final report

Project Code: A.ENV.0059

Prepared by: AMIC

April 2007

Date published:

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 991
NORTH SYDNEY NSW 2059

Environmental Best Practice Guidelines for the Red Meat Processing Industry

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government and contributions from the Australian Meat Processor Corporation to support the research and development detailed in this publication.

contents

Foreword – AMIC Environment Best Practice Guidelines manual

Australia's red meat industry has a long and proud history – and continues to demonstrate its admirable ability to meet consumer demands.

Customers, both domestic and internationally, are demanding food that is environmentally-sustainably produced.

The Red Meat Industry Best Practice Guidelines for the Environment will help processors satisfy consumers by strengthening industry initiatives including the introduction and adoption of modern technologies and practices, and staff training.

Our red meat industry is vital to the Australian economy. It currently generates around $15 billion annually and directly employs more than 25,000 people. Last year, the industry generated more than $7 billion in export earnings.

The industry recognises that sound environmental practices and profitability go hand-in-hand. The industry needs to be seen to be a safe and environmentally aware producer of quality food – a powerful advantage in an increasingly competitive world market.

Industry participants and the environment have much to gain from the better-management of natural resources such as water. Similarly, maximising energy efficiency reduces emissions and makes good business sense.

These guidelines detail the procedures and technologies that processors can use to achieve leading environmental outcomes while maximising profits.

The guidelines will also reinforce the steps the industry has taken to become more environmentally conscious, and promote the extra measures being adopted.

I commend Meat and Livestock Australia, the Australian Meat Processing Corporation and the many industry representatives who contributed to the project.

I have no doubt that the industry will embrace the guidelines as it has past environmental initiatives.

Peter McGauran
Australian Government Minister for Agriculture, Fisheries and Forestry

Introduction

The red meat processing industry is one of Australia's largest rural value-adding industries and operates processing facilities across the nation. It has the potential for a large environmental impact on the Australian continent. In recent times the industry has made significant efforts to invest in modern technologies, practices and staff training to ensure environmental protection and the use of resources in a responsible and efficient manner. This has been assisted by an industry funded environmental research program dedicated to meat processing since 1993.

"Environment Best Practice" describes practices and technologies that provide the best outcomes for the planet we live on. Examples may include:

- effective "end-of-pipe" waste treatment technologies,
- eco-efficient operation
- appropriate monitoring and reporting.

The Best Practice described in this guideline is consistent with the many stringent regulations which govern the operation of meat processing facilities, including environmental regulations. However, there are other important regulations, which concern food safety. In some instances, environmental efficiency must be judiciously sacrificed to ensure that the meat product is safe to eat. This compromise is recognised within the Guideline.

The Best Practice described is also that which experts intimately familiar with the Australian industry consider economically viable and – in the case of technologies – have been proven at full scale. Many technologies and practices currently fail these tests, but over the course of the next few years they may become accepted as best practice. The Guideline is a living document and will be revised to capture these "rising stars" of best practice performance.

The Guideline is a set of 6 independent, yet related modules which define current environmental best practice for meat processors in Australia in areas of critical importance. They cover the following topics as diverse as odour and air quality, wastewater treatment and its irrigation to land, the issues of waste solids and energy management. Water and energy comprise urgent and very topical issues for the industry.

The aim of the Best Practice Guideline is to provide an agreed and consistent statement of current environmental best practice in the Australian meat processing industry which promotes efficient consumption of resources and minimises its ecological footprint.

The Guideline describes current best practice technologies and practices for environmental protection in an Australian context. It:

- is not prescriptive on the industry – their adoption however has been endorsed by the Australian Meat Industry Council (AMIC).
- accounts for differences in processing scale and context (one size does not fit all) across the Australian processing industry.

The "Introduction to the Red Meat Processing Industry" module provides useful facts and context for newcomers to the industry and assists an understanding of the environmental context within which the industry operates.

Each module was developed by contractors with expertise in the area who worked closely with a steering group from the AMPC Environmental Committee. The work began in mid 2004 and the modules were submitted to AMIC in October 2005. Each guideline was reviewed at least twice by steering committee members and edited both for technical rigour and consistent style and language.

AMIC adoption of the IBPG was agreed in the February 2006 National Council meetings subject to sign off by AMIC members, which was completed successfully in June 2006.

FAQs Sheet: Industry Best Practice Guidelines (IBPG) Environment

1. What are the IBPG?

The IBPG are a set of 6 independent, yet related guideline modules which define current environmental best practice for meat processors in Australia in areas of critical importance.

2. Why adopt the IBPG?

The red meat processing industry is one of Australia's largest manufacturing sectors and represents the largest rural export industry by value. By adopting the IBPG, the red meat processing industry in Australia demonstrates a voluntary commitment to operate their businesses at a high standard of environmental practice. The IBPG defines such practice and allows the industry to be accountable for its performance.

3. What is Environmental Best Practice in meat processing?

Environmental best practice in the red meat processing industry is processing meat to achieve company objectives while minimising the ecological footprint of the operation. This is done by maximizing resource consumption efficiency, using best available knowledge, practices and technologies and minimising emissions.

4. Will the IBPG be available to the public?

Yes, the IBPG are intended as a publicly available document demonstrating to the community the commitment the processing industry makes to protect the Australian environment.

5. Is the IBPG a technical document?

No. The IBPG are not intended to act as a source of technical information on the environmental topics covered. This information is available in other industry and MLA publications or from experienced industry personnel. The guidelines seek to describe general best practice on environmental topics of importance to meat processing.

6. Are the IBPG mandatory guidelines?

No. Conformance with the IBPG by red meat processors is entirely voluntary. However, the national peak council representing Australian meat processors, AMIC, has endorsed them and recommended that all processors aim to achieve the standard of environmental conduct described.

7. Do the IBPG override State or Commonwealth Environmental guidelines?

No. Meat processors are still required to achieve compliance with State and Commonwealth environmental regulations. The IBPG seek to outline how this can best be achieved in a manner that is most appropriate for the industry and which allows for some of the industry's unique constraints.

8. Do the IBPG represent world best practice?

No. While some aspects of the IBPG may describe World Best Practice, the intent of the IBPG is rather to set a line in the sand that defines current Australian best practice in environmental management for red meat processors. In many aspects, the uniqueness of Australia's climate, geography and urban demography means that Australian environmental practice is often at the forefront of World best practice.

9. How were the IBPG produced?

Key industry executives and environmental managers requested that Meat & Livestock Australia prepare a set of guidelines that would define the current practices that represent environmental best practice. Each module was prepared by contractors who were skilled in the topic and understood the meat industry. Members of the AMPC Environment Committee assisted by providing comments on the draft documents. The guidelines were produced under the technical direction of Dr. Mike Johns, who assists Dr. Stewart McGlashan in the Environment R&D program for MLA.

10. Are the IBPG intended to cover all Australian red meat processors?

Yes. There is a significant range in the type, size and geographical location of Australian meat processors. The IBPG have been written to attempt to ensure that they allow for all of the many variations and permutations in the way the industry operates.

Meat Processing

Introduction to the red meat processing industry

TABLE OF CONTENTS

MEAT LANGUAGE

Term	Definition
AQIS	Australian Quarantine Inspection Service
AUS-MEAT	Authority for Uniform Specification of Meat and Livestock: is the national industry owned organisation responsible for the objective description of Australian meat and livestock. AUS-MEAT also provides monitoring and accreditation of quality assurance systems for livestock producers, abattoirs, feedlots and wholesalers.
BOD	Biochemical oxygen demand: a measure of the quantity of dissolved oxygen consumed by micro-organisms that breakdown the biodegradable constituents in wastewater
Boning Room	The physical area where carcase meat is cut down into smaller portions and prepared for packaging
By-product	A secondary or incidental product made as a result of manufacturing an original product. In the meat industry 'by-product' often refers colloquially to the products of the rendering plant.
Carcase	The name given to an animal after it has been slaughtered and dressed
Carcase dressing	The process of removing the hide/skin and viscera from an animal following slaughter and its subsequent trimming and presentation for further processing for human consumption
Carcase specifications	The means of describing required carcase characteristics when ordering meat
COD	Chemical oxygen demand: a measure of the quantity of dissolved oxygen consumed during chemical oxidation of wastewater
Cross contamination	When contamination is passed from one surface to another. Examples include carcase to carcase and worker to carcase contamination.
DAF	Dissolved air flotation, a type of wastewater treatment technology
Electrical stimulation	Electrical stimulation is the application of an electric current to a carcase soon after slaughter. Its main benefit is to reduce meat toughness as a result of carcases with 'active' muscles being placed in very cold chillers. Other benefits include improved bleeding of the carcase, improved meat colour and reduced amount of 'drip' from meat cuts.
Hide	The outer skin of cattle removed after slaughter
Livestock	Animals kept on a farm, and would commonly include sheep, cattle, pigs, goats, deer, alpaca
Meat processing plant	The 'factory' where the animals are processed resulting in meat and meat by-products. In Australia, meat processing plants are also commonly referred to as meatworks or abattoirs.
Mutton	An older sheep, defined by having one or more (up to 8) permanent incisor teeth
Offal	Edible internal parts of an animal, eg: heart, liver, kidney
Paunch	The stomach and its contents in sheep and cattle
Portion Control	The preparation of specific cuts of a given weight and cost, particularly for the food service trade, allowing uniformity of serves and determination of cost per portion
Potable water	Water suitable for human consumption
Race	Narrow walkway or passage
Rendering	The process undertaken to convert by-products (secondary meat and animal products) into value added products such as tallow, meatmeal and bloodmeal
Saveall	A device for physically separating solid and floating phases from wastewater
Service kill	Slaughter and processing of animals for a third party
Skin	The outer skin and wool combination removed from a sheep or outer skin and hair combination removed from a goat after slaughter
Slaughter Floor	The physical area in an abattoir where an animal is slaughtered and processed to a carcase
Stickwater	The liquid waste from rendering plants; particularly the water-rich stream from tallow polishing centrifuges. Blood stickwater refers to the liquid phase after steam coagulation of blood.
Stunned	Rendered unconscious
Tallow	Refined fat produced from beef animals
tHSCW	Tonnes Hot Standard Carcase Weight as determined using the AUS-MEAT standard
Veal	Meat produced from a calf
Viscera	The digestive tract of an animal

1.0 Overview of the Red Meat Processing Industry

Many products of the red meat industry are used daily in nearly all aspects of our lives. While many enjoy a BBQ and wear leather shoes, few have an understanding of the process undertaken between the farm and retail shop, or of the scope of the industry that produces these products.

While meat is derived from a number of sources, this module focuses on the processing of:

- beef and veal
- sheepmeat and lamb
- goatmeat

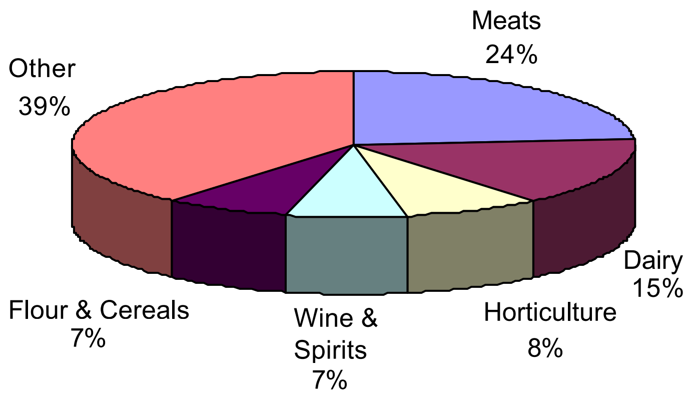
This module provides an introduction to the red meat processing sector, an overview of the industry, including the processes undertaken; and the various challenges it confronts, particularly environmental challenges.

1.1 Industry value

The red meat processing sector is one of the largest sectors within Australia's food processing industry and is a large employer, dominating the scape of many regional cities and towns. In 2000/01 the red meat processing sector:

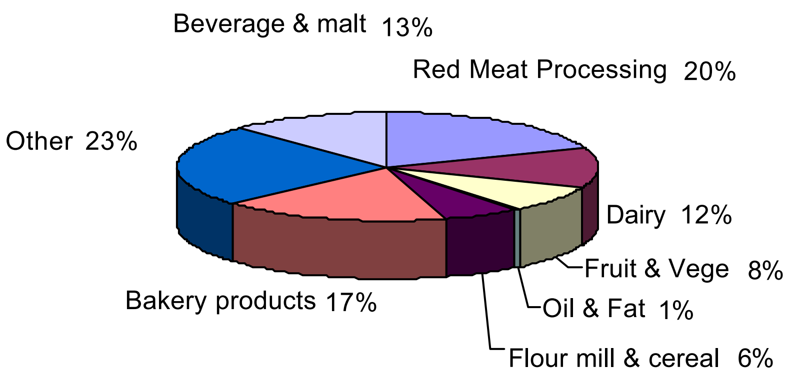
- accounted for around 24% of total economic value within Australia's food processing industry; and
- employed approximately 28,000 people.

Figure 1: Value of meat within the food processing sector (2000-01 data)



Source: Australian Food Statistics 2003, AFFA

Figure 2: Employment in the Australian processed food industry (2000/01)



Source: Australian Commodity Statistics 2003, ABARE

As well as supplying quality meat to domestic consumers the Australian red meat industry exports to over 100 countries around the world. Exporting is vital to the Australian red meat industry with Australia rated as the largest meat and livestock exporter in the world, despite being a relatively small producer overall – only producing 9% of the world's lamb and mutton supply and 4% of the world's beef and veal supply.

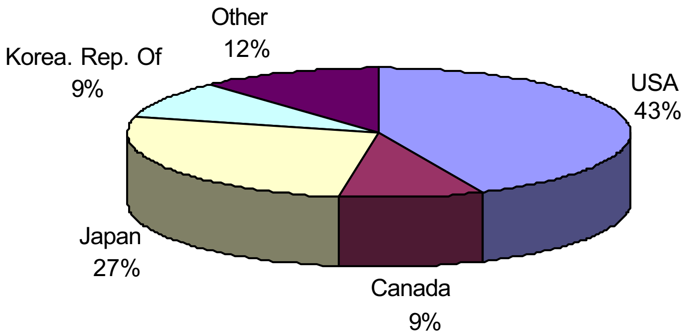
QUICK FACTS

- *The total value of Australia's off-farm beef and sheepmeat industry was $14.5 billion (2002/03 figures - MLA estimates and ABS statistics).*
- *The total value of domestic consumer expenditure for beef and sheepmeat is approximately A$7.7 billion (2003 figures - MLA estimates).*
- *The total value of Australian beef and sheepmeat exports is A$4.2 billion (2003 figures - DAFF volumes, ABS unit values).*
- *The total value of other products associated with the red meat industry is A$2.6 billion (2003 figures - DAFF volumes, ABS unit values).*

Over 60% of Australian beef production is exported (893,300 tonnes in 2002/03). The largest customers for Australian beef in recent years have been:

- United States of America (USA)
- Japan
- Republic of (South) Korea.

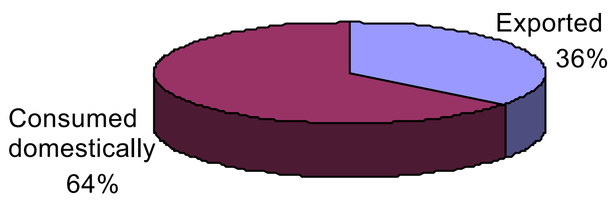
Figure 3: Export markets for Australian Beef



Source: Australian Commodity Statistics 2003, ABARE

Although 68% of lamb and 38% of mutton produced in Australia are consumed domestically, Australia is the world's largest exporter of mutton and the second largest exporter of lamb.

Figure 4: The export and domestic disappearance of Australian lamb and sheepmeat



Source: Australian Commodity Statistics 2003, ABARE

Australia is a relatively small producer of goatmeat but in 2002/03 was the largest exporter. Australian goat slaughter in 2002/03 was around 1.1 million head, with approximately 15,000 tonnes of goat meat exported to key markets, including:

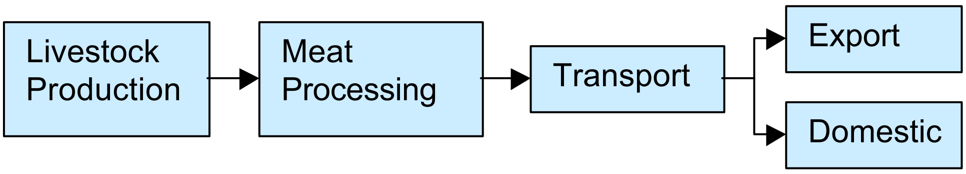
- USA
- Taiwan
- Canada.

The value of Australian goatmeat exports in 2002/03 was valued at over $46.9 million.

1.2 Industry structure

The meat production chain consists of a series of integrated sectors, from on-farm through meat processing to final sale to consumers. The meat processing sector is the link between on-farm production and retail.

Figure 5: The meat production chain



Source: Work arrangements in the Australian Meat Processing Industry – Labour Market Report, 1998.

The red meat processing sector consists of a diverse range of establishments from small, family owned businesses processing less than five tonnes of carcase product per day, through to large corporate firms, processing over 600 tonnes of carcase product per day. These establishments vary in the:

- type of animals processed;
- proportion of production exported;
- proportion of production boned or processed on behalf of others; and
- geographic location.

Table 1: Varying characteristics of meat processing plants

Characteristic	Ways that establishments may vary
Location	• By State (differing legislative requirements)
Ownership	• Family owned vs. corporate • Australian vs. overseas
Throughput	• Ranges from less than 5 tonnes of carcase product per day to over 600 tonnes of carcase product per day
Type of service	• Service kill only • Part-service, part-own account • Own account only
Processing level	• Slaughter floor only • Boning room only • Slaughter floor plus integrated boning room • Slaughter floor, boning room plus further processing (eg portion control)
Market	• Export (licensed by country) • Domestic
Production type	• Single-species plant • Multi-species plant

CASE STUDY

The following table summarises four case studies based on actual data, demonstrating the diversity of operations within the red meat processing sector.

	Company 1	Company 2	Company 3	Company 4
Annual throughput (Estimated Tonnes Carcase Weight)	399,788	35,200	30,985	10,400
No. of abattoirs	4	3	1	1
No. of employees	4,800	250	350	60
% exported	85%	0%	100%	0%
Species processed	Beef only	Beef, sheep and pigs	Beef, sheep, deer, veal, and goats	Sheep and lamb

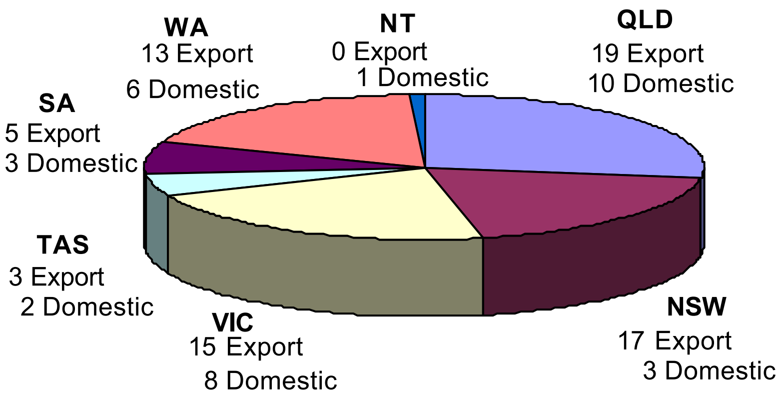
- *Company 1 is a large corporate company operating four beef processing plants, employing more than 4,800 people, and is integrated with four feedlots. The main facility processes 18,000 cattle per week and is the single largest processing establishment in Australia. They sell beef to both the export and domestic markets.*
- *Companies 2 and 3 are both multi-species processing plants with similar throughput and employees, however they target different markets. Company 3 may be subject to additional legislative requirements if the country that it exports to has requirements over or above the Australian Standard.*
- *Company 4 is a small family operated business targeting the domestic market only.*

Like many other agricultural industries in Australia, the red meat processing industry operates in highly competitive domestic and international markets. It has seen a considerable number of plant closures and a trend towards consolidation over recent years.

Despite a significant reduction in their number over the past decade, red meat processing establishments remain widely distributed throughout Australia. The majority of AUS-MEAT accredited abattoirs in Australia are located within the grain-livestock belts of Victoria, New South Wales and southern Queensland.

An abattoir that has accreditation through AUS-MEAT has systems in place and can provide assurances on the quality of the product. The labelling and description of the product is a standard system used domestically and internationally for Australian product. AUS-MEAT accredited abattoir systems are audited by AUS-MEAT.

Figure 6: Number of AUS-MEAT approved processing plants in Australia



Source: AUS-MEAT Accreditation List 2004

FURTHER INFORMATION

- *An up-to-date list of plants is available from AUS-MEAT or on their website www.ausmeat.com.au*
- *Information about the highest trade value abattoirs is available in the Feedback Magazine 'Top 25 Processors', Meat and Livestock Australia, 2004* (7)

1.3 Meat processing and hygiene

Meeting community expectations for environmental management as well as food safety is a particular challenge for the red meat processing industry. A conflict often arises between the requirements for safe food production and good environmental management.

Two examples of the contradiction between safe food production and environment are:

- Meat is required to be refrigerated to minimise growth of spoilage / health risk organisms, however refrigeration is a tax on energy consumption.
- The preparation of safe product during processing is aided by the use of water to wash contaminants from carcases. This procedure however, while important for food safety, places a high demand on water resources.

The red meat processing industry is faced with ever increasing environmental pressures, such as:

- stricter wastewater quality requirements
- tighter environmental emission regulations
- higher community expectations.

Environmental efforts in the red meat processing industry have focussed on the:

- reduction of water consumption

- effective treatment and utilisation of wastewaters
- utilisation of animal by-products
- reduction of energy consumption
- reuse of waste solids
- reduction in odour
- reduction in noise.

To ensure that meat and meat products for human consumption comply with food safety requirements and are wholesome, strict regulations govern the meat processing industry, including:

- All processing plants must be licensed and meet the requirements of the *Australian Standard for the hygienic production and transportation of meat and meat products for human consumption (AS 4696-2002)*.
- To be eligible to produce meat for export to specific countries, processing plants must be licensed by AQIS and accredited by AUS-MEAT.

The need for high levels of sanitation and the need to keep the product cool results in meat processing plants using very large quantities of water and energy to ensure food safety requirements are met. The ability of a meat processing plant to reduce usage of these resources or to improve efficiency is often limited by the stringent food safety regulations in place, rather than a plants' willingness to improve their environmental performance. Examples of options that could be adopted to improve efficiency of resource use may be water reuse and recycling.

Boot washing facility

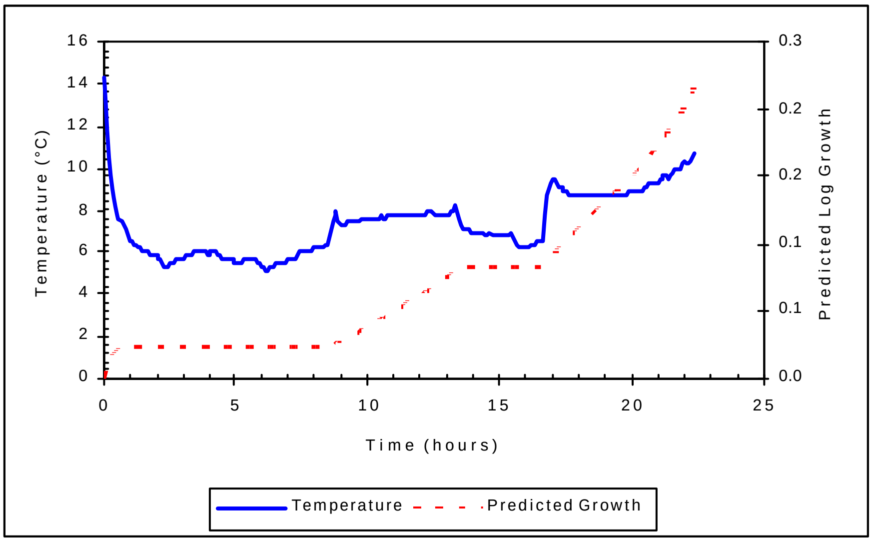
FURTHER INFORMATION

For further information, please refer to:

- *Australian Standard for the hygienic production and transportation of meat and meat products for human consumption (AS 4696-2002)*[(2)]

Predictive modelling is used as a means to monitor food safety. The Australian Standards impose requirements on temperature over time to minimise the amount of microbes on meat product. Figure 8 shows the predicted growth of *E.coli* using time and temperature data.

Figure 7: Example of predicting *E.coli* growth using time and temperature information



Source: Calculation using E.coli Predictive Model developed by the University of Tasmania.

To avoid carcase contamination hygienic practices, such as regular hand washing, and the washing and sterilising of equipment are undertaken. Commonly known terms in the Australian meat processing industry today are those of Good Manufacturing Practices (GMP) and Good Hygiene Practices (GHP). GMPs and GHPs take a common-sense approach to discern whether an action or stage of a process will influence the food safety aspect of a product. The Australian Standard requires:

- Hand, apron and boot wash areas located at entrances to all ‘clean areas’, where staff are to wash their hands, aprons and boots before entering and exiting. Hand wash stations are also located throughout process areas.
- Knives, steels and other equipment used in processing, to be washed and sterilised regularly, and whenever chance contamination has occurred.
- Any hooks, rollers, skids or gambrels used during slaughter, dressing and chilling are to be cleaned or sterilised between uses on dressed carcases.
- Head hooks are to be sterilised between heads.
- Water for sterilisation of equipment to be 82 C or above.

Hand-washing and sterilisation unit

1.4 Product outputs

While the major product from beef cattle, sheep and goat production is meat for human consumption there are many by-products that result. The nature of meat processing means that for every unit of meat produced there is a proportional amount of other materials produced, such as:

- offal
- hides/skins
- fat
- blood
- manure
- paunch contents.

By-products are often a forgotten part of meat production, but they are significant, both in terms of their value ($A2.6 billion in 2003) and their use in nearly all aspects of our daily lives.

Table 2: By-products of meat processing

By-product	Possible uses
Hides and skins	• Leather for goods like shoes, handbags, jackets and furniture; wool
Fat	• Edible tallows (eg frying fats, shortening for baking, oil for use in bakery products, confectionery and industrial margarine); inedible tallows (eg soap and cosmetics, lubricants, leather dressings, candles and tallow for tanning leather)
Blood	• Dried for use as fertiliser; manufacture of high value therapeutics; the various components of blood such as albumin, fibrinogen and blood cells may be collected separately, mainly for use in laboratory procedures
Lungs, liver, kidney and heart, tongue and brains	• Trimmed and packed for human consumption; pet food; rendered into meat meal
Horns and hooves	• Glue and Neatsfoot oil
Bone	• Bonemeal for production of fertiliser, glue, bone china and bone charcoal
Intestines	• Smallgoods casings and strings for musical instruments
Hair	• Artists' brushes; as a binder in asphalt paving and plaster
Manure	• Sold as is or combined with other materials, such as sawdust, green waste, paunch manure and no commercial value (NCV) skins, in a composting process. Suitable for agric ulture, landscaping, home lawns and gardens
Ovaries	• Oestrogens and progesterone
Pancreas	• Insulin and trypsin
Pituitary	• Adrenocorticotropic hormone (ACTH)
Testes	• Hyaluronidase

The conversion of by-products into saleable product reduces environmental burdens by diverting waste away from landfills. However meat processors must manage other subsequent environmental impacts.

For example, rendering, while it recovers tallows and meal for beneficial use, greatly increases the pollutant load of wastewater and risk of odour emissions. Similarly, other by-product recovery processes such as offal recovery and hide treatment increases wastewater generation. Other environmental impacts, such as increased energy consumption and odour generation, may also be associated with by-product recovery processes.

2.0 The Process

The main stages of meat processing are:

- Preparation for slaughter
- Slaughter
- Hide/skin removal
- Removal of internal organs
- Trimming and carcase washing
- Weighing and grading
- Chilling
- Boning
- Packaging
- Freezing or cold storage
- Plant cleaning.

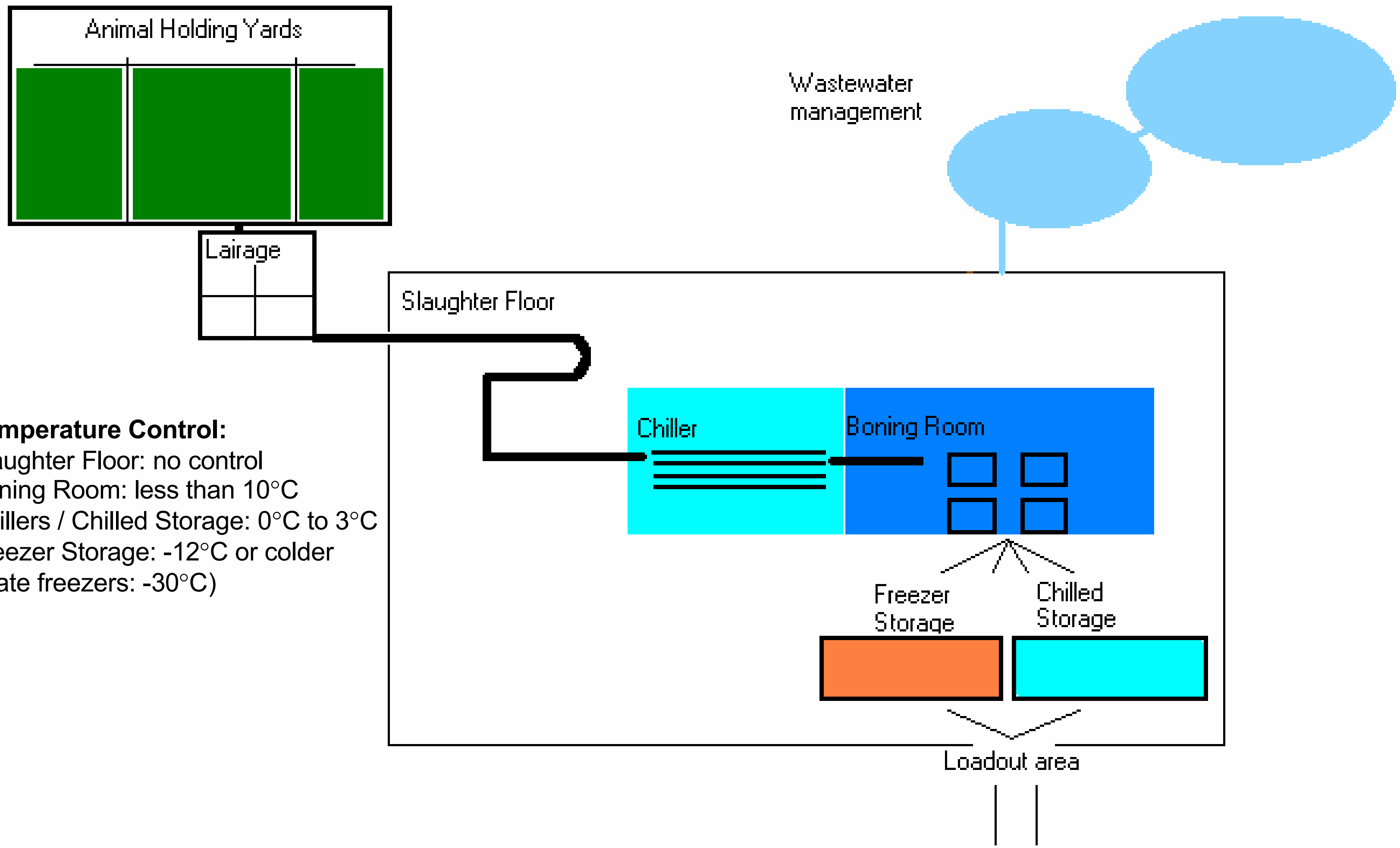
In addition to these generic processes, some establishments may also undertake other activities, such as:

- Rendering
- Hide and skin processing
- Blood processing.

Other operations that are undertaken at a meat processing establishment include:

- Water pre-treatment
- Paunch processing
- Wastewater treatment and discharge.

Figure 8: Overview of a processing plant



Temperature Control:
Slaughter Floor: no control
Boning Room: less than 10°C
Chillers / Chilled Storage: 0°C to 3°C
Freezer Storage: -12°C or colder
(plate freezers: -30°C)

The following sections discuss the main stages of meat processing and highlight the environmental issues associated with each stage.

2.1 Preparation for slaughter

When livestock arrive at the meat processing plant they are unloaded from trucks into lots according to their different vendors, and placed in holding yards. If the plant is located close to residential areas or other noise-sensitive receptors, the noise generated from various items of equipment and the manoeuvring of trucks delivering livestock can cause a nuisance.

Livestock holding yards

Prior to slaughter animals may be treated to remove any visible dirt from their hides or pelts. Cattle are normally washed, either manually or with fixed sprays. The amount of water used for washing depends on the type and cleanliness of the stock, increasing significantly if they are received in a dirty condition. An extra 80-100 litres/head can be used for the additional washing of dirty stock. Some plants impose an extra charge to process dirty cattle or offer an incentive for the delivery of clean cattle.

Although not washed, it is preferred that sheep and lambs arrive at an abattoir for slaughter having been crutched, to remove any faecal or urine stained, dirty or mud caked wool.

Washing cattle to clean hides of visible dirt

Stock delivery trucks and holding yards are washed to keep them clean from urine and manure. Animal manure adds to the pollutant load of wastewater, containing:

- phosphorous
- nitrogen
- organic carbon.

