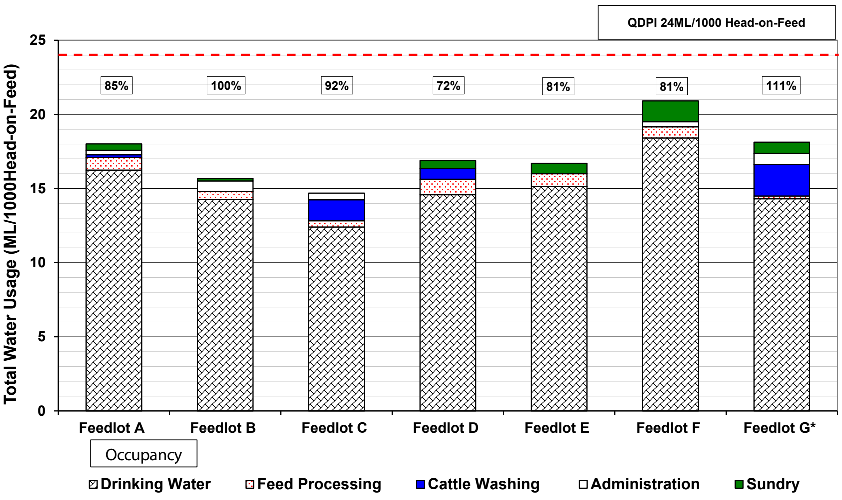

FEEDLOT DESIGN AND CONSTRUCTION

4. Water requirements

AUTHORS: Rod Davis and Peter Watts

Introduction

With the variable climate and greater stresses being placed on water resources, water availability and security cannot be taken for granted. Water is a vital resource for lot feeding and can also be a significant expense.

Most of the water used is for cattle to drink; it is also used for feed processing, cleaning yards, machinery and cattle washdown, other general practices around the feedlot and in amenities for people working on the feedlot. Water is also lost through evaporation and seepage from open storages. An accurate understanding of water usage in the industry is important for determining licence requirements for water supply.

Design objectives

The design objectives for a feedlot's water requirements are to

- meet the feedlot's total annual water requirement
- provide an unrestricted, reliable supply of water to livestock at all times of the year
- provide water that is clean, fresh and free from contamination for livestock
- meet the peak water intake requirement for feedlot cattle, especially during summer
- minimise losses and maximise water use efficiency
- ensure that the quality of the water (which includes temperature, salinity and impurities) does not affect livestock performance or welfare
- provide water that is clean, fresh and free from contamination for people.

Mandatory requirements

Compliance with

- Australian Animal Standards and Guidelines for Cattle (DAFF,2013).
- National Guidelines for Beef Cattle Feedlots in Australia (MLA, 2012a).
- National Beef Cattle Feedlot Environmental Code of Practice (MLA, 2012b). Performance measure 1.5.2 states that a feedlot has a water supply able to sustain the operations of the feedlot under normal conditions.
- relevant state and local authority codes and regulations as applicable to feedlot development water requirements and licensing.
- quality standards for beef cattle drinking are outlined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) (ANZECC and ARMCANZ 2000).

Technical requirements

To identify feedlot water supply and system requirements, the following steps should be conducted

- Determine the feedlot total water supply requirements. Read this section and *Section 28 – Feed preparation and storage* and *Section 41 – Cattle wash facilities.*
- Complete an inventory of all water sources, supplies and related problems (Refer *Section 3 – Water supply sources and onsite storage*).
- Identify any potential water shortages or water system problems (Refer *Section 3 – Water supply sources and onsite storage*)
- Identify solutions to improve water supply or water systems (Refer *Section 14 – Water reticulation systems*).

Total water requirements

A rough overall estimate of the daily requirement for watering stock is 5 litres per 50 kg liveweight, but this is greatly influenced by animal feed intake, ambient temperature and the weather. Traditionally, the total annual water requirement for feedlots has been based on the QDPI Reference Manual for Beef Cattle Feedlots value of 24 ML/1000 head on feed. This figure makes an allowance for uses other than cattle drinking requirements, such as trough cleaning, minor leakages and veterinary purposes, but not for significant other usage.

Total clean water usage is the combination of drinking water, feed processing, cattle washing (where this practice is undertaken), administration and direct sundry uses such as trough cleaning, dust control, vehicle and facility cleaning and indirect sundry 'uses' such as evaporation. This does not include water used for effluent dilution.

