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Review of On-Farm Food Safety Best Practice

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Abstract

The safety of meat as food is of critical concern to the meat industry. In the US, the rigorous enforcement of a specific and objective zero tolerance policy has promoted extensive research in this area. This research has confirmed that the hide is the source of most carcass contamination and that cleaning it before its removal prevents almost all carcass contamination. Consequently US meat processing plants are implementing systems for washing cattle post-knocking. Investigations into a wide range of options for reducing the pathogen load of the animal are also ongoing. By contrast, the Australian Standard for Hygienic Production and Transportation of Meat and Meat Products for Human Consumption (AS 4696:2002) requires that "reasonable steps are taken to present animals for inspection in a clean condition". Because AS 4696:2002 is far less specific and less objective than the US policy the required standard of cattle cleanliness varies widely between processing works. The most common means for meeting AS 4696:2002 is washing of live cattle. This raises concerns about cattle welfare and stress and the subsequent effects on meat quality. The best system is likely to involve washing cattle post-knocking at processing plants but this has been rejected by the processing sector. Nevertheless ongoing negotiation is recommended. Alternatively, the adoption of the Clean Cattle Assessment Scheme to enable objective identification of the cattle that require cleaning (preferably at the processing works) and washing of these cattle is recommended. Further research into methods for improving the efficiency of hide cleaning is supported.

Executive Summary

The safety of meat as food is of critical concern to the meat industry. A quality systems approach to food safety suggests that the best approach is to eliminate or reduce contamination to a safe level as early in the supply chain as possible. Because of the way they are raised feedlot cattle are subject to hide contamination by mud and faeces. Particularly in North America, considerable research into preharvest interventions has been conducted. The Australian feedlot industry is significantly different to that of North America, but there is a danger of large international customers for Australian meat taking up North American codes of practice in their purchasing specifications. Additionally, practices recently introduced into the North American industry may have benefit to Australian producers.

The purpose of this project (PRMS.075) was to identify the practices that the North American livestock sector has adopted to reduce microbial contamination to a safe level and to then compare these with those practices used in the Australian livestock sector. The project also aimed to find why particular recommended practices have or have not been adopted in Australia. For the recommended practices not currently followed in Australia the project aimed to identify the scientific support for the practices and suggest further investigations that might be needed to prove or implement these practices in Australia.

Research in North America has been driven by the implementation of the “zero tolerance” policy for faecal contamination by the United States Department of Agriculture Food Safety Inspection Service (USDA-FSIS) and the adoption of performance standards for *Salmonella* in raw ground meat and carcasses. The *Salmonella* performance standards raise the standards by moving the requirements from visible (faecal matter) to invisible (*Salmonella* organisms). The zero tolerance policy is specific and objective and it has been rigorously implemented, with corrective action taken even when the source and composition of minute amounts of matter on carcasses are sometimes uncertain.

The Australian standard most comparable with the US zero tolerance policy is the Australian Standard for Hygienic Production and Transportation of Meat and Meat Products for Human Consumption (AS 4696:2002). AS 4696:2002 is far less specific and less objective than its US counterpart with the principle pathogen control measure being a requirement that “reasonable steps are taken to present animals for inspection in a clean condition”. The subjective nature of assessment means that cattle cleanliness standards vary between Australian processing works. *The adoption of the Clean Livestock Assessment Scheme at both feedlots and processing works by those inspecting cattle for slaughter would promote more objective assessment of cleanliness and is recommended.* To meet AS 4696:2002 feedlots wash cattle to remove dags and other visible contamination. There is a clear emphasis on dag removal rather than pathogen removal. *Research into the effectiveness of recycled wash water versus clean wash water for reducing hide contamination is recommended.*

The focus of the more general feedlot guidelines and codes and the National Feedlot Accreditation Scheme (NFAS) is the implementation of good design and management and sound husbandry practices. Most Australian feedlots, particularly those participating in the NFAS, have adopted sound design and management principles that are conducive to reducing the pathogen load within pens and associated transfer to stock (particularly to their hides in the form of dags) and are

consistent with US recommendations. However, t*he updating of the requirements of the NFAS to specifically address the issue of presentation of cattle for slaughter is recommended.*

Recent US research confirms that the hide is the source of most carcass contamination and that cleaning the hide before its removal will prevent almost all carcass contamination. *This is a crucial finding and the direction of most Australian research funding in this area towards improving the efficiency of hide cleaning is recommended.*

Live cattle washing is not commonly practiced in the US due to welfare and animal stress concerns. Instead, US processing plants are installing and using systems for washing cattle post knocking. The Australian feedlot industry shares these concerns. However, up to 40% of cattle from Australian feedlots are washed live at the feedlot to ensure they meet the requirements of AS 4696:2002. The Australian processing sector is generally reluctant to adopt cattle washing at the processing works and the requirements of AS 4696:2002 prevent soiled cattle from being cleaned post-knocking since cattle must be clean when presented for slaughter. *Further work to encourage cleaning of cattle at the processing works only if needed (after assessment using the Clean Livestock Assessment Scheme) OR preferably post-knocking is recommended. Revision of AS 4696:2002 may be necessary to allow cleaning of soiled cattle post-knocking at processing works.*

The Australian feedlot industry is actively researching improved methods for cleaning live cattle hides, including the addition of enzymes to cattle wash water for more rapid dag removal. *Further research aimed at improving the efficiency and effectiveness of cattle hide cleaning is supported.*

While the US is actively researching methods to reduce the pathogen load that cattle carry internally, the Australian industry is not. In particular, the Australian industry does not support the use of antibiotics for controlling faecal shedding of pathogens except as a last resort.

The use of sodium chlorate for controlling *E. coli* 0157:H7 appears promising, particularly since research suggests that its addition to the last feed (about 24 hours pre-slaughter) is very effective against foodborne pathogens in the gut. A downside is that it would add further salt to the feedlot effluent and manure, possibly affecting future reuse. *Nevertheless, further research into this application may be warranted.*

Taking cattle off feed or manipulating their diet pre-dispatch to processing works is not condoned as it may not have the desired effect and may also reduce cattle welfare, performance and meat quality.

As new research findings and recommendations emerge it is critical that they are transferred to lot feeders, meat inspectors and processors. The development, regular updating and circulation of this information to all stakeholders is strongly recommended.

Interventions must be adopted on the basis of scientifically sound data, not on preliminary findings. The effectiveness, cost effectiveness and acceptability to industry of existing and alternative intervention strategies need to be assessed.

Contents

1 Background

The safety of meat as food is of critical concern to the meat industry. It is recognised that food safety needs to be controlled through the supply chain, though most controls over microbial contamination of meat currently occur in the abattoir.

Human illnesses from meat products are mainly caused by faecal contamination by bacteria such as *Salmonella*, *Campylobacter* and *Escherichia coli* 0157:H7 (CAST 2004). Animals may carry these microorganisms within their intestinal tracts and excrete them in faeces. If some faeces remain on the animals meat contamination by these microrganisms can occur during slaughter. Beef carcase contamination has been correlated with faecal pathogen shedding. However, Rowland *et al.* (1999) were unable to find a consistent association between the level of dags on cattle hides and carcase contamination by pathogens. Nevertheless, any reductions in pathogen numbers on the hides of cattle going to slaughter will be helpful in preventing contamination of meat.

A quality systems approach to food safety suggests that the best approach is to eliminate or reduce contamination to a safe level as early in the supply chain as possible. Particularly in North America, considerable research into ‘preharvest’ interventions has been conducted.

The Australian livestock industry and the feedlot sector are significantly different to those in North America, but there is a danger of large international customers for Australian meat taking up North American codes of practice in their purchasing specifications. Additionally, practices recently introduced into the North American industry may have benefit to Australian producers.

The purpose of this project (PRMS.075) was to identify the practices that the North American feedlot industry has adopted to reduce microbial contamination to a safe level and to then compare these with those practices used in the Australian feedlot industry. For practices that the Australian feedlot industry has not adopted, further research was undertaken to identify the scientific support for the practices and to suggest further investigations that might be needed to prove or implement these practices in Australia. Hence, the project findings provide a starting point for the assessment of the value of the practices for adoption within Australia.

2 Project Objectives

The project objectives were:

- To review recent scientific summaries and best practice guides produced for the livestock sector in North America and identify the recommendations made.
- To determine which of those recommendations have been implemented in Australia, and whether this is as a result of regulation, industry accreditation scheme requirement or common practice.
- To consider the recommendations that are not followed in Australia and identify the scientific evidence that may be available to support the practice.
- To identify the practices not currently implemented in Australia that have good scientific support and might improve meat safety.
- To suggest the investigations that might be necessary to prove or implement these practices in Australian conditions.

3 Methodology

Step 1 of this project involved collation of North American documents and Australian production standards, codes of practice and published reports pertaining to the project objectives.

Step 2 involved gathering data on the intervention and management strategies currently in use by industry.

Step 3 (which occurred concurrently with step 2) involved a desk-based review of the literature collected in step 1.

Step 4 involved the collation of the final report including the survey results.

Step 5 will involve the presentation of the results of the project at a suitable industry forum to validate the approach taken, engage stakeholders with the issues and potential actions to be taken following the consultancy. This step will occur after the remainder of the project is undertaken since its timing depends upon both the completion of the final report and the timing of a suitable forum.

4 Review of Literature

4.1 Introduction

Recent major outbreaks of foodborne illnesses have raised community interest in the food safety of meat. To prevent these outbreaks it is important to control pathogen levels throughout the supply chain. Currently most controls over microbial contamination of meat occur in the abattoir through the adoption of Hazard Analysis and Critical Control Points (HACCP) and these measures have been effective in reducing carcass contamination (Elder *et al.* 2000). The pathogens causing these illnesses often originate during the preharvest stage on the farm. A quality systems approach to food safety suggests that the best approach is to reduce contamination to a safe level (consider this as an alternative to ‘during the preharvest stage’ - as early in the supply chain as practicable) during the preharvest stage. Hence, greater emphasis needs to be placed on intervention strategies that reduce the pathogen load pre-slaughter.

Human illnesses from meat products are mainly caused by faecal contamination by bacteria such as *Salmonella*, *Campylobacter* and *Escherichia coli* 0157:H7 (CAST 2004). Animals carry these microorganisms within their intestinal tracts and excrete them in faeces. Meat can be contaminated if some faeces are transferred to the meat.

Faecal bacteria are resilient in a range of natural conditions. Microbial populations in faeces carried by cattle remain high even after cattle leave a feedlot (Wang and Makin 2001). If some faeces remain on the animals meat contamination by these microrganisms can occur during slaughter. Photo 1 and Photo 2 show how large amounts of faeces can be present on feedlot cattle. Although a definitive causal relationship between reducing the pathogen load on-farm and reducing disease outbreaks has not been conclusively demonstrated for many pathogen-disease combinations (Isaacson *et al.* 2004) beef carcase contamination has been correlated with faecal pathogen shedding (Elder *et al.* 2000). However, Rowland *et al.* 1999 were unable to find a consistent association between dag loading and carcase microbiological levels.

Nevertheless, any reductions in pathogen numbers on the hides of cattle going to slaughter will be helpful in reducing the risk of meat contamination. Food safety is vital to consumer confidence and to protecting and growing markets for meat and meat products. It is important that meat and meat products from Australian feedlot cattle meet the highest possible food safety standards. Hence, it is important to ensure that the hides of cattle are visibly clean and also have low pathogen counts when presented for slaughter. There is a need to further investigate how this can be achieved by the use of suitable intervention strategies in the preharvest stage.

Photo 1 Dags on feedlot cattle

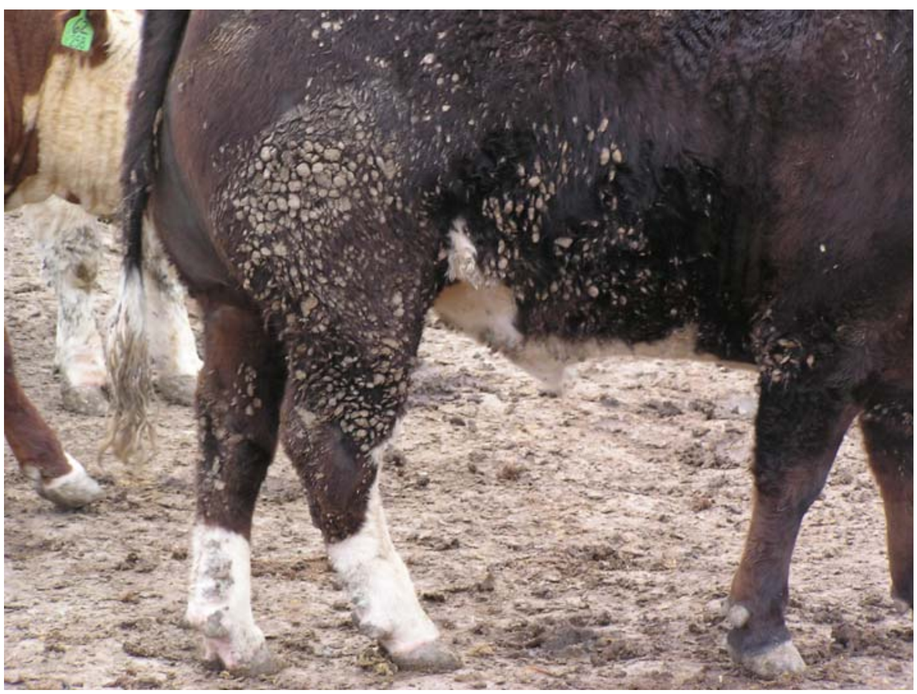

Photo 2 Close-up of dags on a feedlot steer

4.2 Current North American Standard and Policy

Considerable research into preharvest interventions has recently been conducted in North America. This research has been driven by the implementation of the “zero tolerance” policy for faecal contamination by the United States Department of Agriculture Food Safety Inspection Service (USDA - FSIS) and the adoption of performance standards for *Salmonella* in raw ground meat and carcasses.

Under the “zero tolerance” policy, any small fibrous or plant-like brown, yellow or green spots on the carcase are assumed to be faeces. Patches of visible faeces less than one inch in diameter on the carcass are removed by knife-trimming or steam vacuuming before the carcasses have their final wash and are placed in coolers. The zero tolerance policy has been rigorously implemented, with corrective action taken even when the source and composition of minute amounts of matter on carcasses are sometimes uncertain (CAST 2004).

The adoption of performance standards for *Salmonella* levels in raw ground meat and carcasses has also triggered changes in slaughtering practices. These raise the control requirements from visible (faecal matter) to invisible (*Salmonella* organisms). While the limits set have been controversial, they have led to improved slaughtering management and a reduction in the *Salmonella* count in fresh meat. They have also led to meat processors trying to find gaps in their practices where meat contamination may occur and triggered associated changes in practices.

4.3 Current North American Practices, Research and Recommendations

4.3.1 Introduction

Intervention strategies adopted in the preharvest stage of production range from frequent cleaning of water troughs to administering direct-fed antimicrobials prior to slaughter. A number of documents have been produced in recent times as best practice guides or scientific summaries. This section comprises a summary of some of the preharvest components of these documents.

4.3.2 Best Practices for Beef Slaughter

Developed by the National Meat Association, Southwest Meat Association, American Meat Institute and National Cattlemen’s Beef Association (2003), this document covers best practices for use throughout the slaughter process to achieve a visibly clean carcase and to reduce the frequency of pathogenic contamination.

