ensure they are not damaged in desludging operations. Similarly, synthetic liners should not be damaged by desludging operations. Where the liner has been damaged, it should be repaired promptly or replaced at the completion of cleaning operations, and before there is another inflow.

Design standard

- Holding ponds should have sufficient storage capacity so that:
  - Normal holding ponds (i.e. those from which wastewater is routinely extracted for land application) spill no more frequently than an average of one in 10 years.
  - Evaporation ponds (i.e. those from which there is normally no land application of captured wastewater) spill no more frequently than an average of one in 20 years.
- The holding pond should have a weir and bywash capable of discharging the peak flow from the controlled drainage area from a 50-year ARI design storm.
- A minimum freeboard of at least 0.9 m should be provided between the crest of the discharge weir and the crest of the holding pond embankment.
- The holding pond should be underlain by a minimum of 300 mm clay or other suitable compactable soil, or by a synthetic liner able to provide a design permeability of $<1 \times 10^{-9}$ m/s (~0.1 mm/d).

An acceptable design method

Daily-step hydrological modelling of the controlled drainage area and holding pond should be used to establish that the proposed holding pond would spill less frequently than an average of one in 10 years (or one in 20 years in the case of an evaporation pond). The meteorological data set used should be representative of the site[8], and cover a period of at least 100 years (i.e. a data set covering ≥36,524 days).

[8] SILO Data Drill interpolated datasets (http://www.longpaddock.qld.gov.au/silo/datadrill) are available for any centre in Australia, and excepting very remote sites, should provide acceptably reliable daily climate data for these computations.

A number of small catchment hydrology models are commonly used in the design of a feedlot. Provided these models are known to regulatory authorities, or sufficient information can be provided on the computations and assumptions (along with data files), these models should generally be acceptable to regulatory authorities.

Alternatively, the relatively simple (but still robust) United States Department of Agriculture Soil Conservation Service (USDA SCS) rainfall runoff model (Mockus, 1964 and Mockus, 1968) can be used to estimate runoff from the controlled-drainage area. The basis of the Rainfall Runoff Model is an equation:

$$R = \frac{P - 5 \times \left[\left(\frac{1000}{K} - 10\right)\right]^2}{P + 20 \times \left(\frac{1000}{K} - 10\right)}$$

where:

R = runoff (mm)

P = precipitation (mm)

K = a catchment index (or curve number) representative of the soil-cover complex in the catchment

Different values of the catchment index, K_1, K_2 and K_3, are applied to represent respectively very dry, normal, or very wet soil/manure moisture conditions. The K values typically applicable to feedlot catchments are shown in Table A.5. The model will also require input of the period of the year when the soil-cover complex is dormant. Values for the pen and hard catchment areas in the controlled drainage area do not change throughout the year (i.e. they are not affected by the dormancy factor). Soft catchment areas might be considered dormant in winter in northern Australia and summer in southern Australia (and possibly mid-winter as well, depending on the locality).

Table A.5. Suggested values for K_1, K_2 and K_3 in the USDA rainfall runoff model (source Skerman, 2000)

Catchment	K_1	K_2	K_3
Pens	92	93	95
Hard catchment	96	96	96
Soft catchment	57	75	88

These runoff calculations should be applied in a water balance for the holding pond that accounts for the following:

- evaporative losses
- seepage losses
- any extractions made for the land application of wastewater
- the pond capacity used in storing sludge.

Modelled wastewater applications should be based on correcting the soil moisture deficit and meeting plant nutrient needs based on their stage of growth. Assumptions made about the timing of applications (e.g. application made only in fine weather in the 'x' weeks before seasonal cropping) should be explicitly stated. In addition, reasonable expectations of cropping activity and the yields in that location should be used (i.e. the modelled wastewater applications must realistically reflect expected management practices).

The holding pond water balance will typically have to be run through a number of times to determine a pond capacity that notionally spills at the required frequency (i.e. no more often than an average of one in 10 years for a 'normal' holding pond and one in 20 years for an evaporation pond). Once a pond has 'spilled' in this type of modelling, the likelihood of another modelled spill occurring within the next few days is quite high; thus, modelled spill events within 30 days of one another should be treated as a single spill for the purpose of these model calculations. In practice, it is more likely that a feedlot manager would be able to intervene in these circumstances, and possibly avert secondary spills.

An allowance of at least an additional 10% of pond storage capacity should be made to accommodate sludge that will progressively build up in the pond.

Design storm methods

Historically, feedlot holding ponds were designed on the basis of a major storm event (e.g. able to contain runoff from a 20-year ARI 24-hour design storm). *The 24-hour design storm* represents the largest amount of rainfall expected over a 24-hour period. The rate is the basis for planning and designing stormwater management facilities and features.

The intent of this approach was that the designed holding pond should spill only at a frequency less than one in 10 years (not necessarily only one in 20 years). However in practice, spills from holding ponds designed on this basis were found to occur at a frequency much greater than an average of one in 10 years. On analysis, it was found these spills followed a series of closely spaced, but relatively unexceptional, rainfall events rather than one major or exceptional storm. The design storm method was failing to account for the cumulative impact of a series of wet weather events (such as might be experienced in a wetter-than-average season). In most Australian states, the design storm approach is no longer considered acceptable, and alternative design methods should be adopted.

Alternative design methods

State agencies regulating feedlot development may also nominate other acceptable methods, such as the standard tabulated method used in Queensland. However, many of the methods that do not use site-specific daily-step hydrological modelling are better suited to smaller developments. Larger feedlots, or those located in sensitive sites, will generally need to undertake more robust modelling approaches.

Performance indicators

The following indicate satisfactory performance:

- Spill frequency does not exceed an average of one in 10 years for ponds from which effluent is taken for land application, and one in 20 years for ponds which rely solely on evaporative loss to control water volumes.
- Biological activity in the ponds should provide for:
  - rapid stabilisation of the pond contents following a significant inflow
  - odour emissions remaining within acceptable limits.
- Local groundwater quality should not be affected by seepage from the holding pond.
- No catastrophic failure of pond embankments.

Monitoring requirements

- Record and report any pond spills (including details of antecedent weather conditions, and any relevant management actions).
- Sample and analyse surface water upstream and downstream where spill material enters any stream or watercourse.
- Record any desludging, cleaning and maintenance operations.
- Monitor water quality in any groundwater bores or installed piezometers[9].
- Quarterly inspections of embankments, with particular note of any potential structural problems (e.g. cracking or slumping of banks and batters) that might affect the integrity of the structure – noting the date of inspections and any significant outcomes of that inspection).

[9] In some locations in some states it may be a requirement of any development consent or feedlot licence that piezometers be installed for this purpose.

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Appendix B. – Separation distance guidelines

Preamble

The use of appropriate separation or buffer distances is a well-established and widely recognised means of mitigating the impacts on community amenity that arise from odour, dust, noise and other fugitive emissions[1] from beef cattle feedlots.

A fundamental principle applied in determining the separation distances applicable to fugitive emissions is that they tend to radiate out from a source, and be diluted. This applies particularly to the major airborne emissions from feedlots. Averaged over the longer term (e.g. a year or more), during which winds will to some extent blow from all directions, the concentration of an emission arriving at a receptor will broadly be a function of the inverse square law. That is, the dilution or dispersion will be proportional to the square of the distance between the receptor and the source.

Intuitively, emission rates, and hence the required separation distances, would be expected to have a direct relationship with the scale of the activity (i.e. the number and type of feedlot cattle on hand). However, the inverse square law requires some additional modification to account for site-to-site and time-to-time variations in the following factors:

- feedlot design and management (in particular manure management)
- climatic and meteorological conditions
- the vegetation cover and topography of the intervening terrain (i.e. the aerodynamic or surface roughness)
- the risk of downslope or katabatic drainage.

The specific response of individuals to these emissions, or even the same individual in a different environmental context, is highly variable. Individuals differ in their 'sensitivity' to aesthetic impacts, and that sensitivity often depends on the context. For example, the sensitivities of occupiers of a dwelling on a farming property or in a rural residential development might differ markedly from those of the occupiers of a house in an urban environment. An individual from an urban environment does not generally have the same day-to-day exposure to the range of odours or noises characteristic of rural environments. These individuals are therefore more likely to be sensitive to what to them are alien or unfamiliar odours, noises and dust levels. This reaction is similar to the increased sensitivity of rural residents to distinctly urban levels of noise, traffic or odour. To address this variability in sensitivity, a probabilistic factor can be incorporated into separation distance calculations to account for the size and likely sensitivity of the exposed population[2]. Hence the value applicable in determining the separation distance from a rural dwelling with two or three occupants would be different from that applied to a large urban area with thousands of residents.

[1] Fugitive emissions are diffuse emissions that do not arise from point sources, such as vents, stacks, ducts and exhausts. Fugitive emissions originate from a very wide range of activities; not just those in feedlots. They typically arise from evaporation or volatilisation, windblown or mechanical disturbances, equipment leaks and noisy activities. It is considered impractical or impossible to capture or contain such emissions – hence these emissions are termed fugitive.

[2] The larger the population, the more likely that particularly sensitive individuals will be present.

In both the preceding and following discussion, no clear distinction has been made between the rates of dilution of the various forms of fugitive emissions from beef cattle feedlots. Separation distances have traditionally been applied to address feedlot odour impacts; however, these distances will typically be more than sufficient to mitigate noise, dust, and most other aesthetic impacts from a feedlot development. Both dilution and settling act jointly to progressively reduce airborne particulate concentrations more rapidly than any chemical degradation of odorous compounds.