Figure 1 presents total water usage data from seven Australian feedlots between 2007 and 2009. The total water usage ranged from 14.5 to 20.5 ML/1000 head-on-feed; 90% of this was used for drinking when no cattle were washed, 84% during months when cattle were washed. Over a year, cattle drank an average of 40 L/head/day (31–46 L/head/day).

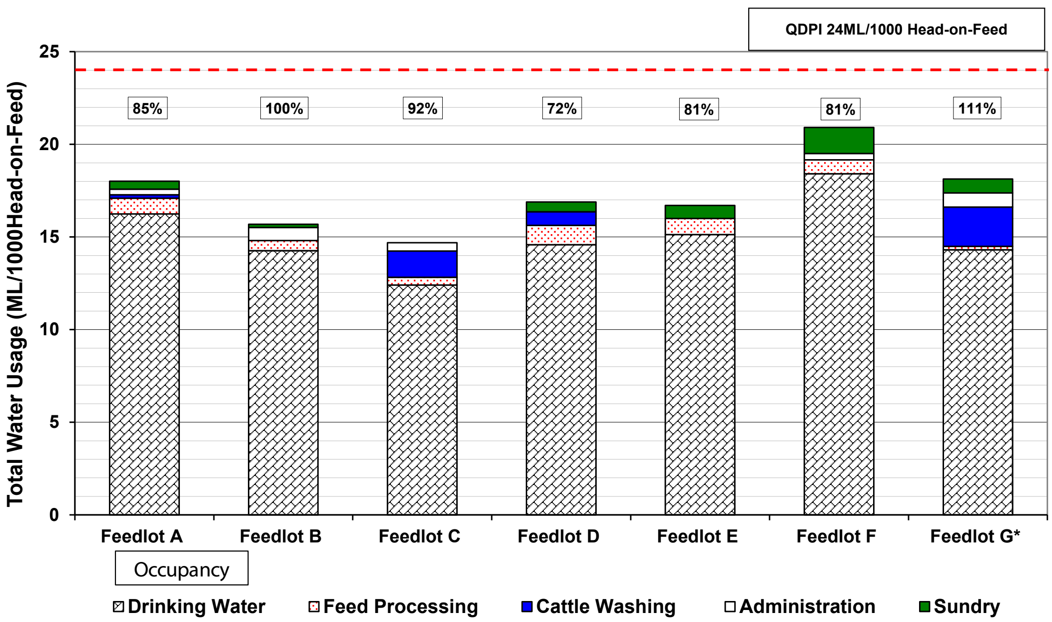

Figure 1. Total annual water usage (ML/1000 head-on-feed) for seven feedlots (Davis et al. 2009)

Livestock drinking water

Water is vital for livestock survival, but restricting water intake also immediately reduces feed intake and so cattle performance and production.

The water requirements of livestock are met by

- water consumed voluntarily (i.e. water that is drunk)
- water consumed in feed
- water retained within the body due to oxidation reactions involved in metabolism.

Factors affecting water consumption

The quantity of water consumed by feedlot cattle depends on environmental factors (e.g. ambient temperature and humidity), drinking water temperature, water quality, ration composition (nature of food and dry matter content), feed intake, size of the animal, rate and composition of gain, frequency of watering and individual variation between animals.

Environmental factors

Water intake increases with higher ambient temperature. Other environmental factors affecting the volume of water consumed by the animal include relative humidity, wind speed, solar radiation and rainfall.

Breed

Bos indicus cattle drink significantly less than the *Bos taurus* breeds.

Diet composition, feed intake and body size

The dry matter content and the nature of feed both affect water consumption. Cattle eating more, drink more.

Growing animals require more and better quality water than those that have finished growing and are being fattened, but heavily finished cattle need more water than leaner beasts.

Water intake

Over a year at seven Australian feedlots, cattle drank an average of 40 L/head/day. At a subtropical feedlot, they drank 44 L/head/day, while those at a feedlot that experiences cold winters, mild summers and high rainfall drank 30 L/head/day.

However, there appears to be no consistent relationship between heat load index, rainfall and temperature on drinking water consumption.

Seasonal variation in daily drinking water consumption

Daily water consumption patterns in lot-fed cattle vary with the season and can range from about 14 L/head/day to 75L/head/day. Daily drinking water consumption differs between summer and winter (Figure 2) and with significantly different patterns.