Manure can be collected prior to wash-down to reduce the amount lost to wastewater however the ease of collection varies considerably from one site to the next.

2.2 Slaughter

In Australia, animals must be slaughtered humanely. Animals are moved down a race, restrained to control their movement and stunned so that they are unconscious prior to the start of the slaughter process. This process is undertaken to meet the requirements of Animal Welfare Codes of Practice and relevant State legislation. Some abattoirs will slaughter animals to meet various religious requirements, including Halal. From slaughter, an animal is then processed to the carcase stage by a series of procedures, this series being commonly referred to as the 'slaughter chain'.

A restraining unit at slaughter

Animals are bled immediately after stunning, while still unconscious, to stop the blood supply to the brain and to remove blood from the carcase before further dressing procedures commence. This bleeding process is commonly referred to as 'sticking'.

Blood is valuable if recovered for processing, but is a highly polluting substance. Therefore the efficient recovery and segregation of blood is an important means of reducing the pollutant load in wastewaters.

2.3 Hide/skin removal

After slaughter the carcase is moved to a legging stand where the skin is opened and the hocks and hooves, hide/skin and head are removed. Mechanical pullers are normally used to remove the hide/skin.

The entire process of slaughter and hide/skin removal must be undertaken hygienically to avoid contamination of edible meat product with microorganisms that may reduce shelf life or be harmful to consumers.

2.4 Removing internal organs

The process of opening the carcase and removing the internal organs is called 'evisceration'. Once removed, the internal organs are placed on a table known as the 'viscera table', where qualified inspectors inspect them. The viscera table is sterilised between viscera inspection to avoid cross contamination.

Some modern viscera tables incorporate systems that turn wash sprays on only as the table moves forward, however older stye tables may run continuously, increasing hot water usage. Alternatives to the use of hot water at this point are limited due to the strict hygiene standards in place.

The internal organs that are removed are referred to as offal. Offal products include:

- heart
- liver
- lungs
- kidneys
- thick/thin skirts (diaphragm)
- paunch/tripe (stomach)
- runners (intestines)
- pancreas
- brain
- testes

Small stock evisceration table

These products are transferred to a separate production area. Here edible offal products are:

- segregated
- trimmed to specification
- washed
- packaged

Hand-washing offal

Offal cleaning and washing machines use large volumes of both hot and cold water.

Other edible offal products, such as paunch and runners, require their contents to be emptied before they are washed, trimmed to specification and packaged. In most plants the paunch contents are washed out of the rumen then recovered from the effluent stream by screening. Paunch contents are disposed of by composting.

Any inedible offal, condemned products and trimmings are collected and turned into useful products via the process of rendering.

2.5 Trimming and carcase washing

Trimming occurs to remove excess fat, bruising or visible contamination. Meat processing plants attempt to collect fat and meat tissue trimmings to avoid these materials being lost to the wastewater stream. Fat is dropped into bins, chutes or conveyors and transported to rendering facilities for either edible or inedible product.

Following trimming, carcases are often washed, either manually or by using automatic carcase wash systems, to remove bone dust generated during carcase splitting. Some processing plants have, however, moved away from full carcase washing, relying on the trimming process and spot cleaning with steam-vacuum systems instead. In most cases however, food hygiene targets, rather than water consumption considerations, will dictate the preferred techniques for carcase cleaning.

2.6 Weighing and grading

Following trimming the carcase is weighed and graded, although additional grading may occur after chilling. Producers are often paid on carcase weight and grade so these must be accurate and consistent between processing plants. A standard (AUS-MEAT) is used to ensure processors trim and prepare the carcases to the same level before weighing and grading.

2.7 Chilling

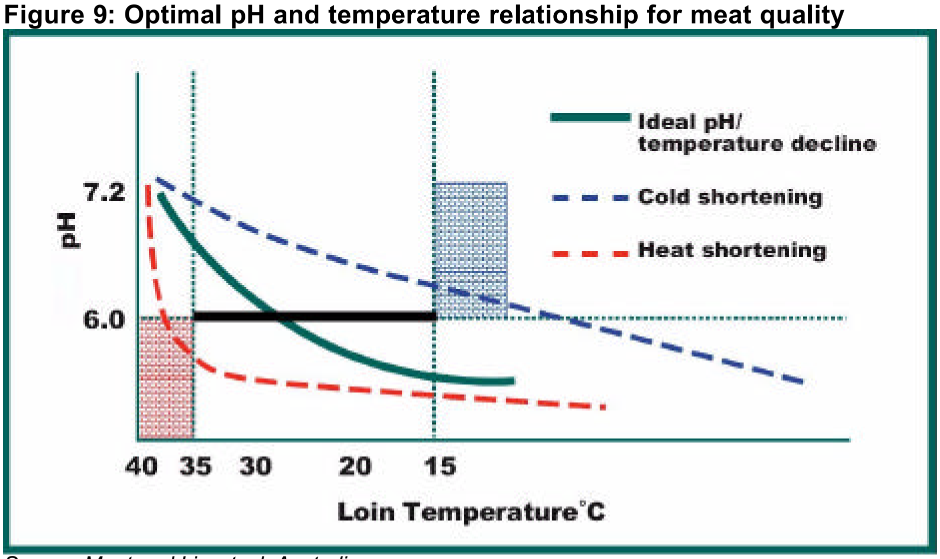
After weighing, the carcase is refrigerated in a large cold room, known as the 'chiller'. The perishable nature of meat products means that they need to be chilled, frozen or cooked in order to preserve them. This involves the use of electricity for refrigeration and heat for cooking (at plants that undertake further processing).

To achieve food safety requirements, meat needs to be chilled to 4°C or colder within 12 hours from slaughter.

The temperature of meat products is critical to food safety. Research has defined the best temperature range over time to achieve requirements for safe food and product quality. Once again, balancing the challenges of food safety, product quality and environmental requirements becomes an issue. The food safety aspect requires product to be chilled to lower temperatures in a quicker time than would be required from a meat quality perspective, where steadier chilling will result in a higher quality product. However, in consideration of the environment, less chilling time means less energy is used.

Figure 9 below shows the optimal meat quality pH and temperature relationship over time.

Figure 9: Optimal pH and temperature relationship for meat quality



Source: Meat and Livestock Australia

Carcases hanging in a chiller

2.8 Boning

After the meat has been chilled, it can either be sold as a whole or part carcase, or cut into smaller pieces, called primals. This process is known as 'boning'. Examples of primals include a whole rump or set of ribs.

Half and quarter carcases are generally bought by large meat wholesalers or butchers, who then do their own boning. Some meat processing plants have their own boning rooms where carcases are further processed.

In the boning room, people called 'boners', cut the meat down into primal cuts and then 'slicers' trim and prepare the primal cuts for packaging.

Any trim and bones that result from this process are collected for rendering.

2.9 Packaging

Meat is packaged in a variety of ways for ease of handling and transportation for both export and domestic markets.

Cardboard is the largest packaging input and the largest packaging waste item. The other important packaging material is plastic, which is used for vacuum pack bags, plastic sheeting, and strapping.

In relation to the type of packaging used, meat plants are generally constrained by customer specification, particularly in export markets. Plants do however have control over the wastage of packaging materials.

2.10 Freezing or cold storage

Once packaged, cartons can either be:

a. stored in cold storage (0-4 C); or
b. frozen (<-18 C)

Meat is frozen to extend shelf life if it is to be held for extended periods of time.

The process of chilling and/or freezing product, together with refrigerated storage is the largest consumer of electricity in a meat plant.

Plate freezers stack, freeze and store product

2.11 Plant cleaning

Plant cleaning takes place both during and at the end of production, but most of the cleaning effort occurs at the end of the production day.

Dry cleaning of plant and equipment prior to wash-down is widely practiced in the industry, which can reduce water used by 20-30%. Dry cleaning also reduces the solids and pollutant load of the wastewater.

The Australian Standard requires:

- Cleaning compounds (eg detergent and sanitisers) to be approved for use in meat processing premises.
- Any chemical residue to be removed from surfaces likely to contaminate edible product by thorough rinsing with potable water before the area or equipment is used for handling edible product (except when approved for use without a final rinse).

The Australian Quarantine Inspection Service (AQIS) requires that chemicals used on a plant are approved for use, to ensure that meat product is not contaminated and against requirements for export customers.

2.12 Rendering

Rendering is the process undertaken to convert by-products into value added products such as tallow, meatmeal and bloodmeal. Abattoirs have been considered to be the original recyclers. Rendering is coming under increasing pressure from environmental authorities to eliminate, or at least severely reduce, the release of undesirable odours into the atmosphere – especially where a plant is located near residential developments. The effluent from rendering also significantly increases the pollutant load of wastewater.

External view of the rendering facility at an abattoir

2.13 Hide and Skin Processing

Skin preservation by dry salting is a common procedure at processing plants that export skins for tanning. After salting, skins are left to dry for a minimum of 5 days. During this period, the salt draws the moisture out of the skin and wool, together with the protein-filled fluids contained in the attached flesh.

The effluent from drying sheds is therefore highly saline and has a very high biochemical oxygen demand (BOD).

Many hides from cattle are left 'green' and only chilled at the processing plant, before going to the manufacturer for production.

2.14 Blood Processing

The efficient recovery and segregation of blood is an important means of reducing the pollution loads in wastewaters, since blood is a highly polluting substance. An operation with an efficient blood recovery system will have a lower polluting load than one that allows blood to flow to the wastewater stream.

3.0 Resource Use

The main resource inputs in meat processing are water, energy, packaging materials and chemicals.

While these resources are typical of many food processing sectors, meat processing plants use very large quantities of water and energy due to the:

- highly perishable nature of the product;
- need for high levels of sanitation;
- need for high temperatures for hand-washing (42°C) and sterilisers

(82°C);

- need to keep the product cool.

The following table presents a summary of the red meat processing industry averages for water and energy use in 2003.

Table 3: The approximate quantities of water and energy consumed at a meat plant

KPI	Score 2003	Units
Water		
Raw Water Usage	10.6 (sheep and cattle)	kL/tHSCW
	1,480 (cattle only)	L/head
Wastewater Generation	10.0 (sheep and cattle)	kL/tHSCW
	1,400 (cattle only)	L/head
Energy		
Energy Usage	3390 (sheep and cattle)	MJ/tHSCW
	463 (cattle only)	MJ/head

Source: MLA, Industry Environmental Performance Review 2003

kL = kilo litres MJ = megajoules L = litres

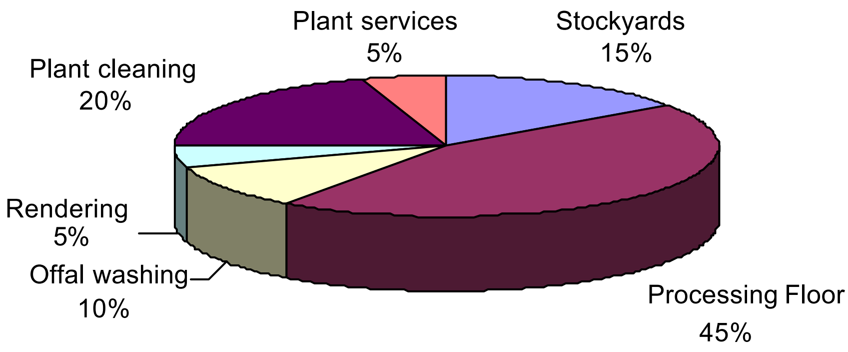
3.1 Water

Water is a very important input for meat processing. The need to maintain strict food safety standards means that it is used in considerable quantities for the washing of livestock and products and the cleaning and sanitising of plant and equipment.

Daily water usage of a typical meat processing plant[1] is shown in the following figure.

[1] NOTE: In this example a 'typical meat plant' is defined as a plant processing approximately 150 tonnes HSCW per day, which is equivalent to 625 head of cattle per day, based on a conversion rate of 240kg/head. Production is assumed to take place 5-days per week, 250 days per year, and boning and rendering takes place. Water usage can vary considerably from one plant to another, so this should be regarded as an example only.

Figure 10: Water use at a typical meat plant



Source: Adapted from the Eco-efficiency manual for meat processing 2002

Water usage varies considerably from one plant to another depending on their circumstances. For example, modern plants may be easier to clean due to improved plant layout and equipment design. Since water use is also dependent on operator practices staff awareness and supervisor vigilance have a large bearing on consumption.

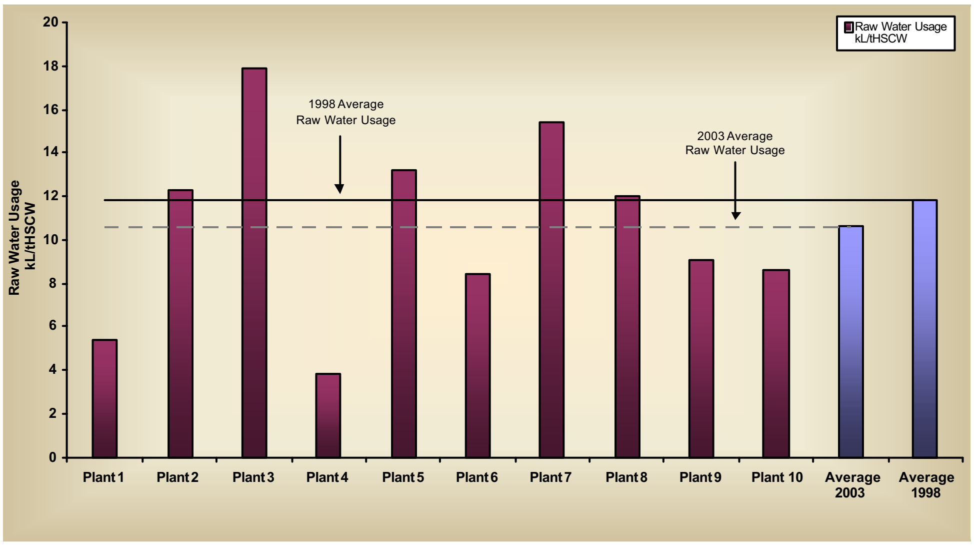
Findings from the 2003 Industry Environmental Performance Review indicate that the red meat industry in Australia has made good progress in reducing overall raw water usage.

FURTHER INFORMATION

For further information, please refer to:

- *The Eco-Efficiency Manual* [19]
- *Industry Environmental Performance Review, 2003* [10]

Figure 11: Raw water usage 1998 vs 2003



Source: MLA, Industry Environmental Performance Review 2003

A food safety issue arises in that only potable water can be used when it will come in contact with edible product, as water being reused may be a source of product contamination. The red meat processing industry is currently investigating potential opportunities for water reuse, taking into consideration food safety requirements.

3.2 Energy

The use of energy for refrigeration and equipment sanitation is important for ensuring good quality meat products. Energy consumption depends upon the:

- age and size of the plant
- level of automation
- range of products manufactured

Thermal energy, in the form of steam and hot water, is used for cleaning, heating water, sterilizing and rendering. Steam and hot water is typically produced from boilers powered by coal, oil, gas or electricity.

Electricity is used for the operation of machinery and for:

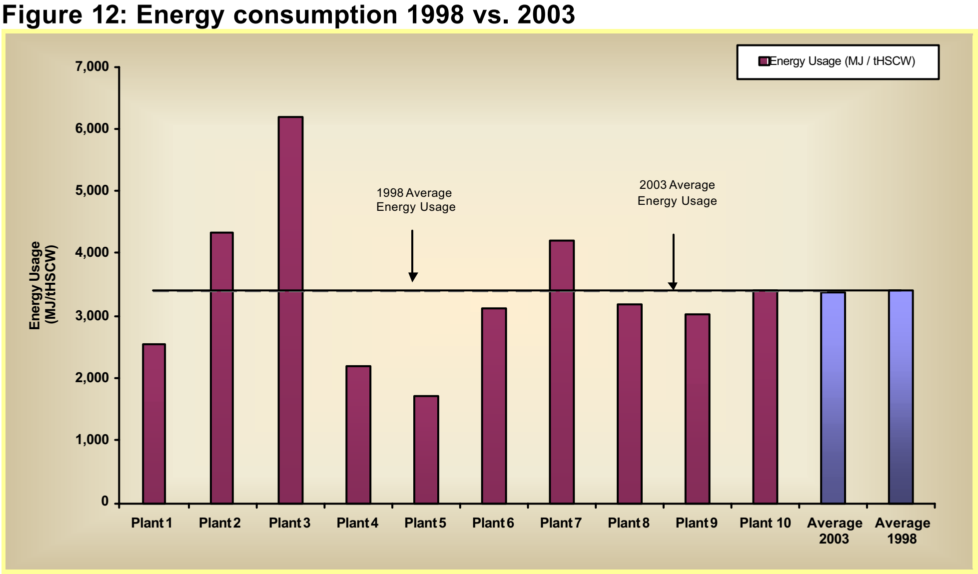
- refrigeration
- ventilation
- lighting
- the production of compressed air

Refrigeration plant room

Refrigeration is the largest user of electricity at meat plants. The other large usage areas are the multitude of motors that drive pumps, fans, conveyors, and hydraulic systems.

While energy is an area where easy financial savings are possible, findings from the 2003 Industry Environmental Performance Review suggest the industry has made limited progress in reducing the amount of energy used in the production process.

Figure 12: Energy consumption 1998 vs. 2003



Source: MLA, Industry Environmental Performance Review 2003

In time it can be expected that government and regulatory authorities will place greater emphasis on reducing energy usage and greenhouse gas emissions.

3.3 Packaging materials

Governments around the world are trying to reduce packaging waste through increasingly stringent regulations. These take many different forms, from mandatory recycling together with minimum recycled content laws through to complete landfill bans.

For the meat industry, packaging must be designed to minimise waste (less packaging) and enable recycling, reuse or recovery (incineration with energy recovery), while ensuring a hygienic meat product that is delicious to eat. Value added products would generally use a higher proportion of packaging material.

3.4 Chemicals

Chemicals are only used for cleaning, sanitising, hook cleaning, and in some cases water and wastewater treatment.

Many large meat processing plants use automatic dosing systems, which dispense the correct amount of cleaning agent. Small plants however may opt for manual dosing, which requires close attention to the recommended chemical dosage rate.

Increasingly, environmentally friendly cleaning and sanitising agents are becoming available. These are proven to be as effective as conventional products, but are generally less hazardous to the receiving environment and staff.

4.0 Waste Generation

The main wastes from meat processing operations are:

4.1 Wastewater

Wastewater from meat processing contains high levels of:

- biodegradable organic compounds
- fats
- nutrients, especially nitrogen and phosphorus
- and microorganisms

Due to their location at the fringes of urban centres and the volume of wastewater, many meat processing plants either treat their own wastewater, or provide pre-treatment prior to sewer discharge. The wastewater is well suited to treatment by biological methods and is frequently reused by irrigation to land. There are negligible amounts of substances that persist in the environment.

Recycling of treated effluent back to the factory is generally prohibited by food safety regulations and there are only very restricted opportunities for recycling. There is, however, increasing third party reuse.

Aerial view of a processing plant and wastewater treatment

4.2 Waste solids

Large quantities of waste solids are generated by meat processing. Most of the parts of the animal that cannot be directly sold are rendered to generate valuable tallow (fat), meatmeal and bonemeal which are protein-rich. Some waste solids, however, are unsuitable for reuse in this manner and include:

a. yard manure;
b. paunch (stomach) contents consisting of partially digested grass or grains;
c. waste solids recovered from the effluent by screens or other devices;
d. skins with no commercial value;
e. packaging wastes, which consist mainly of plastic and cardboard.

Land disposal by spreading or burial has been the traditional method of disposing of solid and semi-solid wastes. However, composting systems are now widely used to permit reuse of the nutrient-rich organic material. Plastics, metal and cardboard are often recycled where possible or sent to landfill.

A mature pile of compost

4.3 Odour and air quality

Unpleasant odour emissions have characterised the meat processing industry in the past. These arise mainly from:

a. rendering and skin processing operations within the facility;
b. effluent storage and treatment operations;
c. animal holding pens.

To minimise emissions, the industry has adopted a variety of odour minimisation strategies coupled with air capture from particularly high-risk areas and treatment using recognised and effective odour treatment technologies.

An important factor in preventing community nuisance from meat processing operations is ensuring that Councils maintain adequate buffer distances between operating meat processing plants and new housing developments.

Other air quality impacts include boiler stack emissions, drier exhausts and dust from animal or vehicle movements on-site. These are typically managed in accordance with licence requirements.

FURTHER INFORMATION

Further information on wastewater treatment and odour management is available in the CSIRO/University of Queensland publication, 'Abattoir Waste Water & Odour Management' [16]

5.0 Industry Best Practice

The main environmental concerns of the red meat processing industry can be categorised as follows:

a. Waste solids generation and disposal
b. Waste water treatment and disposal
c. Odour and associated air impacts
d. Energy management

The Meat Processing Industry Best Practice Guideline consists of several modules covering each of these key aspects. Including this document, Introduction to the Red Meat Processing Industry, the other Guideline modules are titled:

- Wastewater Treatment
- Odour and Air Quality
- Waste Solids
- Energy Management
- Effluent Irrigation

These modules are designed to give you further information regarding the application of, and the commitment by the industry to current best practice to minimise undesirable environmental impacts of meat processing and maximise positive environmental outcomes for Australia.

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Energy

Table of Contents

Abbreviations & Acronyms

AGO	Australian Greenhouse Office
COP	Coefficient of performance
COSP	Coefficient of system performance
CO_2-e	carbon dioxide equivalent
EEAP	Enterprise Energy Audit Program
EEBP	Energy Efficiency Best Practice Program
EPA	Environment Protection Agency/Authority
GHG	Greenhouse gas
kg	Kilogram
kL	kilolitre (1000 litres)
kVA	kilovolt-amperes (apparent power)
kVAr	kilovar (magnetising or reactive power)
kW	kilowatt
kWh	kilowatt hour
m^3	cubic metres
MJ	mega joule
MLA	Meat and Livestock Australia
MSM	Multi speed motor
R&D	research and development
SEAV	Sustainable Energy Authority of Victoria
SEPP	State Environmental Protection Policy
SOx & NOx	oxides of sulphur and nitrogen
TDS	Total dissolved solids
tHSCW	Tonne hot standard carcase weight
TWh	Terawatt hour
US EPA	United States Environmental Protection Agency
VSD	Variable speed drive

Environmental Objectives

- Comply with all relevant legislation and regulations
- Efficient consumption of energy resources thereby reducing greenhouse gas emissions
- Demand management to reduce electricity load factor
- Continuous improvement in environmental systems and performance

Possible Environmental Impacts

Energy utilisation at a meat processing enterprise has environmental impacts at both local and National/Global levels.

Local	**National/Global**
• Smoke (visible plume + particulates) from combustion processes including boilers and direct fried driers • Visible steam vapour from process equipment • SOx and NOx from combustion processes • Solids disposal from boilers using solid fuels • Refrigerant release	• Carbon dioxide emissions and greenhouse impacts both directly from in-house combustion processes and indirectly from electricity consumption

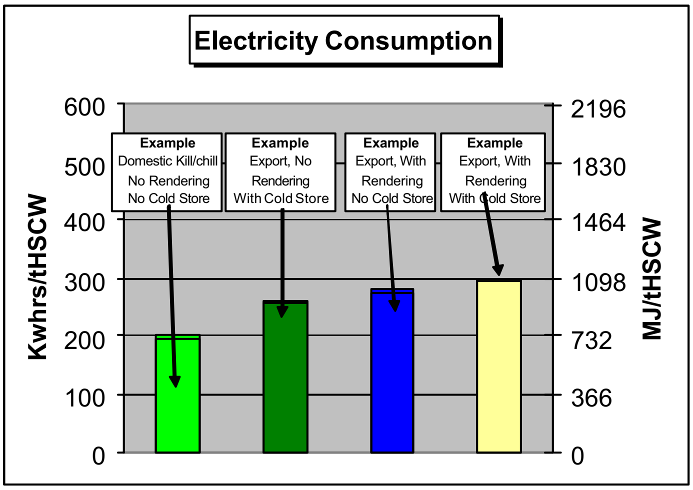
Key Performance Indicators

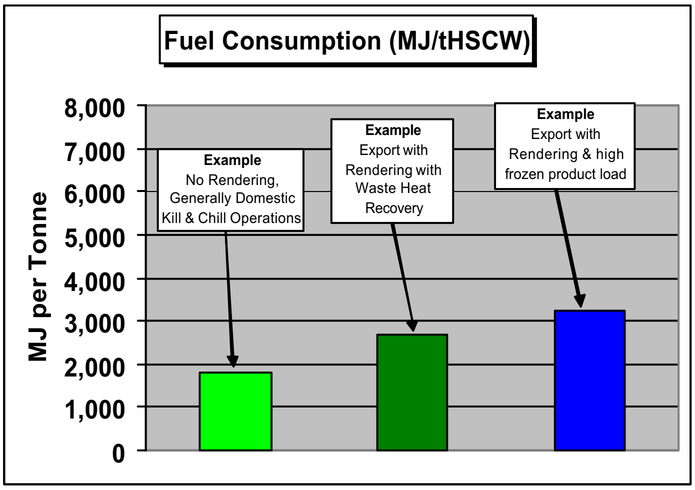
The following table presents a summary of the red meat processing industry energy utilisation in 2003. These averages represent a number of enterprises employing a variety of processes at the individual enterprise level.

KPI	Average	Range	Units
Energy Usage	3390	2000-6000	MJ/tHSCW
	465	100-1000	MJ/head
Greenhouse Gas Emissions	525	250-900	kg CO_2-e/tHSCW
	75	15-170	kg CO_2-e/Head

Source: MLA, Industry Environmental Performance Review 2003

- These KPIs relate to medium to large integrated export abattoir facilities, processing > 100 t HSCW/day.





Further details of the objectives of the pieces of legislation are provided in Appendix 2.

Current Legislation and Regulation	
Commonwealth	Legislative instruments refer to management of energy efficiency and greenhouse gases include: • National Environment Protection Measures (Implementation) Act 1998 • National Strategy for Ecologically Sustainable Development • National Greenhouse Strategy • Greenhouse Challenge Plus All businesses using more than 0.5 petajoules of energy per year will be required to undertake a rigorous energy efficiency opportunity assessment every five years and commencing in 2006. Meat industry data suggests this will only apply to companies processing in excess of 150 thousand tonnes HSCW/annum.
States	There are an increasing number of environmental plans and recommendations coming into place focussing on mandatory targets for high end energy users.
Victoria	In Victoria in addition to management of various air pollutants, SEPP include a Protocol for the Environmental Management of Greenhouse Gas (GHG) Emissions and Energy Consumption (PEM 824 – See Reference 8). EPA Licence holders (scheduled premises) must complete a number of key steps including: • Undertake an Energy Audit including a profile of baseline energy consumption • Prepare a greenhouse emissions inventory • Formulate an emission reduction / improvement plan with quantified savings EPA-Victoria, with SEAV has developed an "Energy & Greenhouse Management Toolkit" which is a useful reference for those companies wishing to establish an energy and emissions management system. (See References 'Energy Management System')
NSW	Draft Guidelines for Energy Saving Action Plans mean that the highest commercial and industrial energy users, as designated by the Minister for Energy and Utilities, will be required to develop and implement Energy Savings Action Plans

Further details of the objectives of the pieces of legislation are provided in Appendix 2.

Environmental Best Practice Overview	
Knowledge of Energy Consumption • Measure & monitor consumption including load profiles (daily, seasonal, annual, etc) in order to compare performance against projections, and balance energy demand over time • Quantify and rank energy using plant & equipment.	**Appropriate Equipment Design & Selection** • Ensure all process equipment is energy efficient and appropriately sized for the load. • Apply energy efficiency principles to minimise energy consumption. • Implement heat recovery and reuse systems (eg hot water generation from rendering operations)
Management Focus on Energy Management • Include all costs including supply, operating and maintenance costs when assessing energy reduction initiatives	**Compliance** • Ensure energy management meets regulatory requirements.

Blast chiller fans

Best Practice Information

The meat industry utilises significant quantities of fuel and electricity. Well designed steam raising, hot water generation, process equipment and refrigeration plant can reduce energy costs and contribute to a reduction in greenhouse gas emissions.

The aim of this document is to assist the meat processing sector to achieve industry best practice for energy management.

Best practice energy management involves:

- Minimising heating fuel consumption
- Minimising electricity consumption
- Maximising heat recovery
- Monitoring and actively managing energy consumption
- Implementing continuous improvement

1.0 ENERGY OVERVIEW

Energy is used in meat processing to provide heating, refrigeration, motive power and lighting. Energy consumption depends on the range of processes conducted by the enterprise. In general:

- Fuel is used to produce steam (sometimes hot water directly)
- Steam is used for process heating and to generate hot water
- Waste process heat is recovered to generate hot water
- Some fuel is used for direct fired drying and on-plant vehicles
- Electricity is used to provide motive power for refrigeration, mechanical handling, size reduction, process machinery, hand tools and lighting.

Thermal energy, in the form of steam and hot water, is typically produced from boilers powered by coal, oil, gas or biomass. Steam is used for rendering, generation of hot water (82^{o}C for sterilising and 45^{o}C for cleaning) and process heat (eg scald tanks, white offal processing, protein coagulation and tank heating).

Waste process heat, particularly from rendering, is recovered for the generation of hot water.

Refrigeration is the largest user of electricity at meat plants. Other large usage areas are the multitude of motors that drive process equipment, pumps, fans, conveyors, and hydraulic systems.

Energy consumption depends upon the:

- age and size of the plant
- processes conducted on the plant
- extent and ratio of product chilling and freezing
- plant capacity utilisation

- plant operating schedules (eg single, extended, multi shift)
- range of products and co-products manufactured.

An estimate made of fuel use in the Meat and Meat Products Manufacturing industry was provided in a report prepared by Energetics for SEAV in March 2004 based on information available from the Australian Greenhouse Office. This information confirms that two thirds of the energy is used as fuel and one third as electricity with a total industry use in the order of 12 Petajoules.

SUMMARY	Percentage	Value (Petajoules)
Fuel	67%	8.3
Electricity	33%	4.1

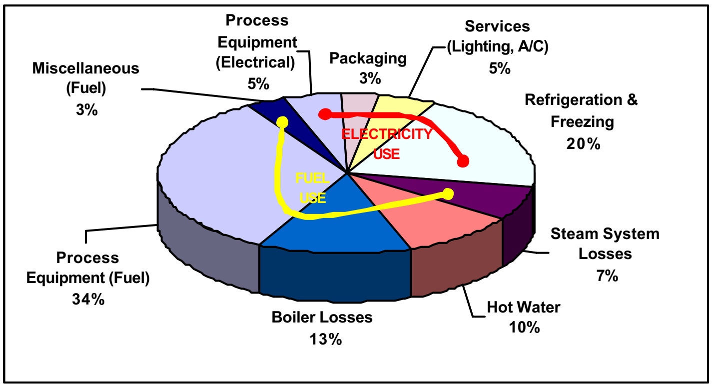
The cost of energy represents in the order of 5% of non-livestock operating costs (approximately $10/head – 2004) with electricity representing 3%-4% and fuel 1% to 2% of costs (ProAnd – Meat Industry Benchmarking Studies).

In the Energetics report, an estimate was also made of the break-up of energy use in the meat processing industry based on energy audit data and industry economic data. These estimates are provided below to provide an indication of the relative importance of energy use components.

Fuel	Equipment Type	Percentage	Value PJ
Electricity	Process Equipment (Rendering, Dressing, Boning etc)	5%	0.6
Electricity	Packaging	3%	0.4
Electricity	Services (Lighting, A/C)	5%	0.6
Electricity	Refrigeration and Freezing	20%	2.5
Gas/Other	Steam System Losses	7%	0.8
Gas/Other	Hot Water	10%	1.3
Gas/Other	Boiler Losses	13%	1.7
Gas/Other	Process Equipment (Rendering, Singeing, Scalding etc)	33%	4.2
Gas/Other	Miscellaneous (Fuel)	3%	0.4
	TOTAL	100%	12.5

Further Information

- *the Energy Efficiency Improvement Potential Case Studies* [1]



The Energetics report identified a series of best practice energy efficiency opportunities for the sector and these are provided in Appendix 1 with comments on current level of adoption by the industry.

2.0 FUEL SELECTION

Fuels are used for a variety of purposes in meat processing including steam raising, direct fired heating (eg pneumatic ring dryers, rotary kiln driers, hot water heaters, etc), process purposes (eg singeing & scalding) and for vehicles (forklifts, trucks, etc).

Fuel Source	Utilisation
Coal	Steam raising
Sawdust/biomass	Steam Raising
Fuel Oil	Steam Raising
Tallow	Steam Raising
Natural Gas	Steam raising, Direct heating, Process
LPG	Steam raising, Direct heating, Process, Vehicles
Butane	Steam raising, Direct heating, Process, Vehicles
Diesel	Direct Heating, Vehicles

An estimate of fuel use based on information available from the Australian Greenhouse Office indicates the total use and relative importance of various fuels in the meat processing sector. Electricity and natural gas represent two thirds of energy consumption.