Using the S-factor equation

The equation

The S-factor equation has been used in some Australian states to determine the minimum separation distances required between various types of receptors and a beef cattle feedlot development. A similar approach has been successfully applied to other forms of intensive animal housing, such as piggeries and poultry sheds, and to some forms of industrial development.

Regulatory agencies have found the S-factor approach generally produces conservative estimates that more than comply with the quantitative performance criteria set out in relevant environmental legislation, regulation and policy. There has been some validation of these outcomes for feedlots using the theoretically more robust approach of dispersion modelling.

The S-factor equation itself has the general form:

$$D = \sqrt{N} \times \mathrm{S} \qquad \text{or} \qquad D = N^{0.5} \times \mathrm{S}$$

where:

- D = required minimum separation distance (m)
- $\sqrt{}$ or $^{0.5}$ = square root
- N = feedlot capacity in standard cattle units (SCU)
- S = composite site factor

This equation states that the required minimum distance (D) is equivalent to the product of the square root of the feedlot capacity, in standard cattle units, and a site-specific composite factor, S.

The converse of the above S-factor equation is:

$$N = \left(\frac{D}{S}\right)^2$$

This form of the equation can be used to estimate the maximum number of standard cattle units (N stated in SCU) that might potentially be stocked on a site, given the available separation distance (D) and the applicable composite site factor (S). However, where this approach is used with a prospective view to taking up the maximum allowable capacity (subject to any necessary development consent), regulatory agencies and consent authorities can justifiably ask that the available distance be first formally verified by another independent and suitably qualified party, such as a registered surveyor.

The above equations are a simple variation of the inverse square law. The site-composite factor, S, is the variable that accounts for the site-to-site and time-to-time variations previously described.

The composite site factor

Site-to-site and time-to-time variations are addressed by way of a composite site factor, S, which is given by:

$$S = s_1 \times s_2 \times s_3 \times s_4 \times s_5$$

where: s_1 = design and management factor
s_2 = receptor type factor
s_3 = topography or terrain factor
s_4 = vegetative cover factor
s_5 S= wind direction factor

Explanatory notes and methods for determining values for the S factors (i.e. s_1, s_2, s_3, s_4 and s_5) are provided in the following section.

Component S-factor values

s_1 – Feedlot design and management factor

Odour emissions from feedlots are related to factors such as the depth of manure on the pen surface and its moisture content. These are, in turn, related to factors that include the climatic conditions at the site, pen cleaning frequency, and stocking density.

- In most states, feedlots have previously been subject to a four-tiered classification scheme (e.g. classes 1–4 or A–B). In future, all new or expanding feedlots will operate at the equivalent of a Class 1 or Class A standard (i.e. adopt best management practice). Thus, these guidelines provide only a single set of s_1 values. Previously, different s_1 values applied to different classes of feedlot.
- Pre-existing feedlot developments may have development consent, operational licences or similar legal instruments that allow these feedlots to operate at these superseded classes (i.e. 2–4 or B). These guidelines are not intended to directly affect the way those feedlots are managed, with the previous standards continuing to be applied to those developments until such time as their operational conditions or consents are formally changed.
- One criterion applicable under pre-existing Class 1 or Class A standards is that feedlot pens should be cleaned sufficiently often so that the depth of dry manure on the pen surface should not exceed 50 mm. Note: wet manure is considerably bulkier than dry manure so that it may be substantially deeper than 50 mm yet the feedlot must still comply with these guidelines. Measuring the exact depth of manure in a feedlot pen can be difficult (e.g. conditions can vary within and between pens; the manure surface may be uneven; and there may be a diffuse interface between the manure pack and the underlying pen surface). For practical purposes, the maximum pen cleaning interval that

provided the required maximum manure depth has traditionally been used as a substitute for actual manure depth measurements. These guidelines adopt a similar approach.

- The relevant maximum pen cleaning interval under this guideline is 13 weeks.
- For comparable odour emission rates, pens must be stocked at a lower density (i.e. greater m^2/SCU) in a wetter climate than in a drier one (with all other factors equal). Thus, s_1 values for specific stocking densities are provided for an average annual rainfall of either <750 mm or >750 mm. While separating into only two rainfall categories may appear broad, feedlots in Australia are rarely located in areas with an annual rainfall greater than 750 mm. In the wetter areas, rainfall will probably exceed evaporation for more of the time and this is more important than the amount of rain, and manure on the pen surface will be, on average, significantly wetter. Thus two rainfall classes have been found to provide a relatively reliable and easily quantified indicator of the net effect of climatic conditions.
- The applicable values for s_1 (rounded to the closest whole number), based on average annual rainfall and pen stocking density, are provided in Table B.1.

Table B.1. Values of S_1 as related to average annual rainfall and pen stocking density

	Average annual rainfall		
	<750mm	>750mm	S_1 value
Stocking density (m^2/SCU)	11	16	62
	12	17	60
	13	18	57
	14	19	55
	15	20	52
	16	21	50
	17	22	47
	18	23	45
	19	24	42
	20	25	40

These s_1 values assume compliance with the pen cleaning intervals mentioned above.

Stocking densities greater or less than those shown in the above table may not comply with the Code, and specialist advice should be sought before considering stocking densities outside of the ranges shown in the above table.

Specific s_1 values for stocking densities between the above values can be calculated by direct interpolation. For example, for a feedlot having a stocking density of 12 m²/SCU, and is located in an area experiencing less than 750 mm per year of rain, the following calculations would apply:

1. Reading the s_1 values for tabulated stocking density values:

$$10\ m^2/SCU = 65$$
$$15\ m^2/SCU = 52$$

2. Thus the s_1 values decrease by 13 units between 10 and 15 m²/SCU or 2.6 units/m²/SCU. Consequently, the applicable s_1 value can be determined as:

$$\begin{aligned} s_1@12\ m^2/SCU &= 65 - (2 \times 2.6) \\ &= 59.8 \\ &\approx 60 \end{aligned}$$

Or, in one operation:

$$\begin{aligned} s_1@12\ m^2/SCU &= 65 + \frac{(65 - 52)}{(10 - 15)} \times (12 - 10) \\ &= 59.8 \\ &\approx 60 \end{aligned}$$

s_2 – Receptor factor

The s_2 values used in separation distance calculations assume that sensitivity to odour will vary in the population (i.e. not all people will be offended by the same odour). The greater the exposed population, the more likely it is that 'sensitive' individuals might be exposed to nuisance odour. Thus the s_2 value for a large population centre (and the minimum separation distance) is greater than that for a single farm dwelling (Table B.2).

Table B.2 Values of s_2 applicable to population centres

Receptor type	s_2 value
Large town (>2,000 persons)	1.6
Medium town (>500–2,000 persons)	1.2
Medium town (>125–500 persons)	1.1
Small town (>30–125 persons)	1.0
Small town (>10–30 persons)	0.6
Rural residential development (<1 ha lots)	1.0
Rural residential development (>1 ha lots)	0.7
Single rural or farm dwelling	0.3
Rural school (not located in a town)	0.3
Rural church or hall (not located in a town)	0.2
Low-use public area	0.05

- s_2 values greater than 0.05 would apply to high-use or high-value public areas, even though these are located in rural areas (e.g. a frequently visited national park . Where high-use or high-value sites exist, the responsible regulatory authorities should be consulted early in the planning process to determine an appropriate value.

s_3 – Terrain factor

The terrain is known to affect the spread and concentration of odours. A phenomenon known as katabatic drainage is one example; it typically occurs at night when rapidly cooling air near the ground becomes denser (and heavier), and slowly sinks. Where the local terrain slopes, this sinking results in the air draining down the slope (in much the same way as rainfall runoff) while tending to follow natural drainage lines.

Katabatic drainage will trap any odours emitted from ground level sources (e.g. manure on pen surface). Due to the low wind speeds and the stable atmospheric conditions that typically prevail at night (and are necessary for the required atmospheric cooling), there is limited mixing or dispersion of odour trapped in katabatic flows. Thus, nuisance odour might be encountered further from the source than would be the case under neutral or unstable daytime conditions.

Where odour is being emitted from a relatively large area (e.g. a feedlot), the convergence of katabatic flows into natural drainage lines can increase the distance required for dilution and dispersion to occur—the more confining the drainage line or valley, generally the further downstream the odour extends. Katabatic effects are generally more pronounced under clear conditions in winter when back-radiation and stable and shallow atmospheric boundary layers can readily form at ground level.

> The risk of katabatic drainage increases with slope since the speed of air movement (*u*) is directly proportional to the square root of the sine of the angle of the slope (a); expressed mathematically: $u \propto \sqrt{\sin a}$

Air speed is also inversely proportional to the surface roughness or turbulent drag of the terrain. As a result, katabatic drainage will tend to be more significant in steeper, relatively smooth terrain (e.g. the lower slopes of a treeless ridge) than in flatter, rougher terrain (e.g. a gently sloping, moderately wooded plain).

As katabatic drainage generally follows the natural drainage system, a receptor located lower than the feedlot, but not within the same subcatchment, would not normally be exposed to odour associated with katabatic flows. A receptor located upslope of a feedlot will not be affected by odour from katabatic drainage from a source downslope. Relatively rough terrain between a receptor and a downslope source of odour will reduce the likelihood of odour problems.