In the preharvest stage of production, the document emphasises the importance of clean cattle trucks, receival and unloading facilities and holding pens. It recommends the cleaning of cattle washing areas, races and equipment with pathogen-free water. Regular cleaning and sanitisation of water troughs and feed bunks is also recommended.

If cattle arrive at the processing works with visible mud or faeces on their hides there is a higher risk of meat contamination. The document suggests that processors consider implementing a mud-score system to allow them to identify cattle that are more likely to fail the zero tolerance policy requirements. This could also be used to provide feedback to feedlot operators which would help them to understand their performance.

The document recommends that suitable feed withdrawal procedures be used for cattle fed in lairage to allow for proper evisceration and processing.

The document questions the performance of cattle washing in reducing microbial loads. It indicates that cattle washing demonstrably reduces visible contamination and improves sanitary dressing procedures at some establishments. Misting the cattle does help to reduce the levels of dust and dirt (which may carry pathogens) on the slaughter floor. However, it emphasises the importance of developing site-specific cattle washing procedures.

The document indicates that research into the potential benefits of adding antimicrobials to cattle washing systems is ongoing.

4.3.3 Preharvest Food Safety Strategies in Feedlot Animal Production

The focus of this paper written by McClanahan (2005) is the potential role of HACCP and food safety intervention strategies in the feedlot environment.

To ensure consistent production of high quality, safe beef products, the National Cattlemen's Beef Association (NCBA) and the USDA FSIS have made food safety their highest priorities. NCBA oversaw the development of state Beef Quality Assurance (BQA) programs in the US. The BQA programs have incorporated Best Management Practices (BMPs) into all stages of beef production and have been well accepted by producers as implementation is simple and economical. They have improved the quality and safety of beef in the US (Roeber *et al.* (2001) cited by McClanahan 2005).

The adoption of BQA programs has been successful in the beef industry providing a pathway for the implementation of HACCP principles. Both focus on the reduction of chemical, physical and microbial hazards to produce safe food while providing good management and husbandry within the feedlot.

Specific preharvest management and design strategies to reduce the risk of microbial hazards to humans include:

- building sloping pens to improve drainage.
- increasing the frequency of pen cleaning and replacement of bedding.
- putting a suitable number of cattle in each pen (stocking density).
- maintaining good general hygiene including cleaning of bucket loaders, feed bunks and water troughs.
- feeding probiotics to reduce *E. coli* 0157:H7 populations in the faeces.

There is ongoing research into the detection, epidemiology and ecology of *E.coli* 0157:H7 and the development and implementation of preharvest intervention strategies. This includes research into:

- Feed Additives. Competitive exclusion feed additives that introduce non-pathogenic bacteria to compete against pathogens within the rumen and intestines. *Lactobacillus* direct-fed microbials can be effective in reducing *E. coli* 0157:H7 shedding and hide contamination without detrimental effects on performance (Brashears *et al.* 2003 cited by McClanahan 2005). Probiotics have also reduced *E. coli* 0157:H7 levels in faecal and hide samples (Younts-Dahl *et al.* 2004 cited by McClanahan 2005). The dietary inclusion of Tasco 14®, a seaweed extract, for 14 days before slaughter reduced faecal shedding of *E. coli* 0157 by cattle (Braden *et al.* 2004 cited by McClanahan 2005).
- Dietary modification. There has been research into changing cattle from grain to forage-based diets (Callaway *et al.* 2003) and fasting before slaughter (Jordan and McEwan 1998 cited by McClanahan 2005). There have also been investigations into the relationship between grain composition of diets and *E. coli* populations in faeces. More work is needed in this area.
- Drinking water treatments. Adding sodium chlorate to water reduces intestinal and faecal populations of *E. coli* 0157 in cattle (Callaway *et al.* 2002 cited by McClanahan 2005). The effect of using electrolysed oxidising water to control *E. coli* 0157 levels in livestock water has also been researched (Stevenson *et al.* 2004 cited by McClanahan 2005).
- Vaccinations. Vaccinations against *Salmonella* and *E. coli* 0157:H7 show great potential. Trials have shown that vaccinations significantly reduce *E. coli* 0157:H7 shedding of yearling cattle (Potter *et al.* 2004 cited by McClanahan 2005).
- Antibiotics. Oral dosing with neomycin sulfate can reduce *E. coli* 0157:H7 levels in faeces (Elder *et al.* 2002 cited by McClanahan 2005). The effect of monensin sodium on *E. coli* 0157:H7 is also being researched (Bach *et al.* 2002).
- Animal / Environmental Management. According to Herriot *et al.* (1998) (cited by McClanahan 2005) there are no specific proven environmental strategies that directly affect the occurrence of zoonotic pathogens. However, the relationship between feedlot feed bunks and water troughs and food-borne pathogens is being investigated (Bach *et al.* 2002). Research into water troughs showed that they may serve as *E. coli* 0157:H7 reservoirs (LeJeune *et al.* 2000 cited by McClanahan 2005). Weaning, pre-conditioning and transportation also influence faecal shedding of *E. coli* 0157:H7 (Bach *et al.* 2002 cited by McClanahan 2005).

McClanahan (2005) confirms that intervention strategies seem to be effective in reducing the load of pathogenic bacteria at the preharvest stage which should reduce the risk of meat product contamination. Further research into these intervention strategies will provide crucial information to identify the critical control points most important in improving food safety. Preharvest pathogen control and intervention strategies have major limitations and must be economically viable. Also, the adoption of pharmaceuticals as preharvest interventions will probably require Food and Drug Administration (FDA) approval.

4.3.4 Preharvest Food Safety and Security

This paper was published by the American Academy of Microbiology (Isaacson *et al.* 2004). It identifies that recent major outbreaks of foodborne illnesses commenced through contamination during the preharvest stage. It also states that, apart from basic hygiene practices, few food safety controls are in place in preharvest environments mainly because of a lack of available information.

Isaacson *et al.* (2004) recognise that it would be practically impossible to eliminate pathogens from the preharvest environment. They suggest that a more realistic goal would be the reduction of pathogen numbers, through preharvest food safety interventions, to levels that would reduce the hazard to public health.

Isaacson *et al.* (2004) identify that bacterial numbers in livestock environments increase with:

- increasing stocking densities.
- contaminated water or feedstuffs.
- agreeable climates, poor water or waste handling.
- contact between infected and uninfected stock.
- recycling of waste products.

Isaacson *et al.* (2004) suggest that on-farm pathogen loads may be reduced by:

- suitable handling of water and waste.
- decontamination strategies.
- control of disease vectors.
- disinfection programs.
- the use of antimicrobial treatments.
- the use of probiotics (possibly).

The paper identifies some recognised risk factors pertaining to pathogen transport including:

- the age at which animals are first exposed to pathogens.
- the type and quality of feeds provided.
- animal health status.
- antibiotic exposure.
- exposure to wildlife, which may be carrying pathogens.
- exposure to livestock animals that are shedding pathogens. The introduction of new stock on the farm is a critical farm security point.
- season and climate.
- transportation of animals.
- standard of hygiene of lairage and at the slaughter plant entry.

- hygiene within the environment, including effluent management.

The paper identifies the importance of maintaining the microbiological standard of cattle feed, water, circulating air and objects the cattle come into contact with. It also emphasises the importance of maintaining good management and quality assurance practices in preventing pathogen distribution. It indicates that while the type of feed the cattle consume affects the types and load of pathogens carried through its influence on the pH of the rumen fluid, no specific dietary changes predictably alter the pathogenic flora within the intestines. The use of probiotics in feed look promising for controlling the carriage and shedding of pathogens. However, more field studies are needed to develop dependable techniques for their usage. Since some studies indicate that probiotics may be used over the life of the animal this may be a costly option. The use of probiotics for competitive exclusion of pathogens may gain favour as the routine use of antibiotics is phased out. FDA has already approved a specific product comprising a defined culture of microorganisms for competitive exclusion of pathogens.

Isaacson *et al.* (2004) suggest that many intervention strategies that would appear appropriate intuitively are either ineffective or not cost-effective. There is a need to assess existing and alternative intervention strategies, particularly strategies incorporating pro-active preventive elements, on the basis of effectiveness and cost-effectiveness.

A number of research needs are raised in Isaacson *et al.* (2004) since comparatively little is known about efficacy of preharvest food safety in relation to human health. It will be important to:

- validate intervention strategies.
- develop tools to detect and enumerate pathogens. Rapid molecular detection tools need further work.
- determine the impacts of chronic and mild foodborne illnesses.
- investigate the use of functional genomics in preharvest food safety applications.
- understand pathogen ecology on-farm.
- examine the costs associated with preharvest interventions.
- preharvest food safety targets and priorities should be set to achieve specific public health outcomes.
- studies to quantify the relationship between pathogen load and product contamination are needed. Effective sampling methods and quick and cheap methods to quantify pathogen loads in the preharvest environment need to be developed.
- risk assessments specifically targeting preharvest food safety risks are needed.
- detailed studies and specific criteria for measuring the efficacy of preharvest intervention strategies are needed.
- guidelines for on-farm best management practices need to be implemented to minimise pathogen contamination of livestock.
- better information needs to be provided to the public in relation to pathogens on the farm.

- extensive testing of the effectiveness of probiotics and competitive exclusion approaches in controlling pathogens in livestock are needed before they can be endorsed or widely adopted.

4.3.5 *E. coli* 0157:H7 Solutions: The Farm to Table Continuum

This paper was published by the Cattlemen's Beef Board and the National Cattlemen's Beef Association as an output of the San Antonio *E. coli* summit. It presents the commitments made by the following sectors involved in the beef industry: producer, slaughter / fabrication, processing, food service / distribution sector and retail sector. The points of focus for the producer sector were:

- To maintain current good management practices of clean feed, water pens and cattle.
- To evaluate the adoption of scientifically proven interventions or Good Management Practices (GMPs).
- To maintain open communication and to share data pertaining to preharvest interventions and GMPs. This was seen as critical.

The producer sector identified the following research needs:

- To investigate promising feed and or water additives including Tasco 14®, sodium chlorate, neomycin and direct-fed microbials.
- To research vaccines as a longer term strategy. Although this technology looks promising there have been no large scale studies.
- Cattle cleaning systems. These are a short-term approach that show promise in significantly reducing the microbial load of cattle in the preharvest stage.
- There is a need to address information gaps like the reasons behind the high pen-to-pen variation in *E. coli* 0157:H7 levels in cattle from the same feedlot and inconsistent reductions in *E.coli* 0157:H7 from pen cleaning, trough washing, cattle segregation and dietary manipulation.
- Industry and USDA must work together to hasten approvals for in-field testing of promising interventions.
- There is a need to evaluate systems using a combination of intervention strategies.
- Interventions must be adopted on the basis of scientifically sound data, not on preliminary findings. This is important since bad data can lead to bad decisions.

4.3.6 *E. coli* 0157 Solutions: The Pre-Harvest Commitment

This brochure was produced by the Beef Industry Food Safety Council in 2004 for use by cattle breeders, backgrounders and lot feeders. The document provides information on *E. coli* 0157 in cattle and potential ramifications for the beef industry. It emphasises that beef producers must be aware of the status of research into this pathogen and their role in controlling it. It includes principle-based husbandry practices for use by producers.

The maintenance of clean, well-drained production areas that are free of vermin and pests (e.g. biting insects) assists in optimising animal health and welfare. Provision of clean feed and clean water is also identified as a basic principle of cattle production.

The brochure documents a range of management practices for controlling *E. coli* 0157 that have been investigated. A summary of the findings of this research is reported as follows:

- Market classification and animal age does not influence *E. coli* 0157 prevalence.
- Stocking density and pen cleaning do not influence the presence of *E. coli* 0157.
- Although drinking water may distribute *E. coli* 0157 to a susceptible herd, there is no conclusive evidence that aggressive and frequent water trough cleaning affects *E. coli* 0157.
- There is no link between the presence of *E. coli* 0157 in feed and it's prevalence in live cattle.
- Research does not support changing cattle from a high-concentrate to a high-roughage diet as an *E. coli* control measure. It has not been demonstrated that feeds containing whole cottonseed, barley, barley silage or soybean meal reduce *E. coli* 0157 prevalence. The only expected outcome of a sudden dietary change is a reduction in animal performance.
- Since *E. coli* 0157 is present in many non-bovine species including rodents, scavengers, wild ruminants, domestic animals and birds the access of these animals to feed commodities and prepared feed should be restricted.
- Contamination of feed products can occur through the use of contaminated processing equipment. In particular, equipment used to clean pens or move manure or mortalities should not be used to prepare rations unless first being thoroughly cleaned and disinfected.
- Research into the relationship between *E. coli* 0157 and flies is inconclusive. However, principle-based husbandry should incorporate one or more Integrated Pest Management strategies such as:
    - Mechanical / Habitat removal – drainage of standing water, use of baits, pen cleaning, removal of weeds, sanitation (removal of spoilt or spilt feed, water trough maintenance, manure composting, removal and composting of mortalities and limiting the on-site storage of hay).
    - Biological – use of parasitic wasps or targeted microorganisms like *Bacillus species (thuringensis).*
    - Chemical – Spray, mist, fog or sprinkler application or use of insecticide baits.
- There has been little research into the effectiveness of actions during the time period from when cattle leave the feedlot to hide removal at the processing plant. However, there are plenty of opportunities for cross-contamination during this time. Lot feeders should ensure that the internal surfaces of cattle trailers are free of visible faeces and have been cleaned and disinfected before loading. Holding pens need to be cleaned between groups of cattle.
- Probiotics – Bovamine and other probiotics are effective in reducing *E. coli* 0157 prevalence in faeces. Bovamine is approved for use in livestock and is commercially available.
- Tasco 14®, a seaweed extract, reduces *E. coli* 0157 levels but adversely affects animal performance. Research is ongoing. Tasco 14® is approved for use in livestock and is commercially available.

- Sodium chlorate used intraruminally or added to feed or water was effective in reducing *E. coli* 0157 levels. However, it was not approved for livestock at the time the brochure was published.
- Vaccines are effective in reducing *E. coli* 0157 in hide and faecal samples but doses and administration of these vaccines are still being studied. These were not approved for use at the time the brochure was published.
- Antibiotics – Ceftiofur significantly and quickly reduces *E. coli* 0157 shedding between treatment days two and five. Efficacy of the antibiotic declines beyond day five of treatment. More research with naturally-infected cattle is warranted. Use of neomycin sulfate, including in drinking water, effectively reduces *E.coli* 0157. However, neither antibiotic had FDA approval for control of *E. coli* 0157 at the time the brochure was published.
- Bacteriophages are unproven in reducing *E. coli* 0157.
- Water treatment – at the time the brochure was published, chlorination and electrolysation of water were unproven as methods for reducing *E. coli* 0157 in live animals although laboratory trials had been encouraging. Further research is needed.
- Preharvest / harvest interface (time period from when cattle leave the feedlot until their hides are removed at the processing works) – Live cattle cleaning systems and hide washes are being researched, along with other methods that could be used during this production stage.