Further Information

- *the Energy Efficiency Improvement Potential Case Studies* [1]

Fuel	Percentage	Value (Petajoules)
Black Coal	18%	2.3
Wood, Wood waste	5%	0.7
LPG	7%	0.9
ADO	1%	0.1
Fuel Oil	3%	0.3
Natural Gas	33%	4.1
Electricity	33%	4.1
TOTAL	100%	12.5

Oil fired boiler

LPG tanks

General principles in maximising efficiency of process heating includes:

- Maximise efficiency of generation in boiler (boiler efficiency)
- Maximise efficiency of distribution of steam and hot water around the plant
- Maximise efficiency of end use of process heating, by ensuring that:
    - end use equipment uses as little as possible to achieve the desired outcome
    - end use equipment is only running when required.
- Implementation of combination of controls:
    - software – documentation of operating procedures, employee training & awareness, maintenance scheduling
    - hardware – appropriate control equipment, where possible implement automated feedback control.

Boiler efficiencies vary depending on the fuel used. Approximate boiler efficiencies for different fuels are:

Fuel	Boiler Efficiency
Coal	76%
Fuel Oils	79%
Natural gas	80%

2.1 Steam Raising

Steam is raised in the meat processing sector to provide heat for rendering and ancillary processes, and to generate hot water (when there is no on-site rendering) or to supplement hot water generated from heat recovery systems.

Factors affecting boiler efficiency best practice include:

- Maintain steady, continuous load
- Well designed & maintained control equipment
- Regular tuning of burner controls
- Clean heat transfer surfaces and comprehensive insulation
- Good management of condensate return and blow-down to maximise heat recovery
- Appropriate feed-water treatment to minimise scaling and corrosion.

Smaller establishments, where there is no rendering operation, often install hot water boilers.

A comprehensive checklist of factors affecting boiler efficiency is provided in Appendix 3.

Further Information

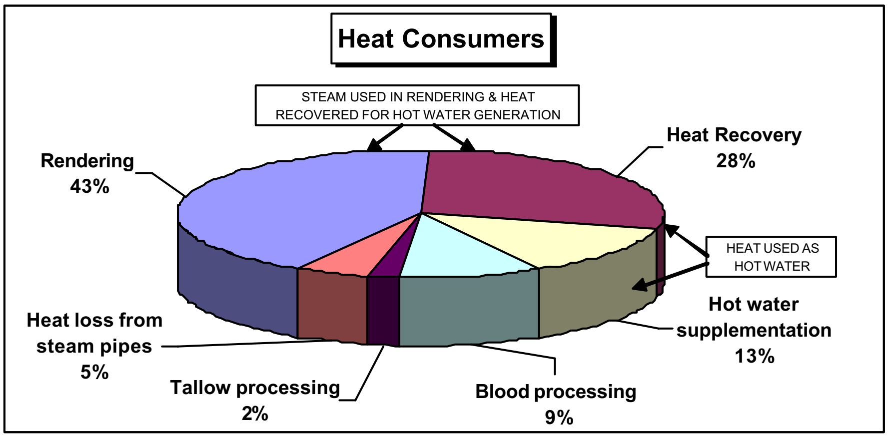
More information is available in the various editions of the following publications, as listed in the Steam Raising References:

- *the Energy Management Brochure For The Meat Processing Industry*
- *Sustainable Energy Authority Victoria*
- *UK Energy Efficiency Best Practice Program, 1994*

Steam vacuum cleaning of carcases

2.2 Steam Reticulation & Use

In a typical integrated meat processing plant with dry rendering, steam is raised to produce process heat for rendering and, from which heat is recovered for hot water generation, supplementary steam is used to generate hot water and for other process uses. An indication of the relative importance of heat users is provided in the following pie-chart. (Note: in wet rendering plants with direct fired driers fuel is used to directly heat dryer air).



Source: Adapted from Reference 2

Rendering plant energy utilisation and heat recovery issues are addressed in Section 2.5 and supplementary hot water heating is most commonly performed through the use of plate heat exchangers (see Section 2.3).

Scald tanks are often heated with direct steam injection in order to quick start up. It is preferable to combine both direct injection for start up and indirect heating for process operating periods.

General principles for sound steam reticulation practices include:

- Monitor steam use by department
- Ensure steam mains are properly sized, laid out, drained and vented, maximising the opportunity for gravity return of condensate
- Minimise steam leaks
- Insulate all steam pipes, flanges and valves and bare process plant surfaces
- Blank off or remove redundant steam piping
- Maintain high process plant loads, and minimise hot idle time
- Ensure process temperatures are well controlled and as low as possible
- Ensure the correct type of steam trap used for each application and that it is correctly installed and regularly maintained
- Maintenance program to detect and repair steak leaks and operation of steam traps
- Where possible increase the amount of condensate recovery and insulate condensate returns.

A comprehensive checklist addressing steam reticulation is provided in Appendix 5 – Steam Reticulation Checklist.

Apron wash

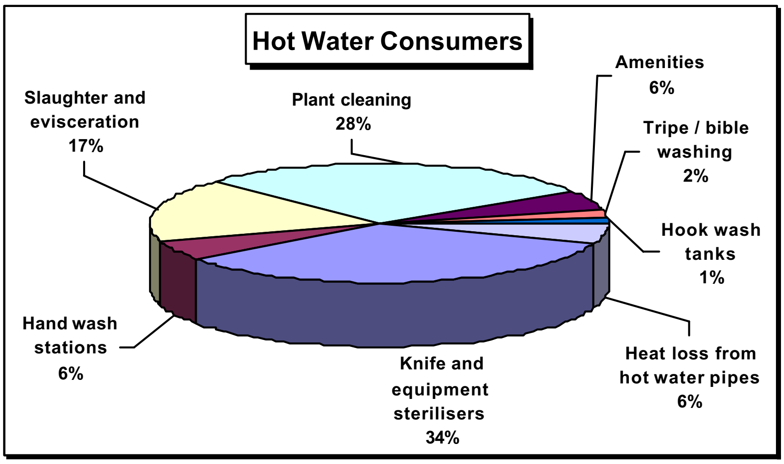
Further Information

- *Refer to the UK Energy Efficiency Best Practice Program* [21]

2.3 Hot Water

Large quantities of hot water are used in meat processing plants. The hot water use is driven by food safety requirements, so all of the suggestions provided must be considered in light of food safety and hygiene requirements.

The following pie chart provides an overview of the major hot water consumption in a typical export meat processing plant.



Source: Adapted from Reference 2

Hot water (82^{o}C and above) is used for sterilising equipment including knives, hooks, viscera tables and hand tools. Approximately 25% of incoming water is used as hot water.

Warm water (approximately 45^{o}C) is used mainly for hand and apron washing and wash-down purposes. Approximately 10% of incoming water is used as hot water.

Water at intermediate temperatures is also used in processing (eg white offal processing systems, scalding operations, etc).

End-of-production wash-down can involve a variety of rinse and sanitation cycles that utilise hot, warm, intermediate and cold water in varying proportions depending on the procedures in place.

Domestic registered processing plants generally use less hot water than export plants.

A hot water boiler is used where waste heat for hot water production is not available

2.3.1 Hot Water Generation

Heat Recovery

- Maximise the recovery of heat from rendering plants to generate hot water
- Recover hot water at as high a temperature as practical, (ie close to 80^{o}C) in order to minimise the discharge of hot water to the wastewater system and loss of energy from the system
- Heat recovery generating hot water at 60^{o}C generates an additional 50% volume compared with 80^{o}C, so consider how to balance heat recovery with hot water requirements to ensure that hot water does not flow to waste.

Hot Water Storage

- Install sufficient hot water storage to take into account any mismatch between the timing of generation from heat recovery and hot water demand
- Insulate hot water storage tanks.

Supplementary Heating

- Install efficient heat exchangers to generate or supplement the heating of hot water prior to delivery to the user Departments. Generally plate heat exchangers are used for supplementary heating and condensate is recovered
- Keep delivery temperatures as low as possible while still complying with hygiene requirements
- Use appropriate water treatment to minimise the accumulation of scale on heat transfer surfaces.

2.3.2 Hot Water Reticulation

Ring Mains

- Install ring mains for hot water supply in order to eliminate end-of-line temperature losses
- minimise distances between hot water generation and end use where practical, avoiding dead legs, long pipe runs and height variations in pipework wherever practicable
- ensure pipework diameter and system pressure is the minimum for the task required
- Insulate ring mains and consider how location of ring mains can minimise heat losses eg avoid elevated outdoor pipe runs if underground culvert is available
- Install and maintain mixing valves to provide intermediate temperature water
- Ensure program of regular of inspection of ring main to detect and repair leaks on a regular basis.

2.3.3 Hot Water Use

Efficient handwash and steriliser operation minimise energy waste

Hot Water General Use

- Ensure all hot water flows cease when they are not required through the use hardware or software eg electronic sensors and timers provide good flow control for intermittent devices
- Control hot water flows to meet and not exceed the required duty eg infra-red sensor or knee operated hand washing stations
- Monitor and maintain hot water flow controls.

Sterilisers

- Replace continuous overflow sterilizers with intermittent devices using infra-red sensors
- Ensure that continuous overflow devices are not overusing hot water by the use of inline flow restrictors
- Consider retrofit of inline flow restrictors for existing sterilisers, to limit maximum flow rate
- Ensure sterilisers are double skin insulated types, to minimise heat loss and reduce potential for worker injury
- Consider whether some sterilisers can be removed.

Hot Water Mixers

- Utilise hot water mixers to balance demand.

Viscera Tables

- Viscera tables are large users of both hot and cold water. Optimise viscera table cleaning operations to produce an acceptable surface cleanliness with a minimum of hot water, including shutting off flow during breaks. Ensure the design of the washing system and nozzles provides acceptable surface cleaning without excess use of water.

General equipment

- On larger floors, consider segregation of water supply to areas, so that flow can be sequentially started or stopped
- Consider installation of motion sensors for flow control
- Consider minimising the amount of carcass and working surface washing, through system automation, improved controls and nozzle design.

Plant Cleaning

- Ensure nozzles on hot water hoses have an efficient spray pattern, adequate but not excessive water pressure and are regularly maintained

- Ensure that hot water hoses cannot be left running unattended, through the use of triggers.

Water Re-Use

- Re-use hot water spent from hygienic operations in Departments that can use hot water that need not be potable. eg recover clean water from sterilizers, hand-wash basins and viscera table washing for use in yards or rendering raw material washing operations, hash washer, gut washing etc.

Further Information

- *Energy Management Brochure For The Meat Processing Industry* [22]

2.4 Heat Recovery

Heat recovery from vapour should be considered if there is a use for the hot water obtained. The advantage of heat recovery is significant and it is well worthwhile making a careful study in any plant where vapour is produced to ensure the hot water generated from heat recovery is maximised, such as cooker vapours in the rendering plant.

Meat processing plants have a large demand for hot water to address hygiene needs and plant wash down. Hot water tanks are required to store hot water in order to match heat recovery timing with hot water demand.

Examples of available heat sources and potential users of recovered heat are:

Potential heat sources	Potential users of recovered heat
Rendering process Screw compressor lubrication oil cooler	Hot water (82ºC) production, Warm water (43ºC)
Refrigeration de-superheater & condenser Condensate return & Boiler blowdown	Pre-heating boiler feed
Carcase singeing	Scald tank heating

Condensers are used to cool rendering vapours to minimise odour emissions and generate hot water for plant use

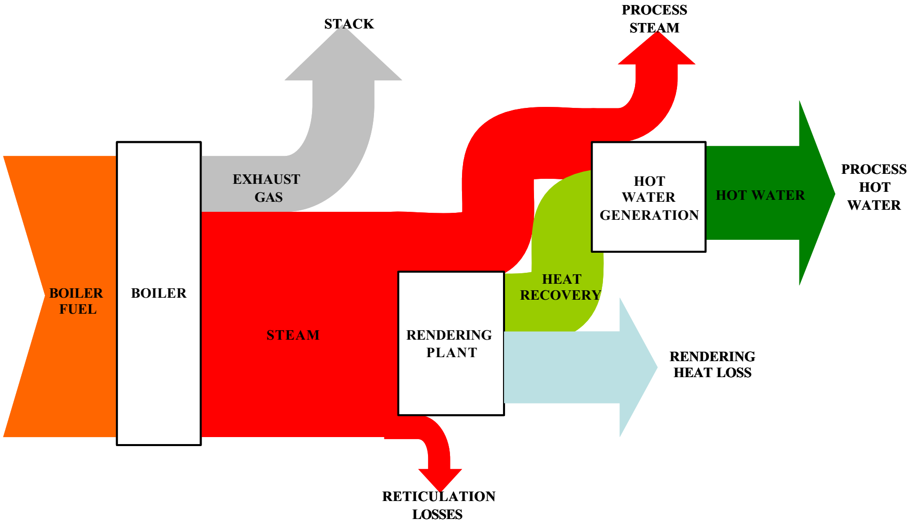
Further Information

- *Energy Management Brochure For The Meat Processing Industry* [23]
- *Heat Recovery, Sustainable Energy Authority Victoria* [24]

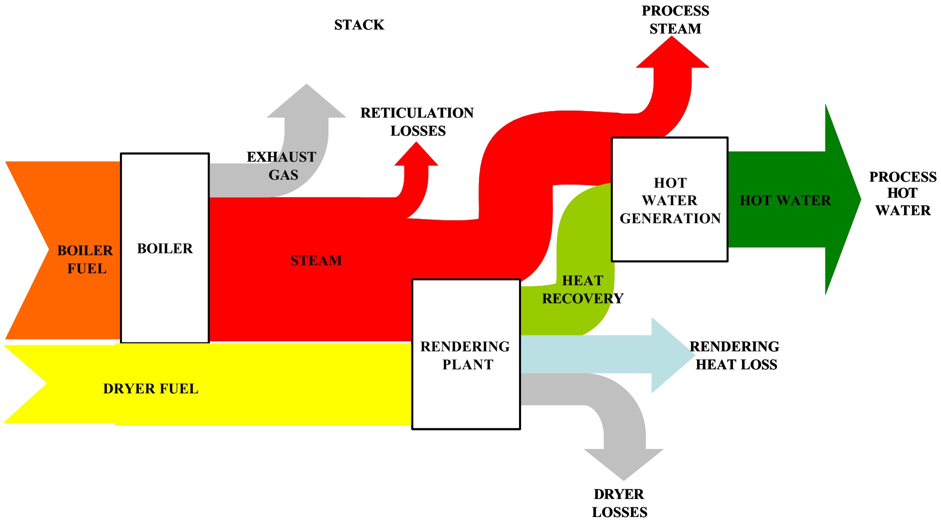
2.5 Product Rendering/Drying

The following figures provide typical Sankey diagrams for heat use in rendering plants. In dry rendering plants heat is recovered from the cooking vapour condensing system. In wet rendering with direct fired drying heat is recovered principally from the dryer.

SANKEY DIAGRAM – TYPICAL HEAT USE DRY RENDERING



SANKEY DIAGRAM – TYPICAL HEAT USE WET RENDERING – DIRECT FIRED DRYING



General principles in maximising the energy efficiency of rendering include:

- Minimise the amount of water entrained in the material entering the rendering plant
- Maximise the amount of condensate recovery in dry rendering systems
- Maximise the amount of heat recovery from cooker vapours
- Insulate equipment such as cookers and driers, to minimise heat loss and improve the working environment.

In order to minimise energy requirements it is important to minimise any added water in the blood or rendering raw material. If washing of the raw material is necessary to obtain satisfactory quality finished meal and tallow or water needs to be added for transport lubrication, then the raw material needs to be drained. In principle raw material should be collected with minimal inclusion of added water, with a preference for screw conveyors rather than pneumatic systems with blow tanks if plant layouts allow.

Further Information

- *Eco-Efficiency Manual for Meat Processing* [2]

One water outlet running at 20 litre/minute can add over 1 tonne of water to the raw material every hour. Rendering plants are generally sized in the order of 5-10 tonne/hour. The effect on the volume of raw material and the subsequent energy demand is significant (10-20% of the load). The energy consequences have a greater impact in evaporating processes such as dry rendering.

Process and storage tank heating should be provided by sufficient heat transfer surface area (eg steam coils) fitted with steam traps and condensate recovery. Tanks should be insulated and have controls installed to operate at the lowest required temperature. Locating the tanks in a sheltered position may also assist with minimising the heat losses (undercover, out of prevailing wind), as can scheduling of loading operations to minimise the heating requirements for the tanks.

2.5.1 Wet Rendering

Continuous low temperature wet rendering systems involve direct injection of live steam into a cooking vessel where the rendering raw material is heated for a short period prior to passing to a centrifugal decanter system to separate the liquid and solid phases.

The solid phase is dried in either a direct heated rotary kiln type continuous drier, or in an indirect (steam) heated disk dryer. Both of these drying systems are normally fitted with heat recovery systems for the generation of hot water for use in the meat processing plant.

While continuous low temperature rendering generally requires less heat input than dry rendering systems as less moisture is evaporated, from an energy point of view there are some disadvantages:

- Condensate return is low due to the use of live steam
- Waste heat recovery efficiency is reduced in direct fired drying systems.

In order to address other environmental issues, a number of wet rendering systems have been retro-fitted with waste heat evaporators to process the stickwater from the primary decanting system.

Water inclusion in the raw material needs to be minimised, condensate recovery should be maximised, and steam lines and hot surfaces of the rendering system should be insulated.

2.5.2 Dry Rendering

Dry rendering involves evaporating the moisture from the rendering raw material in either a batch processing system (batch cookers) or in a continuous dry rendering vessel. Both systems utilise steam for indirect heating/drying of the rendering raw material.

Dry rendering systems are fitted with vapour condensers to recover waste heat for the production of hot water for use in the meat processing plant.

Water inclusion in the raw material needs to be minimised, condensate recovery should be maximised, and steam lines and hot surfaces of the rendering system should be insulated.

2.5.3 Blood Processing

Blood is processed by direct steam injection into an in-line coagulation system, followed by centrifugal separation of solids and liquid. The solids are then dried in a direct fired pneumatic ring dryer.

Due to the low temperature and dust content it is not practical to recover waste heat from the direct fired pneumatic drying system.

Direct steam injection into the coagulator means that no condensate is recovered.

All steam lines and hot surfaces of the pneumatic drier and blood processing system should be insulated.

Modern energy efficient blood processing unit

2.5.4 Summary

In best practice rendering systems, regardless of the system in operation the net energy use should be monitored and minimised. Rendering plants use around 70% of the heat generated on a meat processing plant, of which around 40% is recovered to generate hot water. See Section 2.2.

Steam use in the rendering plant needs to be monitored as does the fuel use in any direct fired drying process. The heat recovered needs to be calculated from the temperature and volume of hot water generated from the heat recovery system.

Different types of energy are used within the meat plants, with different units of measurement (tonnes coal, kWh electricity, m^3 gas, etc.). It is convenient to convert them to a common unit, such as megajoules (MJ). The following calorific values and conversion factors are typical:

Coal	30.7 MJ/kg
Natural gas	39.5 MJ/m^3
Fuel oil	43.1 MJ/kg
LPG	49.6 MJ/kg
Electricity	3.6 MJ/kWh
Steam	2.8 MJ/kg steam
Hot Water (85^{o}C)	280MJ/klitre
Hot Water (45 ^{o}C)	120MJ/klitre

Monitoring net energy use will identify inclusion of free draining water significantly better than monitoring of products yields.

Further Information

- *Energy Management Brochure For The Meat Processing Industry* [25]

2.6 Insulation

In order to reduce heat losses and ensure worker safety both hot and cold surfaces need to be insulated. General principles for good insulation practices include:

- Insulation should be fitted to
  - hot surfaces above 50^{o}C
  - all refrigeration suction lines
  - cold surfaces below 10^{o}C.
- Correct installation, avoiding damage due to impact, weather or wear, and no open joints, is required to maximize the effectiveness of the insulation
- The technical suitability of an insulation system is of primary importance; however availability, service and cost should also be taken into account

(such as clearance around pipes, additional weight, heat losses through conduction to supports)

- Insulating pipes, flanges and valves, with removable jackets to give access where required
- Preventing the ingress of water or chemicals
- The insulation of hot gas ducts and flues for safety and to prevent internal condensation and possible corrosion.

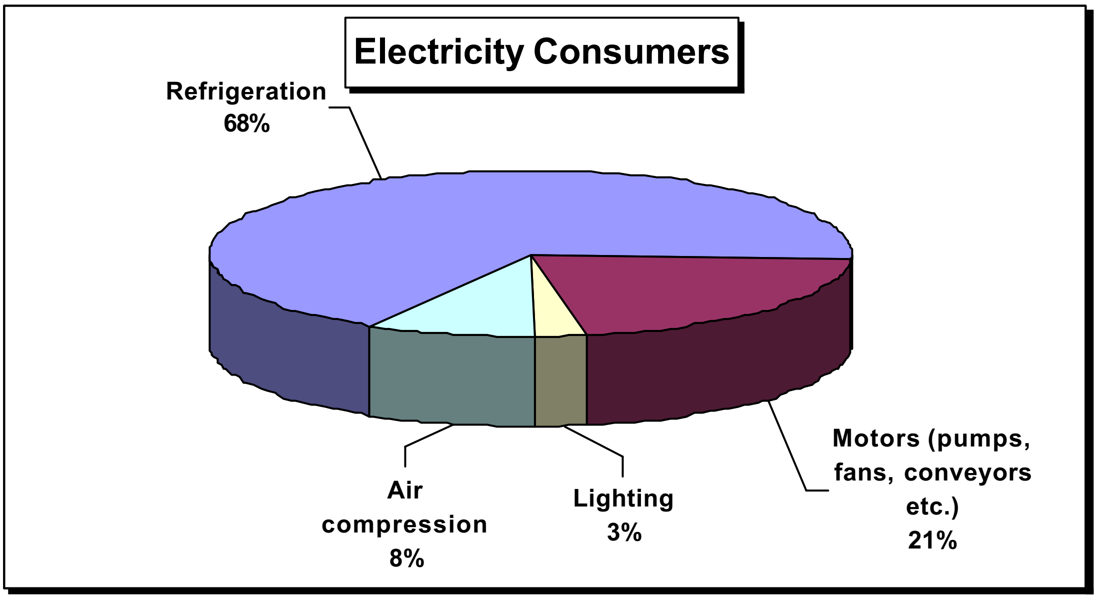
A comprehensive checklist addressing insulation issues is provided in Appendix 4 – Insulation Guidelines.

Further Information

- *UK Energy Efficiency Best Practice Program* [17 / 19]
- *Sustainable Energy Authority Victoria* [18]
- *Insulating steam distribution valves and flanges, CarbonTrust* [20]

3.0 ELECTRICITY USE

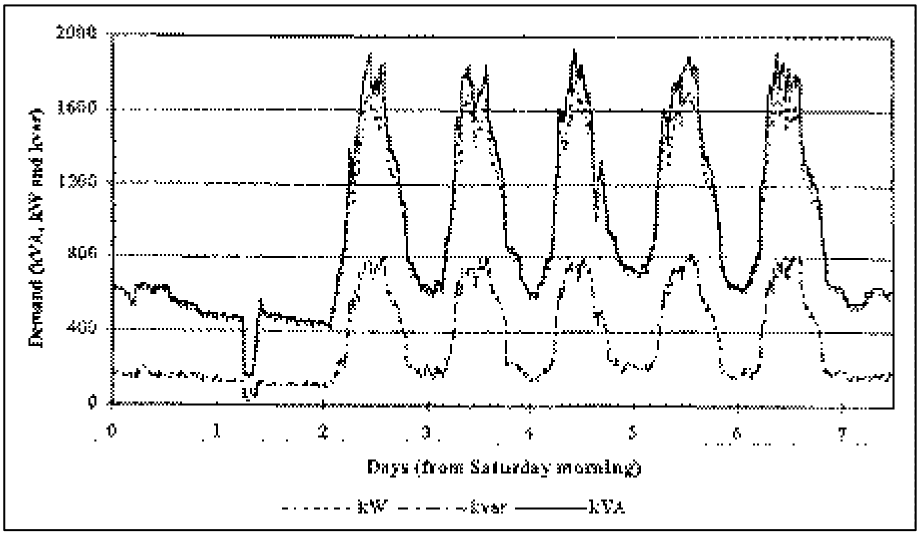
Electricity is consumed to provide power principally for refrigeration, process equipment and lighting. The following pie-chart provides an indicative consumption profile for a typical export meat processing plant with rendering facilities. Significant variation to this profile will occur with different refrigeration requirements (eg domestic operations handling carcases with no boning, absence of rendering, level of mechanisation, etc).



Source: Adapted from Reference 2

The level of electricity consumption will depend upon the factors outlined in section 1.0 Energy Overview.

A typical load curve for a five day single shift operation is shown in the following diagram. As the meat processing industry increases the implementation of extended and double shift operations, the electrical load factor significantly improves.



A series of general principles can be adopted to achieve best practice electricity consumption, regardless of the actual equipment installed and plant operating characteristics.

Electricity charges at consumption levels associated with meat processing almost always include demand and consumption charges. Successful electricity saving projects need to address the benefits of both demand impact and consumption reduction.

These principles include:

- Rescheduling processes to reduce demand coinciding with peak times
- Selecting appropriate evaporating temperatures and maintaining the lowest achievable condensing pressure
- Adopting good door management principles in cold rooms
- Ensure that all electrical equipment (eg lights, conveyors, heaters, etc) is switched off when not in use
- Ensure compressed air is only used when needed and that the system is in good condition with no leaks
- Ensure selection and maintenance of most energy efficient equipment.

The following sections address electrical energy consumption systems in more detail.

Refrigeration compressors are high energy consumers

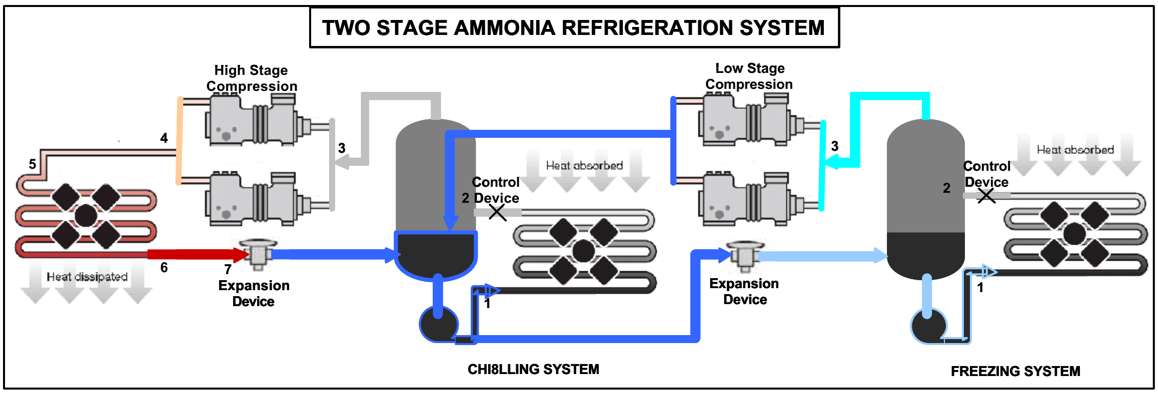
3.1 Refrigeration

Refrigeration accounts for between 60% & 70% of electrical use in meat processing operations. The energy efficiency of a meat processing refrigeration system can be influenced by:

- Reducing the refrigeration heat load
- Reducing the associated electrical use (eg fans, lights, etc), or
- Improving the refrigeration plant coefficient of performance

Best practice meat processing refrigeration systems aim to achieve effective and rapid carcase chilling and plant freezing is a two stage pumped refrigeration system (see following diagram and description). The pumped system (flooded evaporator) is preferred as control of the refrigerated space is improved, particularly under varying load conditions (eg early stage carcase chilling) and evaporator coil surfaces are kept continually wet. Both factors contribute to improved refrigeration efficiency.

Best Practice Meat Processing Refrigeration Cycle



Ammonia refrigerant systems are current best practice in meat processing operations. Typically the energy requirement for freezing in a two stage ammonia refrigeration system is in the order of half that required by alternative HFC refrigerants.

3.1.1 The Refrigeration Load

The cooling load on the refrigeration system determines the size of the refrigeration plant and therefore its power consumption.

The load is usually made up of a number of different components such as:

- Product load
- Heat gains through walls, floor and ceiling
- Heat gains from air changes through doors etc
- Heat from fan motors and lights in the refrigerated space
- Heat from pumps and other electrical devices in the refrigerated space
- Heat from people and handling equipment, such as fork-lift trucks, etc
- Defrosting.

Product load in active chilling and freezing facilities in meat plants is typically 80% of the total cooling load and can only be lowered by reducing production.

It is important to ensure that refrigeration compressors operate at better than 75% of full load. The product heat load varies significantly over time and it is desirable to have a range of compressors sizes installed and system controls that ensure compressors are adequately loaded.

Heat leakage occurs through ceilings, floors and walls and can be reduced by sound insulation design and installation. Insulation properties deteriorate with time and thermal imaging can be used to assess leakage and make repairs.

Air infiltration through doors leads to increased refrigeration load and condensation. A chiller door open to a slaughterfloor could increase the refrigeration load by 33kW. Doors must be easily opened and closed (preferable mechanically operated rapid door technology), and staff encouraged to implement good door management practices.

The fan load dominates electricity use within the active refrigerated space (ie chillers, freezers). Best practice control of refrigerated space involves implementation of refrigeration cycles to suit product requirements, including fan speed control. While high air velocity reduces refrigeration time, a doubling of air velocity requires an eight fold increase in fan power.

While lighting is a relatively small load in refrigerated spaces, energy savings can be made by good lighting design and management.

With implementation of correct temperature setting and controls, defrosting of chilling cycle evaporators is not required. It is important to control air ingress into frozen storage space as air moisture will form ice on the evaporator and freezer structure. Good door management and integrity of vapour seals reduces moisture ingress and therefore defrost requirements.

Internal heat sources impact twice, since heat generated from the evaporator fan motor and lighting must be removed from the cold store by the refrigeration system.

Plate freezer

The energy efficiency of a refrigeration system is expressed as the Coefficient of Performance (COP) and this should be monitored to determine any deterioration in performance. In a typical meat processing plant with both chilling and freezing duties, a good performance COP would be in the region of 2.5 kW refrigeration/kW compressor power.

Further discussion on COP and COSP is provided in Appendix 6. This Appendix also discusses other factors such as compressor selection and impact of refrigerant charge.

3.1.2 System Selection

Selection of the refrigeration systems can have a significant impact on electrical consumption.

Blast freezers require significant electricity to operate the fans installed in the refrigerated space, and the heat generated form these fans adds load to the refrigeration system. Best practice blast freezing involves a 48 hour freezing cycle for standard meat cartons (air speed approx 3m/s) as the energy requirement associated with fan speeds to achieve a 24 hour cycle (air speed approx 10m/s) is excessive.

Plate freezers do not require fans, as freezing is performed by conduction rather than convection. As a result, plate freezer systems have a significantly better COSP and consume less energy per tonne of meat frozen compared to blast freezers. Energy required to freeze product in a plate freezer can be 30% to 40% lower than that required in a blast freezer and freezing can be accomplished in a 24hour cycle.

Chiller design should be optimised to ensure even temperature and air flow throughout the chiller to provide good quality product with minimum shrink loss.

3.2 Drive Motors

There are a large number of motors installed in meat processing plants that drive process equipment, pumps, fans, conveyors, and hydraulic systems. The load characteristics of the motors vary from relatively constant load (eg conveyors and pumps) to significant shock loads (eg some size reduction equipment). Drive motors are invariably supplied with the equipment provided by the manufacturer. When retrofitting equipment or motors, best practice requires specification of duty and starting/control system. The AGO maintains a Motor Solutions Website to assist in the selection of motors.

Further Information

- *www.greenhouse.gov.au/motors*

The following provides a best practice checklist to assess on-site use of drive motors:

Reduce Motor Load

- Optimise the efficiency of the process that the motor is driving
- Ensure that transmission between motor and driven equipment is efficient
- Establish sound monitoring & maintenance programs
- Ensure the control system is effective.

Motor Losses

- Specify higher efficiency motors where feasible
- Avoid using oversized motors
- Check that voltage imbalance, low or high supply voltages, harmonic distortion or a poor power factor are not causing excessive losses.

Motor Speeds

- Due to the cube law applying to pump or fan applications, even a small reduction in speed can produce substantial energy savings
- Use variable speed drives (VSDs) where several discrete speeds or an infinite number of speeds are required. Although often the most expensive option, the many benefits and large energy savings from VSDs make them the usual choice for speed control
- Use multiple speed motors (MSMs) where two (and up to four) distinct duties exist
- Ensure the correct pulley ratio where belt drives are used.

Equipment Redundancy

- Check that changing requirements have not eliminated the need for the equipment altogether.

Switch Motors Off

- Time the switching according to a set program or schedule
- Monitor system conditions, and switch off the motor when it is not needed
- Sense the motor load so that the motor is switched off when idling.

3.3 Electricity – Other

3.3.1 Air Compressors

Compressed air in the meat industry is used by air driven hand tools, pneumatic actuation systems and material transport systems. The compressed air is generally required to be provided at around 700kpa (100psig). Single stage, reciprocating or screw compressors are most commonly used.

Examples of equipment types and free air usage are:

Device	Litre/second
Hide skinning knives	6-7.5
Fat & Bone trimmers	4
Circular breaking saw	13
Large reciprocating saw	25
Small reciprocating saw	13
Small scribing saws	8.5-10
	Litre/cycle
Beef hock cutter	0.5
Smallstock hock cutter	0.1
Smallstock brisket scissors	9

The greatest demand for compressed air in meat processing operations is that usually associated with pneumatic systems for material transfer. These are usually batch systems operated from a blow tank. A typical blow tank system will use in excess of 2.5m^3 of free air per blow cycle.