Where a receptor is located at a similar elevation to an odour source, the effects of katabatic drainage will be greatly reduced where they are separated by undulating terrain, e.g. a series of rolling hills and rises (Table B.3).

Table B.3 Values for s_3 applicable to various terrain conditions

Terrain description	s_3 value
Confining valley[1]	2.0
Katabatic drainage area – slope >2%[2]	1.2
Outside sub-catchment – downslope[3]	1.0
Flat terrain[4]	1.0
Undulating low-relief terrain[5]	0.9
High-relief terrain with receptor upslope[6]	0.7

Table B.3 notes:

[1] Applied to a receptor located in a confining valley, downslope of the site, which would be expected to be exposed to frequent katabatic drainage events (sometimes referred to as a 'valley drainage zone').

[2] Applies to a receptor located directly downslope of the site, where the falling grade between the nearest point of the feedlot complex and the receptor is >2% and there is an associated risk of katabatic drainage.

[3] Applies where the receptor is located downslope of the feedlot, but does not share the same sub-catchment (i.e. katabatic drainage from the feedlot does not drain through the site).

[4] Relief between the site and the receptor, and in their immediate environs, is slight (<10 m).

[5] Relief between the site and the receptor, and in their immediate environs, is moderate (10–90 m).

[6] The receptor is situated up-slope of the site, in moderate to high relief terrain (>90 m) such that the rising grade between the site and the highest intervening terrain feature is >10%.

n.b. The term 'relief' in the above notes is as defined in the *Australian Soil and Land Survey Field Handbook*, McDonald, R.C., Isbell, R.F., Speight, J.G., Walker, J. & Hopkins, M.S., (1998), CSIRO, Collingwood, Victoria.

s_4 – Vegetation factor

Vegetative cover is a major factor in the drag that the earth's surface exerts on air moving over it. Generally, the rougher the surface, the more turbulent the air flow, and the more mixing and dilution of the air. The drag exerted by vegetation is related to the height, shape and spacing of obstacles or 'roughness elements' (e.g. buildings and trees). While height is a major factor, maximum turbulence occurs when the surface is a mixture of various sized obstacles of various heights. Thus, the surface roughness of a typical eucalypt forest, where cover is not uniform and tree heights vary significantly, will be greater than that of a pine plantation or rainforest with their more uniform height and closed canopy (Table B.4).

Table B.4 Values for s_4 applicable to various forms of vegetative cover

Vegetation description	s_4 value
Crops only (no effective tree cover) [1]	1.0
Open grassland (few trees, long grass) [2]	0.9
Woodland	0.7
Open forest	0.6
Forest with significant mid and lower storey vegetation	0.5

Where variable upper storey vegetation exists between the feedlot site and the receptor, intermediate s_4 values can be broadly estimated using the regression equation:

$$S_4 = 0.307 \times e^{(1.47 - 0.07 \times \log H - 0.133 \times C^{0.5})}$$

where: H = average tree height (m)
C = % crown cover

Crown cover is the percentage of the intervening land area covered by the tree canopy. This can be readily estimated from good-quality aerial photography, satellite images or by reference to standardised examples in vegetation management guides.

Any value derived using the above equation should be checked to ensure it is within the expected range. Values that differ from the tabulated value suggest that crown cover and/or tree height have been incorrectly estimated.

Table B.4 notes:

[1] 'Crops only' implies annual field crops are sown on a seasonal basis and that the intervening land is bare for at least part of the year – isolated, scattered or small clumps of trees are not sufficient tree cover to provide for a higher value.

[2] Open grassland' applies to areas where there is a permanent cover of perennial pasture, having a height of around one metre, and with a sparse or scattered tree cover over the extent of the buffer area. Heavily grazed pasture, where the height of the vegetation is less than one metre, would not qualify for this s_4 value. Similarly, a few isolated clumps of vegetation would not qualify. In theses two cases, a value of 1.0 may be more appropriate.

s_5 – Wind direction factor

Wind direction has the potential to increase the exposure of a receptor located in the downwind path (Table B.5). While most Australian feedlot sites will have some form of prevailing wind, it is unlikely that it will blow from that general direction (±40° of the direct line) for most of the time (>60%).

Sites that experience a regionally-dominant wind are often located near the coast, or on very exposed sites (e.g. atop a mountain range), or at latitudes near the path of mid-latitude high pressure cells crossing the continent.

Locally-dominant wind directions can occur where sites are located in terrain that restricts the directions from which the wind blows (e.g. in a confining valley, or at the footslope of a major range). Care should be taken to ensure that dominant wind directions are not due primarily to katabatic effects, which should have been considered in the s_3 terrain factor. Dominant wind directions where wind speeds are less than 2–3 m/s are more likely due to katabatic effects.

Table B.5 Values for s_5 as affected by wind direction

Wind frequency	s_5 value
High frequency towards a receptor[1]	1.5
Normal wind conditions	1.0
Low frequency towards a receptor[2]	0.7

Table B.5. notes:

[1] A high frequency is classed as one where the wind is blowing directly towards and within ±40° of the centre-line between the centre of the feedlot and a receptor, for at least 60% of the time.

[2] A low frequency is classed as one where the wind is blowing directly towards and within ±40° of the centre-line between the centre of the feedlot and a receptor, for less than 5% of the time.

Cumulative effects

Where two cattle feedlots, or a cattle feedlot and some other intensive livestock facility such as a piggery, poultry shed or dairy feedlot are in close proximity, the likelihood of a cumulative impact must be considered in estimating required separation distances.

Scenarios include:

- Two intensive livestock feedlots are so close that it is necessary to treat them as if they were a single entity – that feedlot having a capacity equivalent to the combined capacities of the two facilities.
- Two intensive livestock facilities are not sufficiently close to be considered as a single facility, but are closer than 120% of their combined separation distances from the receptor.
- Situations where the two intensive livestock facilities are separated by more than 120% of their combined separation distances from the receptor.

These scenarios, and receptor configurations, are illustrated in Figure B.1, Figure B.2 and Figure B.3 respectively.

It should be noted that if Feedlot ‘a’ is the existing feedlot, then the separation distances required from that particular facility do not change (i.e. the altered requirements apply only to the new development).

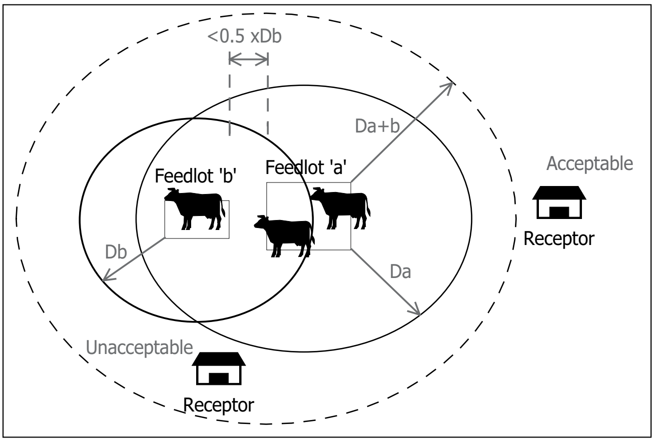

Figure B.1 Two feedlots treated as one – separation distances for single (combined) feedlot apply if two facilities are separated by less than half the shortest separation distance.

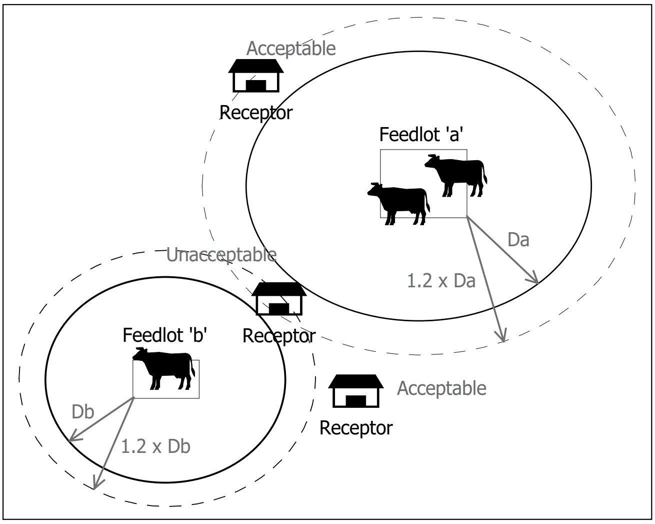

Figure B.2 The receptor is unacceptably located within the 120% overlap zone.

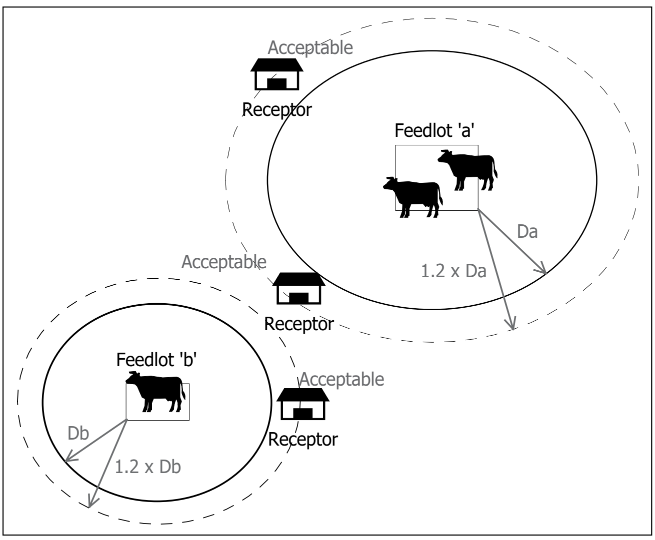

Figure B.3 Facilities separated by more than 120% of their combined separation distance – normal separation distances apply.