A number of important knowledge gaps were identified in the brochure. In addition to needs identified by Isaacson (2004), these include a need to:

- better understand *E. coli* 0157 shedding, particularly in the areas of seasonal and regional variation, pen to pen variation, persistent colonisation of both pens and individual cattle, and relationships between cattle and transmission vectors (e.g. other animals, insects, water).
- study animal to animal transmissions during the preharvest / harvest interface, including the effect of cattle handling on carcase contamination during this time.
- understand microbiological and pathogen ecology under the influence of husbandry practices aimed at reducing the pathogen load. Measures to control one pathogen may also influence others. It is important to understand these effects.

4.3.7 Intervention Strategies for the Microbiological Safety of Foods of Animal Origin

This issue paper was published by CAST (2004). It emphasises the importance of food safety to consumer confidence. It addresses the issue of the microbiological safety of animal-derived foods during production, processing, retailing and food service. It describes intervention strategies to prevent, remove or control these hazards. It also makes recommendations for the development and application of intervention processes to reduce the incidence of human illnesses from foods of animal origin.

The feed and water consumed by the animals are vehicles for the introduction of pathogens to the animals' body. Research by McChesney (1995 cited by CAST 2004) showed that 82% of meat and bone meal (MBM) and 37% of vegetable protein (mainly soyabean meal (SBM)) samples tested contained *Salmonella* although only 16% of the mixed diets tested *Salmonella* positive. Research by APPI (2000 cited by CAST 2004) indicates that *Salmonella* is present in about 25% of US MBM and SBM. Testing of European Union and Australian feedstuffs indicates that *Salmonella* levels are typically about 1% (Sperber 2000 pers. comm. cited by CAST 2004). *E. coli* 0157:H7 is commonly found in the water of farm and feedlot water troughs (Hancock *et al.* 1998 cited by CAST 2004). Hence these are a potential source of disease transmission. Faecal contact between animals in feedlots and in transit is identified as a primary source of disease transmission between cattle. Pests like rodents, birds, flies and other insects are identified as possible disease vectors for feedlots.

The paper identifies the potential for using Quantitative Microbial Risk Assessment (QMRA) as a powerful tool to identify intervention strategies during preharvest and throughout the food production continuum that may effect the greatest improvements in public health. However, further development of QMRA is needed before it can be routinely used in this application.

A range of production interventions with the potential to reduce pathogen levels on meat are summarised. These include:

- Feed additives and treatments including:
    - pelletising at temperatures exceeding 80^{o}C to control *Salmonella* based on the work of Cox *et al.* (1986) and Himathongkham *et al.* (1996).
    - mixtures of ammonium formate, ammonium propionate and sodium sorbate to control *Salmonella*, particularly in liquid feed based on the work of Anderson *et al.* (2000).
    - sodium chlorate to control *E. coli* 0157:H7 and *Salmonella typimurium D104* based on the work of Anderson *et al.* (2000).
    - propionic acid and heating to control *E. coli* 0157:H7 and *Salmonella typimurium D104* based on the work of Matlho *et al.* (1997).
- Competitive exclusion. CAST (2004) cite the success of Zhao *et al.* (1998) in demonstrating that certain isolates of *E. coli* are antagonistic to the growth of *E. coli* 0157:H7. For most cattle it cleared the rumen, colon and faeces of *E. coli* 0157:H7 within 12 days of treatment commencing. The research of Brashers *et al.* (2000 cited by CAST 2004) also confirmed that *Lactobacillus* spp. is an effective agent against *E. coli* 0157:H7.
- Bacteriophages and vaccines. These can either kill pathogens directly or prevent their colonisation within animals. Research by Waddell *et al.* (2002 cited by CAST 2004) demonstrated that bacteriophage treatment hastened faecal shedding in calves. Traditional vaccination programs are unlikely to control pathogens in cattle because of the nature of the ruminant digestive system. Novel approaches that are being investigated include: the targeting of specific genes in pathogens and the development of vaccines against the proteins involved in the pathogen's attachment to the intestinal lining of the animal. Research into the development of a vaccine for the control of *E.coli* 0157:H7 in cattle is underway.
- Husbandry practices including:
    - cleaning and disinfecting water troughs to control various pathogens based on the work of LeJeune *et al.* (1997).

- using organic acids to acidifiy water to pH 3.5 or chlorination to control various pathogens based on the work of Byrd *et al.* (2001).
- sodium chlorate addition to water pre-slaughter to control various pathogens based on the work of Anderson *et al.* (2000).
- grain-based finishing diet to decrease faecal shedding time and control *E. coli* 0157:H7 based on the work of Garber *et al.* (1999).

4.3.8 What Are We Doing About *Escherichia coli* 0157:H7 in Cattle?

This review was written by Callaway *et al.* (2004). The introduction recognises that the cattle industry and researchers have for many years focussed on improving meat quality post-slaughter. While this has produced significant reductions in carcase contamination, illnesses from contaminated meat still occur. This has prompted a change in focus towards intervention strategies to control pathogens in the preharvest stage.

The paper identifies that it is difficult to diagnose infection of cattle by pathogens on-farm. Often the pathogens have little or no impact on cattle health or production efficiency. As well, faecal shedding of *E. coli* 0157:H7 may be highly variable, with a positive test being followed by days or even weeks of clear results. The tests are also expensive and time consuming. Hence, strategies cannot be designed to target a small diagnosed percentage of the cattle in the feedlot but must be applied to cover all cattle in the feedlot.

A range of strategies is available to reduce foodborne pathogen numbers in cattle. These include: probacterial, antipathogen and feeding and management approaches.

Probacterial strategies include probiotics and competitive exclusion.

- It has been demonstrated that adding *Lactobaccillus acidophilus* culture to finisher cattle diets can decrease *E. coli* 0157:H7 shedding by over 50% (Brashears *et al.* 2003a cited by Callaway *et al.* 2004). Moxley *et al.* (2003) (cited by Callaway *et al.* 2004) also produced a promising, although not statistically significant, reduction in faecal shedding of *E. coli* 0157:H7. This product is currently available on the market and is in use by cattle producers.
- It has recently been demonstrated that competitive exclusion and other probiotics may be effective in reducing *E. coli* 0157:H7 and other bacteria in the digestive systems of cattle (Zhao *et al.* 1998, Tkalcic *et al.* 2003, Zhao *et al.* 2003 cited by Callaway *et al.* 2004). A competitive exclusion culture for cattle is currently being developed for commercialisation and field testing was expected to occur within 12 months.

Antipathogen strategies specifically target and destroy pathogens. They include antibiotics, ionophores, bacteriophages, use of metabolic pathways and immunisation.

- The use of antibiotics as growth promotants has become controversial, mainly because of concerns about antibiotic resistance. However, it has been confirmed that some antibiotics directly affect intestinal populations of pathogens. For instance, Elder *et al.* (2004) (cited by Callaway *et al.* 2004) found that faecal shedding of *E. coli* 0157:H7 was significantly reduced through the use of neomycin. This drug is not of importance to human medicine and only has a 24 hour pre-slaughter withdrawal period. However, because it is closely related to other drugs used to treat human infections, resistance issues still need consideration before it is widely adopted. It should only be used for this purpose until alternative and less controversial intervention strategies emerge. At the time the review was written discussions with the FDA were underway to allow the use of neomycin to reduce *E. coli* 0157:H7.

- Ionophores are widely used as growth-promotants in cattle production. They seem to mainly inhibit gram-positive bacteria, while most foodborne pathogens of human interest are gram negative (Edrington *et al.* 2003c cited by Callaway *et al.* 2004). Hence, they could be advantageous to pathogens although *in vitro* and *in vivo* studies have demonstrated that this does not happen with *Salmonella* and *E.coli* in ruminants (Edrington *et al.* 2003b, c cited by Callaway *et al.* 2004).
- Bacteriophages are viruses that kill bacteria and are commonly found within the intestinal tract of cattle. They are very specific in their action and can target a specific bacterial strain (Barrow and Soothill 1997 cited by Callaway *et al.* 2004). An encouraging, though not statistically significant, reduction in *E. coli* 0157:H7 numbers throughout the intestinal tract has been demonstrated after bacteriophage treatment (Callaway *et al.* 2003b cited by Callaway *et al.* 2004). Since the effectiveness of bacteriophage treatment in real-world conditions has been variable, more investigations are needed before these can be recommended as a control measure for foodborne pathogens in cattle.
- It is possible to inhibit specific pathogens using metabolic pathways. It has been demonstrated that adding chlorate to cattle drinking water significantly decreased *E. coli* 0157:H7 numbers in the rumen, caecum and faeces of cattle (Callaway *et al.* 2002, 2003a cited by Callaway *et al.* 2004). Because chlorate is very effective against foodborne pathogens in the gut its addition to the last feed (about 24 hours pre-slaughter) has been suggested (Anderson *et al.* 2000a cited by Callaway *et al.* 2004). At the time the review was written the FDA was considering whether to approve the use of chlorate for food animals.
- The use of immunisations against pathogens in the gut is a new application. A vaccine against *E.coli* 0157:H7 has recently been developed (Finlay 2003 cited by Callaway *et al.* 2004) and it is effective in decreasing faecal shedding of these bacteria (Moxley *et al.* 2003 cited by Callaway *et al.* 2004). It is currently undergoing field trials before commercialisation for use with feedlot cattle commences. The use of this vaccine together with the *Lactobacillus* culture was tested to see if any synergies were achieved. This was not the case (Moxley *et al.* 2003 cited by Callaway *et al.* 2004). However, the vaccination appears promising and may be used with other more compatible pathogen-reduction methods.

Although good husbandry optimises cattle performance, it is yet to be demonstrated that it affects the carriage or shedding of foodborne pathogens by cattle.

- The type of grain used in finisher diets has a direct impact on faecal shedding of *E. coli* 0157:H7, with barley diets linked to higher shedding rates (Dargatz *et al.* 1997). It has been found that abruptly switching cattle from a finisher diet to a hay diet significantly decreased faecal *E. coli* populations which could be used to reduce *E. coli* loads at the processing works (Diez-Gonzalez *et al.* 1998, Keen *et al.* 1999 cited by Callaway *et al.* 2004). However, other research showed that longer term forage feeding had no effect on or increased *E. coli* 0157:H7 shedding (Hovde *et al.* 1999, Buchko *et al.* 200a, b cited by Callaway *et al.* 2004). Abruptly changing the diet from grain to forage appears to be effective in reducing pathogen shedding although the scale of the effect is variable and remains controversial (Callaway *et* *al.* 2003 cited by Callaway *et al.* 2004). It is also important to consider the effect of a change in diet on carcase quality and the financial implications and infrastructure requirements.

- Research has shown that water troughs provide a reservoir for the spread of *E. coli* 0157:H7. If this is a significant cause of *E. coli* 0157:H7 transfer between stock there are opportunities to intervene to control the bacteria (LeJeune *et al.* 2001 cited by Callaway *et al.* 2004). Possible options include: chlorination, ozonation, frequent cleaning and the use of screens to decrease the organic solids in the water.

The paper concludes that a range of methods have the potential to reduce the incidence of foodborne pathogens on animals presented for slaughter. However, for many of these, further research is needed.

4.3.9 Cleaning up Cattle

In this extension article, Grandin (2002) provides information lot feeders can use to present cattle with a low pathogen count for slaughter.

Grandin (2000) cites research undertaken by D. Smith of the University of Nebraska showing that 23% of cattle from five feedlots tested positive to pathogens and that muddy feedlot pens produced a higher percentage of infected cattle. Hence Grandin (2000) identifies the importance of measures to keep cattle clean including:

- regular pen scraping to keep the pens dry preferably using box scrapers to keep the pen surface smooth which avoids formation of bog holes.
- The construction of feedlots with pen slopes of 2-4% to promote drainage.
- mounds within pens.
- 20 foot aprons.
- use of bedding.
- frequent removal of sediment from water troughs and water treatment either with 5 ppm chlorine to reduce infection rates or with sodium chlorate which reduces *E. coli* 0157:H7 levels in the intestinal tract of animals, as demonstrated by research at Texas A & M University.

Grandin (2000) sees competitive exclusion as a promising emerging technique for controlling *E.coli* 0157:H7, suggesting that the use of dietary probiotics is a much better approach than the use of antibiotics. Vaccines are viewed as the ultimate answer.

However, Grandin (2000) is opposed to washing cattle to remove mud because of the stress to the cattle and the associated increases in dark cutters.

4.3.10 Control Measures for *E. coli* 0157:H7 at the Producer Level

In this extension article, Willms (ND) identifies the control measures graziers and lot feeders can use to control *E. coli* 0157:H7 on-farm. The measures needed to control this pathogen in feedlots include:

- prevention of cattle grazing pastures recently spread with feedlot manure (e.g. backgrounding cattle).
- frequent cleaning of water troughs.
- regular bunk cleaning. This reduces the likelihood of faecal contamination of feed.
- regular feeding. Irregular feeding or withholding feed may cause cattle to shed large numbers of *E. coli* 0157:H7 in their faeces.

Willms (ND) claims that there is no evidence that *E. coli* 0157:H7 is antibiotic resistant or that probiotics prevent infection by this pathogen.

4.3.11 Recent Update on American Practices

Dr Tommy L Wheeler, Acting Research Leader, Meat Research Unit of the US Meat Animal Research Center, USDA (pers. comm. 23 November 2005) advised that, as of November 2005, sodium chlorate, vaccines and antibiotics have not been approved for use by cattle for the control of *E. coli* or other pathogens. However, Dr Wheeler understands that sodium chlorate is likely to be approved soon. Some vaccines have also been submitted for approval.

Dr Wheeler confirms that research conducted over the past 6-8 years shows that the hide is the source of most carcass contamination and that cleaning the hide before its removal will prevent almost all carcass contamination. FSIS has also approved hide washing but does not require that it is done. Cargill Meat Solutions has spent millions installing hide washing cabinets in all of their plants. The cattle are stunned, bled and then pass through the cabinet. After the cattle passes through the cabinet the pattern lines where the hide will be opened are vacuumed to remove excess water. If the cattle are particularly dirty the dags are removed before they are put through the cabinet. This is the most extensive hide washing used. Other companies use variations of this with water only. Live cattle washing is rarely done because of concerns about animal stress and welfare.

4.4 Current Australian Guidelines and Production Standards

4.4.1 Introduction

Various guidelines, codes of practice and production standards apply to the lot feeding sector of the Australian beef industry. Some of these documents provide information on standards and practices required at meat processing plants. Meat safety inspectors are responsible for inspecting cattle prior to slaughter to ensure that they are clean and healthy. Meat safety inspectors may restrict or prevent the slaughter of cattle that are soiled or unclean and daggy cattle from feedlots as these animals pose a risk of contamination of meat. The principle Standard requiring the clean presentation of cattle for slaughter is SCARM (2002a). Other documents emphasise the importance of best design and management practices. These practices are compatible with minimising hide contamination.

A summary of applicable current documents follows.

4.4.2 Australian Standard for Hygienic Production and Transportation of Meat and Meat Products for Human Consumption (AS 4696:2002)

The broad objective of this Standard (SCARM 2002a) is to ensure that meat and meat products for human consumption are wholesome and comply with food safety requirements. The Standard includes separate food safety outcomes and requirements to ensure that meat and meat products are wholesome at each stage of production. It incorporates objectives to ensure that the food safety and wholesomeness of meat and meat products can be guaranteed including requirements for the implementation of systems to identify, trace, recall and to ensure the integrity of meat and meat products. It includes animal welfare objectives since these influence both food safety and public expectations for meat and meat products.