The following provide details of best practice associated with the operation of compressed air systems in the meat industry.

Air compressors

Compressor selection

- Select or operate compressors at 70 to 80% duty cycle

- Modern screw compressors can have inbuilt VSD's which allows them to efficiently operate over a wide load range.

Good housekeeping

- Turn off compressors during non-productive hours
- Review the air pressure required. If it can be reduced it will reduce consumption and leakage
- If some applications require higher pressures or have longer operating hours than the rest of the system, investigate installing a dedicated compressor
- Compressors operate more efficiently using cool air
- Control/sequence compressors to operate on a "demand-controlled" basis. Compressors use as much as 70% of on-load power when they are idling
- Carry out "out of hours" surveys, to listen for leaks, locate and eliminate
- Isolate redundant piping
- Install an air receiver with volume greater than 10 litres per compressor kilowatt.

Treatment

- Treat the bulk of the air to the minimum level possible, and improve the quality for specific appliances if required.

Use of Compressed Air

- Make sure that air tools are not left running when not in use
- Consider alternatives to compressed air hand tools. Where possible replace air motors with correctly specified electric motors
- Eliminate unregulated compressed air use endpoints (eg quarter-inch pipe instead of correct nozzles).

A detailed checklist is provided in Appendix 7.

3.3.2 Lighting

Lighting Design

- Lighting design must provide conditions for the users to carry out their tasks safely, comfortably and with high productivity. The lit appearance of the building interior is important for example the lumen requirements for inspection zones.
- Select the lamp for the application particularly with regard to its colour performance and its operating characteristics etc. Then select the lamp with the highest efficacy (lumen/Watt). Use the most energy efficient ballast units, with the required control e.g. dimming etc.

Lamp Type	Efficacy lumen/Watt
Incandescent – Tungsten Filament	8 – 12
Incandescent – Tungsten Halogen	12 – 24
Compact Fluorescent	50 – 85
Tubular Fluorescent	65 – 100
Low Pressure Sodium	100 – 190
High Pressure Sodium	65 – 140
High Pressure Metal Halide	70 – 100

Daylight

- The provision of daylight in a building can have important benefits on the productivity of the occupants. It can also have important benefits in saving energy used for lighting. This requires careful design, of the window system, as well as the lighting system. Examples include maximising the amount of daylight in stockyards, slaughter floors, skins sheds etc.

Lighting Controls

- Use occupancy controls to ensure that lights are not left on unnecessarily such as storeroom, meeting rooms, stair wells. This will make for an energy efficient lighting installation and save the user money.
- Good lighting controls, including switches and manual/fixed dimmers, operated either manually or automatically via light and occupancy sensors, provide important benefits in terms of energy efficiency. They must be user friendly and seen by the occupants as an important benefit and hardly noticeable in their operation. Examples include daylight sensors in the stockyards and outside areas.

Ventilation

Meat plants require ventilation for both non-refrigerated and refrigerated spaces.

In non-refrigerated spaces, comfort conditions for the employees provide the basis for the ventilation requirement. Ventilation fans fitted with VSD's improve control of comfort conditions and minimise energy use.

In refrigerated work-spaces, the ventilation requirement is set by the number of number of employees in the workspace. 5litre/sec of fresh air is required per person. Ventilation air volumes should be reviewed against employee numbers and checked to ensure that required levels are not significantly exceeded.

Aeration

Some meat plants are implementing forced aeration wastewater treatment systems in order to comply with increasingly stringent discharge requirements.

Due to the high biological oxygen demand of meat processing wastewater, the electricity consumption required to provide adequate aeration can be considerable and the system generally runs 24 hours a day seven days a week.

Even for aeration systems following anaerobic digestion, it is common to have in excess of 50kW of aeration installed. This is greatly increased in treatment systems such as Sequenced Batch Reactor and Activated Sludge.

Implementation of aeration control through measurement of dissolved oxygen levels and feedback control of the aerator can reduce the electricity required for aeration.

Switchboards

Thermal imaging of switchboards is becoming common practice in the industry.

The thermal imaging can display unnecessary energy use but is more important to detect poor connections and potential safety hazards.

3.4 Power Factor

Power factor is a measure of how effectively electrical power is being used by a system.

If the Power Factor of a system is low, it uses more power than it needs to do the work. This results in:

- excessive heat being generated
- extra maintenance costs
- the potential for fires in extreme situations

- low voltage conditions which result in sluggish motor operation and dim lights.

Optimise Power Factor

- The use of Power Factor correction equipment in the form of a capacitor bank should be installed as close as possible to the meter point or the equipment that is the main culprit
- A power factor of better than 0.96 is considered best practice for meat plants. Power factor correction systems can achieve power factors better than 0.99.

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NSW Department of Energy, Utilities and Sustainability and WA Sustainable Energy Office - The Energy Smart Toolbox provides information, knowledge and resources relating to energy efficiency and energy management.

http://www.caddet.org/links/index.php

This is a good general website that provides links an updates on energy efficiency and renewable energy technologies.

http://www.eere.energy.gov/femp/operations_maintenance/

US Federal Energy Management Program information with advice on operation and maintenance of energy using systems http://www.steamingahead.org/

Steaming Ahead provides advice and solutions to enhance steam systems

http://www.oit.doe.gov/bestpractices/

US Department of Energy – Advice from the US Energy Efficiency & Renewable Energy Best Practice Program

APPENDIX 1

Energetics EEI Opportunities

Energy efficiency improvement (EEI) opportunities in the meat industry identified by Energetics Pty Ltd, "Energy Efficiency Improvement Potential Case Studies – Industrial Sector" (Reference 1)

ELECTRICITY	RECOMMENDED ACTION	COMMENT ON DEGREE OF USE
All Electricity	High efficiency motors	Some as motors are replaced and upgraded
All Electricity	Energy monitoring and control	Increasing as part of supply arrangements
Packaging	Improve operating practices to balance demand & minimise energy waste (e.g. breaks, out of hours)	
Process Equipment (Rendering, Dressing, Boning, Pumps, etc)	Improve operating practices to balance demand & minimise energy waste (e.g. breaks, out of hours)	Increasing as extended and double shift operations are introduced
Process Equipment (Rendering. Dressing, Boning, Pumps, etc)	Variable speed drive control and automation of motors & pumps	Significant use of speed control in some areas
Refrigeration & Freezing	Control of refrigeration equipment in chillers, freezers & cold stores to minimise energy consumption	Majority have a degree of SCADA control implemented
Refrigeration & Freezing	Maintain chillers, freezers and cold storage fully sealed when not required	Mostly practiced
Refrigeration & Freezing	Automate temperature profile control and implement fan speed controls	Mostly practiced
Refrigeration & Freezing	Optimise condenser operation (e.g. pressure reduction using fan speed control, purging operation)	Majority have a degree of SCADA control implemented
Refrigeration & Freezing	Optimise ancillary equipment (e.g. Variable speed drives for cooling tower fans, cooling and chilled water, refrigerant pumps)	Majority have a degree of SCADA control implemented
Refrigeration & Freezing	Optimise compressor performance (e.g. Staging controls, Variable speed drive control, electronic expansion control)	Majority have a degree of SCADA control implemented
Refrigeration & Freezing	Optimise design of blast tunnel fans	Increasing use of plate freezers

		Blast freezers on 48hour cycles
Refrigeration & Freezing	Utilise high efficiency, multiple stage refrigeration plant	Two stage ammonia plant with liquid recycle fitted in most circumstances
Services (Lighting, A/C Boiler)	Implement best practice lighting technology & lighting controls (e.g. in vacant areas, offices, carcass stores)	Mostly implemented as lighting reviewed and upgraded to meet AQIS requirements
Services (Lighting, A/C Boiler)	Optimise heating, air conditioning controls and set points	Some plants have full supervisory control systems implemented

FUEL	RECOMMENDED ACTION	COMMENT ON DEGREE OF USE
All Fuel	Energy monitoring and control	Some implementation
Boiler Losses	Install oxygen trim control	Some implementation
Boiler Losses	Automate blowdown on Total Dissolved Solids and recover heat to boiler feedwater tank	Some implementation
Boiler Losses	Install economiser on boiler flue gas	Limited installations
Boiler Losses	Upgrade to a high efficiency modulating burner with low turn down ratio	Some implementation
Hot Water	Reduce hot water usage using efficient nozzles, trigger action valves, etc	Mostly practiced
Hot Water	Maintain hot tank and line insulation, repair leaks	Mostly practiced
Hot Water	Recovery heat from refrigeration superheat to pre heat hot water	Limited
Process Equipment (Rendering, Singeing, Scalding, etc)	Optimise loading of render plant & balance with hot water heating demand to even steam demand	Mostly practiced
Process Equipment (Rendering, Singeing, Scalding, etc)	Cover surface, insulate and recover heat from all hot water tanks and vessels	Mostly practiced
Process Equipment (Rendering, Singeing, Scalding, etc)	Heat recovery from rendering plant exhaust streams	Almost always practiced
Steam System Losses	Maintain steam traps, optimise condensate return, insulate all valves, flanges, lines, remove dead legs, & repair leaks	Mostly practiced

APPENDIX 2

Legislation

LEGISLATION	OBJECT OF THE LEGISLATION
National Environment Protection Measures (Implementation) Act 1998	The objects of the Act are: • to make provision for the implementation of national environment protection measures in respect of certain activities carried on by or on behalf of the Commonwealth and Commonwealth authorities • to protect, restore and enhance the quality of the environment in Australia, having regard to the need to maintain ecologically sustainable development • to ensure that the community has access to relevant and meaningful information about pollution.
National Strategy for Ecologically Sustainable Development	The core objectives of the NSESD strategy are: • to enhance individual and community well-being and welfare by following a path of economic development that safeguards the welfare of future generations • to provide for equity within and between generations • to protect biological diversity and maintain essential ecological processes and life-support systems. The Guiding Principles are: • decision making processes should effectively integrate both long and short-term economic, environmental, social and equity considerations • where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation • the global dimension of environmental impacts of actions and policies should be recognised and considered • the need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection should be recognised • the need to maintain and enhance international competitiveness in an environmentally sound manner should be recognized • cost effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms • decisions and actions should provide for broad community involvement on issues which affect them,

National Greenhouse Strategy	The goals of the NGS are: • To limit net greenhouse gas emissions, in particular, to meet our international commitments • To foster knowledge and understanding of greenhouse issues • To lay the foundations for adaptation to climate change.
Greenhouse Challenge Plus	Greenhouse Challenge Plus is designed to • Reduce greenhouse gas emissions • Accelerate the uptake of energy efficiency • Integrate greenhouse issues into business decision-making • Provide more consistent reporting of greenhouse gas emissions levels. All existing members of Greenhouse Challenge, Greenhouse Friendly and Generator Efficiency Standards become members of Greenhouse Challenge Plus on 1 July 2005. For the majority of participants, the decision to join Greenhouse Challenge Plus is voluntary. However from 1 July 2006, participation in Greenhouse Challenge Plus will be a requirement for Australian companies receiving fuel excise credits of more than $3 million. Proponents of large energy resource development projects will also be required to participate in the programme. More information on the mandatory elements of Greenhouse Challenge Plus will be available in 2005
Relevant legislation, policies and programs in the states and territories	Legislation affecting land use and development is the responsibility of the States and Territories and concentrates on processes affecting the consideration of applications for the use or development of land, such as zoning or permit issuing procedures. Legislation in a number of jurisdictions specifies environmental objectives however only limited planning legislation specifically requires the consideration of greenhouse emissions in making planning decisions. In **VICTORIA** in addition to management of various air pollutants SEPP includes a Protocol for the Environmental Management of greenhouse gas (GHG) emissions and energy consumption (PEM 824). EPA Licence holders (scheduled premises) must complete a number of key steps including: • Undertake an Energy Audit including a profile of baseline energy consumption • Prepare a greenhouse emissions inventory • Formulate an emission reduction / improvement plan with quantified savings The policy aims to ensure businesses take up cost effective opportunities for Greenhouse Gas mitigation and integrate GHG and energy issues with existing environmental management procedures and programs. It is likely in future years that other states will adopt similar requirements.

APPENDIX 3

Boiler Efficiency Checklist

Factors affecting boiler efficiency best practice include:

Load Scheduling

- Maintain load requirements that are steady, consistent and continuous
- Minimise periods of no load or low load, and short-term load swings
- Schedule the boilers to match the steam demand
- Eliminate, where possible, the use of boilers on hot standby at full pressure
- Set boiler sequencing controls (when installed in a multi-boiler plant) to adjust the number of boilers and firing rate to suit the load pattern.

Heat Transfer Surfaces

- Maintain clean gas and water side heat transfer surfaces. Cleaning is required if the flue gas temperature increases by 20–40ºC compared with the clean boiler condition.

Radiation Losses

- Maintain boiler insulation in good condition
- Ensure all pipe-work, valves, flanges and fittings in the boiler-house are insulated and replaced after maintenance work.

Boiler Operation

- Maintain all boiler kit in good condition
- Provide superior controls & regular burner servicing to improved fuel to air ratios.

Scaling

- Provide proper feed-water treatment and regular cleaning of the water side of boiler tubes to ensure that any precipitated salts do not adhere to heat transfer surfaces.

Corrosion

- Control pH levels in the boiler to give an alkaline environment in a safe range (pH 8.2–12.5)
- Limit the oxygen concentration in boiler water
- Add neutralising or filming amines to control corrosion in condensate systems when required.

Boiler Water Treatment & Conditioning

- Reducing feed-water TDS reduces blow-down and saves energy
- Maximising condensate return
- Provision of sound chemical control will save money and protect assets.

Blow-down

- Automate blow-down
- Minimise blow-down
- Control TDS limits to minimize boiler blow-down
- Maximise the amount of condensate returned.

Heat Recovery

- Implement blow-down heat recovery.

Burner Management

- Check combustion conditions (flue gas temperatures, flue gas constituents, flame shape, fuel and air trim settings) as a matter of routine
- Minimise flue gas oxygen levels without producing smoke or excessive levels of unburnt carbon.

Variable Speed Drives

- Variable speed drives help to reduce electrical power consumption significantly at low speed operation, reduce average noise levels, provide more flexible control, and improve combustion control on boilers.

APPENDIX 4

Insulation Guidelines

Insulation will reduce heat losses and the following checklist provides best practice guidelines.

General Principles

- Hot surfaces above 60°C and most of those above 50°C should be insulated. The insulation of many surfaces below 50°C will often also be justified, particularly from a cost saving point of view. Surfaces include valves and flanges, in addition to pipes and other plant
- Pipes carrying chilled water and other refrigeration services should be insulated to prevent condensation and heat gain
- Incorrect application can reduce the effectiveness of the insulation.
- It is important when installing insulation to ensure that:
    - the insulation will not suffer subsequent damage due to impact, weather or wear. The ability of the insulation type to withstand the conditions in which it will be placed must be considered
    - removable insulation jackets are used where necessary to give convenient access
    - there are no open joints in the insulation; overlapping of two layer insulation should be carried out if necessary
    - heat losses by conduction to supports are eliminated as far as possible. The use of insulated pipe supports should be considered
    - proper on-site supervision is provided; for example, by using specialised insulation contractors. Insulation is often not as efficient as it could be because it has been applied under poor conditions. If insulation is stored prior to application, care must be taken to avoid physical or weather damage
    - as much work as possible is done off site prior to delivery so that installation times can be minimised and the risks involved can be reduced.

Pipes

- Pipe insulation is the most common form of insulation used in industry
- Flanges and valves need to be insulated. Preformed, easily removable insulation sections tailored to these items of pipe-work fittings are available. Ideally the thicknesses of insulation on flanges and valves should be the same as that on the adjoining pipe; this may be impractical due to space and other limitations
- As an indication of the scale of heat loss from flanges and valves, an un-insulated valve would lose heat equivalent to a 1 m length of un-insulated pipe, and an un-insulated flange will lose half this value

- Pipes also lose heat through their supports, and these should be insulated
- Good insulation can be ruined by the ingress of water or chemicals.

Vessels and large curved surfaces

- When insulating vessels, the need to dismantle associated pipe-work and remove inspection covers should be anticipated. Permanent insulation should end sufficiently far away from flanges and fittings to enable bolts to be withdrawn, with removable sections used to complete the insulating layer. For external applications or where fluid spillages can occur, the permanent insulation should have a suitable finish to prevent fluid ingress when removable sections are not in place
- Special consideration should be given to the support of insulation for vessels and columns subject to wind loads
- Where a vessel containing a hot liquid has an open top, additional heat loss can occur by evaporation. This loss can be minimised by adding a blanket of commercially available floating plastic balls to the surface of the liquid. A single layer of balls which covers 91% of the surface of the liquid would reduce the energy input required to maintain the tank liquid at 90°C by 70%.

Hot gas ducts and flues eg boiler stack, cooker stacks etc

- The insulation of hot gas ducts and flues should be carried out for two main reasons:
    - for safety, because of the high external temperatures
    - to prevent internal condensation, normally caused when internal surfaces fall to a temperature below the dewpoint of the gases being conveyed. Condensation can lead to corrosion, particularly in the exhaust ducts of oil-fired boiler plant where the flue gases are acidic. It is important to ensure that there is no ‘bridging’ in the insulation, which could result in local cold spots. Care should also be taken at access points for temperature and sampling probes and any expansion joints should be adequately insulated to prevent corrosion.

Furnaces and kilns

- Whichever method of insulation is used, heat losses affected by insulation are:
    - the loss through the furnace walls due to conduction, convection and radiation
    - the loss due to the thermal mass of the furnace.
- These losses can be minimised by proper insulation
- In continuously operated furnaces, the heat loss through the walls at full working temperature is much greater than the energy required to heat up the mass of the furnace. Thus in continuously operated furnaces insulation is required to prevent heat loss through the walls and roof
- The insulation of furnaces requires careful consideration of the changes in temperature that may occur during operations.

Boiler plant

- The insulation of boiler plant is normally carried out adequately by the boiler manufacturer, either at the manufacturer's works or during installation on site. The insulation will generally take two forms:
    - mineral fibre slabs fixed to the outer surface of the boiler shell, with an appropriate finish, to inhibit heat losses from the working medium of steam, water or thermal fluid. Damaged mineral insulation should be replaced when necessary, together with the finish, to ensure continued efficient insulation
    - other insulation applied to air-exposed surfaces containing hot gases. For example, combustion chambers and flues.

Safety aspects

- There are many safety factors which must be considered when applying thermal insulation. In all cases where operator/fire safety has to be taken into account, reference should be made to the appropriate health and safety legislation, and to the instructions of the insulation manufacturers
- Where it is not possible to protect surfaces from direct contact, effective guards should be installed, such as wire mesh screens.

Design aspects

- Build adequate insulation into plant at the design stage; retrofitted insulation is often less efficient due to space restrictions, lack of support for the insulation, etc
- It is essential that thermal insulation for plant and equipment is considered early in the design stage, such that an insulation contractor can submit a suitable system that can be incorporated by the plant designer. In retrofit situations, insulation has to be built around the existing plant design and the best solution may not be feasible
- Items that should be considered during design include allowing sufficient clearance around pipes and equipment to fit adequate insulation, and allowing for the additional weight of the finished insulation system
- The technical suitability of an insulation system is of primary importance, although availability, service and cost should also be taken into account.

APPENDIX 5

Steam Reticulation Checklist

The following is a checklist of factors that will allow improved management of steam reticulation

Metering

- Meter the steam used by each department
- Regularly check the amount of steam used by each department.

Operation

- Minimise leaking joints and glands, or leaking valves and safety valves
- Insulate all steam pipes, flanges and valves
- Blank off or remove redundant steam piping
- If practicable pre-heat material with waste heat before processing
- Insulate bare process plant surfaces
- Load the process plant as much as possible and minimise the hot idle time
- Maximise air recirculated in steam heated hot air dryers and avoid excess cold air infiltration
- Ensure process temperatures are well controlled
- Ensure process steam pressures are no higher than they need to be
- Use steam pressures as low as possible when using direct steam injection
- Keep steam supplied to process plant as dry as possible
- If peak loads are inevitable ensure the boiler house is given adequate warning
- If possible stagger peak processes to even out steam demand.

Steam Traps

- Ensure the correct type of steam trap used for each application and that it is correctly installed and regularly maintained
- Protect each trap with a strainer followed by a sight glass
- Fit check valves after the traps when necessary, especially if the condensate is lifted directly to an overhead return
- Only fit by-passes around steam traps when essential and ensure they are correctly used
- Properly vent each steam space for maximum output and even heating
- Where possible improve condensate recovery gravity drainage to a receiver from which a pump can lift the condensate

- Minimise waste flash steam. Use flash steam heat be in low pressure plant, for pre-heating cold material, for heating water or return to the boiler feed tank
- Minimise condensate waste
- Insulate condensate return systems and feed tanks
- Maintain steam traps regularly.

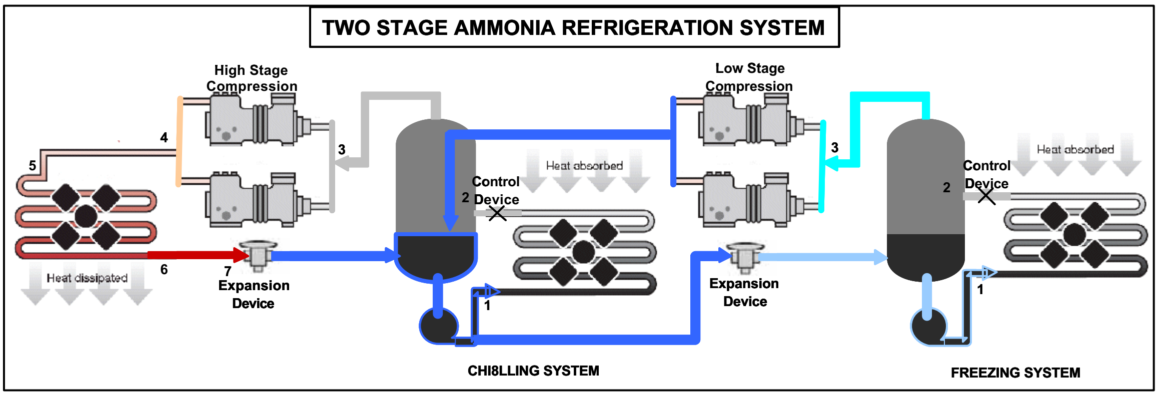
Heat Recovery

- Recover heat from boiler blow-down, hot liquors and contaminated condensate.

Design

- Ensure steam mains are properly sized, properly laid out, properly drained and properly vented
- Allow for expansion
- Install separators be improve steam quality.

APPENDIX 6
Refrigeration



Best Practice Meat Processing Refrigeration Cycle

1 ➔ 2	Intermediate pressure (chilling duty) and low pressure (freezing duty) ammonia (1) in the evaporator absorbs heat energy and changes from a saturated liquid to a saturated vapour. The cooling effect of the evaporator is governed by the difference in temperature between the medium being cooled and the evaporating refrigerant. In chilling duties the evaporator should be designed to minimise chiller shrink loss and improve refrigeration efficiency.
2 ➔ 3	The refrigerant vapour picks up more heat energy between the evaporator and the compressor. This is bad for efficiency and is minimised by insulation.
3 ➔ 4	The superheated vapour enters the compressor where its pressure is raised. There will be a large increase in temperature, because energy of compression is transferred into the refrigerant as heat, thus raising its temperature (superheat). Compressors are the main power users in refrigeration systems. Compressor energy consumption is affected by: • The compressor displacement (m^3/sec) • The difference between the evaporating and condensing temperature – also known as the temperature lift • The temperature of the superheated suction vapour.
4 ➔ 5	The very hot vapour loses a small amount of heat to ambient air in the pipe-work between the compressor and condenser. This is good for efficiency.
5 ➔ 6	The high pressure superheated vapour flows into the condenser. The condenser efficiency is affected by the temperature of the cooling air or water and the size and design of the condenser.

6 ➔ 7	A further reduction in temperature may occur between the condenser and the expansion device. This is good for efficiency.
7 ➔ 1	The high pressure sub-cooled liquid passes through the expansion device. There is no energy loss or gain through the expansion device.

COP and COSP

The energy efficiency of a refrigeration system is expressed as the Coefficient of System Performance (COSP).

$$COSP = \frac{CAPACITY(KW)}{POWER(KW)}$$

The power input is that of the compressor and all other motors (e.g. fan motors and pumps and controls) associated with the system.

Efficiency can also be expressed as COP – this is just the efficiency of the compressor, it does not take into account the power input of other electrical components such as fan motors and pumps.

The COP varies depending on the temperature lift of the system – the temperature lift is the difference between the evaporating and condensing temperatures. The capacity of the compressor increases when the temperature lift reduces;

- the compressor power input decreases when the condensing temperature is lowered
- the compressor power input increases when the evaporating temperature is increased, but the increase in power input is not as great as the increase in capacity (hence the COP still goes up).

The temperature lift reduces if:

- the condensing temperature is lowered; and/or
- the evaporating temperature is raised.

An increase of 1°C in evaporating temperature or a reduction of 1°C in condensing temperature will increase the compressor COP by 2 – 4%. Or put another way: A decrease of 1°C in temperature lift will cut running costs by 2 – 4%.

The condensing temperature will be lower if:

- A condenser with a high basic rating is used (this is usually a larger condenser)
- The condensing temperature is allowed to float down with the ambient temperature. The average ambient temperature in the UK is about 10°C – taking advantage of this rather than holding the condensing temperature artificially high saves a significant amount of energy – probably in excess of 25% for many systems
- Water is used instead of air as the condenser cooling medium (include the fan motors and pumps associated with water-cooled condensers and cooling towers in COSP calculation)
- It is also important that condensers do not become blocked, or their flow of cooling air or water becomes impeded in any other way.

The evaporating temperature will be increased if:

- An evaporator with a higher basic rating is used (this is usually a larger evaporator)
- The evaporator is defrosted when necessary. When the evaporating temperature of an evaporator cooling air is below 0°C, ice will build up on the coil block. This must be regularly removed through an effective defrost procedure. It is also important to ensure the evaporator is clean.

Other Factors

Compressor efficiency

- The efficiency of different compressor types and manufacturers varies, and not necessarily according to price – it is important that the most efficient compressor for a particular application is carefully selected. This depends on the size of the cooling load, the refrigerant used, the temperature of the application and the average temperature of the cooling medium (i.e. ambient air or water).

Refrigerant charge

- The amount of refrigerant has a significant effect on temperature lift – too much or too little refrigerant charge reduces efficiency. Systems that leak refrigerant consume more power than necessary.
- Systems that are overcharged can, in certain cases, also consume more power than necessary and have more refrigerant to lose in the case of a leak.

Refrigerant Type

- The refrigerant type also has an effect on energy use. The variation can be as high as 10%, but this benefit can only usually be achieved when the hardware is optimised to suit the refrigerant chosen. The most efficient refrigerant for an application depends on the compressor used, the temperature of the application and the average temperature of the cooling medium (i.e. ambient air or water). For meat industry operations ammonia is the refrigerant of choice.

Superheat

- The superheat of the suction vapour should be as low as possible – warmer vapour reduces the capacity of the compressor without reducing its power input. On direct expansion systems, this is achieved by correctly controlling the expansion device, and on all system types, by insulating the suction line.

Liquid Sub-cooling

- The amount of sub-cooling of the liquid refrigerant entering the expansion device should be as high as possible – this increases the capacity of the system without increasing power input.

APPENDIX 7

Compressed Air Checklist

The following provides a checklist for compressed air energy efficiency:

Good housekeeping

- Turn off compressors during non-productive hours
- Review the air pressure required. Maintain main compressor discharge pressure under 770kpa (110 psig). If it can be reduced it will reduce consumption and leakage
- If some applications require higher pressures or have longer operating hours than the rest of the system, investigate installing a dedicated compressor
- Compressors operate more efficiently using cool air
- Control/sequence compressors to operate on a “demand-controlled” basis. Compressors use as much as 70% of on-load power when they are idling
- Reduce instances of multiple compressors operating at part load simultaneously
- Minimise compressor operating unloaded for extended periods of time
- Initiate an effective system for reporting leaks. Carry out an “out of hours” survey, to listen for leaks, locate them and tag
- Make sure all redundant piping is isolated
- Check that the condensate collection system is working correctly, and that there is no constant bleed of air. Fit electronically operated condensate traps, which are more reliable
- Install an air receiver with volume greater than 10 litres per compressor kilowatt.

Treatment

- Treat the bulk of the air to the minimum level possible, then improving the quality for specific appliances
- Check the pressure drop across the pre- and after-filters. If it is above 0.4 bars the filter may need replacing
- Measure the dryer inlet temperature. This should not exceed 35°C with the compressors on full load.

Use of Compressed Air

- Over 90% of energy used by a compressor is turned into heat, so consider whether a heat recovery system can be fitted to the compressor(s) and use this heat elsewhere

- Use of higher efficiency nozzles (which entrain free air) can maintain performance, yet reduce the distribution pressure and hence energy consumption
- Make sure that air tools are not left running when not in use
- Check that compressed air is not used for ventilation or cleaning purposes, such as blowing off swarf
- Consider alternatives to compressed air hand tools. Where possible replace air motors with correctly specified electric motors
- When purchasing a new compressor, take into account its energy efficiency, since electricity will be the major running cost
- Eliminate unregulated compressed air use endpoints (eg quarter-inch pipe instead of correct nozzles).

Calculating Compressed Air Leakage

The best way to establish the amount of leakage in a system is by measurement. In the absence of suitable measuring devices, a no-load test should be carried out to establish the percentage leakage from the system. Two possible methods are as follows.

a. For compressors in on/off mode

This applies to compressors that are operated in an on/off load, i.e. when the compressor is on-load it produces a known amount of air.

- Close down all the air-operated equipment
- Start the compressor and operate it to full line pressure, when it will off-load. Air leaks will cause the pressure to fall and the compressor will come on-load again
- Over a number of cycles, make a note of the average on-load time (T) and average off-load time (t)
- Total leakage can then be calculated as follows:

$$\text{Leakage (litres/second)} = \frac{Q \times T}{T + t}$$

where Q = air capacity of the compressor (litres/second), T is the average on-load time (s) and t is the average off-load time (s).

b. For modulating compressors

This test is more difficult, as the compressor output is unknown. The following method can be used if you have a pressure gauge downstream of the receiver.

- Calculate the system volume of air (V) in litres. This can be estimated as the volume of air mains downstream of the receiver isolating valve, including all the pipe-work (25 mm and above) and the receivers

- Pump up the system to operating pressure (P1) and then close the isolating valve
- Record the time (T) for pressure to drop to P2
- Leakage can then be calculated as follows:

$$\text{Leakage (litres/second)} = \frac{V \times (P1 - P2)}{T}$$

where V is in litres, P1 and P2 are in bar$_g$, and T is in seconds.

Wastewater

TABLE OF CONTENTS

Abbreviations and Acronyms

AMT	Australian Meat Technologies
ANZECC	Australian and New Zealand Environment and Conservation Council
AQIS	Australian Quarantine & Inspection Services
BNR	Biological Nutrient Removal
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
d	day
DAF DO EPA	Dissolved Air Flotation Dissolved Oxygen Environment Protection Authority
h	Hour
HRT	Hydraulic Retention Time
HSCW	Hot Standard Carcase Weight *
IAF	Induced Air Floatation
kL	kilolitres
KPI	Key Performance Indicator
LTR	Low Temperature Rendering
mg/L	milligrams per litre
ML	Megalitre
NGR	No Guideline Recommended
NS	Not stated
O&G	Oil and Grease
pa	per annum
SBR	Sequencing Batch Reactor
TSS	Total Suspended Solids
t	tonne
TDS	Total Dissolved Solids
TN	Total Nitrogen
TP TSS	Total Phosphorus Total Suspended Solids
UF	Ultrafiltration
WWTP	Waste Water Treatment Plant

*HSCW = weight of animal - (head + feet + blood + hide + viscera)

Environmental Objectives

- Operate a sustainable, robust and efficient wastewater treatment system.
- Consistently achieve effluent disposal regulatory compliance.

Possible Environmental Impacts

- “Receiving water” impact as a result from effluent disposal, if discharged to a river.
- Soil impact as a result from effluent disposal via land irrigation.
- Odour emissions from wastewater treatment operations.
- Greenhouse gases resulting from biological pond emissions and energy usage for wastewater treatment plant operation.

Key Performance Indicators

	Benchmark		
	Large	**Small**	
Water Usage	10.6	<5	kL/tHSCW
Wastewater Generation	10	3-4	kL/tHSCW
Wastewater Loads			
➢ Phosphorus	➢ 0.34 kgP/tHSCW		
➢ Nitrogen	➢ 2.0 kgN/tHSCW		

- **Large** relates to medium to large integrated export abattoir facilities, processing > 100 t HSCW/day.
- **Small** relates to domestic abattoir facilities processing <50 t HSCW/day.