Report requirements

The following basic requirements indicate the information that regulatory agencies and consent authorities are likely to require when assessing a development application that uses the S-factor method to determine separation distances.

Feedlot design and management factor (s_1)

The following should be provided:

- A site plan showing the various parts of the feedlot complex that may be a source of significant odour such as:
  - feedlot pens
  - handling yards
  - drainage system
  - sedimentation system
  - holding pond
  - composting or manure stockpile pads.
- Details of the following:
  - feedlot capacity (SCU and head)
  - entry and exit weights
  - likely days on feed
  - average annual rainfall
  - stocking density
  - manure cleaning practices.
- Details of any exceptional mitigation measures that apply.

Receptor details (s_2)

The following should be provided:

- A list of the nearest potential receptors in each direction considering the likely separation distance.
- Estimates of the number of persons residing in dwellings or urban areas, or using non-residential receptors and the times that non-residential receptors are used.
- A scaled plan or plans capable of verifying the distance of each receptor from the feedlot complex.

Terrain factor (s_3) and vegetation factor (s_4)

The following should be provided:

- Description of the local terrain, including topographic features, slopes and drainage patterns – where this varies for individual receptors this should be noted and explained.

- Description of the local land use and vegetation, in particular areas of remnant vegetation, state forest, national park, vegetative buffers subject to covenants, or other vegetation that might reasonably be considered a permanent feature for the life of the feedlot (i.e. 30 years).
- Aerial photographs, satellite images, topographic maps and/or vegetation maps with a resolution sufficient to verify the general nature of land separating the feedlot from the receptors.

Calculation of separation distance

The results of separation distance calculations should be provided, listing the distance from each of the identified receptors.

Odour dispersion modelling

In some circumstances (e.g. large feedlot developments or developments on complex sites), odour dispersion modelling may be required to support an application for a new or expanding feedlot. The modelling process utilises realistic odour emission data and site-specific climatic data to determine the probability of a particular odour level being exceeded at nearby receptors. Specialised consultants are usually employed to undertake this work.

Weather stations

Many feedlots have installed on-site weather stations to measure and record climatic data such as temperature, humidity, wind direction and wind speed. This data is helpful in the day-to-day operation of the feedlot, and may also be valuable for the investigation and verification of any complaints received from nearby receptors regarding odour and dust. Reference to wind data recorded at the time of detection of the odour or dust may enable the feedlot operator to demonstrate that the feedlot was unlikely to have been the source of the problem. This data can also help in identifying management practices that may have contributed to the complaint; modifying these practices may assist the feedlot to avoid future complaints.

Bibliography

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Appendix C. – Clay lining of feedlot pens, pads and drainage system

Preamble

Runoff from the feedlot pad contains organic and mineralised manure constituents that could pose a significant ecological hazard if they were released, uncontrolled, into the environment.

If a groundwater assessment indicates a high potential for contamination of underground water resources because of leaching of nutrients through permeable, underlying soil or rock strata, an impermeable barrier will be needed between the contaminant and the groundwater. This is required if the permeability of underlying soil/rock strata exceeds 0.1mm/day (3.5 cm/year).

This impermeable barrier is generally created using a liner made of compacted clay or other suitable compactable soil materials. Where these materials are not available, a synthetic liner (polymembrane) may be used. Synthetic liners tend to be expensive, require specialist installation and are hard to protect from damage by cattle and cleaning equipment. Clay liners tend to be the most common form employed in feedlot construction, and the following section outlines the characteristics of suitable clay lining material.

Design standard

- Clay liners should have a maximum permeability of 1×10^{-9} m/s (0.1mm/day) for distilled water with 1 m of pressure head.
- Clay liners must be of sufficient depth so that the integrity of the structure is maintained throughout the general working of the feedlot.

Clay liners

Clay liners are commonly used in industry for a range of contaminants including liquid effluent.

For a given soil, permeability is related to soil particle composition, moisture content and level of compaction; and there are limits to the permeability that can be achieved at any level of compaction. *In-situ* and laboratory measurement of permeability is difficult, and relatively inaccurate. Also, some soil types, because of their physical and chemical properties, are impermeable *in-situ*, but fail to meet the design standard when measured in the laboratory.

For these reasons, rather than relying on permeability standards, this section provides guidance on specifications for materials and construction methods to be used for clay lining.

The specifications in Table C.1 provide guidance on the selection of the correct materials for use in the liner. Soils may need to be mixed or engineered to produce a material that meets the specifications.

Table C.1 Specifications for clay liner materials

Soil characteristic	Acceptability criterion	Test method
Percentage fines	More than 25% passing 75 µm sieve More than 15% passing 2 µm sieve	AS 1289 3.6
Liquid Limit	Less than 70	AS 1289 3.1.2
Plasticity Index	More than 15	AS 1289 3.3.1
Emerson class number	5 to 6	AS 1289 3.8.1

Areas to be clay lined within the controlled drainage area include:

- effluent catch drain
- sedimentation system
- holding ponds
- manure stockpile and composting pad
- any area where contaminants are stored or handled.

Because of the formation of a low permeability soil-manure interface layer, clay lining is not generally required on the feedlot pen and yard areas.

Trafficability of clay lined materials

The liner should be trafficable for cattle and equipment. To ensure that the integrity of the liner is maintained, the depth of the liner should be sufficient to ensure that equipment does not damage it during harvesting of manure. The minimum depth recommended for the clay liner is 300 mm after compaction. Periodic repair of the liner will be necessary due to the wear and tear associated with cattle traffic and normal cleaning operations.

The mechanical strength of liners can be tested using the Californian Bearing Ratio (CBR) test, which was developed for measuring the load-bearing capacity of soils used for building roads. The test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area in both the saturated and dry conditions at a specified compaction. The minimum standard for CBR wet and dry is 20%.

Particular attention should be applied to the load-bearing capability of areas where cleaning or harvesting of dry waste is undertaken, including:

- feedlot pens
- effluent catch drain
- sedimentation system
- manure stockpile and composting pad.

Construction

All areas to be clay lined should be cleared and grubbed, stripped of top soil and prepared to the required levels and gradients by cutting and filling. The surface of the excavated area should also be tined before the clay material is placed to produce a satisfactory bonding surface.

The clay lining material should be placed in layers of 150 mm (±50 mm). Each layer should be tined, wetted to ±2% of optimum moisture content (AS 1289 5.1.1) and compacted to the required compaction (relative to the maximum dry density, AS 1289 5.4.2) that is needed to achieve the required permeability of 1mm/day.

Appendix D. – Manure and carcass composting

Preamble

Composting is the microbiological breakdown of organic matter into partly decomposed residues called compost or humus. These residues are slowly broken down to form simple inorganic compounds (e.g. carbon dioxide, nitrate, potassium, sulphates). Because they break down slowly, these residues contribute significantly to the store of organic carbon in the soil. Increasing the levels of soil organic carbon improves soil structure, water holding capacity and fertility.

Composting is a natural process where ever there is a substantial build up of organic matter (e.g. the floor of a rainforest or in a swamp). In feedlots, the manure scraped from the pens and the carcasses of any animals that die are both suitable for composting, although they require different management.

Composting

Aerobic and anaerobic composting

Composting in the absence of oxygen is anaerobic composting. While anaerobic composting is effective, it tends to produce odorous emissions. Stockpiling manure will most likely result in anaerobic composting but, if unmanaged, is not likely to be an efficient process.

Composting in the presence of oxygen is aerobic composting. The benefits of aerobic composting include:

- minimal odour emissions
- carbon dioxide (CO_2) is emitted instead of methane (CH_4)[1]
- aerobic composting is exothermic[2].

If aerobic composting is properly managed, the amount of heat generated should be sufficient to reduce the viability of any pathogens and weed seeds which may be present in the raw material.

While composting can reduce the presence of some harmful constituents, it should be noted that:

- composting is not 100% effective in eliminating pathogens and seeds
- harmful inorganic metals and their compounds are not affected by composting
- strong acids and alkalis are not removed and are likely to impede composting
- composting can produce small amounts of some plant and animal toxins—although this is more likely in poorly managed systems.

[1] Not only is CO_2 a less potent greenhouse gas than CH_4, these CO_2 emissions should have no net effect on greenhouse gas levels since the total amount of CO_2 that might be generated would be equivalent to the amount of CO_2 originally assimilated from the atmosphere in producing the organic matter that is now being biodegraded.

[2] Produces heat.

Feeding the microbes

In addition to a feedstuff (i.e. the carbon in organic matter), composting organisms require adequate quantities of the nutrients essential for their growth (such as nitrogen, phosphorus and sulphur). The adequacy of the nutrient supply can best be judged by the ratio between the amount of carbon and the amount of each nutrient. As nitrogen is likely to be the limiting nutrient when composting feedlot manure, the carbon to nitrogen (C:N) ratio typically becomes the critical constraint.

When the C:N ratio is too low (less than 15:1), the microbial activity may rapidly deplete available oxygen and increase the temperature of the compost to levels lethal for aerobic microorganisms. The compost pile may then become anoxic or anaerobic resulting in odorous emissions and excessive nitrogen loss. Under aerobic conditions, nitrogen in the organic matter is broken down into ammonia (NH_3) which can rapidly volatilise from the pile.