Pattern of consumption

During summer, cattle start to drink from the earlier sunrise, with consumption peaking between 10.00 and 14.00 hours. It then drops about mid-afternoon, peaks again between 16.00 and 17.00 hours, after which it gradually decreases until a few hours after the later sunset when it remains steady until midnight.

In winter, cattle also start drinking at the later sunrise with water consumption peaking at 13.00-16.00 hours. It then decreases from late afternoon until a few hours after the earlier sunset after which consumption remains steady until midnight.

Peak demand

The peak flow rate demands are much greater during summer than during winter. The average peak flow rate on summer days can be nearly 70% higher than on winter days, with a maximum peak flow rate being 50% higher. Water consumption varies through the day, and the peak reticulation rate must be incorporated into the design of the feedlot water supply.

Feedlots located in hot and humid climates should have their water supply system and capacity of the on-site water storage designed to accommodate peak demand in the order of 75 L/head-on-feed/day during summer months.

Feedlots located in climates with temperatures around 20°C can be expected to have an average demand for drinking water in the order of 30 L/head-on-feed/day.

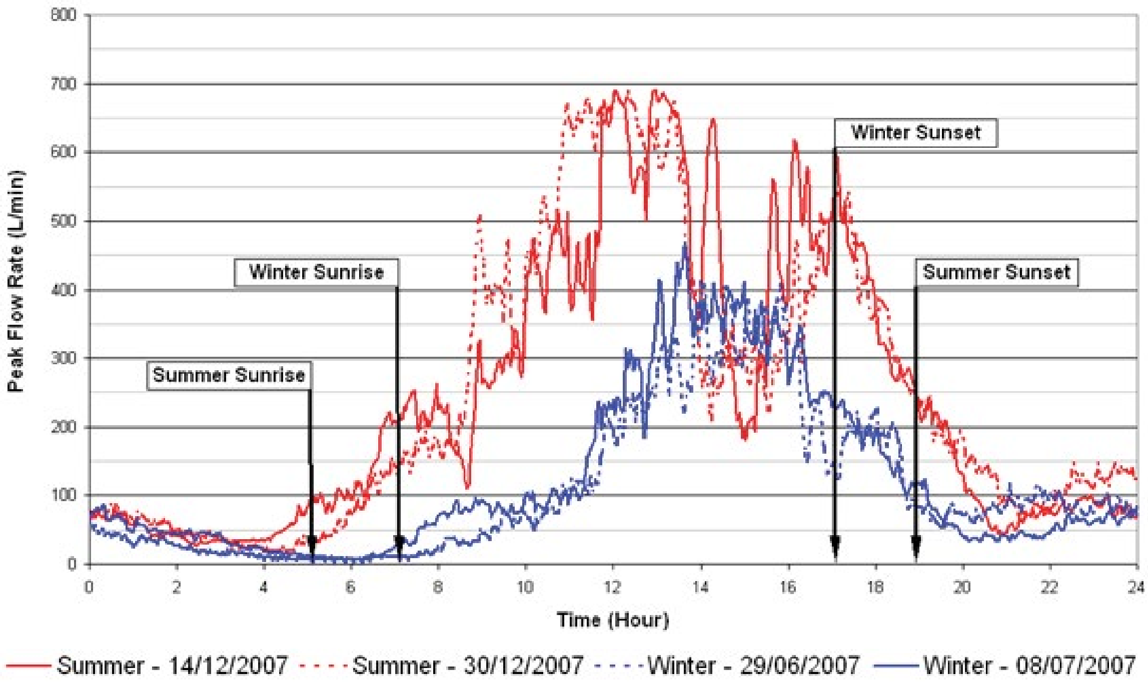

Figure 2. Comparison of daily consumption of drinking water between summer and winter

Diurnal variation in drinking water consumption

Drinking water consumption increases with increasing heat load (Figures 3 and 4) with peak drinking water consumption occurring about two hours after the peak heat load each day.

Water consumption varies throughout the day, and the peak reticulation rate must be incorporated into the design of the feedlot water supply. Peak drinking water consumption occurs about two hours after the peak heat load each day, with two distinct drinking periods throughout each day linked to the feeding periods.

During these periods, consumption peaked at 4.8–5.6 L/head/hour, thus peak flow rate needs to be about 25% greater than the average daily demand (litres/head-on-feed/day) and 100% greater than the average monthly demand (litres/head-on-feed/month). Hence, a water supply and reticulation system needs to be capable of delivering up to double the average monthly demand.