The Standard acknowledges that food safety risks extend right throughout the meat production chain. As a result it includes outcomes for the receival and slaughter of animals; carcase dressing; processing; packaging; handling and storage; construction of premises for slaughtering and processing; and transportation of meat and meat products. Process control shall be achieved through the application of Hazard Analysis Critical Control Point (HACCP) methodology which means a system that identifies, evaluates and controls hazards of significance to food safety.

A number of clauses within the Standard are applicable to the presentation of cattle for slaughter.

Part 2 of the Standard is entitled “Wholesomeness and Operational Hygiene”. Section 4 of part 2 is entitled “Operational Hygiene”. The outcome of section 4 is “Operational hygiene process controls ensure the production of meat and meat products that are wholesome”. Clause 4.3 states:

“At the end of each day’s operations holding pens are cleaned to the extent necessary to ensure that:

(a) contamination is not transferred from the pens to areas used for slaughter and dressing animals; and

(b) pests are not attracted to the pens.

For the meaning of *holding pen* see clause 1.3."

(in clause 1.3 holding pens "means a pen used or to be used to hold animals in preparation for their slaughter").

Part 3 of the Standard is entitled "Slaughter and Dressing of Animals". Section 8 of part 3 is entitled "Ante-Mortem Inspection and Disposition". The outcome of section 8 is: "Only animals fit for slaughter for the purpose of producing meat and meat products for human consumption are slaughtered". Clause 8.4 states that "Reasonable steps are taken to present animals for inspection in a clean condition". Clause 8.5 states that "Animals that are not clean are not passed for slaughter or are passed for slaughter subject to conditions that ensure they do not contaminate animals, carcases and carcase parts during slaughter, dressing, post-mortem inspection and disposition." Clause 8.9 states "One of the following dispositions is applied to the animals:

(a) passed for unconditional slaughter; or

(b) passed for slaughter subject to conditions specified by the meat safety inspector; or

(c) withheld from slaughter; or

(d) condemned."

Clause 8.16 states "An animal required to be withheld from slaughter:

(a) is identified and segregated from animals not required to be withheld from slaughter; and

(b) is submitted for ante-mortem inspection and disposition before slaughter."

Section 19 of Part 7 covers general matters. Clause 19.2 states that "The premises and equipment:

(a) are not a source of contamination of animals, meat and meat products and do not jeopardise the wholesomeness of meat and meat products; and

(b) facilitate hygienic production; and

(c) can be effectively inspected and monitored."

Clause 19.3 states that: "The premises and equipment (other than equipment that is disposable and is not reused) can be effectively cleaned and maintained. (Note: The definition of premises includes any outdoor areas such as lairages; see clause 1.3)." (Under clause 1.3 Premises "means a place where operations to produce meat or meat products are carried out and includes:

(a) any area (whether enclosed or built on, or not), building, facility fixture and fitting at the place; and

(b) a part of any area, building , facility, fixture or fitting referred to in paragraph (a).

Various other clauses in this section provide construction standards.

The standard is less objective and less specific than the North American USDA-FSIS zero tolerance policy. It does not provide for rigorous control over pathogen contamination of hides as it focuses on subjective visual assessment of these. Hence, the required standard of hide visual cleanliness varies considerably between meat processing plants.

From 1 July 2004, each export registered processing works was required to have an Approved Arrangement under the Australian Standard for the Hygienic Production and Transport of Meat and Meat Products for Human Consumption (AS 4696-2002). The approved arrangement must be: HACCP based, supported by its pre-requisite program and include any necessary product integrity programs that allow AQIS to issue export meat and meat product certification (Department of Agriculture, Fisheries and Forestry 2005).

4.4.3 Model Code of Practice for the Welfare of Animals: Livestock at Slaughtering Establishments

The aim of this model code of practice is to encourage the efficient, considerate treatment of animals so that stress is minimised. It is intended to be used by all people involved in the management of animals at slaughtering establishments, including truck drivers, stockmen, slaughtering staff, inspectors, veterinarians and abattoir management. It covers design and construction of stock unloading ramps, unloading, unloading of crippled or downer stock, stock holding facilities and management, slaughter methods and a range of topics pertaining to poultry (SCARM 2002b).

There is limited information in this Code specific to presenting clean animals for slaughter. Clause 2.1.1 specifies that "Unloading facilities must be constructed and maintained so that they do not cause injury, soiling or suffering to animals". Clause 2.5.2.5 specifies, in part, "Holding pens, and feed and water facilities for all species, should be cleaned after each day of use".

4.4.4 Australian Model Code of Practice for the Welfare of Animals: Cattle

This code of practice was developed by the Standing Committee on Agriculture, Animal Health Committee or SCARM (1992a). It covers basic welfare needs, intensive cattle systems, cattle handling facilities, management practices and health among other topics. It does not specifically provide measures to reduce the pathogen load of cattle going to slaughter.

4.4.5 National Feedlot Accreditation Scheme (NFAS)

The National Feedlot Accreditation Scheme (NFAS) is an industry self-regulatory quality assurance scheme that was initiated by the Australian Lot Feeders' Association (ALFA) and is managed by the Feedlot Industry Accreditation Committee (FLIAC). Its objective is to promote the adoption of Quality Systems for beef feedlots to improve product quality. It aims to ensure the Australian beef feedlot industry develops a responsible feedlot management program to:

- enhance the marketing prospects for grain fed beef by raising the integrity and quality of the product.
- establish a viable mechanism for industry self-regulation.
- improve the image of feedlots held by the community, particularly relating to environment and animal welfare matters. (Aus-Meat 2001b).

Under the NFAS feedlot operators develop quality systems consistent with this objective and mission but tailored to suit their own operations. NFAS does not specifically address the presentation of cattle for slaughter. However, the requirement to present clean cattle to the processing works and additional special requirements of the works could be incorporated into "Review of Product Requirements" (Bruce Gormley, AUS-Meat Limited, pers. comm. 6 October 2005). Quality systems developed under the NFAS must be consistent with the National Beef Cattle Feedlot Environmental Code of Practice.

4.4.6 National Guidelines for Beef Cattle Feedlots

The National Guidelines were published by SCARM (1992b). Their intent is to provide a broad structure of generally accepted principles for the establishment and operation of feedlots. They cover environment protection, animal welfare and approval processes. They do not specifically address presentation of cattle to the processing works or methods to reduce pathogen loads.

4.4.7 National Beef Cattle Feedlot Environmental Code of Practice

ALFA developed this code of practice in 2000. Its purpose is to make a public commitment to strive towards achieving environmental management best practice. It has a strong focus on management practices that provide the following outcomes:

- effective utilisation of effluent and manure.
- protection of the land.
- protection of groundwater resources.
- protection of surface water resources.
- protection of community amenity.

It provides operational practices and performance indicators to meet a range of specific objectives. These covers aspects like:

- the provision of food and water of an adequate quality.
- pen designs that drain well.
- regular pen cleaning and maintenance.
- suitable management of spilt or spoilt feed.
- the adoption of practices that control flies and vermin.
- proper disposal of mortalities.

Its clear focus is environmental management and it does not specifically address the presentation and microbial loading of cattle to processing works.

4.4.8 Code of Practice: Cattle Welfare in Feedlots

ALFA published this code of practice to provide a standard for the handling and care of feedlot cattle (ALFA 1997). It covers livestock management, feeding management and general in-yard management. It does not specifically address practices to reduce the pathogen load of cattle received at processing works.

4.4.9 Cattlecare

Cattlecare was developed by the Cattle Council of Australia and is supported by MLA. It aims to assist producers to develop Quality Assurance programs that will ensure the beef they produce is clean and wholesome and of a quality demanded by the markets (Aus-Meat 2001a). Hence, there is scope to address reducing the pathogen load of cattle received at processing works through a Cattlecare QA program.

4.4.10 State Feedlot Guidelines

<u>*Queensland*</u>*: "Reference Manual for the Establishment and Operation of Beef Cattle Feedlots in Queensland"*

The Queensland Feedlot Advisory Committee (FLAC) produced this reference manual in 2000. The manual acknowledges that the "National Guidelines for Beef Cattle Feedlots in Australia" is the primary reference document for the establishment and operation of Australian feedlots. This manual is intended to complement the National Guidelines by:

- providing guidance and interpretation on methods presented in the National Guidelines.
- expanding on the methods and standards presented in the National Guidelines by providing best management practices.
- Suggesting best management methods and standards for managing issues not covered by the National Guidelines.

The manual aims to promote the development and operation of Queensland cattle feedlots in accordance with the principles of ecologically sustainable development. The clear focus of the manual is sound environmental management. Hence, the practices to reduce the pathogen load during the preharvest stage are not specifically addressed.

<u>*New South Wales*</u>*: "The New South Wales Feedlot Manual"*

This manual was developed by The Inter-Departmental Committee on Intensive Animal Industries (IDC) (Feedlot Section) (1997). It comprises four main parts:

- issues in starting a feedlot including design and construction.
- feedlot operation.
- financial aspects.

- specific technical issues pertaining to cattle husbandry.

There is no specific information on intervention strategies for pathogen control at the preharvest stage.

Victoria: "Victorian Code for Cattle Feedlots"

This Code was developed by the Victorian Feedlot Committee in 1997 to promote the orderly and economic development and operation of Victorian feedlots. It provides environmental standards that allow the cattle feedlot industry to meet community expectations for environmental protection. The Code is a planning document. The design and operational requirements section does not cover specific strategies to reduce the pathogen load of the cattle in the preharvest stage.

South Australia: "Guidelines for the Establishment and Operation of Cattle Feedlots in South Australia"

These guidelines were developed by the Department of Primary Industries South Australia and Office of the Environment Protection Authority (1994). They were developed to enable the orderly development and economic operation of feedlots, while also minimising adverse environmental impacts and protecting cattle welfare. They cover the feedlot approval process, planning principles, site selection, design requirements, operational requirements, environmental monitoring, public and environmental health, animal health regulations, animal welfare, abattoirs and other topics. The guidelines do not provide any specific guidance on reducing pathogen load of the animals at presentation to the processing works.

Western Australia: Guidelines for the Environmental Management of Beef Feedlots in Western Australia.

These guidelines were developed by the Department of Agriculture, the Department of Environmental Protection and the Water & Rivers Commission in 2002. They were developed to provide information on the legislative requirements that cattle feedlots must fulfil and guidance on acceptable environmental management practices. They provide good information on feedlot design and operational requirements. However, they do not specifically address the interventions to reduce pathogen loads of animals presented to processing works.

4.4.11 Conclusions

While all of the national and state based guidelines and codes of practice provide design and operational parameters, only SCARM (2002a) specifically addresses the requirement of presenting clean stock to the processing works. AQIS inspectors administer this requirement and decide whether cattle are acceptably clean for slaughter. The "Review of Product Requirements" component of a NFAS QA program could identify that it is necessary to present clean cattle to the processing works. The documents collectively require the adoption of practices likely to produce a clean environment including:

- the provision of food and water of an adequate quality.

- pen designs that drain well.
- regular pen cleaning and maintenance.
- suitable management of spilt or spoilt feed.
- the adoption of practices that control flies and vermin.
- proper disposal of mortalities.

4.5 Australian Industry Practices

4.5.1 Introduction

A significant body of research into methods for cleaning livestock for presentation for slaughter has been undertaken in Australia. This section provides a summary of the findings of this research. In addition, it includes the findings of a survey of ten feedlot operators from four states (Queensland, New South Wales, Victoria and Western Australia) who were interviewed regarding intervention strategies they use in the preharvest stage to reduce the pathogen load of their cattle. In addition, a specialist feedlot nutritionist (Dr John Doyle) and a specialist feedlot veterinarian (Dr Kev Sullivan) were interviewed.

4.5.2 Summary of Recent Australian Research

4.5.2.1 Preparation and Delivery of Clean Livestock

This project (Rowland *et al.* 1999) addressed the issue of improving carcass hygiene by cleaning cattle and sheep before slaughter. It comprises a review of literature; a survey documenting industry practices and attitudes; and winter and summer trials to assess the efficacy of different methods of producing clean cattle along with the cost, effect on meat quality, effect on skin/hide value, occupational health and safety considerations and animal welfare implications.

A survey of 174 people representing feedlots, producers, saleyards, abattoirs and transport companies from Northern Australia to Southern Australia was conducted. All sectors generally agreed that it was necessary to present clean livestock for slaughter, with mud, faeces and dags considered the major contaminants pre-slaughter. It was generally agreed that contamination of livestock follows seasons, with most contamination seen during winter nationally, although in summer, northern Australian processors commented the soil load is high. At the time of the survey, feedlots, producers and abattoirs were not generally cleaning livestock before transportation from the premises. The cost of cleaning livestock was not well understood by the industry and where costings had been prepared they were incomplete.

The critical points for the preparation and supply of clean livestock identified by industry in the survey include:

- transport.
- clean yards in feedlots.
- on-farm practices.
- time spent in lairage.
- water pooling on floors in lairage, feedlots or saleyards.

Many different methods of dag removal from feedlot cattle were identified in the report. These fall into two main categories, mechanical (Rockdale Robotic Dag Removal System (RRDRS), shearing, hand raking) and chemical (washing, detergents).

Major findings from two trials conducted in winter and one conducted in summer:

1. There is no direct correlation between dag loading of the live animal and the microbiological quality of the carcasses.
2. The level of *E. coli* on the carcasses tested was very low and well within the USDA Mega-Reg requirements (USDA 1993 cited by Rowland *et al.* 1999).
3. All treatments were effective at reducing dag loading of live animals, assessed using the UK Clean Livestock Grading System (MHS 1997 cited by Rowland *et al.* 1999). The treatments included: pre shear / shear; shear, preshear / wash; spray wash without detergent; pre-shear / wash and detergent; wash and detergent; pre-shear RRDRS, RRDRS, hand-rake; air knife post slaughter; Parke Rota Shear post slaughter. Only shearing totally eliminated the loading.
4. Differences in other parameters assessed:

- Lowest stress was seen in animals in the spray wash and detergent, spray wash and pre-shear/shear groups.
- The spray wash, wash and detergent, RRDRS and the post slaughter air knife treatments had the lowest OHS risks.
- The wash and detergent treatments and the two post slaughter treatments (air knife and Parke Rota Shear ™) had the lowest costs, with treatment costs for the full range of treatments varying from $0.55/head to $7.99/head.

Recommendations from this work include:

- Washing alone may achieve adequate microbiological quality of carcasses.
- If hygiene of cattle could be maintained during transport, cattle could be cleaned either on-farm or on-lairage
- If using mechanical dag removal methods, animals should be cleaned at least seven days before slaughter to reduce incidence of stress.
- New treatments should be benchmarked against washing and zero treatment in this report.
- A system for the description of the cleanliness of livestock should be introduced into the Aus-Meat Livestock language.
- There is scope for the EMO's (Export Meat Orders) (AQIS 1999 cited by Rowland *et al.* 1999) to be redrafted so that the meat processing sector operates in terms of outcomes, rather than having to adhere to prescriptive or subjective assessment criteria.