When the C:N ratio is too high (>30:1), the composting microbes will be effectively starved of nitrogen. The curing process will then be extremely slow resulting in insufficient space on the composting pad.

An acceptable range of C:N ratios is between 15:1 and 25:1.

The C:N ratio of feedlot manure varies with factors such as the frequency of pen cleaning, feedlot rations and weather conditions. In older, weathered manure, the ratio is often lower than desirable, and additional carbon (as sawdust, wood shavings or waste paper) may have to be added before composting. Depending on the timber species, the carbon to nitrogen ratio in sawdust and wood shavings can range from 200:1 to 500:1. Once the C:N ratio of the raw manure and the sawdust are known[3], they can be blended so that the C:N ratio of the mix falls within the acceptable range.

The C:N ratio of carcasses is quite low, and a source of extra carbon has to be provided for successful carcass composting. Sawdust, wood shavings and poor quality pasture hay or crop stubble[4] are suitable.

Aeration

Aerobic microorganisms need access to a ready supply of oxygen. Ideally, the air within the compost should contain more than 5% oxygen (normal air has 21% oxygen). Sufficient oxygen can be provided by:

- forcing air into the material under pressure
- mechanically mixing the compost on a regular basis to keep it porous and allow oxygen to permeate naturally into the material.

[3] Such tests are readily undertaken by analytical laboratories.

[4] Hay and stubble are suitable for manure composting, but their cost would generally preclude their use. Good-quality lucerne hay is too high in nitrogen, but low-protein weather-damaged lucerne hay may be suitable.

In feedlot manure, the necessary aeration is commonly achieved using either:

- machine-turned windrows, or
- aerated static piles (not common in Australia).

Machine-turned windrows involve placing the manure in long thin rows (or windrows) which are regularly turned using a windrow turner which may be simple or complex tractor-mounted or self-propelled. The height, width and profile of the windrow will depend on the windrow turner used, but a windrow that is too high will cause excessive compaction of material towards the base of the pile.

Carcasses for composting should be placed in purpose-built bays, bunks or in a low pile. They should be placed on at least 300 mm of the material being used as a carbon source, and covered with the same material to a similar depth on all sides. The carcass composting area should be protected from scavenging animals and livestock. A front-end loader is typically used for turning carcass compost. Turning will be necessary every two to three months.

Compost that is too wet excludes air, making it anaerobic. To prevent this, windrows and piles should be shaped and orientated so that rainfall is readily shed, and runoff rapidly drains away. This requires the long axis of the windrows being down the slope of the composting pad.

Moisture content

Aerobic microbiological activity is sensitive to moisture content—too little and biological activity slows, too much and the compost may become anaerobic.

Since the composting process is exothermic, heat generated quickly reduces moisture from an active compost windrow or pile. Under warm and dry conditions in Australia, moisture loss can become excessive, and it may be necessary to 'irrigate' the compost to ensure moisture levels remain in the optimum range.

Temperature

Microbial activity is dependent on temperature and maintaining a suitable temperature in the compost involves:

- turning and aerating the material
- maintaining suitable moisture levels
- having a suitable C:N ratio.

A temperature greater than 50°C is generally required to reduce the viability of pathogens and weed seeds, but if it exceeds 60°C, there is a marked increase in the risk of spontaneous combustion.

Compost fires are difficult to extinguish and can be a serious source of smoke and odour. Compost fires can be avoided by:

- monitoring compost core temperatures
- monitoring compost moisture levels

- avoiding excessively large piles or windrows (so that the overlying compost does not insulate the centre of the pile, and so impede the dispersion of heat into the atmosphere)
- pre-mixing any excessively wet manure with a very dry material before placing in the windrow or pile
- ensuring the compost pad drains satisfactorily.

There is no easy way of putting out compost fires, and the approach adopted will depend on the extent of the fire. Exposing the burning material to air may cause it to burn even more vigorously. Attempting to smother compost fires with soil is often ineffective, and fires treated this way may continue to smoulder for many months. In small isolated fires, it may be possible to carefully remove unaffected material until only the burning material remains. Subsequent action would then depend on how large the affected volume of compost is; if the volume of material is relatively small, it might be extinguished with water or simply allowed to burn out. However, expert advice should be sought for anything other than extremely small fires.

Good quality compost

Table D.1 shows some commonly recommended values for rapid and efficient composting. Sub-optimal conditions will normally result in slower composting or a poorly cured product.

Table D.1 Recommended conditions for rapid composting

Parameter	Units	Acceptable range	Optimum range
Carbon to nitrogen ratio		15:1–40:1	25:1–30:1
Moisture content	%	45–65	50–60
Oxygen levels	%	>5	>5
pH		5.5–8.0	5.5–8.0
Temperature	°C	40–65	55–60
Particle size diameter	mm	5–50	5–25

Composting manure will normally reduce the volume of material by about 60 to 70%. The moisture content of compost is generally less than that of stockpiled manure, while the density of nutrients, like nitrogen and phosphorus, is substantially higher.

A number of feedlots in Australia have differentiated their compost by having their product comply with the Australian Standard *AS 4454: 2003 Composts, Soil Conditioners and Mulches*. While this may require increased expenditure, it may also command a premium price, particularly in some niche markets.

Composting pads

Composting must take place on a suitably constructed composting pad that is either within the feedlot controlled-drainage area, or in a separate controlled-drainage area servicing the pad. Details on the construction of composting pads can be found in Appendix C.

Appendix E. – Effluent and manure utilisation

Preamble

Land application of feedlot effluent and manure on areas growing crops or pasture is the most efficient and beneficial means of using the water, nutrient and organic matter in these feedlot by-products.

Because of the wide variety of possible soil, climate, cropping, pasture and management combinations which may be present in utilisation areas, it is difficult to provide precise guidelines for effluent and manure application rates. Information supplied will assist feedlot operators to manage these application rates to ensure the effluent and manure utilisation areas are sustainable. Performance must ultimately be evaluated by monitoring levels of nutrients and salts in the soil, nutrient application rates, plant nutrient contents and harvested plant yields.

To avoid adverse environmental impacts, application rates should not exceed the rates at which the constituents of the effluent and manure (water, nutrients—especially N and P – and salts) are:

- taken up by plants and removed from the site by harvesting
- safely stored within the soil profile
- released into the surrounding environment in an acceptable form.

Nutrient mass balance equation

This relationship is generally expressed as a mass balance equation in the following form:

> Applied nutrient ≤ nutrient in harvested produce + nutrient safely stored in soil + acceptable nutrient losses to external environment

The equation implies that the mass of each constituent is conserved throughout the effluent and manure utilisation process (i.e. the total amount of any element will be present somewhere in the environment). It may be adsorbed into the soil, taken up by a crop, volatilised into the atmosphere or carried into a river in eroded soil—but it will remain in the environment.

The nutrient may be in a different form (solid, liquid or gas), or in a different chemical compound (e.g. nitrogen in ammonia instead of urea). These chemical and physical transformations are cyclical processes. Simplified representations of these cycles[1] as they would apply to a feedlot by-product utilisation area for the major crop nutrients nitrogen, phosphorus and potassium are shown in Figure E.1, Figure E.2 and Figure E.3 respectively.

Determining the pathway an element follows through these cycles then becomes similar to an accounting exercise (i.e. a matter of balancing the ledgers or a 'mass balance'). Each of the critical constituents of effluent and manure should be

[1] The cycles shown are not complete cycles, having been limited to those components of the larger cycle relevant to a feedlot.

considered individually, and the lowest application rate determined based on the above equation should be adopted. These calculations are generally performed on an annual basis or over the growing season of the crop. This approach effectively results in the sustainable recycling of the nutrients and salts back to plant material – which can then be removed from the site for use as a feed source for the feedlot or for sale.

In the mass balance equation, applied nutrient is the quantity of manure or effluent applied (e.g. as t/ha or L/ha) multiplied by the nutrient concentration in the applied material (e.g. as kg/t, g/L or %). If the manure or effluent quantity units (tonnes or litres) are not the same as the concentration units for the bulk product, a conversion factor must be applied.

The mass of nutrient in harvested produce is determined by multiplying yield (e.g. t/ha) by nutrient concentration in the harvested product (e.g. kg/t or %). Normally the yield and nutrient concentration would be established from data recorded for actual crops grown on the site, but this information may not be available for new sites or new crops. Various sources, including local agronomists and state departments of primary industry and agriculture, may have the required data on likely yields and the typical nutrient composition of the harvested produce.

Soil can bind and safely store certain nutrients applied in excess of the immediate or long-term requirements of crops. For nutrients such as phosphorus, the levels of nutrient safely stored in the soil can be significant (refer to later section on phosphorus sorption capacity). However, there are no effective long-term sinks for some nutrients, such as nitrogen, and their excessive applications may result in unacceptable nutrient losses to the external environment.

Nutrient losses to the external environment occur in all ecosystems. Examples include leachate losses of cation forms of potassium, calcium and magnesium; leachate losses of nitrogen (mainly in nitrate form); and denitrification and volatilisation losses of various forms of soil nitrogen. Small quantities of all nutrients, including phosphorus, will also be lost be way of soil erosion. In a by-product utilisation area, the level of losses needs to be relatively small to be acceptable; typically of a similar magnitude to those from the same crops grown in the same locality, or similar to the rate of losses from natural systems.