Further Information

Industry Environmental Performance Review[1]

Current Legislation and Regulation

Commonwealth http://www.ea.gov.au/	• Environment Protection and Biodiversity Conservation Act 1999 • National Environment Protection Council Act 1994
Queensland www.env.qld.gov.au	• Environmental Protection (Water) Policy 1997 • Environmental Protection (Waste Management) Policy 2000 • Water Act 2000 • Water Resources Act 1989 • Integrated Planning Act (1997) • Environmental Protection Act 1994 • Environmental Protection (Waste) Policy and Regulation 2000
New South Wales www.epa.nsw.gov.au	• Local Government Act 1993 • Protection of the Environment Operations Act 1997
Australian Capital Territory www.environment.act.gov.au	• Environment Protection Act 1997 • Environment Protection Regulations 1997
Victoria www.epa.vic.gov.au	• Environment Protection Act 1970 • Melbourne and Metropolitan Board of Works Act 1958 • Planning and Environment Act 1987 • Water Act 1989
South Australia www.environment.sa.gov.au/epa/	• Environment Protection Act 1993 • Development Act 1993 • Sewerage Act 1929 • Water Resources Act 1997
Western Australia www.environ.wa.gov.au	• Environmental Protection Act 1986 • Metropolitan Water Supply, Sewerage and Drainage Act 1909 • Waterways Conservation Act 1976 • Rights in Water and Irrigation Act 1914
Northern Territory http://notes.nt.gov.au/dcm/legislat.nsf	• Waste Management and Pollution Control Act 1998 • Environmental Assessment Act 1994 • Water Act 1992 • Water Supply and Sewerage Services Act 2000
Tasmania www.thelaw.tas.gov.au	• Water Management Act 1999 • Draft Wastewater Management Guidelines for Meat Premises • Environmental Code of Practice for Meat Premises (Slaughtering) 1995 • Environmental Management & Pollution Control Act 1994

Note: The above information is current at the time of publication. It is essential to establish if any subsequent changes or updates have been made.

Environmental Best Practice Overview

Knowledge of Wastewater	**Wastewater Treatment Operation**
◗ Understand water usage and wastewater sources at the meat processing facility. ◗ Appropriate monitoring of water usage and wastewater treatment operations.	◗ Management support. ◗ Appropriate allocation of resources to operate and maintain systems adequately. ◗ Contingency planning. ◗ Monitoring and reporting.
Wastewater Treatment Design	**Compliance**
◗ Appropriately designed wastewater treatment system for: – Receiving environment (i.e. sewer, irrigation, waterway) – Scale and seasonality - operating demands and requirements – Climate and location (i.e. cold/wet, nearby neighbours) – Mixture of plant processes, particularly rendering.	◗ Ensure treated effluent is within regulatory requirements.

Aerial aspect of a Wastewater Treatment Plant

Best Practice Information

The meat industry has to deal with a number of environmental challenges. This includes responsible wastewater treatment and disposal to prevent land and water pollution. A well-designed and managed wastewater treatment system is essential to achieve regulatory requirements and help protect and maintain a sustainable environment.

By focusing on reducing water usage, optimising wastewater treatment and improved waste management, both disposal and treatment costs can be reduced.

The primary aim of this guide is to help achieve environmental best practice guidelines for wastewater treatment in the Australian red meat processing industry and consistently meet the required regulatory standards.

Further Information

- *Eco-efficiency Manual for Meat Processing* [2]
- *Best Practice Wastewater Treatment RPDA*[3]

Best practice wastewater treatment involves:

- Minimising wastewater generation
- Treating wastewater to a standard required for the disposal route chosen
- Monitoring and reporting the treatment system performance
- Increasing recycling and/or reuse to reduce the need for water usage and hence wastewater treatment where regulations and licences permit; and
- Continuous improvement and refinement.

1.0 WATER USAGE

Abattoirs are large users of town water or bore water. Reduction in water usage would have a direct impact on reduced wastewater volumes hence making wastewater treatment and disposal easier and cheaper. Water usage, measured in industry in 2003, currently ranges from 4-18 kL/tHSCW[1] depending on size, product market and export requirements.

Table 1 shows the breakdown (%) of water used in various areas of an abattoir.

Table 1 Water Consumption in an Abattoir

Major Areas of Water Consumption	Percent of Total Fresh Water Consumption
Stockyard (mostly washdown)	7 - 24%
Slaughter, evisceration	44 – 60%
Boning	5 - 10%
Inedible & edible offal processing	7 – 38%
Casings processing	9 – 20%
Rendering	2 – 8%
Chillers	2%
Boiler losses	1 – 4%
Amenities	2 – 5%

The slaughter and evisceration areas are the largest water users and responsible for the majority of cleaning and equipment sterilisation.

The values in Table 1 include water used for daily cleaning and hose-down. Export abattoirs typically use 21-36% of total water use for these purposes. They are required to install a greater number of sterilisers to comply with the high sanitary standards for export.

Food safety regulations stipulate high temperature requirements in certain areas thus 30-40% of water used is either warm (43°C) or hot (82°C).

Further Information

- *For more details on water usage areas refer to Appendix A*
- *Industry Environmental Performance Review*[1]
- *Eco-Efficiency Manual for Meat Processing* [2]
- *Identification of Nutrient Sources, Reduction Opportunities and Treatment Options for Australian Abattoirs and Rendering Plants* [4]

2.0 WASTEWATER CONSITUENTS

Inevitably some blood, fat, manure, meat, paunch and detergents enter the wastewater streams. These wastes contribute to the key constituents, which are described below:

- **Organics** comprising BOD, COD, TSS, oil and grease - are generally biodegradable. If the wastewater is not managed well its degradation by bacteria can cause odours.

- **Nitrogen** (in organic, ammonia and oxidised forms) and **Phosphorous** (typically in the form of organic P or phosphate) are essential nutrients for living organisms. Abattoir effluent contains high levels of both. The degree of treatment required depends on the final disposal route. River disposal requires almost complete removal of both. However only partial reductions in nutrients may be required for land irrigation since they are beneficial for crop growth in sustainable loads.

- **Salt** in effluent comes from animals, water supply and chemical use. Despite high electrical conductivity, only small concentrations of sodium and chloride are normally present, and these are often due to the source water. Care is needed to ensure adequate irrigation areas to achieve long-term environmental sustainability.

- **Micro-organisms** A wide variety of microorganisms are present in untreated abattoir wastewater, including potentially pathogenic microorganisms from animal manure and paunch contents. Many are harmless and assist wastewater treatment.

- **Chemicals** Mainly result from the extensive cleaning and disinfection of the plant on a daily basis. However concentrations are generally low, and do not harm wastewater treatment processes.

- **pH** is typically neutral and **temperatures** can vary from cool to hot in some parts of Australia. High temperatures (greater than 38°C) can enable fats to liquefy and pass through rather than being removed by primary treatment.

- **Toxic compounds and heavy metals** Meat processing wastewater contains negligible amounts of either of these pollutants.

Owing to its composition, abattoir wastewater is very amenable to biological treatment.

Further Information

- *Nitrogen Management Strategy* [11]
- *Identification of Nutrient Sources* [4]
- *Eco-Efficiency Manual* [2]

3.0 WASTEWATER GENERATION AREAS

Generation of wastewater occurs in four main areas, summarised in Table 2. The key aspects of wastewater for treatment are “volume” and “strength”. Volume (kL/day) affects the hydraulic loading and hence efficiency of the wastewater treatment system. Strength (concentration of constituents in the water, mg/L) can impact receiving disposal routes, and hence it’s important to minimise pollutants entering the wastewater streams.

Table 2 Main Wastewater Generation Areas

Facility Area	Flow Volume	Strength
Stockyard	Medium	High
Slaughter / Evisceration	High	Low
Inedible & edible offal processing	Medium	High
Rendering	Low	Very High

Note: The terms low, medium and high are relative, and used in the context of abattoir wastewater streams.

3.1 Manure & Paunch

About 50% of the total phosphorus and sodium contaminants are generated from manure and paunch wastes, which come from stockyard washing, emptying of the animal stomachs and further processing of internal organs. Wastewater from these processes is often combined and referred to as the ‘green‘ stream, and is primary treated separately from the ‘red’ stream. Paunch can be wet or dry dumped and combined with other wastes for composting.

3.2 Slaughter / Evisceration Areas

This “red” waste stream is generated mainly from water used to guarantee modern hygienic practice in the facility, and which becomes contaminated with blood and fats. Blood is the main source of nitrogen followed by urine and proteins from meat scraps. Blood recovery should be maximised and water entering blood containment areas should be avoided.

3.3 Rendering Plants

Rendering, often called the ‘by-products department’, and incorporating blood processing, is responsible for about 60% of COD and 20–40% of the sodium, phosphorus and nitrogen liberated to the wastewater. The major sources of nitrogen, phosphorus and sodium include the raw materials bin drainage and blood processing, whereas COD is primarily sourced from tallow refining. Smaller facilities may not operate a rendering plant. Waste streams from these operations may also be included in “red” streams.

Small amounts of wastewater are generated in other parts of the plant.

Further Information

Details on various areas in a processing plant generating wastewater:

- *Environmental Best Practice Guideline – Introduction to the Red Meat Processing Industry Module*

3.4 Waste Minimisation Strategies

- Minimising waste into the water stream will reduce the wastewater load to the treatment system. This source reduction will have a direct impact on the costs associated with water usage (i.e. treatment and disposal costs).
- It is very important that stormwater be segregated from wastewater streams to the maximum extent possible in order to reduce volumes.
- Appendix A describes waste minimisation strategies for the various wastewater generation areas. Several recent documents assisting in this regard are given in the information box.

Further Information

For more information on how to reduce water usage and waste minimisation strategies known as "Cleaner Production" refer to:

- *Eco-Efficiency Manual for Meat Processing* [2]
- *Water and Waste Minimisation* [5]
- *Nitrogen Management Strategy* [11]
- *EU IPPC BAT Document* [12]

4.0 WASTEWATER DISPOSAL ROUTES

The key disposal routes for treated wastewater (ie effluent) from abattoir operations in Australia include:

1. Sewer
2. Land Irrigation
3. Surface Waters (i.e. rivers, waterways, seaway).

The choice of disposal depends on the location and surrounding environment. An abattoir with nearby residents, no local waterway, inadequate irrigation area and generally wet weather may be restricted to sewer disposal only. Trade waste discharge criteria would need to be met and disposal costs likely incurred, set out by the local authority responsible for managing the sewerage system.

However an abattoir located in a rural area will often dispose via land irrigation and / or to a nearby river. In some instances effluent discharge to rivers continues but is less common due to the high treatment costs associated with the stringent required discharge standard.

Reuse of treated effluent within meat processing plants is typically prohibited for food safety reasons (see Section 5.4.2).

4.1 Effluent Disposal Criteria

Effluent disposal objectives depend on the disposal route and the surrounding environment.

For each disposal route, the effluent must meet the required regulatory disposal standard. These may vary from state to state and are dependant on local and state legislations. The correct effluent disposal criteria should be obtained from the relevant regulatory authority summarised in Table 3.

Table 3 Effluent Disposal Regulation Authority

Disposal Route	Regulation	Authority
Sewer	Discharge concentration / load limits	Local Council
Land Irrigation	Sustainable Loadings	State EPA
Waterway (ie rivers)	Discharge concentration / load limits	State EPA

The state-based discharge limits for each disposal route are shown in Appendix B. Note that these are a guideline only as they were current at the time of print. For current requirements, refer to the appropriate authority.

4.2 Disposal via Sewer

Effluent quality requirements for sewer disposal are stipulated by the local sewerage management authority (ie. Local Council's Trade Waste Authority).

Important factors to be considered include:

- Availability of a nearby sewerage system
- Adequate capacity of the local sewerage treatment plant
- Willingness of the local sewerage authority to accept the effluent under reasonable conditions and at reasonable cost
- Appropriate odour control both on site (i.e. potential close neighbours) and in sewer reticulation
- Appropriate preliminary treatment at the abattoir to meet the disposal criteria
- Annual budget to meet potential head works charges, operating costs and disposal sewer charges.

Small Towns

The most significant factor for disposal of abattoir wastewater to a town sewerage system is the contaminant load (i.e. volume times the strength) in relation to the local town's load production. Abattoirs are large water users and can generate wastewater loads in excess of the town's population.

Large Cities

The basic factor with disposal to sewer in a large city is the cost involved. City sewerage systems treat large volumes and abattoir wastewater is likely to be only a small proportion of the total flow. However it may contain a significant contaminant load, especially with respect to nitrogen. Partially treated abattoir wastewater is likely to be accepted by the sewer management authority, though this may come at a cost.

Sewer charges are rising and the range of parameters that are charged for is increasing. Indicative costs at time of writing these Guidelines can be found in Appendix C.

4.3 Disposal via Land Irrigation

Effluent disposal via land irrigation is the preferred disposal route in rural areas providing sufficient suitable land is available. Providing effluent loadings are sustainable, there are many benefits including nutrient uptake by agricultural produce including stock feed and sustainable tree lots. These can provide a substantial return to the operator.

Disposal Criteria:

Land irrigation is a great example of effluent reuse from the abattoir industry that can be sustainable providing:

- Sufficient area of land, with topography, soils and groundwater conditions suitable for irrigation

- Site available for wet weather storage
- The concentration of salt in the effluent must not be detrimental to the soils at the site or cause a problem elsewhere (i.e. run-off to nearby creek)
- Nutrient loadings must be appropriate to the site and an appropriate management system adopted
- Irrigation Management Plan (IMP) must be implemented.

Due to its importance to the industry, irrigation of wastewater is covered in more detail in the *Environmental Best Practice Guidelines – Effluent Irrigation* module.

Irrigation area for treated effluent

Further Information

For more information regarding irrigation refer to:

- *Effluent Irrigation Manual* [6]
- *Best Practice Wastewater Treatment* [3]

4.4 Disposal via Surface Waters

Surface waters for effluent disposal can be split into two main categories:

- Coastal surface waters (ie estuaries and ocean) and
- Inland surface waters (ie creeks, rivers and lakes).

The requirements for discharge to inland surface waters are much more stringent than coastal surface waters as the potential impact on inland waters is significantly higher.

Important factors to be considered include

- Proximity of the abattoir to a suitable discharge site
- Capital available to build a suitable treatment system
- Space and a management system to deal with the significant quantities of solids generated.

- Annual budget and availability of skilled personnel to operate the system
- Space available for the wastewater treatment system
- Appropriate control of odour from treatment processes.

Disposal Criteria

Historically many abattoirs discharged to surface waters but generally this is not preferred for new plants. This is due to the high treatment costs associated with meeting very strict disposal criteria required in Australia.

The quality of water to be disposed of to surface waters is approaching that of potable water in some inland areas. Testing parasites, pathogens and viruses are becoming a requirement and are generally stipulated by the State Environmental Protection Authority.

Nitrogen and phosphorus in the abattoir effluent may lead to excessive algal and plant growth in the receiving surface waters, particularly if the waters are slow flowing. This requires treatment to a high standard before approval from the regulatory body would be granted.

5.0 BEST PRACTICE WASTEWATER TREATMENT SYSTEMS

Prior to focusing on which wastewater treatment system to use or improve, one should focus on wastewater reduction (ie reduction in water use and waste minimisation and separation).
Remember to consider:

- **Avoid waste production**
- **Reduce water use**
- **Recover wastes**
- **Reuse / Recycle water***
- **Treat and Dispose (last option)**

*** "Quality needs to meet strict food safety requirements and regulations"**

5.1 Factors Affecting Your Decision

By now you should have a good idea on what disposal route or routes you have available and what quality is required for disposal. The next step is to consider the following:

- Space available
- Nearby neighbours (i.e. sensitive to odours, noise)
- Current treatment system
- Site resources and skills to manage system
- Available capital and operating budget
- Before a final system is selected, advice from a wastewater specialist is advisable
- In general, some form of treatment will be required prior to disposal.

5.2 Best Practise Wastewater Treatment in Australia

There are three key wastewater treatment levels that generally need to be considered. Functions of each are described in Table 4. Detailed descriptions, and the advantages and limitations of the various technologies are summarised in Table 11.

Table 4 Typical Extent of Treatment for Disposal Routes

Treatment Level	Main Goal	Disposal Route
Primary	Remove coarse and suspended solids, oil and grease	All, may use advanced primary for sewer.
Secondary	Remove nutrients, organics and pathogens	Irrigation, waterways, possibly sewer.
Tertiary	Disinfection	Possibly waterways, irrigation and reuse.

5.2.1 Best Practice Wastewater Treatment for Sewer Disposal

Effluent disposal via sewer is best suited to generally larger abattoirs located close to residents. Smaller abattoirs maybe challenged with more stringent trade waste agreements.

Best practice wastewater treatment to minimise trade cost charges and comply with trade waste regulations will generally consist of:

- Oil and grease removal
- Suspended solids and BOD reduction
- Monitoring and reporting is typically conducted by the trade waste authority
- Contingency planning as required
- Ensure effective personnel training.

Best practise wastewater treatment systems for sewer disposal are summarised in Table 6 with considerations highlighted in Table 5.

Table 5 Sewer Disposal Treatment System Considerations

Considerations	Treatment option is dependant on	Watchouts
• Trade waste agreement - effluent quality disposal requirements and trade waste charges. • Cost benefit analysis of trade waste charges vs advanced on-site treatment system costs. • Disposal of solids from treatment processes. • Odour management.	• Size of town (small vs large). • Available space on site – extensive of compact. • Nutrient removal requirements. • Any nearby residence – odour management. • Size of town's sewerage treatment system.	• Trade waste requirements can vary significantly – dependant on local authority. • Trade waste requirements are often more stringent in smaller towns due to abattoir's significant load on local wastewater treatment plant. • Impact of future changes in regulations and charges.

Further Information

- *Environmental Best Practice Guidelines – Odour and Air Quality*
- *Environmental Best Practice Guidelines – Waste Solids*

Hydrocyclone

Table 6 Best Practice Wastewater Treatment Systems – Disposal via Sewer

Treatment Type	Current Proven Technology	Comments
Physical (gross solids and fat removal)	Screening (static, vibrating, rotary) Baleen Screw Press Hydrocyclones Savealls Dissolved Air Flotation (DAF) Induced Air Flotation (IAF/CAF)	Screening is essential for coarse solids removal and protection for downstream processes. Rotary screens are common, static are effective for green streams. Savealls, IAF/DAF and hydrocyclone are used for oil and grease and suspended solids reduction. Effluent may be suitable for direct discharge to sewer or for subsequent biological treatment. Green and red streams may be handled separately. High temperatures affect the efficiency of treatment. All technologies generate solid sludge or fatty floats which are unstable and require disposal.
Chemical Treatment	Chemical precipitation (pre-treatment or biologically treated effluent) Electrocoagulation	Must be used in conjunction with solids collection technology, such as DAF or IAF. Common for sewer discharge. Commonly flow paced dosing controls dosing with influent rate. Generates very large sludge quantities. Electrocoagulation may be used on strong streams.
Pond based	Anaerobic Ponds Aerated Ponds Facultative Ponds	Green and red streams combined prior to biological treatment. Common first stage for cost-effective organic load reduction and may produce effluent suitable for discharge to sewer. Uncommon in urban situations, since large area required. Odours can be an issue but can be overcome by installing natural crust covers,. synthetic covers (which remain unproven in large scale operations) or, rarely, covers with gas collection and flaring. Commonly used downstream of anaerobic systems Although requiring less land area, involves more power for aerators. Increased sludge. Less risk of odour emission. Achieve some nitrogen reduction. Effluent suitable for discharge to sewer. Produces effluent suitable for sewer discharge, but require larger land area than ponds above.
Biological Treatment	Activated Sludge Trickling filtration	Generally not used as produce effluent quality much better than sewer standard requirements. Used if TP or TN removal required.

5.2.2 Best Practice Wastewater Treatment for Irrigation Disposal

Effluent reuse via land irrigation is best suited to small abattoirs located in dry areas. However many large abattoirs that have access to large irrigation or crop areas use it successfully. It is important to ensure soils are suitable otherwise long term environmental impacts can occur.

Best practice wastewater treatment will generally consist of:

- Solids and grease removal
- Biological reduction of organic, nutrient and pathogen levels
- At least 6-monthly monitoring of final water quality and associated reporting
- Contingency planning to cover high-consequence events
- Ensuring effective training and resourcing of operating personnel.

For small abattoirs, or where the climate is dry and neighbours distant, effluent may be irrigated with little more than primary treatment to reduce fats and solids. However where wet-weather storage is required, or the abattoir size dictates it, some biological treatment will be needed.

Table 7 Irrigation Disposal Treatment System Considerations

Considerations	Treatment option is dependant on	Watchouts
• Soil is suitable for nutrient and hydraulic uptake. • Sufficient land area. • Wet weather storage requirements. • Sustainable loadings of nutrients and water. • Groundwater vulnerability. • Disposal of solids from primary and secondary (if needed) systems.	• Nutrient removal requirements for sustainable loadings to land. • Any nearby residence – odour management.	• Solids, algae and fats blocking irrigation system. • Odours from inadequately treated wastewater from storage dams. • Effluent quality doesn't degrade the environment long term (i.e. salts, nutrients). • Don't over-irrigate

Anaerobic pond with a naturally formed crust

Table 8 Best Practice Wastewater Treatment Systems – Disposal via Irrigation to Land

Treatment Type	Current Proven Technology	Comments
Physical (gross solids and fat removal)	Screening (static, vibrating, rotary) Baleen Screw press Hydrocyclones Savealls Dissolved Air Flotation (DAF) Induced Air Flotation (IAF/CAF)	Screening is essential for coarse solids removal and protection for downstream processes. Rotary screens are common, static are effective for green streams. Savealls, IAF/DAF and hydrocyclone are used for oil and grease and suspended solids reduction prior to irrigation. Green and red streams may be handled separately. High temperatures affect the efficiency of treatment. All technologies generate solid sludge or fatty floats which are unstable and require disposal.
Chemical Treatment	Chemical precipitation (pre-treatment or biologically treated effluent) Electrocoagulation	Must be used in conjunction with solids collection technology such as settling tank, DAF or IAF. Rarely used for effluent irrigation due to high volumes of sludge produced. Electrocoagulation may be used on strong streams.
Pond based		Green and red streams combined prior to biological treatment.
	Anaerobic Ponds	Common first stage for cost-effective organic load reduction. Odours can be an issue, but can be overcome by installing natural crust covers,.synthetic covers (which remain unproven in large scale operations) or, rarely, covers with gas collection and flaring.
	Aerated Ponds	Commonly used downstream of anaerobic systems Although requiring less land area, involves more power for aerators. Increased sludge. Less risk of odour emission. Achieve some nitrogen reduction.
	Facultative Ponds	Produces effluent suitable for effluent irrigation where nutrient removal is not needed. A downstream maturation pond is typically used to provide some disinfection of effluent prior to irrigation.
High rate Biological Treatment	Activated Sludge	Only used if TP or TN removal required. Typically SBR format.
Land Based	Wetlands	Used as final polishing step. Vulnerable to overloading.
Disinfection	Maturation Pond	Most common form of disinfection, provided organic loading is low.
	Chlorination	Typically recommended where third party irrigation reuse is considered.

5.2.3 Best Practice Wastewater Treatment for Surface Water Disposal

Modern limits for surface water discharge are stringent and require extensive and a highly robust wastewater treatment plant capable of consistent effluent quality regardless of the abattoir operating cycle.

Best practice wastewater treatment will typically include:

- Solids and grease removal
- High efficiency organic and nutrient removal
- Disinfection to at least secondary contact level
- At least weekly monitoring and reporting of system performance
- High degree of contingency planning
- Ensuring effective training and resourcing of operating personnel.

Table 9 Surface Water Disposal Treatment System Considerations

Consideration	Treatment option is dependant on	Watchouts
• Receiving water effluent quality and/or load requirements. • Seasonality impacts on receiving water (eg flows). • Capital and operating costs of plant, especially operating personnel requirements. • Monitoring equipment. • Impact of plant operating cycle (especially shut-down, weekend closure) on treatment performance. • Disposal of biosolids.	• Nutrient removal requirements.	• Operating personnel training. • Biosolids capture and treatment – can be expensive. • Restriction on disposal of chemical sludges.

Sequencing Batch Reactor

Table 10 Best Practice Wastewater Treatment Systems – Disposal via Waterways

Treatment Type	Current Proven Technology	Comments
Physical (gross solids and fat removal)	Screening (static, vibrating, rotary) Baleen Screw press Hydrocyclones Savealls Dissolved Air Flotation (DAF) Induced Air Flotation (IAF/CAF)	Screening is essential for coarse solids removal and protection for downstream processes. Rotary screens are common, static are effective for green streams. Savealls, IAF/DAF and hydrocyclone are used for oil and grease and suspended solids reduction prior to further treatment. Green and red streams may be handled separately. High temperatures affect the efficiency of treatment. All technologies generate solid sludge or fatty floats which are unstable and require disposal.
Chemical Treatment	Chemical precipitation (pre-treatment or biologically treated effluent) Electrocoagulation	Must be used in conjunction with solids collection technology such as settling tank, DAF or IAF. Chemical dosing of DAF may be used for organic load reduction rather than using anaerobic ponds. May be used for phosphorus removal. Electrocoagulation may be used on strong streams.
Pond based	Anaerobic Ponds Aerated Ponds Facultative Ponds	Common first stage for cost-effective organic load reduction. Odours can be an issue, but can be overcome by installing natural crust covers, synthetic covers (which remain unproven in large scale operations) or, rarely, covers with gas collection and flaring. Not used – effluent quality unsuitable for waterways discharge. Not used – effluent quality unsuitable for waterways discharge.
High rate Biological Treatment	Activated Sludge	Used to achieve organic and nitrogen reduction. SBRs tend to be preferred configuration. Waste biosolids require dewatering and disposal Biological phosphorus removal has yet to be demonstrated at full scale.
Disinfection	Chlorination UV disinfection	Remains most reliable and effective technology. Rarely used due to poor transmissivity of effluent.

5.2.4 Effluent Reuse

Effluent reuse opportunities are being considered in Australia in a bid to reduce water consumption. However strict regulations and food safety standards, such as the EU international standards that specifically affect export facilities, prohibit the reuse of water even for non-product contact areas such as stockyard washdown.

The use of potable water and non-potable water in export abattoirs is controlled rigidly by the Export Meat Orders. They stipulate that there must be two separate plumbing systems for potable and non-potable water and that non-potable plumbing is labelled clearly as such.

It is highly unlikely that overseas customer countries, particularly Japan and the United States of America, will approve the direct or indirect use of recycled water in food plants.

Within the limits above, areas where non-potable water could be used include:

General Site Operations

- Cooling tower makeup
- Boiler make up
- Outdoor paved area cleaning
- Watering of landscaped areas
- Cattle truck washing.

Abattoir Operation

- Stockyard washdown
- Inedible offal processing
- Cleaning around wastewater treatment plant
- Cleaning sprays for screens at wastewater treatment plant
- Initial washing of cattle prior to slaughter (followed by a potable water wash).

Tertiary treatment of effluent using dissolved air flotation cell

Table 11 Wastewater Treatment Systems

Process	Photo	Description	Advantages	Limitations
PRIMARY TREATMENT				
Static and Vibrating Screen		Screening removes the solid material from the wastewater. The liquid is separated from the solids by gravity, water action and mechanical forces.	Screens are robust, strong and easy to maintain. There is no electrical energy or mechanical parts needed for static screens. In vibrating screen there is a lower moisture content and solids less easily block the screens.	The screens must be periodically cleaned to avoid solid build up. Screens are not suitable for fat laden material. Static screens have more binding problems than vibrating screens and are more labour intensive to clean. Vibrating screens are susceptible to mechanical failure.
Rotary Screen		Rotary screens are rotating cylindrical wire screens. Effluent typically enters in the centre, with solids discharged at the other end.	Rotary screens are easily cleaned and can handle flow surges. They have a better efficiency than other types of screens for fatty effluent.	There is a risk of mechanical failure as high fat loading or the presence of fibrous solids may bind the screen. The screen requires regular cleaning. The solids removal is limited to screen aperture or staining capacity of accumulated solids.
Screw press		Combines a screen with screw auger to produce dry solid discharge.	Effective for screening and produce better dewatered solids (lower moisture content) compared to screens – important where solids must be taken off-site	High wear and may release more contaminants to wastewater.

Process	Photo	Description	Advantages	Limitations
Hydrocyclones		Uses centrifugal force to separate solids or fats in a conical separator with no moving parts.	Small footprint and HRT. Fat removal less affected by high temperatures.	Need to install a pump. Vulnerable to blockage from fine solids and fat.
Save all		A saveall is a tank that allows floatable material to rise to top of the tank and settled solids to sink.	Saveall are cost-effective for reliable removal of fat. The fat that is removed can become a useful by product. Save all also allows for easy solids removals.	At maximum flow and elevated temperatures savealls operate at low efficiency. Odour can be a problem and mechanical scrapers are not always reliable. The save all is not as effective as a DAF system. Require large footprint.
Electro-coagulation		Uses iron of aluminium dosing in combination with electrical field to remove contaminants.	Highly effective on low volume, high strength streams. No dosing equipment. Removes phosphorus.	Unproven in dilute, high volume streams. Generates high volumes of unstable solids.
Dissolved Air Flotation (DAF)		Wastewater is pressurised then saturated with air. Once the pressure is released solids and fat are floated and removed Chemicals can be added to assist removal. These include; acid, alum, ferric chloride lime, polyelectrolyte and aluminium chloride.	Chemical DAF can effectively remove fats, solids, BOD, nitrogen and phosphorus. Non-chemical DAF is still very efficient in the removal of fats. Reliable, with a small footprint. Best operation when use DAF effluent recycle for air saturation.	Vulnerable to poor fat removal at temperatures above 39^{o}C. Generate low solids, unstable float. Chemical dosing generates high sludge volumes.

Process	Photo	Description	Advantages	Limitations
Induced Air Flotation (IAF) or Cavitation Air Floatation (CAF)		The difference between IAF and DAF is with IAF the bubbles are created by using a pump or venturi system. The bubbles that are internally formed are larger but fewer in number,	Simpler than a DAF. IAF needs no air compressor or recycle pump. It requires lower energy than the DAF and is more efficient than a saveall.	The IAF is less reliable than the DAF. It is difficult to control the amount of air saturation.
BIOLOGICAL TREATMENT				
Aerated Pond		Achieves microbial breakdown of organic material under aerobic conditions. Air provided mechanically, usually by surface aerators.	Reliable, simple to use and have a low odour risk. Good BOD removal. Can achieve high nitrogen removal if required.	Large footprint. Power supply required for aerators. Effluent will have high concentration of suspended solids.
Anaerobic Pond • Natural Cover • Synthetic Cover		Achieves microbial breakdown of organics to mainly gas in absence of oxygen	Simple and easy to construct. They can handle variations in the load of wastewater. Usually form a crust which minimises odour emission. Low sludge formation. Highly cost effective organic removal.	Odour and greenhouse gas emissions. Effluent unsuitable for release to environment.
Facultative Ponds		Combine anaerobic and aerobic breakdown of organics.	Reliable, low maintenance, simple.	Need a large area. There can be algal blooms in some cases and the ponds can be easily overloaded. Seasonality will affect performance.

Process	Photo	Description	Advantages	Limitations
Maturation Pond		Shallow ponds which are highly aerobic	Reliable, low maintenance, simple Achieve disinfection	The limitations of maturation ponds are the same as facultative ponds.
Activated Sludge		An intensified aerated pond, operates by recycling sludge to maintain high bacterial levels. Either continuos flow (using a clarifier at the end) or intermittent (SBR) forms.	Rapid, versatile treatment. Generates very high quality effluent	Expensive to build and operate. Vulnerable to upset, especially where loads are uneven or high in fat. Care needed in shutdowns.
BNR		Refers to use of activated sludge to remove nutrients	Only demonstrated technology capable of cost-effective nitrogen removal, SBR systems are cheaper and more flexible than continuous systems.	
Wetlands		A complex system consisting of plants in a shallow soil matrix. Alternative to maturation ponds.	Suited to specific sites but specialised planning is required. Achieve high suspended solids and pathogen removal. Highly biodiverse.	Lack of design parameters for abattoir effluent. Feed concentrations need to be low. Unpredictable and variable final effluent quality. Large areas required and lack of control during periods of wet weather or floods. Sludge build up over time.

Process	Photo	Description	Advantages	Limitations
TERTIARY TREATMENT				
Chlorination		Chlorination involves adding either chlorine gas or sodium hypochlorite solution into the water to kill microorganisms.	Simple, cost effective, reliable and proven technology. It removes some of the colour from water and is effective against bacteria.	Chlorine can be toxic to wildlife and form THM by-products. It is inappropriate for high ammonia concentrations and is both temperature and pH dependent.
Ultraviolet Irradiation		In ultraviolet irradiation the wastewater is exposed to ultraviolet rays.	UV is more effective in treating viruses than most other disinfection methods. It is chemical free thus is non hazardous. It is rapid and does not require much space.	In order to stop the UV tubes from fouling and decreasing efficiency, regular cleaning and replacement is required. UV irradiation is less effective at high turbidity.

5.3 Best Practice Operational Tips

One of the first steps in meeting wastewater treatment standards is the optimisation of current treatment facilities such as screening, saveall and DAF. Operational tips can help optimise the process and reduce costs. Operating tips are described in Table 12.