In Australia AQIS, through the provisions of the export meat orders (EMO's), restricts slaughter of cattle that are soiled or unclean, as well as daggy animals from feedlots as these animals pose a risk of contamination of meat. In addition to AQIS, the ARMCANZ have endorsed AS4461-2001 and AS4462:1997.

The three rating systems used throughout the world are the England ("Clean Livestock Policy"), Canada ("Mud Score System") and Finland systems. A small number of processors in Canada, the US and Australia are introducing similar systems. The "Mud Score System" and "Clean Livestock Policy" involve a subjective appraisal of contamination to hides. The former is carried out by drovers in pens whilst the latter is carried out at the abattoir. However it is the responsibility of the producer to supply stock in a manner suitable for slaughter. The reliability of the assessment system and the correlation between the assessment score and the microbiological loading of the carcases has been studied in two separate projects (Jordan *et al.* 1999 and Van Donkersgoed *et al*. 1997 cited by Rowland *et al.* 1999). Jordan *et al*. (1999 cited by Rowland *et al.* 1999) found that the subjective rating system provided a highly reliable assessment of the degree of soiling of large numbers of cattle. Van Donkersgoed *et al*. (1997 cited by Rowland *et al.* 1999) examined the relationship between the level of dag on the hide and the level of microbiological contamination. This study showed that there was no consistent association between dag scores and microbiological levels of the carcases.

Rowland *et al*. (1999) stated that a grading system classifying the level of mud, manure and feed (dags) on the hide/fleece should be introduced into the Aus-Meat National Livestock Language (NLL) and Export Meat Orders (held by AQIS). The scheme would be based on a zero to four rating scale. Zero would represent a clean animal (zero dags) with four representing a heavily dagged animal with the majority of the hide covered in dags.

A 2000 draft of the classification system for the Clean Livestock Assessment Scheme developed by the Australian lot feeding industry is shown overleaf. This scheme was accepted by AQIS as a basis for standardising the assessment of the cleanliness of cattle presented for slaughter during a series of industry trials (Des Rinehart, MLA, pers. comm. 16 November 2005). These trials were designed to allow specific feedlot/processor combinations to develop agreed intervention protocols that suited their operations and allowed the processor to achieve the required outcome in terms of carcase cleanliness. It was intended that the trials would examine a range of interventions at both the feedlot and processing works (where both pre and post-slaughter interventions would be studied) and present the outcomes as a series of case studies that would then be available to other industry participants. Unfortunately, the trial work was not accepted by the processing sector.

CLEAN LIVESTOCK ASSESSMENT SCHEME

			DRAFT (21/8/00)		
0		0 to 14% cover Totally Clean.			
			A Loose material only	**B** Fixed Dags Only	**C** Fixed dags and loose material
1		15 to 34% cover Some minor dirt loading on legs & brisket.			
2		35 to 54% cover Reasonable dirt loading on legs, brisket & belly.			
3		55 to 69% cover Substantial dirt loading on legs, brisket, belly and flanks.			
4		70 +cover Heavy dirt loading on legs, brisket, belly, flanks, back and face.			

4.5.2.2 Pathogens in Domestic Meat Animals (On Farm)

This study (Vanselow and Hornitzky 2001) was undertaken to determine and study the prevalence of the major pathogens capable of causing human food-poisoning in slaughter-age animals, and animals at various stages of their production. The study focussed on *E. coli* (CSTEC) and *Salmonella*, with less emphasis on *Campylobacter*, *Yersinia* and *Listeria*.

Faecal samples were collected from the major cattle and sheep producing systems in the eastern states of Australia. CSTEC and *Salmonella* were cultured from 14% and 13% of feedlot cattle properties respectively. Analysis of the CSTEC serotypes demonstrated serotypes associated with serious human disease (eg. 0157:H7 found in only one feedlot) were not commonly found. Serogroup 0111, the most common CSTEC associated with human disease in Australia was not identified in any of the samples. Risk factors were identified in relation to *Salmonella* shedding. These included production type, (intensive industry were higher), drinking water contamination, drought or cold conditions and improper use of manure and effluent.

Main risk factors identified related to access to manure and contaminated water. Recommendations were made to minimise this access and included:

- Not allowing cattle to access effluent ponds and manure piles.
- Cleaning drinking water troughs frequently especially during warm weather and when there is contamination with manure.
- Designing feedlot pens so there is no water run-off into other pens.
- Preventing runoff from water troughs in feedlot pens from running into the pens.
- Frequently cleaning manure from feedlot pens.
- Limiting access of animals ready for slaughter to new cattle.
- Separating hospital pens in feedlot from other pens.

4.5.2.3 Pathogens in Domestic Meat Animals (On Farm)

In this study, Haines *et al.* (2000) examined process interventions for reducing pathogen contamination of carcases throughout the meat and meat product continuum. They identify the importance of HACCP systems designed to prevent contact between faecal pathogens and carcasses rather than visual inspection systems (Hathaway 1997b cited by Haines *et al.* 2000) since the research of Roberts (1980 cited by Haines *et al.* 1980) showed that carcases can be contaminated with up to 10^6 cfu/cm^2 with no visible evidence of faecal contamination on the carcase.

The sources of initial pathogen contamination identified from the work of (Westcombe (1994) cited by Haines *et al.* (2000) are:

- muddy or dusty environments.
- livestock types or breeds.
- transportation and lairage conditions at processing works.

Livestock handling methods identified as factors in the transfer, survival and growth of pathogens include:

- feed type.
- heavy stocking rates.
- grouping together unfamiliar animals and other stressful processes (e.g. transportation).

Handling practices identified as possibly contributing to microbial contamination include:

- use of uncleaned livestock pens and trucks.
- mixing healthy and sick cattle.

The report admits that it is difficult to estimate the number of pathogens that can be controlled at the farm gate, but suggests that this may be a cost effective means for reducing pathogen numbers (Hueston and Ferdorka-Cray (1995) cited by Haines *et al.* (2000)), that reduces the risk of cross-contamination of other livestock prior to slaughter.

The report covers a range of intervention strategies, although the only pre-slaughter strategy detailed is cattle washing by soaking and / or manual hosing. The report states that while washing removes some dirt, mud and faeces, dags still remain attached to cattle (particularly to British breeds). Pre-soaking helps to make dag removal easier. However, it is difficult to clean the underside, brisket and inner-flanks of the animal using manual hosing. The development of chemical cleaners that adhere to the hide and reduce dag formation or enable more ready removal of these may be worthwhile. More research is needed to develop products that have good adherence properties, reduce the microbiological loads of the hides and do not leave chemical residues (Wescombe (1994) cited by Haines *et al.* (2000)).

The report also suggests that the use of vaccinations and competitive exclusion may be effective pathogen control measures (Zhao *et al.* (1995a) cited by Haines *et al.* (2000)).

4.5.3 Summary of Current Industry Practices

A survey of ten feedlot operators, questioning of a specialist feedlot nutritionist and a specialist feedlot veterinarian was used to gain information on preharvest pathogen intervention strategies used in the Australian lot feeding sector. Of the feedlots surveyed 1% to 40% of total cattle are subject to intervention strategies aimed at reducing hide contamination of cattle ready for dispatch to meat processing plants. Intervention strategies are generally carried out a short time (1 day – 1 week) prior to cattle dispatch and they include:

- washing.
- dedagging by mechanical means.
- supplying additional bedding materials (rice hulls).

Factors that determine the necessity of implementing intervention strategies include:

- varying standards at different meat processing facilities.

- climatic conditions (wet conditions mean muddier pens).
- pen cleaning management (clean pens mean cleaner cattle).
- breed of animal British (*Bos taurus*) cattle have longer coats and form more dags than shorter haired Brahman / Brahman cross (*Bos indicus*) type cattle.

4.5.3.1 Cattle Washing

By far the most common intervention strategy employed by lot feeders to reduce hide contamination is cattle washing. Photo 3 shows the interior of a cattle wash. Photo 4 is a close up of flooring, pipework and the drain from a cattle wash. Photo 5 shows the soaking stage of cattle washing Photo 6 shows a wastewater sump from a cattle wash.

Washing typically involves soaking cattle then exposing them to water at high pressure. During soaking, groups of 32-150 cattle are exposed to belly sprays for 20-60 minutes in soaking yards. This process softens dags and reportedly results in minimal stress to the animal. The cattle are then manually hosed with high pressure hoses for up to 100 minutes or yarded into a high pressure pen fitted with belly, and wall sprays delivering water at high pressure for 20-30 minutes. Sometimes cattle are washed first with in the high pressure pen and then manually with a high pressure hose. Using a high pressure hose on cattle can cause bruising and a deal of stress to the animal. Several lot feeders are concerned that washing stresses the cattle and reported that it reduces meat quality (through increased dark cutting). One operator found washing cattle in a race and crush resulted in 70% dark meat.

In some instances cattle are not hosed at high pressure but are instead soaked for an extended period of time (up to 4 hours).

At one feedlot cattle are washed without soaking. Each animal is washed using a high pressure hose. This takes 5-10 minutes per head.

A greater percentage of outgoing feedlot cattle need to be washed during the wet season when there is more wet manure to form dags. In southern Australia the rainfall is winter dominant. The cold temperatures during the peak washing season in southern Australia raises concerns about cattle welfare and stress. Some feedlots also wash cattle at night when temperatures may be even cooler. Dr Sullivan is concerned about the welfare of cattle being hosed for several hours in winter in southern Australia, as are some feedlot operators. Some feedlot operators would prefer washing was conducted at abattoirs where cattle can be kept clean afterwards, where others believe washing at both the feedlot and abattoir is required to reduce pathogen transfer.

Some lot feeders have the capacity to recycle cattle wash water, some use effluent. The use of recycled wash water may promote cross contamination. One lot feeder, and Dr Doyle, questioned whether cattle had lower microbial loads after washing with recycled water. Dr Doyle also questioned whether dags were any worse than dusty coats in terms of microbial contamination of meat. Based on the information provided, lot feeders are generally washing to remove dags rather than dust.

Some lot feeders are proposing to invest in a system that allows water to be reused, as well as heated. This may reduce animal stress resulting in improved meat quality. Some operators have used or are considering using surfactants such as soap in wash water to assist in the softening of dags.

One of the major reasons intervention strategies occur at the feedlot is the requirement to deliver clean, uncontaminated cattle to meat processing facilities. Comments made by lot feeders indicate that different meat inspectors at different processing plants apply different standards for hide contamination. One lot feeder washes only those cattle destined for a particular meat processing plant. Another processing facility receives unwashed cattle from over ten feedlots but asks that lot feeders draft off daggy cattle so that these can be washed at the abattoir.

The cattle most affected by hide contamination and dag formation are British breeds (*Bos taurus*) commonly found in areas with a winter dominant rainfall pattern. Short haired cattle (*Bos indicus*) typically found in northern Australia require less washing as dags form less readily on their short coats.

Currently there is research underway to assess the viability of applying an enzyme to cattle prior to dispatch. Preliminary work on hides is very promising in removing dags. However, tests are yet to be conducted on live cattle. As well, the cost and logistics of sourcing and applying the enzyme to ensure efficacy requires development.

Photo 3 Interior feedlot cattle wash

Photo 4 Flooring, pipework and drain of a feedlot cattle wash

Photo 5 Soaking stage of cattle washing

Photo 6 Cattle wash wastewater sump

4.5.3.2 Mechanical Dag Removal

The Western Australian feedlot involved in the survey is shearing the dags from cattle a few days before dispatch. After shearing, cattle are returned to boggy pens but, with short hair, they don't get daggy again. Occupational health and safety is an issue with this method. Shearing costs about $15/head. (At least one other feedlot in WA also uses this method and it has been tried at two of the other feedlots surveyed).

Some lot feeders are, or have tried, scraping cattle in conjunction with hosing to remove dags.

Both these methods may be dangerous to operators.

Rockdale Feedlot in south-western New South Wales uses the Rockdale Robotic Dag Removal System to pull dags from cattle. Further details are provided in Rowland *et al.* (1999). Dedagging takes about 60 minutes to do 40 head. This method only works on dry dags, otherwise washing is needed.

4.5.3.3 Other Intervention Strategies

Regular pen and loading yard cleaning is critical in preventing dag formation and hide contamination. Clean trucks for taking cattle to meat processing facilities are essential.

Photo 7 Cattle shears used for dag removal at a Western Australian feedlot

Dr Doyle and one of the lot feeders interviewed say that the inclusion of oils in feed seems to produce more oily coats and dags are more readily removed from these. One lot feeder has also observed that cattle with waxier coats form less dags.

One feedlot in southern Australian uses bedding in pens holding cattle that will go out during the wet winter period. The bedding mixes with the manure keeping the dags soft which allows for more ready removal. This feedlot also holds washed cattle in bedded pens to prevent them from getting dirty.

Taking cattle off feed or altering diets before dispatch is not commonly practiced as the stress affects meat quality. Dr Doyle does not support dietary changes to reduce faecal shedding as these may not have the desired effect and may also reduce cattle performance.

The use of feed additives to control pathogens does not commonly occur in Australian feedlots.

4.5.3.4 General Feedlot Hygiene

From an environmental perspective, most commercial Australian cattle feedlots are well designed and managed. A 1991 survey of the Australian lot feeding industry (Tucker *et al.* 1991) revealed some established and emerging design and management trends that have since become common practice. These include:

- preparation of the feedlot pad (floor of pen area) by building-up, grading and compacting to produce a uniform slope and good drainage.
- installation of concrete aprons behind feed bunks and water troughs to prevent the development of low, poorly drained spots.
- regular pen cleaning.
- provision of separate induction and hospital pens.

Since that survey was conducted, further advancements in design and management have taken place. Modern feedlots generally:

- are designed to prevent pen-to-pen drainage.
- either have water troughs at the bottom slope of pens so that wash water and overflows pass directly into below-pen drains or incorporate a sewage system the transports this water directly to either drains or the retention pond.
- do not generally allow cattle to access effluent ponds and manure piles.
- regularly empty and clean drinking water troughs.
- have a program for frequently and regularly cleaning manure from feedlot pens.

5 Success in Achieving Objectives

5.1 Introduction

This section addresses each of the project objectives, identifying how well each has been achieved.

5.2 To review recent scientific summaries and best practice guides produced for the livestock sector in North America and identify the recommendations made

A range of preharvest intervention strategies is currently in use in North America. Following is a summary of these strategies grouped into the following categories: feedlot design and manure management, general husbandry and specific pathogen intervention strategies. Table 1 also summarises the US recommendations.

Feedlot Design and Manure Management

- Feedlots are constructed with pen slopes of 2-4% to promote drainage.
- Clean, well-drained feedlot pens are maintained. Using a box scraper to regularly clean pens maintains an even pen surface which helps to prevent bog holes from forming.
- Suitable stocking densities are used in feedlot pens.
- Manure is mounded within pens.
- Wide aprons are installed behind feed bunks and water troughs.
- Cattle washing areas, races and equipment are washed with pathogen-free water.
- Bucket loaders and equipment used for pen cleaning or mortality management are cleaned and disinfected before being used for feed mixing.
- Water and wastes are suitably handled.
- Disease vectors are controlled. In particular, the access of rodents, scavengers, wild ruminants, domestic animals and birds to feed commodities and prepared feed should be prevented.
- The internal surfaces of cattle trailers are free of visible faeces and have been cleaned and disinfected before loading.
- Receival and unloading facilities and holding pens at processing works are clean.