The following sections provide further information on the use of the mass balance approach as well as more specific aspects of effluent and manure management.

Nutrient limited application rates

There are a number of ways of undertaking mass balance calculations for effluent and manure utilisation areas. Provided they comply with the mass balance principles presented above, they should be acceptable to regulatory authorities and auditors.

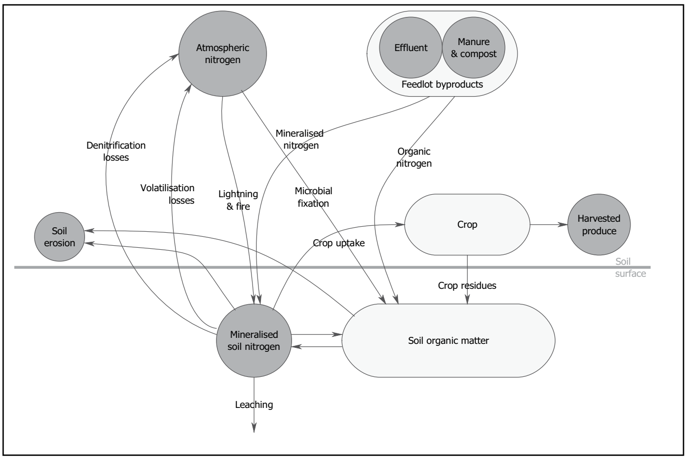

Figure E.1 The soil nitrogen cycle

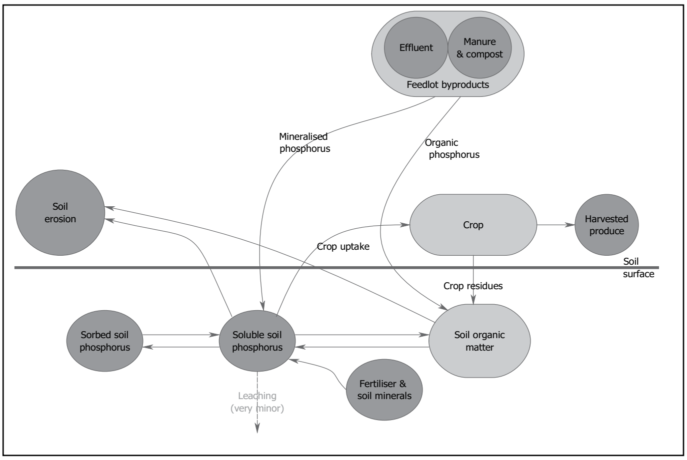

Figure E.2 The soil phosphorus cycle

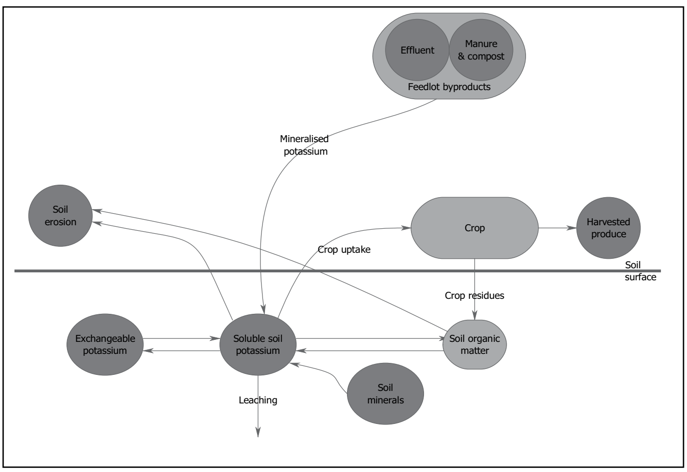

Figure E.3 The soil potassium cycle

One way of expressing the above mass balance equation is in the form of a nutrient limited application rate (NLAR) equation, denoted as:

$$NLAR = \frac{CR + SS + EL}{NW \times 10^{-3}}$$

where:

NLAR	=	nutrient limited application rate of holding pond effluent (kL/ha) or feedlot manure (t/ha)
CR	=	crop requirement for the applied nutrient (kg/ha)
SS	=	soil storage (kg/ha)
EL	=	allowable nutrient losses to the environment (kg/ha)
NW	=	available nutrient concentration in the holding pond effluent (mg/L) or feedlot manure (mg/kg).

Except for phosphorus, soil storage of nutrients is normally relatively small, and can be disregarded. Similarly, allowable nutrient losses to the environment, except for nitrogen, are generally small and can also be disregarded.

The NLAR equation assumes that feedlot manure is applied regularly (e.g. each year or every cropping cycle). If so, the rate of mineralisation does not need to be taken into account, and it can be assumed that the entire amount of applied nutrient is available each year[2]. However, if manure is being applied only intermittently (e.g. once every few years), only a portion (e.g. maybe 50 or 60%) of the nutrients might be available in the first cropping cycle; with smaller portions being available in each subsequent year. When determining the required size of by-product utilisation areas for a new or expanding feedlot, assuming recurrent annual applications will normally provide a worst-case scenario.

The majority of the nutrient constituents in effluent are present in either mineralised form or as readily degraded organic matter, with most of the applied nutrient being available shortly after application.

Composition of effluent and manure

Feedlot manure (see Figure E.4) contains significant quantities of nitrogen, phosphorus and potassium; and a wide range of other macro and micro-nutrients. It also contains large amounts of organic carbon. A large proportion of the plant nutrients in feedlot manure are found in the organic component, and do not become available for plant use until the associated organic matter has been mineralised or degraded. Thus, only a portion of some nutrients, such as nitrogen and phosphorus, are immediately available for plant uptake, with the balance becoming available progressively over a lengthy period (often years) following application. Potassium, however, is generally not present in natural organic compounds, and is generally immediately available for plant uptake or adsorption (as exchangeable potassium) on soil colloids.

The effluent from feedlot holding ponds (Table E.1) also contains substantial quantities of nitrogen and potassium, with smaller, but still significant, quantities

[2] For example, 60% of the material applied this year would become available in this season, along with 30% of the balance of that applied in the previous year and 10% of that applied in the year before that. Thus the potentially available nutrient = 60% + 30% + 10% = 100% of that applied this season.

of phosphorus and other nutrients. The holding pond effluent may also contain modest amounts of organic matter. The actual amount will depend on factors such as the nature of the rainfall events that contributed to the pond influent, and length of time the captured runoff has been stored.

Table E.1 Nutrient concentrations of manure and effluent

	Stockpiled feedlot manure	Holding pond effluent
N%	2	0.08
P%	0.8	0.008
K%	2	0.2

Because plant nutrients in feedlot manure and effluent are not necessarily present in a perfect balance for the nutrient demands of a crop, it is often necessary to supplement feedlot by-product applications with other forms of fertiliser (e.g. superphosphate, DAP) to ensure the crop receives the balanced supply of nutrients required for optimum growth. When compound or mixed fertilisers are used, account needs to be made of the nutrients being applied in addition to those that are deficient.

Comparison of the nutrient composition of the forage oats crop in Figure E.5 with those of feedlot manure and holding pond effluent in Figure E.4, shows that applying either manure or effluent will not completely satisfy the crop's requirements for nutrients (e.g. meeting the crop's nitrogen requirements with only manure or effluent will either over or undersupply phosphorus or potassium). Application of these materials must be managed to ensure a suitable nutrient balance is achieved.

Crop removal of nutrients

The harvesting of agricultural produce, in the form of either plant or animal products, removes substantial quantities of nutrients. The dry matter component of an oat crop at harvest time might contain 2% nitrogen (mainly as protein), 0.2% phosphorus and 1.2% potassium. If the crop yielded 7 t/ha, the associated nutrient removal rates would be 140 kg of nitrogen, 14 kg of phosphorus and 98 kg of potassium. Other crops will have different nutrient compositions, yields, and nutrient removal rates.

If crops or pastures are grazed rather than being harvested and removed from the site, most of the plant nutrients consumed by stock are returned to the soil as manure and urine – with significantly lower nutrient removal.

The nutrients removed in harvested produce are replaced naturally by the ongoing mineralisation of the underlying soil substrate, by atmospheric deposition (e.g. nitrogen and sulphur in rain), and by the direct assimilation of atmospheric nitrogen by soil microbes. However in modern high-yielding agricultural production systems, this natural replacement of nutrients is normally at a rate substantially lower than crop removal rates. It is necessary to either supplement these systems with some form of fertiliser, or allow the ongoing removal of produce to effectively 'mine' the available nutrients. This exploitation of soil nutrient reserves is not sustainable and feedlot by-products can provide a valuable source of the nutrients required to make the system sustainable.

Soil suitability

Good agricultural soils should be used for effluent and manure application. Suitable soils possess a structure that permits air movement and water penetration (which assists seedling emergence and root penetration), and have sufficient depth to permit optimum root development by the crop. Adequate drainage, sufficient water-holding capacity to sustain plant growth between successive irrigations and ease of cultivation are also desirable.

Very sandy soils, poorly structured clay soils and soils with low permeability or high salt content may be unsuitable for effluent application, but are likely to be improved by well-managed manure application. Manure application increases the organic matter content, thereby increasing the water-holding capacity of sandy soil. It also improves soil structure and permeability.