Table 12 Operating Tips for Treatment Systems

Treatment Type/System	Operational Tips
General	• Floor drains, sumps and save-all systems should be kept free of accumulated solids and crusts • Uncontaminated storm water should be excluded from the waste treatment areas • Contingency planning – procedures and stand-by equipment available for accidents or equipment failure • SHEEPSKIN/HIDE PRESERVATION - Preference is of dry salting of skins with dryclean. Where brine is formed keep separated from wastewater stream and dispose of in a sustainable manner
Screens	• Screening surface kept clean • Ensure solids drainage zone free of water • Regular emptying of solids bin (don't let the bin fester) • Minimise aerosols.
Saveall	• Ensure regular cleaning of Saveall area • Regular maintenance (eg. Rubber strips in good condition of scrappers for float and/or collection) • Regular solids removal from bin (don't let the bin fester)
DAF	• Best working temperature <38°C for fat removal • Regular inspection and maintenance of air diffusers • Watch sludge buildup and check air bubble size • Where chemical dosing, ensure dosages are correct
Anaerobic Ponds	• Maintain good crust cover (100%) on pond • Ensure discharge to subsequent treatment units is submerged to minimise odour emissions • Ensure temperature <40°C
Facultative Ponds	• Ensure regular monitoring • Watchout for rising up-dwellings of black sludge (indicates pond has become anaerobic) • Loss of dissolved oxygen concentrations • Monitor pond capacity (eg Depth sludge)

Treatment Type/System	Operational Tips
Monitoring and Reporting	• Weekly visual inspections for systems to sewer or land; daily for system to surface water • Record water usage and flows • Measure pH, temperatures in DAF and anaerobic ponds • Sample and analyse relevant contaminant concentrations routinely

6.0 REFERENCES

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APPENDIX A
Water Usage, Wastewater Sources and Types of Contamination Found at Abattoirs

Area of Process	Activity	Water Usage [a] (kL/day)	Types of Contamination	Waste Minimisation Strategies
Stockyard	Stock watering Stock washing Wash down of stockyard Truck washing	10 70 130 40 **25%**	Soil and bacteria from washing cows. Hair	Pre wash dirty cattle. Ensure all equipment is correctly designed and maintained. Have a suspended mesh floor in the stockyards. Before the wastewater from the stockyards enters the existing effluent system it should be screened for solids. Use recycled water for wash down and stock washing.
Slaughter Floors	Viscera table wash sprays Head wash Carcase wash Carcase splitting saw	60 3 40 1 **10%**	Blood Tissue Fat Detergents Disinfectants	Collect blood into a blood pit. When collecting blood off the floor do not use a hose, instead use a squeegee. Set a standard blood recovery. Keep water pressure at a minimum during carcass washing. Remove all visible contamination by trimming. Always preform dry cleaning before wash down of the facilities. Wash equipment before sterilisation. Turn water streams off when not in use. Select high impact, low flow nozzles. Low temperature water stream for carcase washing. Ban hoses in blood pit.
Paunch, gut and offal washing.	Paunch dump and rinse Tripe/Bible washing Gut washing Edible offal washing	80 30 60 30 **20%**	High BOD High nutrient waste	Collect all solids. Use knee or thigh high-operated valves in the water line. Use dry dumping of paunch material. Any liquid residue from paunch dumping should be treated with the effluent from the rendering plant. Use immersion washing. Use recycled water from the slaughter floor, carcase washing and hand wash basins to clean the inedible products.
Rendering	Rendering separators	10	Nitrogen	Drainage liquid from raw material conveyor and bins should be

	Rendering plant washdown	5 **2%**	Phosphorus Salt BOD Paunch liquid Condensate from a dry rendering operation. Stick water from decanter centrifuges. Stick water from blood coagulation. Tallow wash water from polisher centrifuge.	passed through rendering plant. Wastewater streams should be kept separate from the other wastewater sources in the plant. Little opportunity to reduce overall water usage.
Plant Washing Sterilisers and wash stations Amenities Plant cleaning Plant services	Knife sterilisers Equipment sterilisers Hand wash stations Exit /entry hand, boot and apron wash stations Personnel amenities Wash down during shifts Cleaning and sanitising at end of shift Washing tubs, cutting boards and trays Condensers Cooling tower makeup Boiler feed makeup	60 20 20 **10%** 40 25 **7%** 20 170 30 **22%** 20 10 10 3 **4%**	Blood Trimmings Damaged Cartons Polystyrene Strapping Polyethylene	Wash down should always be preceded by dry cleaning. Correctly separate solid waste from wastewater Limit water pressure and volume. Use belt conveyers to collect trimmings and fats in boning room. Install trays to capture bone dust under boning tables. Order of washing; stands, walls then floors.

Note: This data is an example breakdown of water usage in meat processing. It is based on a 'typical meat plant' which is defined as a plant processing the equivalent of 150 tonnes Hot Standard Carcase Weight (HSCW) per day, which is equivalent to 625 head of cattle per day, based on a conversion rate of 240 kg/head. Water usage can vary considerably from one plant to another, so this should be regarded as an example only.

APPENDIX B
Australian Discharge Limits

Table B1 Sewer Disposal Pollutant Limits

Parameter	Unit	National (ANZECC)	New South Wales	Queensland	South Australia	Victoria	Western Australia
BOD	mg/L	site specific	300[a]	Limits set by individual Councils, generally based on ANZECC criteria.	site specific	Limits set by individual Water Authorities, generally based on ANZECC criteria.	< 3000
COD	mg/L	site specific	< (3 x BOD)		site specific		< 6000
Suspended solids	mg/L	site specific	NS		< 1000		< 1500
Temperature	C	< 38	< 38		< 38		< 38
pH	-	6.0 - 10.0	7.0 - 9.0		6.0 - 10.0		6.0 - 10.0
Oil and grease	mg/L	< 200	< 50[b]		< 100		NS
Ammonia as nitrogen	mg/L	< 100	< 50		< 50		< 200
Kjeldahl nitrogen	mg/L	< 150	< 100		NS		NS
Total phosphorus	mg/L	< 50	< 20		NS		NS
Sulfate	mg/L	< 2000	< 100		< 1500		NS
Chlorine	mg/L	< 10	< 10		< 5		< 10
TDS	mg/L	NS	< 4000		NS		NS

Notes:

(a) Higher values (< 600 mg/L) may be acceptable if sufficient capacity at treatment plant and dilution in sewer is available

(b) Higher values (< 100 mg/L) may be acceptable if volume of the discharge is less than 10% of the capacity of the treatment plant

NS = Not specified

Table B2 Surface Water Disposal Pollutant Limits

Parameter	Unit	National (ANZECC)	New South Wales[b]	Queensland	South Australia[d]	Victoria		Western Australia[c]
		Secondary Contact	90% ile			median	90 %ile	Secondary Contact
BOD	mg/L	NGR	10	Refer to ANZECC criteria[c]	<6	5	10	NGR
Suspended solids	mg/L	< 10% change[a]	15		< 10% change	10	15	< 10% change[a]
pH	-	5.0 - 9.0[a]	6.5-8.5		6.5 - 8.5	6 - 9		5.0 - 9.0[a]
Ammonia as nitrogen	mg/L	0.02 - 0.03[a]	2		Refer to National Guidelines	2.0	5.0	0.02 - 0.03[a]
Total nitrogen	mg/L	0.1 - 0.75[a]	10			10	15	0.1 - 0.75[a]
Total phosphorus	mg/L	0.01 - 0.1[a]	0.3			0.5	1.0	0.01 - 0.1[a]
E.coli	org/100 mL	< 1000	200		150 (primary contact)	200	1000	< 1000
Oil & Grease	mg/L	(e)	2		15 maximum 8 average	non visible		(e)
TDS	mg/L	500[f]	NS		NS	NS		NS

(a) Criteria relates to receiving water, ie after mixing

(b) Source: NSW EPA Submission to Public Inquiry into Management of sewage and sewage by-products in the coastal zone (Table 1, Appendix 3)

(c) Site specific (dependent on environmental value of receiving water body and characteristics of effluent)

(d) Environment Protection (Marine) Policy 1994 - South Australia

(e) Oil should not be noticeable as a visible film on the water nor should be detectable by odour

(f) Based on limits required for good quality drinking water

NGR = No Guideline Recommended

NS = Not Stated

APPENDIX C
Trade Waste Charges & Discharge Factor

Charges Levied on High Strength Trade Waste Generators

	Year	Permit Fee ($/annum)	Flow ($/kL)	BOD ($/kg)	COD ($/kg)	SS ($/kg)	O&G ($/kg)	TKN ($/kg)	TP ($/kg)	Sulphate ($/kg)
QUEENSLAND										
Brisbane (Category D)	2003/04	Min $240.00	$0.43	$0.97-$1.14		$0.48		$0.43	$0.71	
Bundaberg (Category 3)	2003/04	$336.00	$0.84	Unit charges are based on the actual cost to treat the pollutant over the cost to treat domestic sewage concentration						
Caboolture (Category 3)	2003/04	$158.00	$ 0.52	$1.45		$0.38				$0.34
Cairns (Category 3)	2003/04	$169.00	$0.52	$0.88		$0.57				
Caloundra (Category 3)	2003/04	n.a.	$1.31	$0.66		$0.56	$0.56			
Emerald (Category 3)	2003/04	$50.00	$ 0.68		$0.70	$0.50				
Gold Coast (high strength)	2003/04	Nil	$1.00		>1,000mg=$1.00	>300mg=$0.64			>10mg=$7.87	
Ipswich (Category 3)	2003/04	$480.00	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Logan (Category 3)	2003/04	Min $196.00	$0.50	$0.60	$0.37	$0.69	$0.57	$0.57	$0.57	$0.57
Mackay (Category 3)	proposed	$100.00	n.a.		$0.40	$0.75		$2.01	$3.18	
Mareeba (Category 3)	2003/04	n.a.	n.a.		$0.40	$0.55				
Maroochy (Category 3)	2003/04	$64.70	$0.50	$0.93	$0.44	$0.60	$0.60			
Maroochy (high strength)	proposed	Nil	$1.70		>600mg=$0.50	>300mg=$0.87		>80mg=$1.50	>15mg=$3.60	
Noosa (Category 2)	n.a.	$250.00	$0.50	$0.50		$0.50		$1.00	$1.00	
Pine Rivers (Category 3)	2003/04	$80.00	$0.57	>300mg=$0.94	>600mg=$0.81	>300mg=$0.76	>200mg=$0.47	>80mg=$0.59	>40mg=$0.47	>100mg=$0.83
Redland (Category 2)	n.a.	$153.50	$0.80	$0.77	$0.77	$0.35	$0.35			
Rockhampton (Category 3)	2003/04	$150.00	$ 0.40	$0.80		$0.95				
Toowoomba (Category 3)	2003/04	Min $270.00	0-5ML=$0.26 >5ML$0.36	$0.36		$0.41	$0.55	$0.84	$2.80	
Townsville (Category 3)	2003/04	Min $161.44	$0.64	$1.39		$1.61				
Townsville (Category 2)	proposed	Min $203.00	$0.78		$0.73	$0.61				$0.30

NEW SOUTH WALES										
Ballina (Category 2b)	2003/04	Nil	$0.83	>300mg=$1.13	>900mg=$0.35	>300mg=$0.78	>50mg=$1.95			
Bathurst (Category A)	2003/04	$451.10	$0.52	$0.64		$0.50	$1.28			
Coffs Harbour (Category 3)	2003/04	$130.00	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Hastings (Category 3/4)	2003/04	Nil	$0.45	$0.80		$0.70	$1.60			
Hunter (Major)	2002/03	$367.83		$1.80		$1.80		$3.60		$0.10xactual^2/2000
Gosford	2003/04	n.a.	$0.20	$1.30/kL (each 1,000mg)	$1.30/kL (each 1,000mg)	$1.30/kL (each 1,000mg)	$1.30/kL (each 1,000mg)	$1.30/kL (each 1,000mg)	$1.30/kL (each 1,000mg)	$1.30/kL (each 1,000mg)
Shoalhaven	2003/04	$150.00	$0.90	$0.88		$0.67	$0.88			
Sydney (as per risk index)	2003/04	As per risk	n.a.	$0.66xactual/60		$0.71	$1.00	$0.14	$1.11	$0.11xactual/2000

		index		0						
Tweed	2003/04	Nil	$0.65	300-600mg=$0.16 600-900mg=$0.64 900-1200mg=$0.96 1200-1500mg=$1.28 1500-1800mg=$1.60 1800-2100mg=$1.94 2100-2400mg=$2.24		300-600mg = $0.21 600-900mg = $0.84 900-1200mg = $1.26 1200-1500mg = $1.68 1500-1800mg = $2.10 1800-2100mg = $2.57 2100-2400mg = $2.94	50-100 = $0.05 100-150 = $0.20 150-200 = $0.30 200-250 = $0.40 250-300 = $0.50			

VICTORIA										
Barwon	2003/04	As per risk index	$0.89	>500mg=$0.29		>500mg=$0.09		>50mg=$0.32		$0.48
City West (Category 3)	2003/04	0-2.5ML=$225.00 2.5-25ML=$675.24 25-100ML=$2,250.96 >100ML=$6,753.36	$0.36	$0.39		$0.19		>50mg=$0.74		100-500mg=$0.82 >500mg=$1.16
Goulburn Valley (Category 3/4)	2003/04	$100.00	$ 0.30	$0.20				$0.30	$0.80	
South East (Category 3)	2003/04	$225.00-$6753.44	$0.36	$0.39		$0.19		>50mg=$0.74		100-500mg=$0.82 >500mg=$1.16
South West (Category 3)	2003/04	Nil	Specified in individual trade waste agreements							
Yarra Valley (Category 3)	2003/04	Nil	$0.36	$0.39		$0.19		>50mg=$0.74		100-500mg=$0.82 >500mg=$1.16
WESTERN AUSTRALIA										
Water Corporation	2003/04	$159.00	$0.98	0-5,000mg=$0.85 >5,000mg=$1.70		0-2,000mg=$0.80 >2,000mg=$1.60	0-300mg=$0.38 300-600mg=$0.76 >600mg=$1.53	$0.24	$0.26	>50mg=$0.40
AVERAGE		**$1,000.00**	**$0.60**	**$0.80**	**$0.65**	**$0.70**	**$0.85**	**$0.95**	**$2.00**	**$0.60**

Source: assorted service providers

APPENDIX D
Glossary of Terms

Aerobic	biological treatment processes that occur in the presence of oxygen
Anaerobic	biological treatment processes that occur in the absence of oxygen
Best Practice	practices adopted by an organisation that are considered the most effective at achieving the desired outcome within reasonable technical and economic restraints
Biochemical Oxygen Demand	the amount of oxygen utilised by micro-organisms in the process of decomposition of organic material in wastewater over a period of 5 days at 20°C
Chemical Oxygen Demand	a measure of oxygen required to chemically oxidise organic matter in wastewater
Chlorination	the chemical dosing of chlorine for disinfection
Cleaner Production	involves the management of environmental impacts of an organisation or process while improving the economic efficiency of the process
Dissolved Oxygen	A measure of oxygen concentration dissolved in water
Dissolved Solids	salts dissolved in wastewater
E. Coli	one of the coliform bacteria population and is a measure of faecal origin
Effluent	wastewater outflow after one or more stages of treatment
Electrical Conductivity	A measure of the ability of the water to conduct an electrical current. Conductivity is sensitive to dissolved solids and is a good indication of increased inputs of these compounds.
End-of-Pipe	The process of cleaning up wastes once they have been generated
Environment	surroundings in which an organisation operates including air, water, land, natural resources, flora, fauna, humans and their interrelation
Facultative	biological treatment processes in which both aerobic and anaerobic environments exist
Faecal Coliforms	general term for the bacteria produced from the gut of warm blooded animals (used as an indicator of faecal pollution)
Flocculation	involves the physical aggregation of particles, usually by chemical dosing, and subsequent floc formation
Kjeldahl nitrogen	the Kjeldahl test determines the quantity of organic nitrogen and ammonia present in the wastewater

Non-potable	water which can not be used for drinking purposes
Paunch	contents of animal stomachs
pH	a measure of the acidity or alkalinity of the waste
Pickling	the process whereby fellmongered skins are agitated in a brine (salt) or acid mixture prior to tanning
Potable	water which can be used for drinking purposes
Primary Treatment	wastewater treatment which involves coarse and suspended solids and oil and grease reduction
Raw Water	water that has not undergone any treatment
Receiving Water	the waters into which effluent is discharged
Rendering	the cooking of animal wastes followed by drying to produce a proteinaceous meal and tallow
Saveall	A device to allow settling of solid and floating of fat
Secondary Treatment	wastewater treatment by biological processes to remove organic matter
Sewer/Sewerage system	the network of collection, conveyance, pumping, treatment and disposal facilities owned and/or operated by a sewerage authority
Sodium Adsorption Ratio	The SAR ratio is the ratio of sodium to calcium and magnesium. This ratio gives the sodium hazard of the water as excessive sodium in irrigation water can adversely affect soil structure
Stickwater	the liquid waste from either tallow washing or blood processing in rendering plants which is high in BOD, nutrients and salt
Suspended Solids	the insoluble solid matter suspended in wastewater that can be separated by filtration
Trade Waste	the liquid waste generated from any industry, business, trade or manufacturing process not including domestic wastewater
Ultraviolet Irradiation	the use of ultraviolet light for disinfection
Wastewater	raw (untreated) liquid flow from an abattoir
Wet weather storage	storage facility required to contain irrigation water during periods of heavy rain etc when irrigation is not required

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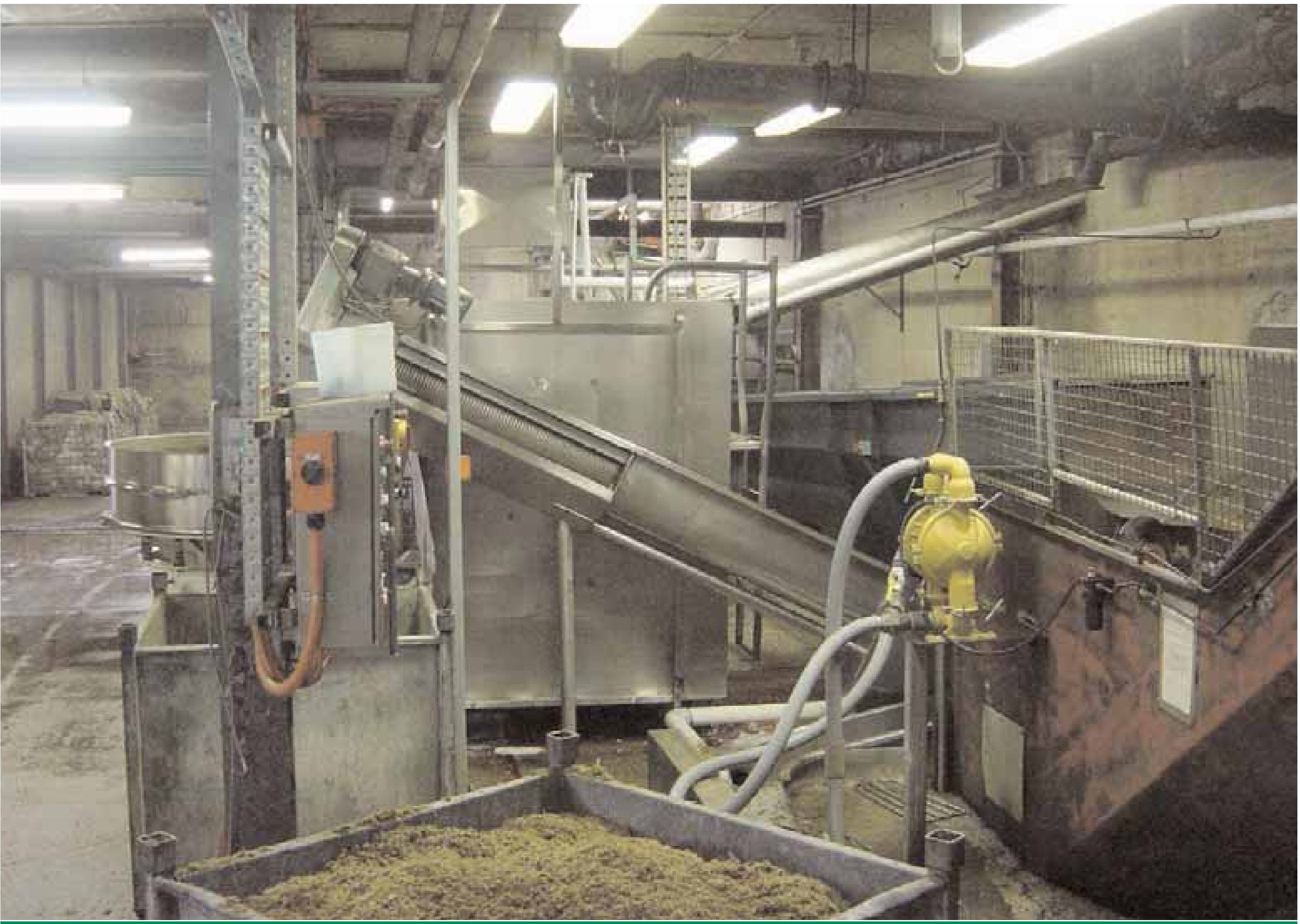
Document Status

Rev No.	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	B Sampson K Hilless	N Georgius		C Hertle		01.03.05
1	B Sampson M Laganistra	N Georgius		C Hertle		20.05.05



Waste solids

Table of Contents

Environmental Best Practice Objectives

- Achieve operation in compliance with statutory and licence conditions applicable to the plant
- Minimise the generation of solid waste and recycle or reuse where possible
- Minimise impacts on the environment associated with waste solids handling, treatment, storage and disposal.

Possible Environmental Impacts

- Soil contamination due to improper storage of waste
- Water contamination as a result of poor management of drainage water or leachate from waste stockpiles or treatment processes
- Atmospheric pollution by dust and odour from treatment operations or poorly managed stockpiles
- Unsustainable disposal of waste solids in a landfill
- Greenhouse gas production from energy consumed in treatment and transport of waste solids
- Effects on local amenity due to visual pollution from poorly located waste and redundant equipment stockpiles
- Food source and breeding ground for vermin, insects and feral animals
- Distribution of weed seeds through poor treatment processing.

Key Performance Indicators

KPI	Industry average (2003)
• Amount of solid waste to landfill	• 15.6 kg/tonne HSCW
• Packaging waste	

- These KPIs relate to medium to large integrated export abattoir facilities, processing > 100 t HSCW/day.

Current Legislation and Regulation	
Commonwealth http://scaleplus.law.gov.au/	• Environmental Protection and Biodiversity Conservation Act 1999 • National Environment Protection Council Act 1994
Queensland http://www.legislation.qld.gov.au/Legislation.htm	• Environmental Protection Act 1994 • Integrated Planning Act 1997 • Environmental Protection (Waste Management) Policy 2000
New South Wales http://www.legislation.nsw.gov.au/	• Protection of the Environment Operations Act 1997 • Environmental Planning and Assessment Act 1979 • Local Government Act 1993 • Waste Avoidance and Resource Recovery Act 2001
ACT http://www.legislation.act.gov.au/	• Environment Protection Act 1997 • Land (Planning and Environment) Act 1991
Victoria http://www.dms.dpc.vic.gov.au/	• Environment Protection Act 1970 • Health Act 1958 • Catchment and Land Protection Act 1994 • Planning and Environment Act 1987
South Australia http://www.parliament.sa.gov.au/dbsearch/legsearch.htm	• Environment Protection Act 1993 • Development Act 1993 • Public and Environmental Health Act 1987
Western Australia http://www.slp.wa.gov.au/statutes/swans.nsf	• Environmental Protection Act 1986 • Soil and Land Conservation Act 1945
Northern Territory http://www.nt.gov.au/lant/hansard/hansard.shtml	• Environmental Assessment Act 1982 • Environmental Assessment and Penalties Act 1996 • Waste Management and Pollution Control Act 1998
Tasmania http://www.thelaw.tas.gov.au/index.w3p	• Environmental Management and Pollution Control Act 1994 • Land Use Planning and Approvals Act 1993

Environmental Best Practice Overview

Waste management plan

Develop a waste management plan that includes:

- waste types and quantities generated
- waste management solutions
- opportunities for minimising waste
- staff training.

Reduce waste

- Consider lifecycle issues when purchasing an item
- Consider processing and packing procedures that minimise waste material.

Reuse/recycle

- Consider purchasing items made from recycled material
- Separate recyclable material from general waste
- Encourage/educate staff to separate recyclables
- Convert organic wastes into usable products.

Minimise waste to landfill

- Monitor & report amount of waste sent for landfill
- Eliminate recyclables from landfill waste.

Processing wastes on site

If processing organic solid wastes on site:

- consider the proximity of neighbours and the property boundary; and
- ensure processing does not contaminate the surrounding environment.

Compliance

- Ensure activities comply with regulatory requirements.

Best Practice Information

Operations at meat processing plants result in the production of a range of solid wastes. Some of these, such as manure and paunch contents, are an unavoidable result of the process, but the impact of others like packaging and equipment can be minimised by judicious purchasing and recycling.

The storage, processing and disposal of waste solids have the potential to lead to environmental degradation if not done correctly. The management of all waste solids should follow the cleaner production hierarchy below:

Cleaner production hierarchy

Most preferred option	**Avoid** – take measures to avoid the waste problem **Reduce** – try to reduce the amount of waste produced
↓	**Reuse** – try to reuse the waste for the same or a different purpose **Recycle or reclaim** – reprocess the waste into a new product
Least preferred option	**Treat** – treat the waste to reduce environmental impact **Dispose** – use only as a last option

The environmental management system (EMS) should include a waste management plan to assist with identifying and dealing with waste issues. The key steps in developing a waste management plan are to describe:

- the activities that generate the waste
- types and amounts of waste that may be generated
- how the waste will be dealt with
- procedures for identifying and implementing opportunities to minimise the amount of waste generated

- procedures for dealing with accidents, spills and other incidents that affect waste management
- details of management system employed to deal with the waste
- how often the performance of the management practices will be assessed
- indicators or other criteria on which the performance of the waste management practices will be assessed; and
- staff training.

Waste exchange databases are maintained in some Australian States. These are facilities that allow generators of waste to contact potential recyclers with the aim of reducing the amount of waste that is deposited in landfills. An example is the program developed by the Victorian EPA and the Victorian Waste Management Association which can be accessed through:

http://www.wastepro.com.au/welcome_exchange.asp

Further Information

- *Environmental Management Systems* [1]
- *Guidelines for the preparation of waste management plans* [2]
- *Environmental Protection (Waste Management) Policy 2000* [3]
  http://legislation.qld.gov.au

Screw presses achieve excellent moisture reduction in paunch solids

1.0 Organic Solid Wastes & Their Characteristics

A range of readily biodegradable organic wastes is produced as a result of meat process operations. Where a plant has sufficient land available and is not located adjacent to a sensitive population, these can be treated on-site to produce a useful and saleable by-product. For plants on sensitive sites, it is best to either transport it to another company-owned site for processing or engage a contractor to transport and process the material.

Typical characteristics of the organic solid wastes generated by meat processing plants include:

- **The quantity generated is directly proportional to animal throughput** and factors such as feed history of the animals, etc. In most instances this cannot be varied significantly due to animal welfare constraints.
- **Biodegradability**. The organic waste solids are very suitable for biological treatment (for example by composting) to produce stable, useful products. Good management of the process is required to minimise problems such as nutrient-rich leachates, odour and vermin.
- **Very wet**. Waste solids produced tend to have very high moisture contents (>85%). This makes them vulnerable to microbial activity and odour production. Care is also necessary to avoid contaminated liquid spilling during transport and processing.
- **Nutrients**. The organic wastes contain nutrients such as nitrogen and phosphorus. These are valuable for reuse. Good management is needed to prevent their loss through leachate and volatilisation.
- **Microorganisms**. The organic wastes contain high levels of microorganisms, potentially including pathogens. A well managed treatment process is essential to ensuring that the final product is safe for use.
- **Toxic compounds & heavy metals**. Meat processing waste solids arise from food manufacture and contain negligible levels of these compounds due to strict control of the supply chain.

When well managed, the organic solids from the meat processing industry are a valuable source of organic carbon and nutrients for many users.

Further Information

- *Waste assessment of contaminants in waste solids from meat processing wastewater streams* [4]

2.0 Organic Wastes Sources

The main types of organic solid waste generated during meat processing and an estimate of their typical (wet weight) quantities recovered is provided in Table 1.

Table 1 Organic Waste Solid Sources

Waste type	Typical quantity (kg/t HSCW)	Range (kg/t HSCW)	Source
Manure (cattle) Manure (sheep) Manure (lambs) Manure (truck wash)	10 per day 9 per day 5 per day	4 – 13 5 – 12 3 – 7 1 - 5	Cattle yards Sheep pens Lamb pens Truck wash
Paunch contents	45	25 - 70	Paunch emptying & washing
Gut contents		15 – 30	Mechanical gut cutting
Solids from primary treatment		150 - 300	Screenings, DAF float, bottom solids
Biological sludges from wastewater treatment	135	70 – 200	Waste activated sludge (10-15% solids)
Dead animals			Stock trucks, yards
NCV Skins			Slaughter floor
Human wastes			Septic tanks

The main quantities produced vary between different plants, but are typically:

- Manure & paunch contents
- Biological sludges, especially where modern aerated wastewater treatment is installed.

Bin of dewatered paunch solids

3.0 Best Practice Management of Organic Solid Wastes

3.1 Manure

Collection

It is preferable to collect manure dry to reduce the solids and nutrients entering the wastewater treatment system from animal holding yards. In unsealed yards, where collection is required, it can be done using a tractor with a front bucket attachment or a front-end loader.

When cattle are in paved holding yards, preliminary animal washing is normally carried out either with fixed sprays or hand-held hoses. Therefore manure and soil is washed away. This stream should be screened as soon as possible or directed to the paunch stream for screening.

Further Information

- *Best Practice Wastewater Treatment, Meat and Livestock Australia* [5]

The use of elevated pens with either mesh or slatted floors for smallstock, allows droppings to fall through to a paved area below. The manure can then be collected dry as necessary.

Manure under the floor of a sheep shed

The wastewater stream from the truckwash is normally combined with the yard washdown stream before primary screening to remove manure and solids.

Storage

The short-term storage of manure should not create a nuisance as long as it is done in an appropriate manner. Wet manure is best stored in a 3-sided bunker with a sealed floor and drainage that can be collected and directed to the sewer or effluent treatment system. Dry manure may be stockpiled on the ground but the area should be bunded to collect leachate in case of heavy rain.

3.2 Paunch contents

Collection

Cattle paunches are the major source of solid wastes from meat processing plants. The manner in which it is collected can have a large effect on the nutrient load of the effluent. Dry dumping of paunches has been advocated for many years and is now gaining wider acceptance in Australia. One study showed that conversion to dry dumping reduced the fraction of the total phosphorus load for the whole plant, generated by paunch processing, from nearly 50% to 16%.

The dry-dumped material can be of variable moisture content depending on the recent animal feed regime and this can pose a challenge when conveying it. Screw conveyors may be used over short distances and pneumatic or positive displacement pump systems over longer distances.

Dry dumping of beef paunches

Further Information

- *Evaluation of beef paunch contents handling practices* [6]
- *An assessment of dry paunch dumping in red meat processing plants* [7]

Paunches from a dry dumping operation will still require washing to remove the remaining material and the effluent from this process should be screened to collect the solids.

Paunch material from dry dumping will require dewatering as will the material from the traditional wet dumping. Different dewatering systems will produce material of differing moisture content. Dewatering systems in order of decreasing moisture are:

- Vibrating screens
- Wedge wire screens
- Screen press
- Screw press.

However, as more moisture is removed from the paunch material, a greater amount of nutrients will be lost with the liquor. It has been suggested that instead of directing this stream to effluent, it could be collected and used to add moisture back to the latter stages of a composting operation.

The paunch material should be dewatered to the extent suited to the subsequent transport and processing.

Dewatering screw system

Transport and storage

Paunch contents are often transported some distance either within the boundaries of the processing plant or over public roads to another site for stockpiling and processing.

When transporting within the site, a suitable vehicle should be used that prevents leakage. Transport off-site will normally require a licensed operator using a vehicle that eliminates release of offensive odours, liquor and solids. Procedures must be followed to ensure that the material is disposed of correctly.

If they are not to be processed immediately, paunch contents can normally be stockpiled without causing offence. The material should preferably be stored in a bunker with a sealed floor in which any leachate or rainwater is collected and directed to wastewater treatment. Under most conditions, a cover is not normally required but if this proves unsatisfactory, the material may be covered with a layer of inert material such as bark or woodchips. If stored on the ground, a compacted earthen or concrete pad should be used to prevent leaching into the ground. Any runoff should be collected for treatment.

3.3 Effluent primary treatment screenings

Collection

Primary screening of the effluent from a meat processing plant will produce a wet product consisting of meat scraps, fat and semi-digested feed that has been washed down the drains. This can be collected in a container or trailer that drains onto a concrete pad which in turn should drain to the effluent treatment system.

The collected material is attractive to flies, so the collection vessel should be covered or sprayed to control flies during summer.

Transport

During transport to the treatment or disposal site the drains from the container or trailer should be plugged to prevent liquid leaking out.

Processing

This material can be rendered or treated along with other solid wastes. Where the rendered products are produced for certain export and domestic markets, this material must be excluded. When included with normal rendering raw materials, screenings should be processed fresh otherwise the quality of the tallow may be affected.

This highly putrescible material should not be stored for longer than one day before mixing with other material for treatment. It should be stockpiled such that any leachate is collected and directed to effluent treatment.