General Husbandry

- Clean feed and clean water are provided.
- Feed bunks are regularly cleaned to reduce the likelihood of faecal contamination of feed.
- Cattle are fed regularly.

- Water troughs are cleaned frequently, ensuring sediment is removed.
- Suitable feed withdrawal procedures are used for cattle in lairage to allow for proper evisceration and processing.

Specific Pathogen Intervention Practices

- Some producers and processors use a mud score system or “Clean Livestock Policy” to identify cattle that are likely to fail the zero tolerance policy requirements.
- Washing of live cattle is sometimes used, although the value of this is questioned. There are concerns about the stress and welfare of the cattle and the associated increases in dark cutters.
- Misting of cattle pre-slaughter is used to prevent loose dust and dirt on the hide from falling onto the carcase.
- There has been a move towards washing cattle after they are knocked and bled. This is in response to research conducted over the past 6-8 years shows that the hide is the source of most carcass contamination and that cleaning the hide before its removal will prevent almost all carcass contamination.
- Feed additives including antimicrobials; Bovamine, *Lactobaccillus acidophilus* culture and other probiotics; Tasco 14® and propionic acid is fed.
- Feed is heated during processing.
- Organic acids (to adjust pH to 5.5) and chlorine (to 5 ppm) are used to treat and disinfect water.

The following preharvest intervention strategies for the control of pathogens on cattle hides are of interest. However, they need further research or development before they can be recommended for adoption:

- Washing or cleaning of cattle after they are knocked and bled.
- Live cattle cleaning systems and hide washes.
- Addition of antimicrobials to cattle washing systems.
- Promising feed and or water additives including Tasco 14®, sodium chlorate, neomycin and direct-fed microbials.
- Bacteriophages and vaccines, including the use of immunisations against pathogens in the gut.
- Sodium chlorate used intraruminally or added to feed or water.
- Antibiotics including ceftiofur and neomycin sulfate.
- Competitive exclusion and other probiotics.
- Ionophores.
- Water treatment including: ozonation and the use of screens to decrease the organic solids in the water.

Interventions must be adopted on the basis of scientifically sound data, not on preliminary findings. This is important since bad data can lead to bad decisions. Existing and alternative intervention strategies, particularly strategies incorporating pro-active preventive elements, need to be assessed on the basis of effectiveness and cost-effectiveness. There is also a need to evaluate systems using a combination of intervention strategies.

5.3 To determine which of these recommendations have been implemented in Australia, and whether this is as a result of regulation, industry accreditation scheme requirement or common practice

Table 1 includes a summary of Australian recommendations, the scientific support for the recommendations, and whether the recommendations have resulted from regulatory pressure, because of the NFAS or whether they are common place.

Feedlot Design and Manure Management

In general, the standard of feedlot design and manure management and cattle husbandry in Australia is similar to North American practice. Partly this is because of regulatory pressure and partly because of the industries desire to meet community expectations for protection of the environment and amenity. The majority of Australian feedlots have developed NFAS quality systems and these have a positive impact on manure management.

General Husbandry

The standard of cattle husbandry in Australia is similar to North American practice. A high standard of cattle care is fundamental to achieving optimal performance. Although aspects like providing clean feed and water, regular cleaning feed bunks and troughs and regularly feeding cattle are addressed in some standards and in the NFAS, the industry would adopt these practices anyway to optimise performance.

Specific Pathogen Intervention Practices

Few of the specific pathogen intervention practices recommended in North America have been implemented in Australia.

By far the most common intervention strategy used in Australia is live cattle washing to remove manure and mud from cattle. This appears to be a direct response to the enforcement of the requirements of AS 4696 which requires that “Reasonable steps are taken to present animals for inspection in a clean condition”. It seems that lot feeders are generally trying to remove visible faeces and mud, rather than pathogens *per se*, to ensure that they pass inspection requirements. Based on information provided by lot feeders, the required cattle cleanliness standard seems to vary widely between processing works.

In North America, there is a far greater emphasis on strategies that minimise the pathogen load carried within the animal. However, this may be because Australian processing works and kill procedures are superior from a hygiene perspective to those used in Northern America. It is also possible that US cattle may carry a higher pathogen load. In Australian works, pathogen testing of carcases is undertaken for export markets (e.g. to demonstrate compliance with the EU and US market requirements) and specific Australian markets (e.g. MacDonalds).

5.4 To identify the practices not currently implemented in Australia and identify the scientific evidence that might be available to support the practices

Few of the specific pathogen intervention practices proposed in northern America are commonly used in Australia.

The North American research to date has focussed on reducing the pathogen load within the animals and subsequent excretion in faeces.

The use of feed additives and water treatments is not commonplace. The use of antimicrobials for control of *Salmonella* and *E. coli* 0157 is not commonplace in Australian feedlots. However, they may be administered to grazing stock. Some Australian cattle organisations do not support the use of antimicrobials.

More recently washing of cattle post-knocking has been adopted in Northern America. This is not practiced in Australia because of the requirement to present clean cattle for slaughter (under AS 4696) and because of reluctance on the part of processing works.

Following is a summary of the scientific evidence to support the use of specific preharvest pathogen intervention strategies not currently adopted in Australia:

- Adding *Lactobaccillus acidophilus* culture to finisher cattle diets can decrease *E. coli* 0157:H7 shedding by over 50% (Brashears *et al.* 2003a cited by Callaway *et al.* 2004). Moxley *et al.* (2003) (cited by Callaway *et al.* 2004) also produced a promising, although not statistically significant, reduction in faecal shedding of *E. coli* 0157:H7. The research of Brashears *et al.* (2000 cited by CAST 2004) also confirmed that *Lactobacillus* spp. is an effective agent against *E. coli* 0157:H7.
- CAST (2004) cite the success of Zhao *et al.* (1998) in demonstrating that certain isolates of *E. coli* are antagonistic to the growth of *E. coli* 0157:H7. For most cattle it cleared the rumen, colon and faeces of *E. coli* 0157:H7 within 12 days of treatment commencing.
- Bovamine and other probiotics have also reduced *E. coli* 0157:H7 levels in faecal and hide samples (Younts-Dahl *et al.* 2004 cited by McClanahan 2005).
- The dietary inclusion of Tasco 14®, a seaweed extract, for 14 days before slaughter reduced faecal shedding of *E. coli* 0157 by cattle (Braden *et al.* 2004 cited by McClanahan 2005). However, its use adversely affects animal performance. Research is ongoing.
- Mixtures of ammonium formate, ammonium propionate and sodium sorbate show potential for controlling *Salmonella*, particularly in liquid feed based on the work of Anderson *et al.* (2000) cited by CAST (2000).

- Propionic acid and heating show potential for controlling for controlling *E. coli* 0157:H7 and *Salmonella typimurium D104* based on the work of Matlho *et al.* (1997) cited by CAST (2000).
- It has been demonstrated that adding chlorate to cattle drinking water significantly decreased *E. coli* 0157:H7 numbers in the rumen, caecum and faeces of cattle (Callaway *et al.* 2002, 2003a cited by Callaway *et al.* 2004). Anderson *et al.* 2000 (cited by CAST (2000) also found that it shows potential for controlling *E. coli* 0157:H7 and *Salmonella typimurium D104*.. Because chlorate is very effective against foodborne pathogens in the gut its addition to the last feed (about 24 hours pre-slaughter) has been suggested (Anderson *et al.* 2000a cited by Callaway *et al.* 2004).
- The use of organic acids to acidify water to pH 3.5 or chlorination assists in the control of various pathogens based on the work of Byrd *et al.* (2001) cited by CAST (2004). Laboratory trials indicate that water chlorination has potential for reducing *E. coli* 0157 in live animals. Further research is needed.
- Sodium chlorate used intraruminally or added to feed or water was effective in reducing *E. coli* 0157 levels.
- Vaccinations against *Salmonella* and *E. coli* 0157:H7 show great potential, significantly reducing *E. coli* 0157:H7 shedding of yearling cattle (Potter *et al.* 2004 cited by McClanahan 2005) and also reducing reducing *E. coli* 0157 in hide and faecal samples. Moxley *et al.* (2003) cited by Callaway *et al.* (2004) also found that a newly *E.coli* 0157:H7 vaccine was effective in decreasing faecal shedding of these bacteria. Doses and administration of these vaccines are still being studied. The use of immunisations against pathogens in the gut is a new application.
- Research by Waddell *et al.* (2002 cited by CAST 2004) demonstrated that bacteriophage treatment hastened faecal shedding in calves. Callaway *et al.* (2003b) cited by Callaway *et al.* (2004) has also demonstrated an encouraging, though not statistically significant, reduction in *E. coli* 0157:H7 numbers throughout the intestinal tract after bacteriophage treatment.
- Oral dosing with neomycin sulfate can reduce *E. coli* 0157:H7 levels in faeces (Elder *et al.* 2002 cited by McClanahan 2005). Ceftiofur significantly and quickly reduces *E. coli* 0157 shedding between treatment days two and five. Efficacy of the antibiotic declines beyond day five of treatment. More research with naturally-infected cattle is warranted.
- Research does not support changing cattle from a high-concentrate to a high-roughage diet as an *E. coli* control measure. Nor does the dietary inclusion of whole cottonseed, barley, barley silage or soybean meal reduce *E. coli* 0157 prevalence. The only expected outcome of a sudden dietary change is a reduction in animal performance.

5.5 To identify the practices not currently implemented in Australia that have good scientific support and might improve meat safety

The use of interventions to improve preharvest food safety is a developing science. Hence, more research is needed before firm recommendations for new practices are made. The practices that appear to have reasonable scientific support, and that might improve food safety, include:

- washing cattle post-knocking.
- addition of *Lactobaccillus acidophilus* culture to finisher cattle diets.
- competitive exclusion through the use of certain isolates of *E. coli* against *E. coli* 0157:H7.
- inclusion of Bovamine in diets.
- adding chlorate to cattle drinking water or to feed.
- adding organic acids to water (to achieve pH 3.5) or water chlorination.
- use of sodium chlorate intraruminally or in feed or water.
- oral dosing with neomycin sulfate and ceftiofur.

5.6 To suggest the investigations that might be necessary to prove or implement these practices in Australian conditions

There is a need to confirm that these methods are practical, cost effective, not subject to regulatory barriers and acceptable to the feedlot industry, meat processors and consumers before recommending their adoption for use in Australian feedlots.

Table 1 – Summary of USA and Australian Recommendations

USA Recommendations	Australian Recommendations	Supporting Evidence for Recommendations	Practicality of Implementation
Backgrounding			
Not grazing backgrounding cattle on pastures recently spread with manure.	Queensland Reference Manual for the Establishment and Operation of Beef Cattle Feedlots in Queensland ("Qld Reference Manual") recommends that: where manure and / or effluent are applied to an established pasture or forage crop, stock should be withheld from grazing the pasture or crop for a period of at least one week for the period from 1 October to 31 March and two weeks for the period from 1 April to 30 September.	The Qld Reference Manual recommendations are based on Canadian research into survival times for *giardia* and *cryptosporidium* in soil, cattle faeces and water. The manual suggest that these recommendations should be applied on a precautionary basis until suitable Australian research becomes available.	The spreading of manure on grazing land is uncommon because the low nutrient removal rates in these systems do not match nutrient additions by manure and also because of the opportunity cost of not using manure as a substitute for fertiliser on cropping land. In addition, it is unlikely that pasture spread with manure would be palatable until the manure had been washed from the leaves by rain. Manure is typically applied to bare land pre-crop. Some cattle are backgrounded or grazed on effluent irrigated forage or pasture. Effluent should be allowed to fully dry from leaf surfaces before grazing is permitted. It is also essential to prevent cattle from accessing effluent ponds or effluent irrigation tailwater collection ponds.

USA Recommendations	Australian Recommendations	Supporting Evidence for Recommendations	Practicality of Implementation
Feedlot Design			
Sloping pens to improve drainage (2-4%).	National Guidelines for Beef Cattle Feedlots ("National Guidelines") 2.1.4: Pens should be constructed on gently sloping land to facilitate drainage without promoting erosion. A slope of 2% to 4% is preferred…Pen surfaces should be evenly graded and compacted to form a smooth surface without hollows. National Beef Cattle Feedlot Environmental Code of Practice ("National Environmental Code") 3.1.2: maintain adequate slope to facilitate drainage. 3.2.2: maintain pen slope. Qld Reference Manual recommends slopes in the range of 2% to 6%, with 3% often optimal and slopes of 2.5-4% required for Class 1 and Class 2 feedlots (i.e. feedlots with a superior standard of design and management). The NSW Feedlot Manual recommends pen slopes of 2-4%. Victorian Code for Cattle Feedlots ("Vic Code") pen floor slope to be between 2% and 6%. Guidelines for Establishment and Operation of Cattle Feedlots in South Australia ("SA Guidelines") recommend a uniform slope of 3-6%. Guidelines for the Environmental Management of Beef Cattle Feedlots in Western Australia ("WA Guidelines") recommend uniform pen slopes of 2-5%. PEN SLOPES OF 2-4% ARE COMMON PRACTICE AS THEY PROMOTE DRIER PENS THAT ARE LESS ODOROUS AND PRODUCE BETTER ANIMAL WELFARE AND PERFORMANCE.	Specific evidence for this recommendation is not provided. However, it is widely established that providing adequate pen slope enables rapid drainage and drying of pens. Drier manure is less likely to contaminate the hides of the cattle. Hence, there is a lower likelihood of pathogen transfer to the cattle.	Most Australian feedlots provide adequate pen slope (typically 2-4%).

USA Recommendations	Australian Recommendations	Supporting Evidence for Recommendations	Practicality of Implementation
Installation of 20 ft (6.1 m) aprons	National Guidelines 2.1.4.1: In general, the surface around feed troughs and water troughs in any permanent feedlot should be protected by a reinforced concrete apron at least 2.5 m wide. Qld Reference Manual, Vic Code: 2.5 m aprons around feed and water troughs made from reinforced concrete or compacted crushed rock. Australian Lot Feeders' Association Code of Practice: Cattle Welfare in Feedlots ("ALFA Welfare Code") 5.3: The pens themselves should be well drained with plenty of area for the cattle to move around with a minimum area of 9 m2/hd stipulated. The NSW Feedlot Manual suggests installing reinforced concrete aprons 2.5 m or wider (up to 4 m wide) around feed troughs and 2.5 m wide reinforced concrete aprons around water troughs. SA Guidelines: recommend aprons 2.5 m wide. WA Guidelines recommend reinforced concrete or compacted gravel or rock aprons 2.5-3 m wide. INSTALLATION OF APRONS 2.5-3 m WIDE IS COMMON PRACTICE AS THIS GREATLY REDUCES PAD MAINTENANCE AROUND THESE HIGH USE AREAS.	Specific evidence for this recommendation is not provided. However, concrete or compacted gravel aprons are mainly installed around feedlot bunks and troughs to prevent bog hole formation in these high use areas. This reduces the likelihood of wet patches within the pad and wet manure that is more likely to contaminate the hides of the cattle. Hence, there is a lower likelihood of pathogen transfer to the cattle.	Most commercial feedlots provide aprons 2.5-3.m wide around feed bunks and water troughs. It would be difficult to economically justify aprons twice as wide. The need for these is also questioned given the high compaction and maintenance standards for Australian feedlot pads.