The flow rate to individual troughs should supply at least the daily peak consumption in a 4-hour period.

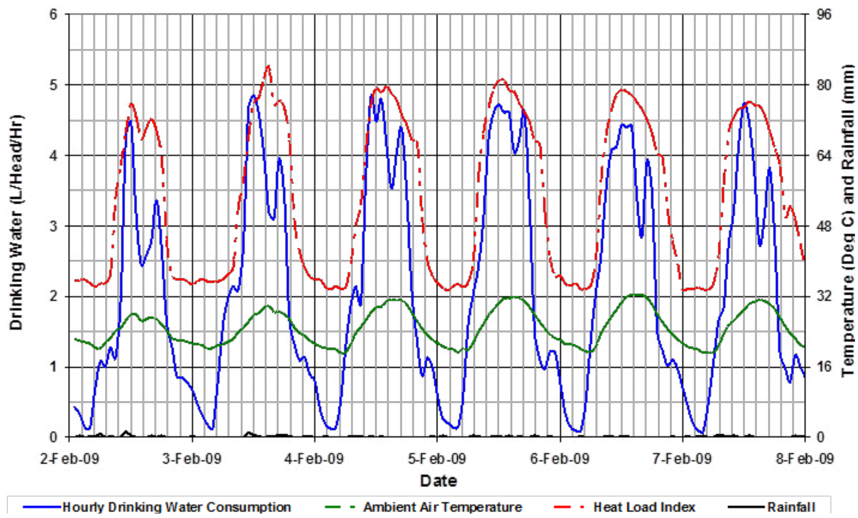

Figure 3. Diurnal variation in drinking water consumption (L/head/hour) at feedlot during a variable heat stress load (February 2009)

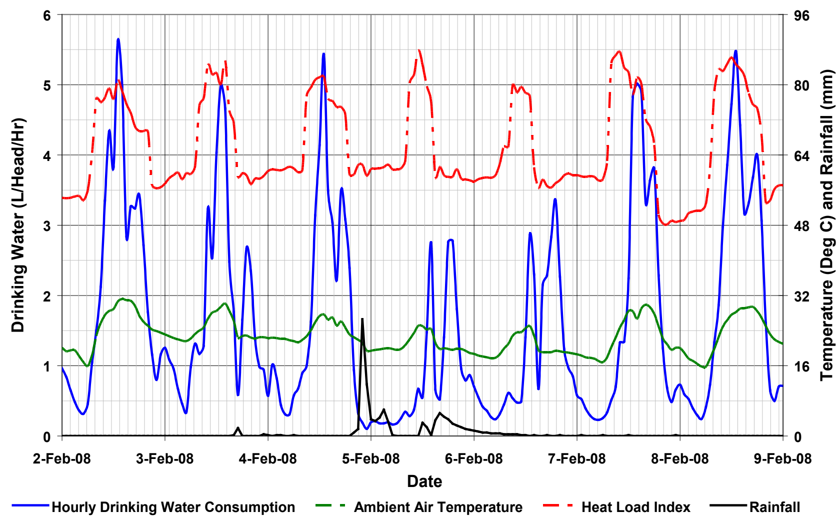

Figure 4. Diurnal variation in drinking water consumption (L/head/hour) at the same feedlot during a consistently high heat stress load (February 2008)

Feed processing

The amount of water used in feed preparation depends upon the feed preparation process used (Refer to *Section 29 – Grain processing equipment*). The different feed preparation processes can be broadly defined as 'wet' (e.g. steam flaking, reconstitution, tempering) and 'dry' processing (rolling).

– tempering

Tempering increases the moisture content of grain to 18–22% and requires the addition of 73–128 L of water per tonne of grain (0.073–0.128 L water per kg of grain).

– steam flaking

Steam flaking usually results in grain with a moisture content similar to that of tempered grain (18–22 %), but may require up to twice the volume of water to account for that lost as escaping steam.

– reconstitution

Reconstitution usually results in grain with a moisture content of 28–32%. Increasing the moisture content of one tonne of grain from 12% to 30% requires approximately 257 L of additional water (0.257 L water per kg of feed).

In Australian feedlots, average water for grain processing ranges from 90 to 390 L/t grain processed depending on the system employed, grain type, target moisture and management of the system. Water used in grain processing is about 4% of total water usage.