Gut floor
static screen

3.4 Saveall and DAF top scrapings

Collection

Recovered fat and protein is continually or periodically scraped off the top of savealls and dissolved air flotation (DAF) systems. This is normally directed straight to a vessel for pumping to the treatment plant.
In some plants hydrocyclones are used to continuously recover fresh fat from the waste water stream. This recovered material may then be included with the normal rendering raw materials without downgrading the tallow.

Processing

The recovered material is normally only about 5% solids and a wet rendering process can be used to produce a low-grade "saveall" tallow. If the material cannot be rendered on site, composting is an alternative recycling option.

3.5 Biological wastewater treatment sludges

Anaerobic lagoons are efficient at digesting biological solids and normally accumulate bottom solids at a slow rate. The rate of accumulation will depend on upstream treatment and loading. When an anaerobic lagoon is desludged, options for managing the sludge include:

- application to suitable land
- drying in on-site drying beds; and
- dewatering to produce a cake that is transported off-site or treated on site.

Some processors operate secondary effluent treatment plants, such as activated sludge systems, from which waste biological sludge must be extracted on a daily basis. As collected, the sludge has a low solids content of about 1%w/v. It is therefore desirable to thicken or dewater the sludge in order to reduce the sludge volume to be disposed of.

This can be achieved by:

- settling in a tank to generate a thickened bottom sludge, or
- mechanical dewatering with addition of a polymer. In this case, the sludge can be concentrated to 10-20% solids using apparatus such as a decanting centrifuge or belt filter press.

At about 15% or higher solids content, waste activated sludge can be stockpiled for short periods without the need for special containment. However rainwater drainage from the stockpile site should be collected for treatment.

The dewatered sludge can be incorporated with other wastes for treatment.

Belt press sludge

3.6 Slaughter and boning waste

Medium to large size meat processing establishments either have an integrated rendering plant or a collection service from a contract renderer to recycle their processing wastes to valuable co-products. However, it is not economical for some small country plants to develop their own rendering facility and they may be too remote for a collection service. This gives them limited options for disposing of these wastes.

Options in this case include:

- **Burial**. This has been a common disposal method but can result in land or ground water contamination. It is not preferred.
- **Composting**. Aerobic composting procedures can be adapted for handling these wastes. The material must be incorporated with a considerable quantity of bulking agent such as sawdust, bark or woodchips. A ratio of 1:1 (v/v) has been suggested to balance moisture and nutrient requirements. Preferably they should only form a minor ingredient of the initial compost mixture which could also include manure and paunch contents. A mechanical aeration system may be needed to ensure adequate aeration. However odour generation is still likely to be a problem.
- **Dry Composting**. This technique has been developed to handle these highly putrescible materials. Similar methods have been developed in Australia and the U.S.A. where the materials are placed on a bed of bark or woodchips and covered with sawdust to a depth of at least 300 mm and left undisturbed for about 3 months or more. By this time most of the organic matter has broken down and the bones are brittle and easily broken. The operation should ensure that material remains well covered with sawdust to discourage birds and vermin. The pile may need to be covered with Hessian or similar material to ensure the sawdust cover remains intact.

This has been called 'dry composting' as no water is added or mixing done at this stage. The material can then be shredded and spread or further composted with manure and paunch material using turned windrows.

Further Information

- *Rotational bunker system composts sheep offal* [8]
- *Alternative waste management for country meat processors,* http://www.ncea.org.au/. [9]
- *Meat by-products as composting feedstocks* [10]
- *AGWISE Project, Book 2* http://www.ncea.org.au/,
- *Food Science Australia Meat Technology Update 02/5*
- *Cornell Waste Management Institute,* http://cwmi.css.cornell.edu/

3.7 NCV sheepskins

Depending on skin and wool prices, bare shorn pelts, predominately from merino cast-for-age ewes, may have little or no commercial value (NCV). It was the practice to bury these in deep pits with a covering of lime. However it was found that they sometimes took up to 20 years to degrade as they were buried in too great a concentration.

In the early to mid 1990s, when the problem of NCV skins was most severe, the Meat Research Corporation funded several projects to develop alternative uses for merino sheepskins and investigate more environmentally sustainable disposal methods. The recommendations for disposal of NCV skins were:

Rendering

Provided quantities were small and the wool short, sheepskins and skin pieces could be included with other raw materials for rendering. Whole skins may need to be manually cut into smaller pieces. If too much wool is included in the standard rendering process, the value of the meal will be reduced.

Burial

It was considered that, although not desirable, the practice of dumping large numbers of skins in clay-lined pits had not lead to environmental harm. The skins dry and lie inert in the ground for many years, slowly degrading. The skins could also be used to rehabilitate degraded land by laying them 3 to 4 deep and covering with about 100 mm of sheep manure and then with topsoil to a depth of about 100 mm. The topsoil is seeded and the treated areas recover with no apparent odour problem and the skins break down rapidly.

Storage

The skins are salted and stored in a shed until the price of sheepskins recovers sufficiently to cover costs.

Composting

Whole NCV skins can be composted with paunch manure and other meat processing wastes. Trials indicated that best results were achieved when a bulking agent such as pine bark was included in the mix and the compost was turned regularly with the addition of water as necessary. When no bulking agent was added, decomposition was slower and higher odour levels were experienced.

Further Information

- *Disposal of NCV Skins [11] and Composting of NCV Skins [12]*

3.8 Dead stock

Sometimes, stock die during transport to the processing plant, or in the yards while awaiting slaughter. Normal practice has been to either process the bodies through the rendering plant or bury them on the plant property. Burial will require approval of the local council and EPA and, due to the possibility of land or groundwater contamination, is unlikely to be approved. Also, some importing countries will now not accept rendered products that have been produced from raw materials that may include dead stock.

Rendering is likely to be the most environmentally benign method for disposing of dead stock, but if it is not an option, disposal methods may be limited to:

- **Commercial landfill.** Some councils and commercial operators will accept dead stock for 'special burial' or disposal to a lined landfill where leachate is collected. They will have a scale of fees based on animal size.
- **Composting.** Dry composting techniques have been developed for processing stock that have died on farms. If the processing plant has a suitable site available, these composting techniques can be applied to the bodies of both smallstock and cattle. It is recommended that compost from animal carcasses should not be used to fertilise grazing land or crops that will be consumed directly by people.

Further Information

o *Natural rendering: Composting livestock mortality and butcher waste* [13]

Dry composting of dead stock

4.0 Best Practice Treatment of Organic Solid Wastes

The organic solid wastes produced from meat processing are eminently suitable to biological treatment processes. Due to their high moisture content, they are not particularly suitable for thermal energy recovery processes without extensive dewatering, which is typically uneconomic. Table 2 summarises current best practice technologies. Composting is the most commonly used.

Table 2 Treatment options for Organic Wastes

Disposal method	Suitable for	Comments
Composting	All organic solids	Composting is by far the most accepted method for treating and recycling nutrients present in all organic wastes from meat processing. Several techniques may be utilised but all produce a stable final material that can be sold as a soil conditioner or ingredient in a potting mix. However the value of the compost may not fully recover the cost of production. The main problem encountered is odour complaints from neighbours in sensitive areas.
Dry composting	Dead animals Slaughter & boning wastes	The pile may need to be covered to protect from the elements and discourage scavengers. A further composting process may need to follow to produce a usable product.
Anaerobic lagoons	Paunch solids Aerobic treatment sludges	The use of an anaerobic lagoon will digest about one third of the paunch material but the lagoon will silt up more rapidly requiring expensive dredging and disposal of the sludge.
Anaerobic digestion	Paunch contents Manure	This is a more sophisticated form of an anaerobic lagoon where the waste is digested in a sealed stirred tank. Biogas is produced (approx 60% methane) which may be flared off or used as a fuel. After 10 – 30 days the solids are separated from the liquid and further stabilised or applied directly to land.
Surface spreading	Paunch contents Manure Anaerobic pond sludge	Although widely used in the past and inexpensive it will now require a permit. It is not preferred as there are environmental concerns as well as the risk of distributing weed seeds.
Sub-surface Injection	DAF sludges Paunch contents Aerobic treatment sludges	Direct soil injection can be practised with the approval of the EPA. It has the advantage of reducing the fly problem but the long term effect on the soil should be monitored.
Ensilage	Paunch contents	Trials have been conducted in the U.S. to produce a cattle feed but paunch has a low feed value and the cost of production and possible negative publicity discourage the process.
Rendering	Primary effluent screenings DAF float	The inclusion of screenings and DAF or saveall scrapings may exclude rendered products from certain markets. A low quality tallow is produced.
Vermicomposting	Manure Paunch contents Aerobic treatment sludges	Worms will readily digest manure and paunch material and the resulting vermicast is claimed to be of high value, but the process requires significant investment and management. Several operations have been successful whereas others have failed.

Composting is discussed more fully in Appendix A.

4.1 Waste to energy

A review was recently completed of technologies that may be suited to production of energy from meat industry wastes. The review considered:

- thermal
- biological
- thermochemical; and
- chemical processes.

Further Information

- *Review of waste solids processing and energy capture technologies* [14]

At present, application of waste to energy technologies in the meat industry in Australia is almost non-existent. This is mainly because the technologies are unlikely to provide an economic advantage over current practices. Major factors in this are the high water content of meat wastes and the comparatively low energy costs in Australia. The capital and operating costs of most waste to energy processes exceed the possible revenues obtained from sale of the electricity generated.

Experience overseas and in other industries has shown the financial viability of conventional waste to energy plants is normally accomplished through fees paid to plant operators by waste generators for disposal of wastes.

However, if there is some future development in Australia, such as a BSE outbreak, and the present practices of rendering and composting cannot be continued, more expensive technologies, such as waste to energy, may have to be applied. Technologies that appear to be most suitable for wet meat wastes include:

- thermal pressure hydrolysis; and
- thermal depolymerisation and chemical reforming.

4.2 Choice of technology

Considerations regarding the choice of technology to handle meat industry solid wastes include:

- Capital and operating costs
- Availability of processing site, equipment and skills required for the process
- Potential adverse effects on the environment
- Opportunities to outsource the technology
- Regulatory constraints
- Quantity & characteristics of the product
- Product market and value.

Gas engine, running on biogas

5.0 Best Practice Management of Packaging Wastes

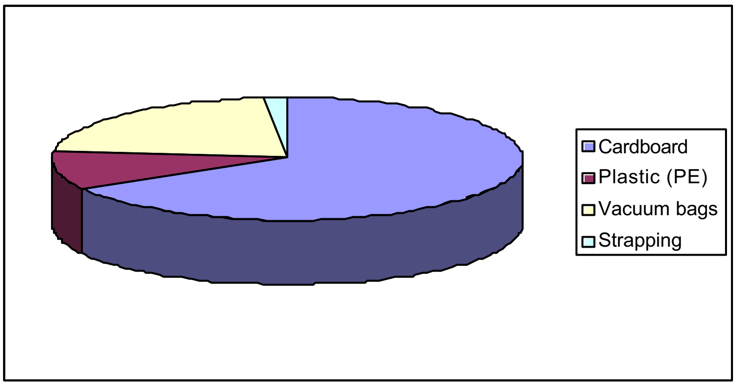
Relative to other industries, the meat industry is a heavy user of packaging materials. Recycling rates for many of the packaging components can be low. Best practice management of packaging wastes involves full use of cleaner production hierarchy principles to achieve the best environmental outcomes.

Estimated total usage of packaging materials and waste produced is summarised in Table 3 and Figure 1 from a 1996 report to MLA.

Table 3 Estimated quantities of major packaging materials used by the Australian meat industry

Packaging	Domestic (tonnes)	Export (tonnes)	On-plant waste (tonnes)	Total (tonnes)
Cardboard	14,191	28,568	985	43,745
Plastic (PE)	232	2,471	141	2,735
Vacuum bags	1,607	1,681	320	3,608
Strapping	375	781	23	1,179

Figure 1 Estimated proportions of packaging wastes



Best management of packaging wastes is detailed below for the major materials.

5.1 Cardboard

Waste cardboard occurs from packaging for consumables and equipment delivered to the site and as waste from the packaging of the meat products. Most cardboard can be readily recycled.

Avoid/Reduce

- Do not use or purchase items in waxed cardboard as it is difficult to recycle
- Ensure that new fibreboard packaging is not damaged on arrival and during storage
- Use handling procedures that do not damage cartoned meat to minimise re-packing
- Consider automated carton assembly, as there is up to 50% less packaging waste than with manual assembly due to reduced rejects.

Further Information

- *Trends and future regulatory issues concerning packaging material used in the Australian meat industry* [15]

Reuse/Recycle

- Provide recycling bins for waste cardboard and paper in a convenient position and ensure that all appropriate waste is deposited there
- Purchase fibreboard cartons that have been made from predominately recycled material
- Utilise reusable packaging systems, such as Pallecons, for transport of meat.

Treat/Dispose

- Try to avoid depositing waste cardboard and paper in with general rubbish.

Recycling – cardboard bales

5.2 Plastic

A high percentage of the plastic waste from meat processing plants results from the packing process and consists largely of plastic bags and strapping.

Avoid/Reduce

- The amount of waste from the vacuum packing can be reduced by:
  - choosing the correct bag size to reduce off-cut
  - using a supply of bags on perforated rollstock rather than loose bags that may be dropped on the floor
  - installing equipment that produces bags to length from continuous tube stock.
- Where possible seal cartons using automated gluing machines rather than strapping to reduce waste strapping.

Reuse/Recycle

- Some plastics such as shrink and stretch wrap and bags and liners are made from polyethylene. Provided these are not contaminated with blood, they can be collected in a separate bin for recycling.

Treat/Dispose

- Vacuum bags are made from multiple layers of different plastics co-extruded to form a film and are not readily recyclable
- Heat sealable strapping used in the meat industry is made from polypropylene and is not readily recyclable
- Landfill is currently the only acceptable method for disposal of most plastic film and strapping.

Further Information

- *Trends and future regulatory issues concerning packaging material used in the Australia meat industry* [15]
- *MLA Packaging advisory package* [16]

5.3 Drums

Meat processing plants receive cleaning chemical, lubricants, etc in either plastic or steel drums.

Avoid/Reduce

- When purchasing these items, consider buying the largest containers practicable where compatible with OH&S practices. It is easier to deal with one empty 50 L container than 5 empty 10 L containers.

Reuse/Recycle

- When purchasing, look for the drumMUSTER logo or drums that can be recycled or reused. These can be collected and recycled by your local agent or delivered to a recycling depot. drumMUSTER is a national program aimed at farm chemical containers and supported by chemical suppliers, the National Farmers Federation and the Australian Local Government Association for the collection and recycling of used chemical containers. Suppliers of pest control chemicals may be a member of drumMUSTER.
- Containers without the drumMUSTER logo may also be able to be recycled.
- Before containers are returned for recycling, they should be rinsed properly to remove any chemical residue.
- Drums should be stored in a suitable location prior to recycling or disposal. Particular care needs to be taken to ensure that chemical or petroleum residue does not contaminate the surrounding area.

Treat/Dispose

- Avoid disposing of plastic or metal chemical containers to landfill.

Further Information

- *Refer to the drumMaster website:* http://www.drummuster.com.au [17]
- *Method to properly rinse containers* [18]

6.0 Best Practice Management of Inorganic Solid Wastes

6.1 Boiler ash

Many Australian meat processing plants operate coal-fired boilers to produce steam for rendering and production of hot water. In many parts of the country, coal is the cheapest form of energy but ash handling and disposal is an added cost.

- To eliminate coal and ash handling consider converting to clean burning, gas-fired boilers
- Coal can have an ash content from as low as 3% to over 20%. If convenient and suited to the boiler, purchase coal with a low ash content
- Collect ash in a properly designed bunker or hopper. This should contain the ash so that no dust is generated either during storage or during collection for removal
- Boiler ash can be blended in with other waste materials at an on-site composting operation
- Any storage at the composting site should be done in a manner that minimises dust
- Ash may be collected by a contractor for disposal or use or treatment off-site.

Fly ash

Further Information

- *An experimental study of the effect of coal blending on ash deposition* [17]

6.2 Redundant plant and equipment

Most meat processing plants have an equipment ‘graveyard’ where redundant items are stored until they are either reused or scrapped. If not managed properly, this area can become unsightly and be a haven for vermin.

If it cannot be remotely located, the area should be surrounded by a solid fence and kept tidy by regular mowing and weed and vermin control.

7.0 Best Practice Management of Other Wastes

7.1 Paper towels

A large quantity of paper towel waste is generated at personnel wash stations at entry and exit from processing areas. If this waste can be kept separate from other wastes such as plastics, rubber and general waste, it can be collected for recycling or incorporated in a composting operation.

- Consideration should be given to providing separate bins with appropriate signage for paper towels
- Personnel should be encouraged and educated to use them correctly.

7.2 Office paper

Most offices will produce significant quantities of clean waste paper and shredded paper.

- Where suitable recycling collections are available, bins should be provided for exclusive collection of this paper
- Staff should be encouraged to deposit paper in recycling bins rather than with general rubbish
- If recycling facilities are not available, consideration could be given to including shredded paper in an on-site composting process.

7.3 Canteen wastes

Wastes produced in staff amenities include food scraps and packaging as well as recyclables such as aluminium cans and PET and cardboard drink containers.

- Where suitable recycling collections are available, suitably labelled separate bins should be provided for:
  - Aluminium cans, and
  - Plastic bottles.
- Staff should be encouraged to deposit recyclables in the appropriate bins rather than in general rubbish.

7.4 Human wastes

Due to their location, the majority of meat processing plants are not connected to a municipal sewerage system. Human wastes are normally treated in a septic system and the sludge from septic tanks may need to be pumped out at regular intervals.

- The septic system should be pumped out by a licensed contractor using suitable equipment with a sealed vessel
- The septic sludge should be removed from the site and not mixed with meat processing wastes.

8.0 Monitoring & Reporting

Quantities of solid waste to landfill and the quantity of packaging waste generated should be recorded in order to gauge whether plant performance is in line with reported industry averages and whether improvement is being made. The results of monitoring should be regularly reported to plant management.

Presented below are suggested methods of recording:

- amount of solid waste to landfill; and
- packaging waste.

8.1 Amount of waste to landfill

The amount of waste to landfill can be estimated from the volume and number of bins filled. This should be expressed as weight to landfill against production (ie kg/t HSCW). The two most recent surveys conducted by MLA revealed widely varying quantities of waste to landfill between the plants and for the same plants between surveys. The 1998 survey suggested a benchmark of 5 kg per tonne HSCW for solid waste to landfill whereas the 2003 survey recorded a score of 15.6 kg/t HSCW.

The aim should be to continually reduce the amount of waste to landfill in proportion to production.

Further Information

- *Benchmarking of environmental performance* [20]
- *Industry environmental performance review of integrated meat processing plants in 2003* [21]

8.2 Packaging waste

Packaging waste falls into two categories; wastes that can be recycled, such as cardboard and uncontaminated polyethylene and non-recyclables, such as vacuum bags and strapping. Recording and monitoring the quantities (kg/t HSCW) of these wastes may give an indication of operational problems in parts of the plant.

9.0 Contingency

Contingency plans should be formulated to ensure that solid wastes from the processing plant do not lead to public nuisance or damage to the environment due to events such as:

- equipment failure
- transport breakdowns
- accidents
- extraordinary rainfall.

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Appendices

Appendix A: Composting

Composting can be defined as a biological process in which organic matter is broken down under aerobic and thermophilic conditions into a humus-type end product with by-products of carbon dioxide, water and heat.

A wide range of organic waste materials produced by meat processing plants are suitable for composting.

A variety of composting methods are available. These include:

- static windrow
- turned windrows
- aerated static pile
- in-vessel systems.

Static windrows rely on passive aeration to provide oxygen. Air enters the pile through a combination of diffusion and convective movement through the compost. The size of the windrow and the porosity of the material affect how well this works.

Static windrow composting is suitable only for wastes with a low content of readily biodegradable substrate and an open structure. Wastes with a greater oxygen demand may be diluted with a coarse, porous inert bulking agent.

With static windrows, anaerobic conditions and sub-optimal temperatures are unavoidable and stabilisation periods may range from 6 months to 2 or more years.

Turned windrows are aerated by periodically turning or agitating the compost. This also loosens the structure of the material to facilitate passive aeration and heat removal. A front-end loader or a specialised turning machine is commonly used.

Wastes with higher oxygen demand can be composted and larger windrows can be used than with static windrows. The frequency of turning required to prevent nuisance odours and achieve rapid stabilisation will depend on the waste's oxygen demand and porosity. Stabilisation periods of less than three months are achievable for some wastes.

Aerated static pile composting uses a fan and air distribution system to provide oxygen to the compost. The windrow can be formed over an aeration base and air distribution system or the material can be partially enclosed in a bin with a perforated floor.

Temperature-controlled aeration has been found to give good results where air is supplied to maintain a maximum compost temperature of about 60°C. Forced aeration is normally used but induced aeration has also been applied.

Aeration is normally applied for 3 – 4 weeks during which most of the readily biodegradable material is broken down. This is followed by curing in non-aerated piles for several more weeks, with periodic turning to promote additional stabilisation and ensure a uniform structure and moisture content.

Temperature-controlled forced aeration composting is best suited to stabilising organic wastes that contain highly biodegradable material that have the potential for high oxygen demand.

In-vessel systems utilise a higher degree of control again than aerated windrows. In these systems the compost is normally agitated by rotating the vessel into which air is injected at a rate to control the temperature and provide sufficient oxygen.

This is a highly capital-intensive system best suited to large municipal or commercial composting organisations.

Immature compost row

Composting site

It can be difficult to compost meat processing wastes without generating some odour or dust. Therefore, it may be best for plants located in a sensitive area to transport wastes off-site for processing. If composting on-site, the siting of the composting operation should take into account, the position of neighbours, the position of the office and edible operations, prevailing winds and the distance from property boundaries.

Approximately one hectare of land will be required for every 60 m^3 of waste solids processed per week. The site should be suitable for all-weather operation and be reasonably level and well-drained such that ponding of rainwater does not occur. Runoff should be collected and directed to the effluent treatment system.

A sealed area should be provided for mixing the wastes and bulking agent if used and suitable storage facilities supplied for wastes delivered to the site. A three-phase power supply may be required if a screening plant is provided and a water supply (not necessarily potable) should be provided to allow addition of moisture to windrows and for use in dust suppression.

Further Information

- *Recommended techniques for composting meatworks wastes*
- *Organic waste management strategy M.682*
- *AS 4454-2003, Composts, soil conditioners and mulches*
- *AS 3743-2003, Potting mixes*

Labour and equipment

The labour requirement for a plant processing 500 cattle per day would be about 4 man-hours per day for the collection and composting of wastes.

The minimum equipment suggested for a forced aeration composting operation is:

- A front-end loader with a 1 m^3 bucket and a lift height of 2 m.
- In the case of the aerated static pile method:
  - Three aeration bases with suitable ducting.
  - Three fans and control units.
- A finished compost screening plant.

Compost quality

The compost operator should aim to produce a consistent product, especially in relation to:

- moisture
- pH
- colour
- odour
- particle size.

This may require a consistent raw material and regular monitoring of the process. The finished product should be regularly analysed for pH, moisture and nitrogen.

There may be marketing advantages in producing a product to Australian Standard AS4454-2003 Composts, soil conditioners and mulches.

Marketing

Compost from abattoir wastes can be sold as a soil conditioner, organic fertiliser or ingredient in a potting mix. Value may be added by bagging the product or tailoring to specific markets by screening to a specific size or supplementing with inorganic nutrients.

A recent study showed that meat industry wastes from which composts are produced contained negligible quantities of contaminants such as heavy metals and pesticides.

A study of the Australian market for abattoir compost in 1995 estimated that approximately 17 million cubic metres per year could be produced from Australia's abattoirs. Potential markets for the compost were the urban, horticultural and agricultural segments. The urban and horticultural markets were likely to provide the best return but in order to market all the potential compost, the agricultural market would need to be developed.

A meat processor should develop a marketing plan for the product before establishing a composting operation. The main information required to develop a marketing plan is presented below.

- Identify the main markets within a reasonable distance (say up to 50 km) of the abattoir
- Estimate the quantity and quality of the compost that can be produced
- Match the estimated production with the main potential markets, to ensure that the abattoir can meet the needs of the local available market
- Identify sources of bulking materials for producing the compost
- Determine the market size and price for the compost
- Identify competing products.

In many cases the meat processor may not be interested in producing and marketing the compost. It may be better to engage a contractor, who has an existing marketing network, to collect the wastes and produce the compost.

No matter which marketing method is used, it is likely that full cost recovery is not possible; only an environmentally acceptable and lower cost disposal route for solid waste.

Further Information

- *Organic waste management strategy* [22]

Odour

TABLE OF CONTENTS

Environmental Objectives

Environmental best practice for odour and air quality requires:

- Operation in compliance with statutory and licence conditions applicable to the plant
- Operation to minimise impact on surrounding community air quality
- Achievement of air quality objectives through plant design, operating procedures, waste minimisation, air emissions and odour collection and treatment system design and operation.

Potential Environmental Impacts

Odour Emissions – from operations within the meat processor:

- Animal receival and holding (lairage/pens)
- Rendering and blood drying
- By-product storage and handling
- Waste water treatment
- Waste material disposal and handling

Kill floor and meat processing emissions do not generally cause adverse impacts.

Smoke (particulate emissions)

- Solid fuel combustion
- Plant dust control
- Rendering processes.

Low Level Dust

- Animal movements.

Gaseous Emissions

- Fuel burning equipment
- SOx and NOx
- Greenhouse gases.

Key Performance Indicators

- Odour levels at the nearest receptors
- Contaminant emission concentrations and opacity
- Greenhouse gas emissions (kg CO_2-e/tHSCW)
- Community complaints (complaints/ktHSCW)

Current Legislation and Regulation

Compliance legislation varies from State to State but generally specifies no offensive odour at the nearest receptor or boundary.

Odour guidelines used for *consent and/or planning applications* are based on a dispersion modelling-based criterion. The criterion specifies a maximum odour concentration at a particular exceedence level and averaging time period.

Modelling-based regulation is not generally used for compliance purposes. For this reason odour emission levels for individual odour sources are rarely prescribed in licenses.

Particulate and gaseous emission levels are normally specified as source concentrations.

FURTHER INFORMATION

- *Odour guidelines for each Australian state are available from MLA* [1]
- *A more recent summary is available in the Odour Intensity Report* [2]

Key Legislation by State	
Queensland	*Environmental Protection Act 1994* *Environmental Protection Regulation 1998* *Environmental Protection (Air) Policy 1997*
New South Wales	*Protection of the Environment Operations Act 1997* *Authorised Officers Manual: Abattoirs* *Draft Policy: Assessment and Management of Odour from Stationary Sources 2001*
Victoria	*Environment Protection Act 1970*
South Australia	*Environment Protection Act 1993*
Western Australia	*Environment Protection Act 1986* *Environmental Code of Practice for Abattoirs* *Environmental Code of Practice for Rendering Plants 1991*
Tasmania	*Environmental Management and Pollution Control Act 1994* *Environmental Code of Practice for Meat Premises (Slaughtering) 1995*
Northern Territory	*Environmental Assessment Act 1982* *Environmental Offences and Penalties Act 1996* *Waste Management and Pollution Control Act 1998*
Australian Capital Territory	*Environment Protection Act 1997* *Environment Protection Regulations 1997* *Code of Practice – Livestock and Poultry at Slaughtering Establishments*

Environmental Best Practice Overview	
Processing Plant Location and Site	• Understand site topography and meteorology, and possible katabatic drainage of odours • Site plant to minimise air quality impacts on surrounding community by having regard to dominant and problematical wind directions
Identify all Odour and Air Emission Sources	• Quantify and rank all sources • Apply emission minimisation principles to eliminate/minimise air emissions • Provide air emission treatment to remaining sources as required to meet licence conditions and community obligations
Management Focus on Air Quality	• Training and culture to understand air quality issues • Operating procedures to minimise air emissions • Comprehensive data base on weather conditions and plant operation abnormalities • Reporting systems to retain focus on air quality and maximise the value in the feedback from residents (time, duration, odour character etc.)
Performance Monitoring	• Air quality as a key performance indicator • Include community feedback along with quantitative emission monitoring • Retain staff focus
Community Relations	• Develop a communications strategy which addresses community feedback • Implement a formal complaint handling procedure

1.0 BEST PRACTICE INFORMATION

Achieving best practice in odour and air quality takes account of the following:

1.1 Processing Plant Location

The size and shape of the property on which a plant is to be built will affect the potential for odour and air emissions to impact on surrounding residents. The judicious siting of odorous plant and wastewater treatment facilities on a site is as critical as the selection of the site itself. These criteria apply to new plants and may be difficult to apply to existing plants on well-established sites. Some points for consideration in site selection are:

- City or country location
- Site size and shape
- Avoid obvious katabatic (air drainage) problems
- Larger, rural locations are more tolerant to on-site disposal of waste materials
- Allow for the possibility of including a rendering plant even if the processing plant does not initially intend to process by-products.

1.2 Processing Plant Scale and Scope

- Larger meat processing plants incorporate greater integration of secondary processes – rendering and blood drying for example, which may increase odour emission risks
- Smaller and regional meat processing plants may export secondary processing off-site. In this case, they need only consider animal holding pens, wastewater treatment and possibly thermal plant as odour and air emission sources, although future plans may dictate the inclusion of secondary processing
- Processing plant age
- Equipment and technology upgrades
- Building design and ventilation
- Integration of odour and air emissions controls.

1.3 Raw Materials

- Condition of raw material stored and processed through the by-products (rendering and blood drying) systems.

FURTHER INFORMATION

- _Refer to the MLA Advisory Package on Rendering for specific recommendations_ [3]

1.4 Fuel Sources

Fossil fuel sources for thermal plants determine gaseous and greenhouse gas emissions.

Coal used for fuel at a processing plant

2.0 TYPES OF AIR EMISSIONS

Air emissions fall into three categories, defined below:

2.1 Gaseous Emissions

Gaseous emissions refer to the release of specific chemical compounds into the air from meat processing operations. The National Pollutant Inventory Handbook for Meat and Meat Product Manufacturing lists the following as major gaseous pollutants to atmosphere:

- Ammonia
- Carbon monoxide
- Hydrochloric acid
- Nitrogen oxides
- Particulate matter
- Sulphur dioxide and sulphuric acid
- Total VOCs.

The industry is also a producer of greenhouse gas – particularly carbon dioxide and methane – and many other gaseous pollutants in lesser quantities.

FURTHER INFORMATION

- *National Pollutant Inventory Handbook for Meat and Meat Product Manufacturing* [4]
- *The full pollutant inventory is available on the NPI website at: www.npi.gov.au*

2.2 Particulate Emissions

Particulate emissions refer to the release of discrete particles of material, generally from:

- fuel combustion
- drying processes
- dust from vehicles or livestock movement, or wind action.

2.3 Plant Odour

Although both gaseous and particulate emissions can be odorous, odour emissions represent complex mixtures of components with an associated odour. Meat processing can generate a variety of odorous emissions each with its own complex character, some unpleasant.

FURTHER INFORMATION

- *Investigations of odorous gas emissions from meat and rendering plants* [5]

A typical odour inventory for an integrated meat processing plant demonstrates the contributions of source and treated odours to overall plant odour emissions is presented in Table 1. Odours may be from area or point sources.

2.4 Point and Area Sources

Any of the above categories of emission can be further classified according to whether they are:

- Point sources - comprise a concentrated stream of air or process gas exhausted to the atmosphere through a stack or similar defined outlet. These are the major sources of particulate (solids fired boilers) and gaseous emissions and include some odorous streams.
- Area sources - are generated over large areas rather than a defined point. Examples include compost heaps, wastewater ponds or animal holding yards. They can be more challenging to control.

These boiler stacks are one example of a point source

Holding yards are an area source for emissions

Table 1 – Ranking of odour sources from an integrated meat processing plant

ODOUR SOURCE	ODOUR EMISSION RATE	ODOUR CONCENTRATION
Abattoir Sources		
Kill Floor Vents	X	X
Holding Pens/Yards	XX	X
Wastewater/Waste Sources		
Save All	XXX	XX
Wastewater Screening	XX	XX
Anaerobic Lagoon (crusted)	X	XXX
Aerated Lagoon	X	X
Settling/Holding Ponds	X	X
Effluent Irrigation	X	X
Paunch Storage Piles (static)	XX	XX
Paunch Storage Piles (during turning)	XXXXX	XXXXX
Rendering Sources		
Raw Materials Receival (fresh)	X	X
Raw Materials Receival (imported/aged)	XXX	XXXX
Blood Tank Vent	X	XXX
Cooker Non-condensable Gas (untreated)	XXXXX	XXXXX
Rendering Process Air (effective collection)	XXXX	XXXX
Rendering Room Ambient Air (effective collection)	XX	X
Blood Dryer Stack (scrubbed)	XX	X
Meal Process and Storage Area	XX	XXX
Tallow Loading	X	XX
Odour Control System Sources		
Thermal Oxidiser Stack	X	X
Biofilter Exhaust	X	X

3.0 BEST PRACTICE AIR EMISSIONS MANAGEMENT

Best practice in odour and air quality is strongly influenced by plant location and the proximity of a potentially affected neighbourhood.