USA Recommendations	Australian Recommendations	Supporting Evidence for Recommendations	Practicality of Implementation
General Feedlot Management			
Use of a suitable stocking density.	National Guidelines 2.1.4: Pens should be sized to provide adequate pen area…as a guide, a 600 kg animal usually needs 15 m^2 of pen area. ALFA Welfare Code Appendix 3: Yard Space – minimum 9 m^2/head, recommended 15 m^2/head – cattle with horns should be dehorned or allowed more space. Space for shedded cattle may be less. In cool climates, and with sufficient attention to management, 5.5 m^2 may be sufficient. The National Feedlot Accreditation Scheme (NFAS) stipulates a range of 9-25 m^2/standard cattle unit or head. NSW Feedlot Manual suggests that a 600 kg animal usually needs 15 m^2 of pen area, with optimal stocking rates ranging from less than 10 m^2/head to more than 25 m^2/head depending upon the type of animal, topography and climate. WA Guidelines acknowledge that the NFAS recommends a range of 9-25 m^2/head but states that in WA where many cattle are lot-fed during the wet winter period, stocking densities may need to be reduced to prevent the pen becoming boggy. IT IS COMMON PRACTICE FOR FEEDLOTS TO ADOPT SUITABLE STOCKING DENSITIES.	Specific evidence for this recommendation is not provided. However, higher stocking densities produce a greater manure deposition rate and hence a greater pathogen deposition rate in the pens. Unless manure is more frequently removed the pens will also be wetter and it is far more likely that the hides will be soiled. Hence, there is greater potential for hide contamination with pathogens.	Australian feedlots typically use stocking densities of 12-20 m^2/standard cattle unit, with the heavier densities typically used in drier environments where the additional manure and urine deposition helps to control dust.

USA Recommendations	Australian Recommendations	Supporting Evidence for Recommendations	Practicality of Implementation
Regular cleaning of feed bunks and loaders used to prepare feed.	National Guidelines 2.1.5: Each feedlot should establish an Environmental Management Plan which…should provide for regular cleaning of spilt feed along feed alleys. Model Code of Practice for the Welfare of Animals: Livestock at Slaughtering Establishments ("Model Code – Slaughtering Establishments") requires that holding pens and feed and water facilities at processing works should be cleaned after each day of use. National Environmental Code 3.5.2: collect spilt and spoilt feed around feedbunks, feed bins, feedmills and feed storage areas. Vic Code and SA Guidelines: feed residues are removed from the troughs at least weekly. The NFAS requires the delivery of clean feed to stock. REGULAR REMOVAL OF SPOILT FEED FROM BUNKS IS COMMON PRACTICE.	Specific evidence for this recommendation is not provided. However, cleaning of feed bunks and loaders used to prepare feed should reduce cross-contamination through feed and hence the pathogen load of the cattle.	As a rule, Australian lot feeders regularly remove spoilt feed from bunks. Larger feedlots use separate loaders for preparing feed and handling manure. However, smaller feedlots may use the same loader for both purposes. Most operators are well aware of the need to ensure the loader is clean before being used to prepare feed.
Regular cleaning of water troughs.	Model Code – Slaughtering Establishments requires that holding pens and feed and water facilities at processing works should be cleaned after each day of use. National Environmental Code 3.2.2: maintain water troughs and ensure that drained water does not pond. ALFA Welfare Code 4.2: …stale or spoiled feed must be removed from troughs. 4.5: Water must be clean, fresh and readily available with troughs cleaned regularly. NSW Feedlot Manual: Feed and water troughs should be cleaned regularly. Emphasises the importance of removing mouldy or wet feed, manure and feed residues from feed troughs regularly. Vic Code: troughs should be cleaned as frequently as is necessary to maintain them in a clean condition. The NFAS requires the provision of clean water for stock and regular water trough cleaning. REGULAR CLEANING OF WATER TROUGHS IS COMMON PRACTICE TO PROMOTE STOCK WATER CONSUMPTION AND HEALTH.	The effectiveness of water trough cleaning in reducing pathogen loads is uncertain. CAST (2004) cite the work of LeJeune *et al.* (1997) that showed that cleaning and disinfecting water troughs does control pathogens. However, the Beef Industry Food Safety Council (2004) disputes this indicating that there is a lack of evidence supporting aggressive and frequent water trough cleaning as a means to control *E. coli* 0157.	Water troughs in Australian feedlots are typically cleaned at least weekly and often more frequently.

USA Recommendations	Australian Recommendations	Supporting Evidence for Recommendations	Practicality of Implementation
Regular pen scraping and maintenance, including bedding replacement, to minimise wet manure.	National Guidelines 2.1.5: Each feedlot should establish an environmental management plan… which should provide for: regular cleaning of manure / feed under fences sufficient to prevent build up, periodic removal of manure from pens (at a minimum following each draft of cattle) and repair of the pen surface as required, taking care to preserve the manure pad / soil interface layer. National Environmental Code 3.1.2: maintain the feedlot pen surface to prevent ponding of water; maintain manure depth in pens at levels with allow for rapid draining and drying of pens after rainfall. 3.2.2: remove excess manure from pen surfaces; repair pen surfaces as required (i.e. fill holes); clean manure from under fences, around feedbunks, feed bins and water troughs. ALFA Welfare Code 5.6 …the frequency of cleaning must be such that cattle have sufficient area free of wet manure build-up for resting. Manure must not be allowed to accumulate to the point where reasonable surface drying is delayed after rainfall events. Pressure points close to feed and water troughs, fence lines and drainage lines are to be maintained such that excessive manure accumulation is avoided. The Qld Reference Manual specifies maximum manure removal intervals and maximum manure pack depths for each of its four feedlot classes stocked at 10 m^2/SCU 15 m^2/SCU and 20 m^2/SCU. NSW Feedlot Manual emphasises the importance of regularly removing manure once a depth of 200 mm is reached. The Vic Code and the SA Guidelines specify maximum manure removal intervals for each of their four feedlot classes stocked at 10 m^2/SCU 15 m^2/SCU and 20 m^2/SCU. The WA Guidelines require that manure is scraped up and cleaned from the pens as necessary. The NFAS requires the maintenance of clean pens. REGULAR PEN CLEANING IS COMMON PRACTICE.	Specific evidence for this recommendation is not provided. However, it is widely recognised that regular pen cleaning promotes more rapid drainage and drying of pens. Drier manure is less likely to contaminate the hides of the cattle. Hence, there is a lower likelihood of pathogen transfer to the cattle.	Bedding is used in only a very small number of Australian feedlots. Most of these are shedded although sawdust or rice hulls have very occasionally been used in conventional feedlots. The frequency of changing bedding at these feedlots is unknown.

USA Recommendations	Australian Recommendations	Supporting Evidence for Recommendations	Practicality of Implementation
Mounding manure within pens	This is a common practice in Northern American feedlots during the winter because their pens get very wet and will often freeze. Australian feedlots generally don't have the same requirement to keep cattle up out of thawing manure. Hence, mounding manure in pens in Australian feedlots is seen as a means of stockpiling and reducing manure between pen cleaning operations. NSW Feedlot Manual states that "If pen drainage is adequate, mounds are generally not needed on slopes ranging from 2 to 6%. Mounds in New South Wales are generally seen as a temporary means of mitigating poor pen design". States that permanent mounds should be built from compacted soil, not manure. Vic Code: Includes operational specifications for mounding since the net effect of mounding is to reduce the depth of manure and consequently reduce the odour potential during and after wet weather. SA Guidelines: mounding of manure is not recommended. WA Guidelines: states that mounds may be used in feedlot pens to provide cattle with a dry place to stand or lie down. States that mounds should be constructed of compacted soil.	Specific evidence for this recommendation is not provided. Mounding manure within pens might help to reduce the pathogen load of cattle by reducing manure depth over the majority of the pen surface and hence cattle soiling and associated pathogen transfer to the hide.	In-pen manure mounding is not generally recommended in Australia possibly because poorly located mounds may interfere with pen drainage and because mounded manure becomes compacted by cattle action making it more difficult to remove from the pen. However, mounding is practiced by some to allow sufficient manure to accumulate to maximise the efficiency of manure removal. In terms of pathogen control, the better practice would be to remove the manure from the pen as it is cleaned. It is difficult to see why this practice should be specifically recommended.

USA Recommendations	Australian Recommendations	Supporting Evidence for Recommendations	Practicality of Implementation
Suitable handling of water and waste.	National Guidelines: this issue is covered extensively. E.g. 2.1.4.1 Water troughs should be well separated from feed troughs with provision for any spillage to drain directly to the drainage system. 2.1.4.3 A drainage systems is essential and normally should provide for: diversion banks or drains to exclude external runoff from the feedlot complex to create a controlled drainage area; catch drains within the controlled drainage area to convey stormwater runoff and other liquid effluent from pens, stockpiles and other contaminated area to a holding pond via a sedimentation basin; sedimentation basins; holding ponds, waste utilisation areas; and terminal ponds to collect irrigation tailwaters from effluent irrigation areas pending return to the holding ponds or direct land application. 2.1.4.2 An area needs to be set aside within the controlled drainage area where manure can be stockpiled and composted if necessary. 2.1.5: Each feedlot should establish an environmental management plan… which should provide for: utilisation of liquid effluent and emptying of holding ponds as quickly as practicable following storms but in accordance with crop / pasture moisture requirements. National Environmental Code 3.1.1 Objectives: to capture all effluent from the feedlot controlled drainage area and convey such runoff to an appropriate effluent management system… 3.1.2 Clean and maintain drains and diversion banks. Maintain manure depths in pens at levels that allow for rapid drainage and drying of pens after rainfall. 3.4.2 clean and maintain sedimentation systems and holding ponds to maintain the capacity, freeboard and impermeability. Qld Reference Manual, NSW Feedlot Manual, Vic Code, SA Guidelines and WA Guidelines generally consistent with above. The NFAS requires suitable handling of water and waste.	Specific evidence for this recommendation is not provided. However, it is recognised that manure and effluent contains pathogens. Reducing cattle access to manure and effluent reduces their exposure to pathogens and in particular the risk of hide soiling and contamination by pathogens. Preventing cross contamination of the water supply by keeping manure and water well-separated also reduces the risk of pathogen ingestion by cattle.	Most Australian feedlots handle water and waste suitably due to licence or approval requirements.

USA Recommendations	Australian Recommendations	Supporting Evidence for Recommendations	Practicality of Implementation
Control of disease vectors including feral animals.	National Guidelines 2.1.5: Each feedlot should establish an Environmental Management Plan which…should provide for: suppression of dust and fly and insect pest populations as required. National Environmental Code 3.11.1 Objective: To minimise fly and vermin populations associated with feedlot activities. (Also included as a performance indicator elsewhere in Code). 3:11;2: ensure manure, effluent, spoilt feed, dead stock and pen management practices are carried out; use baiting, trapping and spraying programs; mow problem grass or pasture areas within the feedlot boundaries; and apply insecticide repellents to cattle if required. NSW Feedlot Manual: addresses fly and insect control. Vic Code: requires the maintenance of a program of vermin control. SA Guidelines": include a section on fly control. WA Guidelines: include a section on fly and vermin management. The NFAS requires the control of disease vectors. CONTROL OF DISEASE VECTORS IS COMMON PRACTICE.	Many non-bovine species carry pathogens including *E. coli* 0157.	Most Australian feedlots use a range of pest control strategies including sound manure and waste feed management and strategic baiting. Most are also aware of the importance of excluding feral animals (eg.wild pigs) from feedlots because of the biosecurity risk they pose.
Specific Measures at Feedlot			
Cleaning of cattle washing areas and handling facilities with pathogen-free water.	Model Code Clause 2.1.1 specifies that unloading facilities must be constructed and maintained so that they do not cause injury, soiling or suffering to animals". Clause 2.5.2.5 specifies, in part, that holding pens, and feed and water facilities for all species, should be cleaned after each day of use". Australian Std for Hygienic Production and Transportation of Meat and Meat Products for Human Consumption ("Meat Hygiene Std") Part 2, Section 4, Clause 4.3 requires cleaning of processing works holding pens at the end of each day's operations to the extent required to ensure that contamination is not transferred from the pens to areas used for the slaughter and dressing of animals.	Cleaning of cattle washing areas and handling facilities with pathogen-free water reduces the amount of manure and the total pathogen count in these high-use areas. Hence the risk of soiling and pathogen transfer between animals is also lower.	Cattle washing areas and handling areas in most Australian feedlots are generally left clean after use. However recycled washwater may be used to clean these areas, particularly cattle washing facilities. In most cases the use of clean water for cleaning these areas could be practically implemented.

USA Recommendations	Australian Recommendations	Supporting Evidence for Recommendations	Practicality of Implementation
Live cattle washing	Not specifically addressed in Australian regulations or standards but Part 3, section 8, Clause 8.4 of the Meat Hygiene Std requires that only cattle fit for slaughter for the purpose of producing meat and meat products for human consumption are slaughtered. Most feedlots address this requirement by washing cattle at the feedlot as required to present suitably clean cattle. However, the feedlot industry would prefer that this was done at the processing works and preferably post-knocking. It would also be highly desirable to use a mud score system to determine which cattle require washing.	Extensive recent research confirms that the hide is the source of most carcass contamination and that cleaning the hide before its removal will prevent almost all carcass contamination.	Cattle washing is currently the most common method for cleaning cattle in Australian commercial feedlots. Some feedlots use recycled washwater for cattle washing to conserve water. This practice may achieve sub-optimal pathogen removal. However, most meat processing works also wash cattle prior to slaughter. While the practice of using recycled washwater doesn't stop the transfer of pathogens from the feedlot to the abattoir, it must make the wash at the abattoir easier and more efficient. Where feedlots have very limited water supplies washing cattle with clean water may not be practical. Smaller feedlots are less likely to be equipped with washing facilities due to cost constraints.
Cleaning of cattle trucks.	NFAS requires that clean trucks are used to transport cattle.	Using clean trucks reduces the likelihood of hide soiling and pathogen transfer between animals.	Most Australian lot feeders insist that clean trucks are used to transport their stock to processing works. This is reinforced by biosecurity requirements.