Table 1 can be used to estimate water requirements for grain processing.

Water used in steam generation for grain processing accounts for about 4% of total water usage.

Table 1. Estimation of water usage for grain processing

Final moisture content	Initial moisture content		
	10%	11%	12%
	Water added per tonne of grain (L/T)		
18%	98	85	73
19%	111	99	86
20%	125	113	100
21%	139	127	114
22%	154	141	128
23%	169	156	143
24%	184	171	158

Cattle washing

Feedlot cattle may need to be washed before slaughter to reduce hide contamination (Refer to *Section 41 – Cattle washing*). The cattle most affected by dag formation are British breeds (*Bos taurus*) commonly found in areas with winter-dominant rainfall. Short-haired or smooth-coated cattle (*Bos indicus*) typically found in northern Australia require little or no washing, especially during the dry season.

The volume of water used to wash cattle will depend on the amount of manure accumulated on the cattle, the cleanliness standard required at the processing plant, number of cattle washed, level of wastewater recycling implemented and seasonal conditions.

Cattle washing is more prevalent in areas with winter-dominant rainfall and Bos taurus cattle.

The total water used for cattle washing ranges from an annual average per feedlot of 400 L/head washed to 2,500 L/head washed, but a monthly average water usage up to 3,500 L/head washed has been recorded. In Australian feedlots, water used in cattle washing is about 3.5% of total water usage.

Administration

Administration water usage comprises that used in offices and amenities and more importantly, for watering of lawns and gardens. Administration represents only 2–3% of the total water usage.

The volume of water used for cleaning troughs depends on trough capacity and frequency of cleaning.

On average, each person working on the feedlot may use about 150 L of water per day through toilets, for washing, in the kitchen and laundry. A rule of thumb guide for the number of people required for a feedlot is about one person for every 750 to 1000 head of capacity. At 1 person per 750–1000 head of capacity, water used by people is equal to 0.18 L/head-on-feed/day.

Sundry uses

Minor water use activities may include

- water trough cleaning
- evaporative losses from open water storages (troughs, ring tanks, turkey's nests)
- cleaning – hospital, receival/dispatch areas, feed processing areas, weighbridge
- vehicle and machinery washing bays
- dust control in pens and on roads
- drinking water for horses or other stock.

Water for sundry uses may range from 0.03 to 4.1 L/head-on-feed/day or about 3% of total water usage.

Cleaning water troughs

Water losses at troughs arise from the water lost (dumped) during trough cleaning, evaporation from the surface and sundry pipeline or float fault leakages. Losses associated with trough cleaning are therefore related to trough capacity, as water troughs are completely emptied during cleaning, and cleaning frequency.

Large open-water storage areas can lose over 800 mm/year through evaporation.

Evaporation losses from open storages

Net evaporation loss is the net loss of water from open storages and troughs after accounting for rainfall. Evaporative losses can be significant depending on the area of open storages, particularly in the summer months, which is when demands for water are greatest.

Open-water evaporation is calculated by applying a 'pan factor' to the measured evaporation.

$$E = K_p \times E_{pan}$$

where
E = open-water evaporation (mm/day)
K_p = pan factor, constant determined by the pan siting, relative humidity and wind speed.
E_{pan} = Class 'A' pan evaporation (mm/day)

The net evaporation loss would be estimated as

$$E_N = E \text{ less rainfall}$$

The value of K_p can vary widely. From a farm lagoon containing animal waste, the ratio between lagoon and pan evaporation was typically between 0.7 and 0.8.

The net evaporation loss for Dalby, Queensland could be estimated as follows. Mean annual Class 'A' pan evaporation is about 2000 mm and mean annual rainfall is about 600 mm, with an open-water pan coefficient (K_p) of 0.74 (Weeks 1983).

$$E_N = (0.74 \times 2000 - 600) \text{ mm/yr}$$
$$= 880 \text{ mm/yr}$$

The volumetric evaporation loss can be calculated from the equation below.

Volumetric loss (m^3) = Net evaporation (m) × Surface area of storage (m^2)

Mean annual Class 'A' pan evaporation can be obtained from various sources, including the Bureau of Meteorology or SILO (*www.longpaddock.qld.gov.au*). SILO is an enhanced climate database hosted by the Queensland Science Delivery Division of the Department of Science, Information Technology, Innovation and the Arts (DSITIA). SILO contains Australian climate data starting in 1889, in a number of ready-to-use formats suitable for research and climate applications. Table 2 provides the Class 'A' pan evaporation for various lot feeding regions in Australia.