Phosphorus sorption capacity

To varying extents, soils have an ability, albeit finite, to bind or sorb phosphorus. The sorption process can either temporarily or semi-permanently remove from the soil solution a proportion of the phosphorus applied in excess of crop requirements. This process can be quite complex, being due to chemical and physical processes such as adsorption, absorption and precipitation. It is often difficult to establish which of these processes are responsible for this binding activity in any particular instance. However, the collective outcome of these processes is similar to that which would occur if the reaction was adsorption alone. Consequently, the process is normally referred to as sorption, but includes all the various reactions, including adsorption.

The laboratory tests used to characterise this sorption process are undertaken at a standard temperature (e.g. 25°C), and the analyses are commonly called phosphorus isotherms[3], sorption isotherms or isotherms[4].

Soil scientists often use 'models' to better understand processes such as sorption. These models can be expressed as mathematical equations. Two models commonly fitted to sorption data are the Freundlich equation and the Langmuir equation.

The Freundlich model has the general form:

$$x/m = aC^b$$

where: x/m = phosphorus sorbed per mass of soil (mg/kg)
a = an empirically derived coefficient
b = an empirically derived exponent
C = the equilibrium phosphorus concentration (mg/L)

[3] *Isotherm* meaning a graph connecting values obtained at the same temperature.

[4] It is possible to do isotherm tests for a wide range of soil constituents, and not just phosphorus, and for processes other than sorption or adsorption. Hence referring to these tests as simply *isotherms* is imprecise and technically incorrect.

Likewise, the Langmuir model can be expressed using an equation given by:

$$x/m = \frac{abC}{1 + aC}$$

where: x/m = phosphorus sorbed per mass of soil (mg/kg)
a = an empirically derived coefficient[5]
b = an empirically derived coefficient
C = the equilibrium phosphorus concentration (mg/L)

Isotherm equations other than the Freundlich or Langmuir models can be applied to laboratory-derived adsorption data, and are acceptable provided the model satisfactorily fits the laboratory data.

Plots of the data from six phosphorus isotherm tests based on the equilibrium phosphorus concentration reached in those tests (C in mg/L) and the resultant amount of phosphorus sorbed per kilogram of soil (x/m in mg/kg) are shown in Figure E.4. The Freundlich equation has been fitted to the plotted values in the left hand graph, while the Langmuir equation has been fitted to the same plotted values in the right hand graph.

In this case, the Freundlich equation, as often, provides a better fit than the Langmuir equation. However the choice of model is not important, provided it has good agreement with the laboratory-derived values for the mass of phosphorus adsorbed (x/m) at different equilibrium concentrations of phosphorus (C).

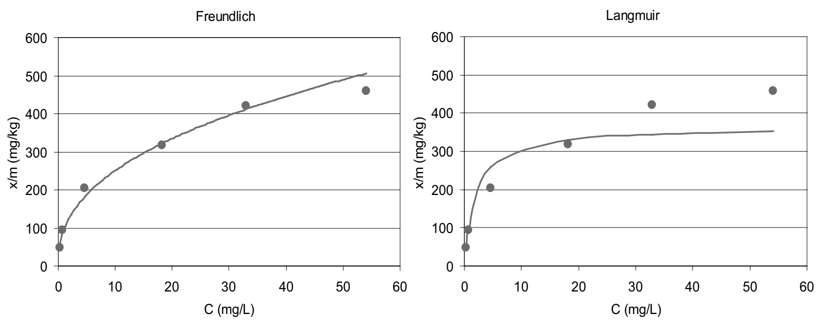

Figure E.4 Freundlich and Langmuir equations fitted for phosphorus sorption isotherm data for soil in a feedlot effluent irrigation area.

Applying the rationale suggested in *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000), an environmentally 'safe' phosphorus storage capacity can be estimated on the basis of the following equation:

$$P = \frac{d \times P_b \times x/m}{100}$$

where: P = phosphorus storage capacity (kg/ha)
d = profile depth (m)

[5] The coefficients *a* and *b* in the Langmuir equation are not equivalent to those used in the Freundlich equation.

P_b = soil bulk density (kg/m^3)
x/m = phosphorus sorbed per mass of soil (mg/kg) at 0.05 mg/L

Assuming that a new feedlot development will have an effective operational life of *n* number of years (e.g. 20 or 30 years), the annual value for the soil storage (SS) variable in the NLAR equation can be determined on the following basis:

$$SS = \frac{P}{n}$$

Effluent utilisation

The annual application rate for each of the constituents of the effluent can be calculated using the NLAR approach. The minimum area required for effluent utilisation will be the largest calculated for any individual constituent. In practice, the salts contained in the effluent are likely to determine the maximum annual effluent application rate. The area required for sustainable effluent irrigation is generally larger than the area that can be reliably irrigated with the available effluent.

Consequently, it is desirable to have reliable supplies of good quality irrigation water for effluent dilution and to ensure that the crops grown on the effluent irrigation area are growing to their maximum potential and utilising nutrients at the optimum rate. Dilution of effluent may be required to prevent leaf burn, yield reductions and soil degradation for some soil-crop combinations.

The timing of effluent management should be matched to crop water requirements and scheduled in a similar manner to normal crop irrigation. Effluent should be applied only after a predetermined soil moisture deficit level is reached. The quantity of effluent applied should not exceed that necessary to top up the soil water storage to field capacity, which is the maximum amount of water a soil can hold under normal drainage conditions.

Provided effluent irrigation is carefully scheduled and managed in this way, irrigation tailwater generation and infiltration of effluent below the root zone should be minimal.

Some form of sprinkler irrigation is generally preferred to surface irrigation methods (e.g. flood) for effluent application. This reduces the potential for runoff, with subsequent need for tailwater collection, and provides for more uniform application. Sprinkler irrigation is the only option for soils that have a high infiltration rate (>10mm/hr).

Manure utilisation

The volume, nutrient composition and salinity of the manure, and the yield, nutrient and salt composition of the harvested crop should be estimated and balanced to determine the area required for manure utilisation and the required application rate. Manure should be spread as uniformly as possible onto cultivation or pasture and the spreading method employed must be capable of applying the manure at the appropriate rate.

Manure is often screened prior to spreading to remove rocks. This produces a more friable product that is easier to handle. Composted manure is also more friable and easier to spread. Specially designed manure spreaders are generally used for applying the manure to the utilisation area. It is important to spread manure when the cultivation soil is dry to avoid soil compaction.

Manure should be incorporated into cultivation as soon as possible after application to minimise gaseous nitrogen losses, reduce the potential for export of nutrients in runoff and reduce odour emissions; however, this is not generally possible when manure is applied to pasture. To minimise the potential for erosion of manure following pasture application, it should be applied only to pastures on relatively flat slopes with good ground cover.

Human and animal health considerations

Community health and workplace health and safety issues should be considered when applying effluent and manure. Caution should be exercised to avoid operator exposure to aerosols when spraying effluent and to prevent spray drift from the site, as the spray droplets may contain pathogens.

Relevant health regulations and guidelines concerning human and animal consumption of effluent-irrigated crops should be complied with. To protect both humans and animals from potential pathogen transfer, withholding periods of up to three weeks apply for stock grazing established pastures or forage crops where manure or effluent has been applied.

Terminal systems

Terminal systems are used to collect and recycle all irrigated effluent tailwater and to manage contaminated stormwater runoff from the effluent irrigation area. Not every site requires terminal ponds/tailwater systems, but they may be required as a risk minimisation measure in areas of high rainfall or where there is a risk that runoff from the utilisation area might adversely impact surface waters nearby.

Terminal ponds are to be sized to capture the first 12 mm of runoff from utilisation areas where there is normally no tailwater generated by feedlot by-product application, and at least 25 mm of runoff where tailwater is generated (e.g. flood irrigation or inefficient spray irrigation).

If terminal ponds are being used, the runoff captured is to be decanted as soon as practicable following runoff-causing rainfall events.

Bibliography

ANZECC and ARMCANZ, (2000), Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000), National Water Quality Management Paper No 4, Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

Appendix F. – Feedlot application documentation

Details of the type of information that may need to accompany a development application for a new beef cattle feedlot are provided below. This list, while comprehensive, is not exhaustive. Fewer details may be required for smaller developments or for a modest expansion of an existing feedlot. There may be a requirement for additional information in some states.