USA Recommendations	Australian Recommendations	Supporting Evidence for Recommendations	Practicality of Implementation
Use of probiotics to reduce *E. coli* 0157:H7 in the faeces (*Lactobaccillus acidophilus*).	There are currently no Australian recommendations pertaining to the use of probiotics to control faecal pathogen counts. Probiotics are not routinely fed to Australian feedlot cattle at this time.	There is evidence that Bovamine and other probiotics are effective in reducing *E. coli* 0157. *Lactobaccillus acidophilus* appears promising for controlling *E. coli*.	Probiotics are readily available in Australia, mostly claiming to improve feed conversion efficiency. However, they not commonly fed in Australia for the purpose of pathogen control.
Use of antimicrobials.	There are currently no Australian recommendations pertaining to the use of antimicrobials to control faecal pathogen counts. The adoption of this practice is not likely to be acceptable to the Australian feedlot industry, which is very conscious of the public perceptions pertaining to the use of antimicrobials and antibiotics.	Research is ongoing.	Use of antimicrobials administered directly to cattle is unlikely to be acceptable to Australian lot feeding industry.
Use of antibiotics.	There are currently no Australian recommendations pertaining to the use of antibiotics to control faecal pathogen counts. However, there are concerns about antibiotic resistance and the Australian lot feeding industry is unlikely to support the use of antibiotics for this purpose.	There is evidence that antibiotics can reduce faecal shedding of *E.coli* 0157:H7. However, depending on the antibiotic used, there are concerns about the potential for this to produce resistance.	There are concerns about antibiotic resistance and the Australian lot feeding industry is unlikely to support the use of antibiotics for this purpose.
Use of sodium chlorate to treat drinking water or provision in feed.	There are currently no Australian recommendations pertaining to the use of sodium chlorate to control faecal pathogen counts.	The addition of sodium chlorate to cattle drinking water or feed is a proven method for reducing foodborne pathogens in the faeces.	The feeding of sodium chlorate in the last meal pre-dispatch shows potential and could be readily adopted if approved. Some operators may have concerns about adding extra salt to already-salty feedlot manure and effluent

USA Recommendations	Australian Recommendations	Supporting Evidence for Recommendations	Practicality of Implementation
Drinking water treatment (acidification, chlorination, ozonation, frequent cleaning, use of screens to decrease the organic solids in the water).	There are currently no Australian recommendations pertaining to the use of drinking water treatments to control faecal pathogen counts.	Research is ongoing.	While at least some of these technologies could be readily implemented at feedlots there efficacy would need to be confirmed and a cost-benefit assessment would be needed to justify their adoption.
Lairage / Processing Works			
Cleaning of cattle post-knocking	This is not practiced in Australia. However, the feedlot industry would prefer that cattle washing was done at the processing works (rather than at the feedlot) and preferably post-knocking. It would also be highly desirable to use a mud score system to determine which cattle require washing.	Extensive recent research confirms that the hide is the source of most carcass contamination and that cleaning the hide before its removal will prevent almost all carcass contamination.	At this stage this strategy is unpractical for implementation due to the requirement under AS 4696:2002 for animals to be presented for inspection in a clean condition and because of general unwillingness on the part of the processing sector to take responsibility for cattle cleaning.

USA Recommendations	Australian Recommendations	Supporting Evidence for Recommendations	Practicality of Implementation
Changing diet types (concentrate to roughage).	The issue of changing diet types immediately pre-slaughter is not addressed specifically in the Australian regulations and standards. However, in terms of general feeding management, the Australian Lot Feeders' Association Code of Practice: Cattle Welfare in Feedlots ("ALFA Welfare Code") 4.4 states that: Ration changes must be made in gradual, safe steps to guard against digestive disorders....	More research is needed before this can be recommended. Some research has shown that switching cattle abruptly to hay significantly reduces faecal *E. coli* populations. Other research shows that grain-based finishing diets decrease faecal shedding time and control *E. coli* 0157:H7. but the effect is variable and the technique is controversial	While this practice could be implemented fairly easily at many feedlots, it is not condoned by the Australian feedlot industry and cannot be recommended until there is solid supporting evidence.
Suitable feed withdrawal procedures in lairage.	Processing works may promote feed withdrawal in lairage to empty the gut and reduce the likelihood of meat contamination during evisceration.	Feed withdrawal in lairage reduces gut contents and hence the likelihood of faecal contamination of meat during evisceration. However, it does induce more pathogen shedding which is likely to increase faecal hide contamination.	This could be implemented easily. However, it may have implications for meat quality and further research is warranted to justify the need for it.

USA Recommendations	Australian Recommendations	Supporting Evidence for Recommendations	Practicality of Implementation
Implementation of a mud score system at processing works.	Australian feedlots developed the Clean Livestock Assessment Scheme. It was accepted by AQIS but not adopted by processors.	Mud score systems provide a highly reliable assessment of the degree of hide soiling. Since the degree of hide soiling is related to carcass contamination there is good evidence to support the adoption of this practice.	It would be highly beneficial to implement the ALFA-designed mud score system at the processing works. The system could be readily implemented at feedlots and this would reduce the number of cattle needing to be washed by providing an objective cleanliness assessment system. Adoption by meat inspectors at processing works would also promote more consistent assessment between plants.

6 Conclusions and Recommendations

Standards, Guidelines and Codes of Practice

The USDA-FSIS zero tolerance policy is specific and objective and it has been rigorously implemented, with corrective action taken even when the source and composition of minute amounts of matter on carcasses are sometimes uncertain.

AS 4696:2002 is far less specific and less objective than the USDA-FSIS zero tolerance policy, with the principle pathogen control being a requirement that "reasonable steps are taken to present animals for inspection in a clean condition".

To meet AS 4696:2002 feedlots wash cattle to remove dags and other visible contamination rather than aiming to remove pathogens. Some of the adopted practices, in particular using recycled untreated cattle washing water to wash other cattle, may present visibly clean cattle but not necessary reduce the pathogen load on the hides to an acceptable level. *Further research into the effectiveness of recycled wash water versus clean wash water for reducing hide contamination is recommended.*

Possibly because AS 4696:2002 does not provide specific or objective guidance for use by AQIS inspectors and feedlot operators, the required standard of slaughter cattle cleanliness varies widely between processing plants.

The updating of the requirements of the "Review of Product Requirements component of the NFAS to specifically address the issue of presentation of cattle for slaughter is recommended.

The incorporation of the Clean Livestock Assessment Scheme into the AusMeat language and the adoption of the scheme at both feedlots and processing works by those inspecting cattle for slaughter is recommended as this would promote more objective assessment of cleanliness.

Australian feedlot standards, codes and guidelines do not specifically address the issue of presenting clean stock to the processing works but do provide design and operational parameters likely to produce a clean environment that is consistent with US recommendations.

Feedlot Design and Manure Management

The good design and management of most Australian feedlots, particularly those participating in the NFAS, is conducive to reducing the pathogen load within pens and associated transfer to stock (particularly to their hides in the form of dags) and is consistent with US recommendations.

There is anecdotal evidence suggesting that the use of bedding in feedlot pens during the wet season may warrant further investigation. The costs of implementing this strategy and the savings in terms of reduced cleaning time and water use need research.

General Husbandry

The high standard of general husbandry practiced in Australian feedlots, particularly those participating in the NFAS, is conducive to reducing the pathogen load within cattle and is consistent with US recommendations.

There is anecdotal evidence that the inclusion of oil in diets may improve the ease of dag removal. Further investigation of this may be warranted.

Specific Pathogen Intervention Strategies

Recent US research confirms that the hide is the source of most carcass contamination and that cleaning the hide before its removal will prevent almost all carcass contamination. *This is a crucial finding and the direction of most Australian research funding in this area towards improving the efficiency of hide cleaning is recommended.*

Live cattle washing is not commonly practiced in the US due to welfare and animal stress concerns.

The Australian feedlot industry is also concerned about the stress and welfare of cattle during washing (particularly in southern feedlots in the winter months) and the subsequent effects on meat quality.

Recently US processing plants have started installing and using systems for washing cattle post knocking.

In Australia, the requirements of AS 4696:2002 prevent soiled cattle from being cleaned post-knocking since cattle must be clean when presented for slaughter. Up to 40% of cattle from Australian feedlots are washed before they leave the feedlot to ensure they meet the requirements of AS 4696:2002. The Australian processing sector is generally reluctant to wash cattle at the processing works. It is very disappointing that feedlots are following strict husbandry and nutritional regimes aimed at producing a quality product and then stressing the cattle at the end of the feeding period by washing them pre-slaughter. Washing cattle is also time consuming and uses large volumes of water. *Further negotiation towards the cleaning of cattle at processing works if required based on assessment using the Clean Livestock Assessment Scheme is recommended. Ongoing negotiation towards the adoption of post-knocking cleaning of cattle hides is recommended.*

The Australian industry is actively researching better methods for cleaning cattle hides, including the addition of enzymes to cattle wash water for more rapid dag removal. *Further research aimed at improving the efficiency and effectiveness of cattle hide cleaning is supported.*

The US is actively researching methods to reduce the pathogen load that cattle carry internally. Promising technologies include: probiotics, antimicrobials, sodium chlorate and drinking water treatments.

From a meat safety perspective, Australia is not undertaking significant research into methods for reducing the pathogen load that cattle carry internally. In particular, the use of antibiotics for controlling faecal shedding of pathogens is not supported by many in the industry except as a last resort. *Since the US industry is very active in this research area and it is not a preferred control method in Australia, research funds would be better diverted to other potential solutions (e.g. improving the efficiency of cattle wash systems).*

The use of sodium chlorate for controlling *E. coli* 0157:H7 appears promising, particularly since research suggests that its addition to the last feed (about 24 hours pre-slaughter) is very effective against foodborne pathogens in the gut. A downside is that it would add salts to the feedlot effluent and manure, possibly affecting future utilisation as a fertiliser. *Further research into the use of sodium chlorate for pathogen control may be warranted.*

US research into the effectiveness of dietary manipulation or taking cattle off-feed in promoting faecal shedding of pathogens immediately pre-slaughter is inconclusive at this stage. The latter is not condoned as it may not have the desired effect and may also reduce cattle welfare, performance and meat quality. *Further research into the effects (benefits and down-sides) of changing cattle to a high roughage diet or of taking cattle off feed for a period of time prior to transport may be worthwhile.*

As new research findings and recommendations emerge it is critical that they are transferred to lot feeders, meat inspectors and processors. The development, regular updating and circulation of this information to all stakeholders is strongly recommended. The preparation and circulation of a handout that highlights what can be achieved by implementing current best management practices is recommended.

Interventions must be adopted on the basis of scientifically sound data, not on preliminary findings. The effectiveness, cost effectiveness and acceptability to industry of existing and alternative intervention strategies need to be assessed.

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8 Appendices

8.1 Appendix 1 – Project Terms of Reference

MEAT & LIVESTOCK
AUSTRALIA

Terms of Reference

Project number: **PRMS.075**
Review of on-farm food safety best practice

1. Key Strategic Issue

This project is one activity to address the issue of understanding the effects of husbandry, preparation for transport, transport and lairage on pathogens and enteric indicators

2. Background

The safety of meat as food is of critical concern to the industry. The major food safety hazards in fresh meats are microorganisms that arise from the animals processed for meat, such as *Salmonella* and pathogenic *Escherichia coli*.

Over the past decade considerable advances have been made in both food safety systems and technologies for ensuring that meat is safe to eat. It is recognized that food safety needs to be controlled through the supply chain, though most controls over microbial contamination of meat occur in the abattoir. A quality systems approach to food safety suggests that the best approach is to eliminate or reduce contamination to a safe level as early as possible in the supply chain.

Particularly in North America, considerable research into ‘preharvest’ interventions has been conducted. These interventions range from cleaning of water troughs, to direct-fed antimicrobials or chemical sterilants prior to slaughter. A number of documents have been produced in recent times as best practice guides or scientific summaries. A draft document on hygienic practices for the control of E. coli O157:H7 has been presented to the Codex Committee on Food Hygiene containing many North American best practices.

3. Issues to be Addressed

The Australian livestock industry and the feedlot sector are significantly different to those in North America, but there is a danger that 'best practices' arising in North America may be required of the Australian industry. For example, large international customers for Australian meat may take up North American codes of practice into their purchasing specifications.

Additionally, practices recently introduced into the North American industry may have benefit to Australian producers.

4. Project Objectives

Review recent scientific summaries and best practice guides produced for the livestock sector in North America, in particular:

- identify the recommendations made;
- determine which of those recommendations have been implemented in Australia, and whether this is as a result of regulation, industry accreditation scheme requirement or common practice;
- consider the recommendations that are not followed in Australia and identify the scientific evidence that may be available to support the practice;
- identify the practices not currently implemented in Australia that have good scientific support and might improve meat safety; and,
- suggest the investigations that might be necessary to prove or implement these practices in Australian conditions.

5. Methodology

This project is a desk-based review of North American documents and relevant Australian production standards and codes of practice etc. The project would probably be conducted entirely by the consultant with minimal interaction without other organisations or persons. However, it would be advantageous to present the results of the project at a suitable industry forum to validate the approach taken, engage stakeholders with the issues and potential actions to be taken following the consultancy.

The documents upon which this review is based must include:

Beef Industry Food Safety Council (2004?)
Production Best practices Producer Resource Guide.
http://www.bifsco.org/BestPractices.aspx

American Society for Microbiology (2005)
Preharvest Food Safety and Security.
Prepared Richard E. Isaacson, Mary Torrence, and Merry R. Buckley.
http://www.asm.org/Academy/index.asp?bid=33019

Council for Agricultural Science and Technology (2004)
Intervention Strategies for the Microbiological Safety of Foods of Animal Origin.

Chair: Michael P. Doyle.
http://www.cast-science.org/cast/src/cast_top.htm

6. Project Proposal Requirements

The project proposal will detail outputs, which might include:
- documentation in both paper and electronic forms;
- a 2 page executive summary;
- an article for a suitable industry publication;
- a presentation to industry;

7. Project Timing

The timing and costing of the project should be based on the project being completed in the shortest timeframe possible. It is anticipated that this project will be undertaken over a 3 month period.

8. Resources Required

The proposal should indicate any requirements of MLA staff and industry personnel. The project will be coordinated by MLA Food Safety Program Manager, Ian Jenson.

9. Selection Criteria and Process for Selection

Research proposals must be well presented and address these Terms of Reference in full.
The successful applicants will be selected on their ability to:
- demonstrate exceptional knowledge and experience in feedlot practice and animal health;
- understand the project issues as they relate to the meat industry;
- demonstrate excellent communication skills;
- provide a methodology that will fulfil the objectives of the project within a clear timeframe;
- disseminate the outcomes of the project;
- submit a cost-effective budget;

The proposal must indicate details of those persons who will be involved in the project.

10. Reporting Requirements

The researcher will furnish a final report giving full details of the results of the work. The researcher shall report directly to the Manager, Food Safety R&D, Client and Innovation Services, Meat & Livestock Australia Limited.

11. Confidentiality & IP

Access to personnel and information will be provided subject to the researcher undertaking to keep information gained as a result of the work confidential between the researcher and MLA. Intellectual property developed as a result of the consultancy will remain the property of MLA. The researcher will be required to enter into a standard contract for services with MLA.

12. Payment of Fees

The proposal should indicate the basis for charging, whether time and materials or a fixed fee. It is also possible to allocate a separate fee for a travel budget, which will be reimbursed based on actual expenditure. An estimate of this cost should be included.
Payment of fees will be full upon MLA acceptance of the attainment of the milestones. Progress payments may be negotiated against project milestones if the size and timescale of the project warrants this. The proposal should indicate these milestones and payments if required.

13. Further Information

If you have questions regarding this project contact:
Ian Jenson
Manager, Food Safety and Strategic Science
Client and Innovation Services
Meat & Livestock Australia Limited
Phone: 02 9463 9264
Email: ijenson@mla.com.au

14. Closing date

Applications should be received at MLA by 11 July, 2005

Meat & Livestock Australia Limited
Level 1, 165 Walker St
NORTH SYDNEY NSW 2060
Or
Locked Bag 991
NORTH SYDNEY NSW 2059