For example, consider a 10,000 head feedlot at Dalby, Queensland with an open water storage and surface area of 1,600 m^2. A net evaporation loss of 880 mm per year at this location represents a loss of 1.40 ML/year or 3,850 L/day on average. This is about 0.4 L/head-on-feed/day — much less than the drinking water intake in the order of 55 L/head/day.

Table 2. Mean annual Class 'A' pan evaporation at various locations

Location	Mean annual pan evaporation (Epan) (mm/yr)
Southern Queensland (Dalby)	2000
Southern New South Wales (Narrandera)	1970
Northern New South Wales (Moree)	2312
Victoria (Charlton)	1788
South Australia (Murray Bridge)	1734
Western Australia (Corrigin)	2060

Table 3 summarises the measured and estimated sundry water uses at seven Australian feedlots (between 2007 and 2009) on a per head on feed basis.

The three largest sundry water losses or uses, namely water storage evaporation, trough cleaning and road watering, depend on the total open water surface area, net evaporative losses, trough size and frequency of cleaning and cleaning method and road maintenance. Sundry losses depend on feedlot design, location (climate) and operational management.

Table 3. Sundry water uses for seven Australian feedlots

Feedlot	A	B	C	E	F	G	H
Water trough evaporation	0.6	0.7	5.1	0.4	0.3	0.3	0.4
Water trough cleaning	35.2	24.2	16.1	10.8	3.9	1.2	15.9
Hospital/Induction cleaning	15.5	0.0	7.7	13.4	2.2	8.4	7.0
Vehicle washing	4.9	0.0	14.5	0.6	0*	0.0	5.5
Road watering	43.8	9.5	3.1	40.6	0*	0.0	0.0
Water storage evaporation**	230	0.0	1450	910	4.3	161	0.0
TOTAL L/head-on-feed/year	330	34.5	1497	977	10.7	171	28.9
TOTAL L/head-on-feed/day	0.9	0.1	4.1	2.7	0.03	0.5	0.1

** Data unavailable **Data estimated (Davis et al. 2009)*

Dilution of effluent

Runoff from the controlled drainage area is contained within a sedimentation and holding pond system. (Refer to *Section 10* for further information on controlled drainage systems.) The effluent may need to be diluted during application as its nutrient level can be too concentrated for complete plant absorption. This can lead to nutrient runoff and contamination of surface or groundwater sources.

The quantity of water used for supplementation or dilution of effluent for irrigation is highly variable between feedlots. Some feedlots use evaporation as the primary means of effluent disposal and do not require additional water for irrigation.

Where effluent is reused for irrigation of crops, the amount of additional clean water required depends on the 'strength' of the effluent being irrigated and the area of land to which it is applied. To illustrate generally, if 50 ML of effluent was to be reused through land irrigation with a 50% dilution rate, then 50 ML of clean water would be required.

Dilution ratio is site specific and should be based on matching nutrient concentration and crop requirements.

Quick tips

- Cattle must have an unrestricted, reliable supply of water at all times of the year.
- Total average annual water requirement for feedlots includes cattle drinking requirements, feed processing, cattle washing, administration and sundry uses (trough cleaning, minor leakages, other stock drinking water, cleaning, dust control) and dilution of effluent.
- The water supply must be appropriately licensed and reliable in times of peak demand.
- Water usage must be understood to maximise water use efficiency.
- Total water usage depends on cattle type and feeding regimes, environmental conditions, climate, feed processing system and management, number of cattle washed and level of wastewater recycling implemented and sundry uses.
- Data from Australian feedlots indicates that the average daily drinking water requirement is in the range of 30–50 L/head/day depending on feedlot climatic zone and cattle type.
- The average daily drinking water requirement in summer ranges from 50 to 65 L/head/day depending on feedlot climatic zone and cattle type.
- Peak hourly drinking water requirement in summer ranges from 4.8 to 5.6 L/head/hour depending on feedlot climatic zone and cattle type.
- Water consumed by cattle accounts for about 90% of the total water usage.
- Water used in feed processing is about 4% of total water usage.
- Water used in cattle washing is about 3.5% of total water usage.
- Water used for sundries is about 3% of total water usage.

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