1. General:

Contact details:

- Applicant
- Land owner
- Feedlot manager
- Property description

Plans and maps:

- Cadastral map (showing property boundaries and ownership)
- Locality plan
- Topographic map
- Local environment plan or planning scheme context
- Aerial photograph

2. Feedlot information:

Proposal outline:

- Operational scale
- Cattle liveweights and SCU
- Stocking density
- Feedlot class
- Construction
- Development staging

Property plan:

- Feedlot site
- Existing buildings and infrastructure
- Access roads
- Drainage lines
- Waste utilisation areas

Feedlot plan:

- Feedlot pens
- Cattle lanes
- Feed alleys
- Handling yards
- Pen layout
- Manure stockpile
- Carcass composting pad
- Feedmill and silage bunks

Plan of controlled drainage area:

- Diversion banks
- Pen drainage
- Catch and main drains
- Sedimentation system
- Holding pond

Plan of waste utilisation area:

- Manure reuse area
- Effluent reuse area
- Watercourses

Traffic:

- Traffic volumes
- Access routes
- Access times

Water supply:

- Source
- Quality
- Legal access
- Adequacy of supply
- Loss of supply contingency measures

Carcass disposal:

- Normal mortalities
- Mass disposal contingency measures

3. Existing environment:

Climatic information:

- Rainfall
  - Historical records
  - Design storm IFD data
- Evaporation
- Temperature
- Wind data

Geology

Landform

Surface water:

- Catchment hydrology
- Surface water quality
- Flood susceptibility

Soils description:

- Field assessment and soil sampling
- Chemical properties
- Physical properties
- Land capability

Vegetation:

- Existing vegetation
- Proposed clearing

Groundwater:

- Hydrogeological assessment
- Groundwater data
  - Bore locations
  - Borehole stratigraphy
  - Standing water level
  - Groundwater quality
- Salinity hazard areas

Buffer distances

4. Solid waste management:

Manure harvesting:

- Cleaning frequency
- Manure management

Manure stockpile:

- Location
- Design and construction
- Drainage
- Management

Nutrients and salt:

- Mass balance
- Manure utilisation plan

Manure spreading:

- Method
- Management

5. Liquid waste management:

Catch and main drains:

- Drain flow rates and capacity
- Management

Sedimentation system:

- System capacity
- Management

Holding pond:

- Pond capacity and overtopping frequency
- Annual runoff
- Management

6. Reuse area hydraulic balance:

Nutrients and salt:
- Mass balance
- Utilisation plan

Liquid waste application:
- Method
- Management
- Terminal ponds

7. Odour, noise and dust:

Odour:
- Generation
- Impact and control

Dust:
- Generation
- Impact and control

Noise:
- Generation
- Impact and control

8. Flora and fauna:

Ecological communities
Threatened and endangered species
Offsets and mitigation
Management plan

9. Archaeological and heritage:

Aboriginal heritage
European heritage
Natural heritage

10. Animal welfare:

Animal welfare
Animal care statement

11. Sundry information:

Erosion and sedimentation control plan:
- Construction phase
- Operational phase

Pest and vermin control
Hazardous and dangerous goods
Visual impact
Economic and social impacts

12. Environmental management plan:

Risk assessment
Mitigation measures
Monitoring program

Appendix G. – Glossary of terms

Aerobic	An environment in which oxygen is present, either in a gaseous or a dissolved form (see anaerobic and facultative).
Aerobic pond	A wastewater-holding pond in which aerobic conditions prevail. For aerobic conditions the combined oxygen demand of chemical reactants and the micro-organisms breaking down organic constituents must be able to be met by the dissolution of atmospheric oxygen, either naturally or mechanically-aided. This generally does not apply to feedlot holding ponds.
Anaerobic	An environment in which oxygen is absent or unavailable (see aerobic and facultative). In feedlots anaerobic conditions commonly occur in holding ponds and manure on the pen surface or in static manure stockpiles.
Anaerobic pond	A wastewater holding pond in which anaerobic conditions prevail. Anaerobic conditions in feedlot holding ponds typically arise where microbial degradation of organic constituents consumes the available oxygen at a rate faster that it can dissolve from the atmosphere into the wastewater.
Average recurrence interval (ARI)	A statistical estimate of the average period in years between the occurrence of an event, such as a flood or storm, of a given size.
Buffer distance	The distance between a feedlot complex or waste utilisation area and a watercourse or wetland when considering waste material such as manure or effluent.
Catch drain	A drain to capture runoff from smaller areas within a controlled drainage area, such as a row of feedlot pens, and convey the captured runoff to the sedimentation system and ultimately, the holding pond.
Community amenity	The maintenance of the environmental attributes that contribute to physical or material comfort of community members.
Compost	An organic material that has undergone aerobic and thermophilic treatment and has achieved a suitable level of 'pasteurisation' and stabilisation or 'maturity'.

Controlled drainage area	A controlled drainage area is a self-contained catchment surrounding those parts of the feedlot complex from which uncontrolled stormwater runoff would constitute an environmental hazard. It is typically established using a series of: • catch drains to capture runoff from the feedlot pens and all other surfaces within the feedlot complex, and ultimately convey that runoff to a collection or disposal system, and • diversion banks or drains placed immediately upslope of the feedlot complex, which are designed to divert 'clean' or uncontaminated upslope runoff around the feedlot complex.
Covered feedlot	A feedlot in which cattle are kept in partially or fully roofed pens, or inside buildings.
Design permeability	A soil material is considered to provide a design permeability consistent with that obtained in laboratory testing to Australian Standard *AS 1289: Methods for testing soils for engineering purposes*, where the same soil material is: • conditioned to provide a moisture content within ±2% of the optimum moisture content required to produce the maximum dry density in accordance with Method 5.1.1 of *AS 1289* • compacted to produce a field dry density of at least 95% of the standard maximum laboratory dry density determined in accordance with Method 5.4.1 of *AS 1289*. Compliance with the design permeability criteria is normally determined by compaction testing of the *in-situ* materials to verify the second dot point above. The design permeability of clay liners in wastewater storages is often of the order of 1 x 10^{-9} m/s (or 0.1 mm/day or 35 mm/yr). Similar design permeabilities are generally applied to clay liners in feedlots, although specific requirements may vary with the location of the feedlot. The permeability of clay liners may vary slightly from the design permeability.
Design storm	A rainfall event, with a nominated average recurrence interval (ARI), that has a duration equal to the time of concentration of the catchment area.

Effluent	The runoff from the controlled drainage area stored in the holding pond.
Energy efficiency	The relationship between the energy input of a system and the output of that system.
Environment	The external or internal conditions (physical, chemical, biological, aesthetic or cultural) that influence the life and well being of an individual plant or animal and their interrelationship with other organisms.
Evaporative pond	A type of holding pond where the primary disposal mechanism of the effluent is by evaporation.
Facultative	Micro-organisms have the capacity to adapt to both aerobic and anaerobic conditions. Environments that are neither entirely aerobic nor entirely anaerobic, or fluctuate between these states, are often referred to as facultative.
Facultative ponds	This is a type of holding pond. Wastewater ponds that are lightly loaded with organic matter, and with large surface areas which facilitate the dissolving of substantial amounts of oxygen, can be facultative ponds. Provided there is not too much turbulence or mixing, a natural gradient can develop in these lightly loaded ponds between aerobic conditions at or near the surface, and anaerobic conditions at depth. The intermediate zone is considered facultative and these ponds classed as facultative. Due to the sporadic and variable nature of inflows into feedlot holding ponds, and the typically high loading rates, it would only be very infrequently that conditions in feedlot holding ponds would be classed as facultative.
Flooding	The inundation of land as the result of the overflow of a watercourse. Overland flow, not directly associated with the overflow of a watercourse, is not considered as flooding in this document. Alternative definitions may apply in local, state or federal government legislation and regulation.
Groundwater	Water beneath the surface of the land.

Holding ponds	A pond designed to capture and store the normal runoff before the captured runoff is either: • applied to cropland, or • evaporated.
Manure	The solid waste produced by cattle. In feedlots this is the material that collects on the surface of the pen and consists principally of cattle dung and urine.
Odour modelling	The use of computer-based mathematical models to predict the behaviour and dispersion of odours emitted into the atmosphere.
Permeability	Permeability is the ability of a material to allow a fluid to flow through it. An impermeable material will not permit any fluid to pass through (very few materials are totally impermeable).
Precipitation	Water deposited on the land in either liquid or solid form. It may include rain, snow, sleet, hail, dew and frost.
Salinity	The level of soluble salts present in water or soil.
Salinity measurements	The electrical conductivity (EC) of water or a soil and water mixture is a widely accepted measure of *salinity*. Electrical conductivity is the ability of a solution to conduct electricity, which is directly proportional to the concentration and the ionic species present in a tested water or soil and water mixture. In soil the electrical conductivity is usually measured in a mixture of one part soil to five parts water (*i.e.* $EC_{1:5}$). The significance of an $EC_{1:5}$ value in respect to plant toxicity is dependent on soil texture. As a result, laboratory $EC_{1:5}$ values are often mathematically converted to saturated extract electrical conductivity values. The resultant values are commonly referred to as EC_{se} or EC_e values. The 'se' or 'e' subscript implies the value is a saturated extract value. EC values obtained from electromagnetic induction surveys are termed apparent conductivity (EC_a). These values do not directly relate to laboratory measured electrical conductivity results.
Sedimentation system	Systems to remove the readily-settleable fraction of the solids entrained in effluent. A sedimentation system may be a pond, basin or terrace that discharges effluent to a holding pond.

Separation distance	The separation distance is the distance between a likely source of an emission and a receptor likely to be sensitive to that emission. A separation distance (also variously referred to as buffer, setback or offset distances) is measured from the nearest physical part of the emission source to the nearest point of the potential receptor.
Surface water	Water on the surface of the land.
Sustainable	Able to be maintained in perpetuity.
Sustainable utilisation	Use of a resource so that it may yield the greatest continuous benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations.
Tailwater	Runoff from an irrigation area which arises when irrigation water is applied in excess of the infiltration capacity of the soil.
Terminal pond	A pond located at the end of an effluent irrigation area. It is intended to capture the initial and possibly heavily polluted runoff from a storm event. It is also intended to capture and hold *tailwater* generated by effluent irrigation systems.
Waste utilisation area	An area of land to which manure or effluent is applied.
Water use efficiency	Increases in water use efficiency arise where water usage is reduced for a given level of production, or there is increased of improved production for a given amount of water used.
Watercourse	A watercourse is defined as being shown as such on an official 1:100,000 topographic map. Alternative definitions may apply in state and federal legislation.

[1] Where feedlots are built close to the crest of a hill or ridge, and there will be no runoff from upslope, it is possible to have a controlled drainage area without any diversion banks or drains.

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