For the purposes of this guide, the following definitions are used:

- **Isolated** - the processing plant and all of its ancillary equipment is located and sited so that there is adequate opportunity for the dispersal of low level odours and settling of low level dust, thus causing negligible impact on neighbours.
- **Sensitised** – the processing plant location and siting is such that low level odour and/or dust may be detectable beyond the plant boundaries under at least some wind conditions and there is a significant sensitivity to air quality from plant neighbours

3.1 General Principles

Graphic modelling of likely odour impacts

Minimisation of air emissions – odour, gaseous and particulate – requires the integration of air quality into all aspects of plant layout, design and operation. Dispersion modelling and knowledge of the dominant and most problematical wind directions should be used to locate odorous plant and wastewater treatment facilities such that dispersion to nearest receptors is maximised.

Where rendering is carried out it is important to maintain by-product material in a fresh condition prior to rendering. While this is not generally a problem for integrated plants, the condition of imported by-product material and blood from off-site can greatly increase odour emissions if this material is in a deteriorated condition. The unloading and handling of this imported material must be carried out without major exposure to atmosphere.

FURTHER INFORMATION

- *An audit of NSW processing plants is reported in a Compliance Performance Report* [6]

3.2 Emission Minimisation

Air emission minimisation optimises process plant design and operating procedures to reduce the load on air emissions control equipment.

Best practice:

- Regular cleaning of holding yards – particularly for processing plants in sensitised areas
- Regular and frequent removal of waste material from the processing plant – either off-site or for further treatment on-site
- Prompt processing of material for rendering
- Avoid receiving aged material for rendering unless appropriate receival and processing systems are in place
- Waste and processed material (meal etc) to be transported around the site in enclosed systems wherever possible
- Non enclosed systems to be accessible for regular clean down
- Proper operation of water treatment systems to avoid odour generation in treatment and holding ponds and during irrigation.

FURTHER INFORMATION

- *WA Rendering Code of Practice* [7]
- *Odour Minimisation Manual* [8]

3.3 Management Culture

Management attitudes will determine the success achieved in emission minimisation and air emission plant operation.

Best practice:

- Air quality as a key management goal in plant operations
- Air quality reporting integrated into overall operations reporting to ensure appropriate attention at all management and operational levels
- The culture of air quality achievement as part of staff training
- Air quality as a goal in it's own right, as well as a result of good housekeeping and other operational procedures
- Formalised contingency plans for the failure of air emissions control plant and other plant and processes which can cause increase air emissions.

3.4 Training

Air quality management should be included as a key operating objective in site inductions and specific training for all employees and staff.

Best practice: Specific training relating to equipment and systems that can effect air emissions should cover:

- Housekeeping and operating procedures which can lead to increased air emissions (particularly odour)
- Operation and maintenance of air emission control equipment under normal and abnormal conditions
- Procedures which can effect (particularly odour) emissions – eg ventilation ducting not reconnected, covers not replaced.

3.5 Plant Design

Processing plant design can minimise air quality and odour impacts by incorporating the following factors in designing new plant or plant upgrades:

Best practice:

- Identification of the major air pollutant and odour emission sources
- Appropriate technology choices to minimise air emissions
- Modelling of the sources on the site to achieve permit limits (or better) at the site boundaries
- Equipment or processes likely to create odour or air emissions should not be located in unfavourable dispersion locations or near site boundaries.

FURTHER INFORMATION

- *Rendering Systems, MLA Advisory Package* [9]
- *Novel Rendering Technology, MLA Advisory Package*[10]

4.0 AIR & ODOUR EMISSION SOURCES & CONTROL

4.1 Rendering

This is the major source of odour emissions from an integrated meat processing plant.

- Primary emission sources should be captured and treated – where odours will be a nuisance to the community. These may include non-condensable vapours from the cooker(s), and possibly press emissions, screw conveyor emissions, meal screening emissions and raw material bins (if imported material is being processed).

Ducting for odour control

- Depending upon the proximity of odour receptors secondary emission sources may also need to be directed to the odour control system. These include raw material bins, meal storage bins and conveyors, tallow storage tanks and blood tanks.

FURTHER INFORMATION

- *Environmental Control in the Rendering Industry, MLA Advisory Package* [11]
- *Cleaning a Rendering Plant, MLA Advisory Package* [12]

Best practise for the effective control of rendering odour in sensitised locations:

- Equipment enclosure - all material transported within the rendering facility is capable of high odour emissions. On the hot material side, this is further aided by the odour sources being within a highly buoyant, elevated temperature, steam environment which leads to rapid dispersal within the building

- Source capture – a hood and ducting system designed to capture and transport the odour sources from the point of generation or release, through a ducting system for treatment
- Efficient source capture permits the exhaust of building ventilation air direct to atmosphere without further treatment
- In the absence of efficient source capture of odours, the rendering building ventilation air should be treated in an odour removal system
- Heat recovery – energy recovery from high temperature rendering vapours to produce hot water for plant use and reduce condensate temperatures to ~50oC
- Odour removal – various technologies are available for the treatment of odorous gas streams – key characteristics are summarised in Table 2. Detailed descriptions of these technologies are included in Appendix 1
- Raw material receival ventilation – not identified as a problem if only fresh material generated on site is processed through the rendering plant. A potential source of odour emissions if aged, outside material is processed through the plant
    - Receival for fresh, site generated, material should be located within the rendering building (or adjacent enclosed space) and be ventilated as part of the building ventilation system
    - Receival for imported and aged material will be external to the rendering building. The receivals area should be designed to meet normal industrial ventilation criteria. Receival bins should be vented to the rendering odour capture and treatment system.

Biofilter

FURTHER INFORMATION

- *Refer to the set of MLA Advisory Package – Rendering information, reference numbers: 8 - 11*

4.2 Blood Handling and Drying

Blood processing is a potential source of particulate and odour emissions from blood storage, drying and dried product handling. Burnt blood can produce a particularly offensive odour.

4.2.1 Blood Receival

Best practice:

- Blood to be received as fresh as possible and processed as soon as practicable
- Aged blood storage should be vented to an odour control system.

4.2.2 Blood Drying

Best practice incorporates the use of indirect contact or low emission direct dryers which minimise the release of odours and particulates in the off gas streams.

Dryer exhaust gas from indirect contact dryers should be treated through a condensor for removal of vapours. Non-condensables should be handled through the odour treatment system.

In applications using direct contact dryers, air quality is usually seen as a particulate control rather than an odour control issue.

Best practice includes:

- Blood as fresh as practical to minimise odour emissions
- Control and monitor dryer operation to eliminate the creation of offensive odours by burning blood
- Dryer exhaust equipped with wet scrubber using water as scrubbing liquor

Where raw materials or the process are likely to cause odour problems, or where site sensitivity could be an issue, non-condensable emissions should be directed to the plant odour collection and treatment system.

4.3 Thermal Plant

- Steam is a requirement in larger, integrated meat processing plants
- Hot water is usually sufficient in smaller plants without rendering facilities.

Fuel options for thermal plant to generate steam and/or hot water include:

Oil fired burner

- Natural gas – reduces Greenhouse emissions; no particulate emissions
- Oil – potential SOx emissions; no particulate emissions
- Coal – its use is favoured by cost and availability; but requires particulate controls and coal specifications to limit SOx emissions
- Wood waste – greenhouse-beneficial through economical re-use of a waste otherwise destined for landfill or incineration
- All – combustion control to limit NOx emissions

Thermal plant is a principal source of:

- Particulate emissions (coal firing)
- NOx and SOx emissions
- Process related Greenhouse gas (CO_2)

4.3.1 Particulate Control

Coal fired boilers are the major point source of particulate emissions to atmosphere. The particles (fly ash) come from the ash content in the coal. The particles are readily removed from the gas stream by the most appropriate of several technologies, selected to suit the permitted emission levels and the type of boiler.

A comparison of available technologies is presented in Table 3.

Best practice:

- Coal specification to suit the boiler plant and minimise particulate and gaseous emissions
- High efficiency cyclone collectors for stoker and grate fired boilers where the emission – 200 - 250 mg/Nm^3 – is permitted under regulations
- Fabric filters for pulverised fuel fired boilers and other plants where a lower emission - <25 mg/Nm^3 – or non-visible stack emission is mandated

Fabric dust filter

Boiler ash and fly ash may be disposed of dry, mixed with other waste material or processed through the plant waste water system.

4.3.2 Sulphur Oxides

Sulphur Oxide (SOx) emissions only arise when sulphur-containing fuel is burnt – coal or fuel oil. Emissions levels can therefore be controlled by limiting the sulphur content in the fuel – often covered in processing plant operating licences. Natural gas is essentially sulphur free.

Low sulphur or sulphur free fuels have an additional benefit of reducing or avoiding acidic corrosion in boiler plant.

Best practice:

- Use natural gas as an energy source where this fuel is economically available
- Where coal or fuel oil are used, the sulphur content is to be monitored and limited
- Wood waste is a low sulphur, renewable resource which can provide beneficial energy recovery from an otherwise waste product.

4.3.3 Nitrogen Oxides

All combustion processes generate nitrogen oxide (NOx) emissions in one form or another. Nitrous oxide (N_2O) is classified as a major greenhouse gas; nitrogen dioxide (NO_2) is scheduled in the Ambient Air Quality NEPM and the National Pollutant Inventory.

In Australia NOx emission levels are universally maintained by control of the combustion process in the boiler.

Best practice:

- Specification of required NOx emission levels for thermal plant
- Regular review of combustion conditions to ensure that the NOx emissions are maintained below permissible levels.

4.4 Building Ventilation

4.4.1 Rendering Building

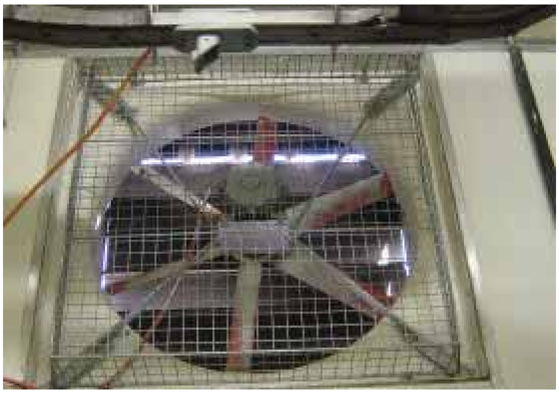
The extent to which the rendering building ventilation will be an odour source will depend upon efficiency of capturing the primary odour emissions. Effective capture at primary odour emission sources should eliminate the requirement for

any treatment of rendering building air emissions.

Pneumatic conveying, storage and handling of meatmeal is a potential source of particulate emissions.

Best practice for rendering facilities located in sensitised sites:

- Building ventilation – rendering building to be fully enclosed, all doorways normally closed, air inlets to building via purpose designed louvres, appropriate air change rate to achieve both satisfactory working conditions and removal of remnant steam and odour. Environmental regulators will require dispersion modelling evidence that the ventilation air will not adversely impact on local receptors. Buildings may be ventilated by:
    - Natural draft through ridge vents
    - Induced draft through roof fans direct to atmosphere
    - Induced draft fan discharging to atmosphere through a stack
    - An induced draft system is preferred for the control over ventilation rate and improved dispersion



Air changes are determined both by environmental and OH&S considerations. For rendering rooms where odour problems occur, 25 – 30 changes/hr have been used. Air exchange rates greater than 40 per hour may be necessary in very hot areas.

FURTHER INFORMATION

- *Environmental Control in the Rendering Industry, MLA Advisory Package* [11]
- *Odour Minimisation Manual for the Meat Processing Industry* [8]

4.4.2 Slaughter Floor, Boning Rooms, Chillers, Freezers

These areas are mechanically ventilated to provide a controlled working environment and are a low to nil odour source.

There are possible odour emissions from paunch and offal handling in the areas between the slaughter floor and rendering.

4.5 Waste Water Management

Solids removal, anaerobic, aerobic and storage lagoons can all emit varying amounts of odours related to the waste water system treatment design and operation.

Wastewater management practices are considered, in this module, only in the context of minimising air emissions.

> ***FURTHER INFORMATION***
>
> - *Refer to the Industry Best Practice Guidelines – Wastewater Treatment*

4.5.1 Primary Treatment

Generally, all wastewater streams receive primary treatment to reduce coarse and suspended solids and fat concentrations prior to further treatment. Equipment commonly found in this area will include:

- Collection pits and pumping
- Static screens
- Rotary screens and/or screw presses
- DAF or CAF units

This area of the wastewater treatment process is potentially the most odorous under *normal* plant operating conditions, particularly when rendering stick water is processed. The handling of solids removed in this part of the plant can also have a major effect on local odour generation.

The need to treat the odours from this source will depend on plant location and is more likely to be an issue for plants in highly sensitised locations. The principal of treatment is to locate the plant within the site to minimise odour at the boundary.

Best practice: Where odours are likely to impact on the community and considering the specific technologies likely to be used in this part of the plant, odour control options should focus on:

- Minimise generation of hot vapours and odours. In most cases, effluent cooling is not practicable due to the high volume of hot water
- Remove all solids and fats recovered from the area, frequently.

Where processing plants are located in highly sensitised locations, additional best practice includes:

- Adopt enclosed technologies (screw press, etc);
- Enclose static or rotary screens
- Pits – minimise openings to atmosphere.

4.5.2 Secondary Treatment

The dominant wastewater treatment process for the industry is anaerobic followed by aerated ponds and settlement/storage ponds. The wastewater at that stage is disposed on site (irrigation) or further treated for off site disposal. Wastewater, after aerobic treatment, may also be recycled onto the site for yard wash down and similar applications.

Anaerobic Ponds

Emissions to atmosphere from the anaerobic ponds are potential high intensity odours. The prevailing and successful method of odour control is the establishment of a strong and stable crust on the pond with the only penetration being a relatively small area around the wastewater inlet.

Best practice - natural crust:

- Regular monitoring of the pond condition and rapid attention to any areas of crust breakdown
- Ensure discharge from pond into downstream unit is submerged on entry.

Well-designed anaerobic lagoons with an effective crust will not emit odours detectable beyond the plant boundary. For this reason the selection of a covered anaerobic lagoon process for odour control reasons is rarely required. Energy recovery can be achieved by fitting a synthetic cover to collect the offgas, but may create a point source, high strength odour discharge if not properly treated. The collected gas has a significant energy value. Plants recovering the energy also require standby capability for use when the boiler, water heater or other thermal device is off line.

Best practice - synthetic cover:

- Cover remains sound and intact
- The integrity of the cover seal to the pond border remains intact
- Back up system for off gas oxidation may be required, particularly in sensitised locations
- Ensure discharge from pond into downstream unit is submerged on entry.

Aerobic Treatment Systems

Odour emissions from facultative, or aerated ponds or activated sludge systems, which are well aerated, are not considered to be of concern, providing the pond is not located on any of the plant boundaries. The odour has a typical 'earthy' smell, not usually associated with the meat processing industry.

Best practice:

- Maintain adequate redox (reduction-oxidation potential) in the system (generally more positive than – 75 mV)
- Desludge ponds when accumulated solids rise to within approximately 30 cm of the water surface.

Settlement and storage ponds are not considered to be an air emission problem providing all of the upstream water treatment systems are properly operated and a positive dissolved oxygen level is maintained at the pond surface.

Best practice:

- Best practice operation of the wastewater treatment system will minimise air emissions.

4.5.3 Tertiary Treatment

Tertiary treatment is not common in the industry, but may be used in specific situations where the wastewater is to be returned to waterways and is required to meet more stringent water quality criteria. Odour or other air emissions are not expected from tertiary treatment systems.

4.6 Irrigation

Potential exists for low-level odour to be released from irrigation with inadequately treated wastewater or wastewater containing insufficient dissolved oxygen.

Irrigation as a means of wastewater disposal normally occurs on meat processing plants with adequate pasture or crop area to manage the water and nutrient load to be disposed of, or has agreements with adjoining landholders for the same purpose. Providing secondary wastewater treatment provides a non-odorous final effluent, irrigation will not create an air quality issue.

FURTHER INFORMATION

- *Industry Best Practice Guideline on Effluent Irrigation also addresses odour issues*

4.7 Yards

Sheep pens

Cattle lairage

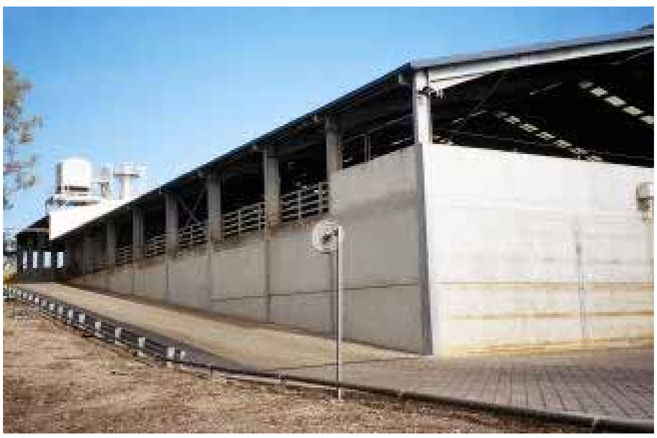
Yards, pens, lairage, ante mortem all refer to the facilities for holding animals prior to processing. These are regarded as area sources of emission.

- Odour sources arise from the production and subsequent handling of manure and urine
- Dust may arise from yards that are open to wind effects and dry enough to permit dust to arise

Design and operation of holding yards can greatly influence the incidence and contribution of low level odour and dust from the processing plant.

Best practice:

- Minimise manure and urine accretion by ‘drop through’ design (for sheep) or hardstand, regularly cleaned (cattle)
- Minimise wind effects by roofing and sheeting
- Water sprays on cattle races for dust control
- Minimise animal movements to minimise dust generation.



4.8 Waste Solids Disposal

4.8.1 Paunch and Waste Solids

A potential odour source arises from the receipt, storage, handling and disposal of a range of putrescible waste materials during meat processing. Paunch storage and composting is highly odorous when the windrows/piles are turned.

Best practice:

- Paunch and similar waste solids should be either treated on site or removed off site daily
- On-site disposal is to be avoided in sensitised areas.

4.8.2 Carcase Disposal

Carcase disposal procedures vary across meat processing plants, based on scope of plant operations and the market requirements for meatmeal.

Best practice:

- Dispose of carcases promptly
- Where the meal is not intended for human consumption, or where export rules permit, carcases are preferably processed through rendering
- Where the meal is intended for human consumption and/or export, or inedible rendering is not possible, composting (wet or dry) achieves good carcase disposal when performed appropriately. NCV skins are also suitable for composting [Ref 13].

Dead stock composting heap

4.8.3 Inert Solids

Inert solids will principally include boiler ash and fly ash. Off site disposal can be included with other waste solids or the material can be handled separately and in such a way that a dust nuisance is not caused.

4.9 Transport

4.9.1 Livestock Transport

Transport of livestock to the meat processing plant can involve air quality and waste issues well outside the plant boundaries with the deposit of urine and manure on public roads. Most transport is conducted by operations independent of meat processing companies and it is the responsibility of these operations and their drivers to comply with their duty of care to the environment. However, the processing plant should encourage drivers to maintain their vehicles in clean condition on leaving the plant.

Best practice:

- Provision of facilities for the washing of transport vehicles, both inside and out, prior to leaving site
- Facilities supported by plant rules requiring a minimum standard of cleanliness prior to leaving the plant
- Agreed routes for all livestock transport

4.9.2 By-products, Waste and Hide Transport

Transport of these materials off-site may be performed by processor company vehicles or contractors. The processor should require contractors to follow best practice.

- By-products - material such as face pieces, dried blood and bone meal
- Hides - untreated cattle hides from the processing plant
- Waste solids - may include paunch contents, solids from waste water treatment, manure (if collected separately) and boiler ash. The resulting product is generally quite wet.

Best practice:

- Prompt removal of waste solids to avoid the generation of odours through aging

- Avoid drips and leaks from trucks
- Cover loads for odour containment and visual reasons
- Wash trucks externally before leaving the processing site (wheels, bodies).

FURTHER INFORMATION

- *Refer also to the Industry Best Practice Guidelines on Waste Solids*

4.10 General Site Dust

General site dust comes from the movement of equipment and animals (particularly cattle) on the site. The effect beyond the site boundaries is visual and inconvenience (dust settling on houses and washing).

Best practice:

- Preferably sealed roads for all main vehicle movements
- Regular watering of unsealed roads and areas
- Removal of dried material from livestock trucks prior to leaving site
- Regular cleaning of cattle lairage
- Dust suppression sprays in cattle races
- Design of lairage to minimise wind effects
- Minimise dust generation by limiting movement of animals.

4.11 Greenhouse Gas

Greenhouse gas is produced *directly* in the meat processing plant through:

- Thermal combustion processes
- Organic gas emissions from the waste water treatment system
- Ancillary plant associated with transport.

Greenhouse gas is produced *indirectly* through electrical energy consumption as, in most cases, power is supplied from fossil fuel fired generation plant.

Best practice:

- Proper operation of wastewater treatment systems (odour minimisation)
- Overall efficient energy utilisation.

Greenhouse gas produced by animals in the meat processing industry is beyond the scope of this document.

FURTHER INFORMATION

- *The Australian Greenhouse Office supports greenhouse gas reduction projects as part of the greenhouse Friendly TM and other programs – www.greenhouse.gov.au*

5.0 CONTINGENCY

Contingency plans for the failure of production equipment are either formalised or understood. Actions to overcome the air emissions consequences of equipment failure should be incorporated into the overall contingency plan. Contingent situations that can effect air emissions – particularly odour – include:

- Malfunction of the plant odour control system
- Equipment failures – fans, motors etc.
- Rendering failure – need to avoid ageing raw material
- Blood drying failure.

Wastewater treatment system malfunction – particularly due to organic overloading of biological system or loss of crust from anaerobic ponds.

Best practice:

- Formalisation of contingency plans
- Integration into the training program
- Extension of those plans to include odour and air emissions minimisation.

6.0 MONITORING AND REPORTING

Monitoring and reporting of air emissions and air quality incidents is mandated under various government and licence requirements and is an important tool in handling community relations.

Statutory reporting can include:

- Regular emission reports for point sources and at processing plant boundaries
- National Pollutant Inventory (NPI) reports
- Other regulatory and licence requirements.

Internal reporting of air quality performance can either be a formal or informal process.

- Formal reporting tends to monitor air quality performance as a management tool and to raise cultural awareness of air quality performance at all levels throughout the plant
- Informal reporting focuses more on reporting by exception – equipment malfunction or incident reports

Monitoring programs are often a licence requirement on some point sources (particulate emissions from boiler plant). Particularly in sensitised situations, plant monitoring should be supplemented with local weather monitoring (wind speed and direction) as a critical tool in handling community and EPA complaints.

Best practice:

- Maintaining licence and statutory reporting requirements
- Formal reporting of air quality performance as well as malfunctions or incidents
- Air quality as a key performance indicator
- Weather monitoring, particularly in sensitive and sensitised locations.

FURTHER INFORMATION

- *Environmental performance for the industry is reported* [14]

7.0 COMMUNITY RELATIONS

Effective handling of community relations is demonstrated in a number of meat processing plants. Many processing plants operating in sensitised areas have established a mutually beneficial relationship with the local community.

Best practice:

- Complaint handling and abnormal events –
  - Formal complaints register and protocol
  - Fast and co-operative response for complaint handling
  - Meat processing plant as the first point for complaints (not EPA)

- Community relations and interaction -
  - Open, two way communications through consultation
  - Maintain communication and feed back in both normal and abnormal times
- Pro-active role in advising of potential problems during shutdowns, process upsets and other abnormal situations.

8.0 References

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Table 2 – Odour Removal Technologies

Technology	Water Scrubbing	Chemical Scrubbing	Biofiltration	Oxidation/Ozone	Thermal Oxidation
Process	Off gases pass through wet scrubber for removal of condensable and soluble gas components	Chemical treatment of off gases in a multi stage wet scrubber. Normally require acid, alkali and oxidation (chlorine) stages	Saturated air treated through biologically active packing at low velocity	Oxidation of odorous gases in a reaction chamber using ozone or 'activated' oxygen	High temperature destruction of organic gas components
Consumables	Water	Acid (sulphuric), alkali (caustic soda), oxidant (eg. sodium hypochlorite, hydrogen peroxide, chlorine dioxide)	Water for cooling and condensation	Power to produce ozone or 'activated oxygen'	Thermal energy – usually natural gas
Odour Outcome	Selective removal of odour compounds; limited effectiveness	Three stage scrubbing normally produces satisfactory odour removal	Can remove to non-detectable levels. Residual odour will resemble biofilter medium character.	Low odour emissions	Non-detectable
Application	Possible low strength odour applications or where high removal efficiency is not required	Normally high strength odour streams because of consumable cost	Both high and low strength odour streams	Both high and low strength odour streams	Operating costs limit use to high strength odours Boilers can be used to oxidise small, high strength flows
Operational/ Maintenance	Occasional scrubber clean out for removal of fats, build ups etc.	Occasional scrubber clean out for removal of fats, build ups etc. Chemical handling	Minimal – maintain biofilter bed moisture; occasional packing replacement (>3 years)	Reaction chamber clean out	Potential build up of fats on oxidiser packing (if used)
Waste Products	Odorous waste water stream	Low-odour waste water stream and chemical wastes	Low odour water stream from condenser/cooler; minor leachate flow from biofilter	Some condensate	Nil

Table 3 – Particulate Removal Technologies

Technology	Cyclones	Fabric Filters	Electrostatic Precipitators	Wet Scrubbers
Process	Centrifugal force removes the dust particles from the gas stream	Particulates removed by passing gas through fabric filter elements – bags. Programmed cleaning regenerates filter capacity	Particulates are electrostatically charged and collected on earthed electrodes	Dust particles are wetted to form agglomerates for removal from the gas stream
Consumables	Nil	Nil	Nil	Water
Emission	Multi cyclones (small diameter) can achieve emissions below 250 mg/Nm^3 on coarse particulates from grate type boilers	Capable of achieving emission below 20 mg/Nm^3 (clear stack) on all forms of coal fired boilers and other dust generating processes	Capable of 30 – 100 mg/Nm^3 on coal fired boilers. May be sensitive to coal quality No application in other areas	Capable of 30 – 150 mg/Nm^3 depending on particle size and scrubber energy consumption
Application	Grate and stoker fired type boilers	All forms of coal fired boilers, meal and other solids handling, storage and bagging applications	All types of boilers. Only applicable to large gas flows – large boilers – and out of the usual range for meat processing industry	All types of boilers, blood dryers and processes where collected material can be returned to the process in wet form
Operational/ Maintenance	Low	Regular bag replacement – 1 – 3 years	Minimal	Occasional scrubber clean out for removal of scale, build ups etc.
Waste Products	Collected ash for dry disposal	Collected ash for dry disposal; other collected product may be returned to process or end product	Collected ash for dry disposal	Collected and discharged as a slurry

APPENDIX 1 – TECHNOLOGY DESCRIPTIONS

A. WET SCRUBBERS

Process and Description

Wet scrubbers can be used for removal of both particulate and gaseous (odorous) contaminants from process and ventilation air streams. Scrubbing liquor is used to agglomerate and increase the mass of particulates or react chemically with gas phase contaminants.

Scrubbing liquor may be any combination of:

- Water – particulate removal and soluble gaseous contaminants
- Oxidising –- for VOC oxidation
- Acidic –for alkaline gases such as ammonia, amines
- Alkaline –for acidic gases such as hydrogen sulphide, mercaptans

Application

Wet scrubbers – water based – are commonly used in treating the exhaust gas from blood dryers and remove any particulate carry over very efficiently

Scrubbers using chemical reagents can be used – usually in a multi stage form – for scrubbing odours. Rendering will usually require oxidation, acid and alkali scrubbing.

Scrubbers can be used for both process gas or ventilation airflows. Typically, separate scrubbing systems would be used due to different scrubbing reagent requirements.

Inputs

Inputs are either water – for particulate removal – or chemical reagents for gaseous scrubbing. Common reagents are:

- Oxidising - sodium hypochlorite, hydrogen peroxide, potassium permanganate - as liquid reagents; chlorine, chlorine dioxide, ozone directly injected in gaseous form
- Acidic – most commonly weak sulphuric acid

- Alkali – most commonly sodium hydroxide

Chemical scrubbers require careful monitoring to maintain reagent concentrations, scrubber performance and minimise reagent waste.

Discharge

Scrubber discharge will be a contaminated liquid stream, which can be returned to the process – as in blood dryers – or sent to the water treatment system. The waste stream may be highly contaminated, but is small in volume in comparison to other wastewater streams and is readily diluted and treated.

The air discharged from a scrubber will be fully saturated with water vapour, leading to a visible emission in colder weather.

B. BIOFILTRATION

Process and Description

Biofiltration is now the most commonly used technology for odour removal in the meat processing industry. The process occurs in two stages:

- Absorption of odorous gases onto an organic packing medium
- Biological destruction of the odorous gases by aerobic bacteria (micro organisms) within the packing medium

The simplest, and most common, biofilters are shallow concrete brick structures with an effective air distribution system in the base and a bed of about 1 – 1.5m of biologically active medium – pine bark, compost etc – through which the air stream passes. Such a simple biofilter requires a large ground area – readily available on most sites.

Other designs are highly engineered – and thus more expensive - to provide multiple layers of organic or inorganic packing and thus occupy a smaller footprint.

Effective operation of the biofilter requires:

- Moisture control of the biofilter bed
- Even air distribution across the total bed area
- Cooling to below 40°C

The most effective means of maintaining moisture control is pre-humidification of the foul airstream and surface sprays on the bed itself

Applications

Biofilters are commonly used in the meat processing industry for all odour control applications from rendering, blood drying, materials handling and all building ventilation.

Inputs

Once bed activity is established, the only input requirements are:

- Water for air stream humidification
- Water to maintain filter bed moisture levels

From time to time (usually 3 or more years) the filter bed may require replacement and topping up in the intervening period.

Discharge

The only discharge from the filter bed is a small quantity of leachate comprising condensation in the incoming ducting and any excess water in the filter bed. The water quantity is very low - measured in litres/hour – but may be very odorous.

C. ADSORPTION

Process and Description

Organic gases (VOC) can be adsorbed into the pores of a material – most commonly activated carbon. The process is most effective at low temperatures – up to 40^{o}C – and humidity below 80%. Such systems are less effective with reduced sulphur compounds and ineffective with sulphur oxides.

Eventually, the activated carbon pores will become saturated. This is remedied in smaller adsorbers by replacing the carbon. In larger units, some form of stripping and VOC recovery may be employed (regeneration). Steam stripping is the most common process.

Applications

Carbon adsorption is very effective on VOC gas streams and is commonly used as back up for other mainstream odour removal equipment. There are obvious limitations in process applications (airstream temperature) and contaminant gas composition.

Inputs

Carbon bed replacement is the major input for smaller units with replaceable beds.

Steam for bed regeneration is the major input for larger, regenerable units.

Discharge

The discharge from replaceable bed units is the contaminated bed itself.

Regenerable units will discharge a mix of water, soluble and non-soluble VOC condensates for further treatment or disposal.

D. OZONE AND OXIDATION

Process and Description

Gas phase oxidation using direct UV radiation or systems producing ozone or oxygen radicals which subsequently oxidise air contaminants forms the basis of this technology.

The direct radiation system may consist of an array of equipment including:

- Fine dust filters
- Ammonia scrubbing – water based
- Grease and fat removal
- UV radiation and VOC oxidation
- Further oxidation from ozone generated in the process
- Adsorption of remaining gas in an activated carbon bed

While appearing complex, the system can be made very compact and be housed within, or adjacent to, the rendering building.

The oxygen radical system requires a clean air supply through the generators. This active air supply is mixed in with the contaminated air stream for odour destruction and a very significant dilution effect.

Applications

Both systems have been supplied in Australia.

Capital and operating costs limit applications to major, highly odorous process streams rather than treating high volume, ventilation air streams.

Inputs

The major input is power for the generation of UV/ozone/oxygen radicals.

Discharge

Oxidation in the gas stream produces no significant discharge as all products exit through the exhaust system.

E. THERMAL OXIDATION

Process and Description

VOCs and most other gases are destroyed by raising the gas temperature to between 700 and 1000°C through some form of incineration. The energy cost is such that:

- Heat recovery is an essential part of the process – either to preheat the incoming gas stream or to produce a useable energy source (steam, hot water) on the plant
- Use is restricted to low flow, high concentration gas/odour sources

Incineration is the most effective technology, ensuring over 99% odour destruction.

The incinerator/combustor design must take account of possible contamination from fats and any solids on heat exchange surfaces.

Flaring is a technology well suited to the combustion of methane and off gas from covered anaerobic ponds, either as the main or back up system.

Boiler/heating plant existing on all meat processing plants can be a very effective incinerator for high intensity odours.

Application

Limited to high strength odours in situations where extremely high destruction efficiency is required; to situations where existing thermal plant can be used as the incinerator or where captured off gas from covered anaerobic ponds is available.

Flaring is suited to highly flammable gas streams without a strong odour or non-combustible component, due to the short residence time for gas destruction in the flare.

Inputs

The major input is thermal energy, usually in the form of natural gas or fuel oil.

Discharge

There is no discharge other than the dissociated gas leaving the incinerator as part of the exiting gas flow.

F. CYCLONES

Process and Description

Cyclones generate centrifugal force as a means of separating particulates from the gas stream. They are used in two forms – separate (large diameter) cyclones in groups of 1 to 4 units or multiple cyclone units installed in parallel in a steel casing (multi-cyclones). The smaller diameter multi-cyclones are more efficient than the large diameter cyclones.

The ash removed from the gas stream is discharged from the bottom of the cyclones for removal.

Application

Cyclones will be used in the following applications:

- Disengagement of pneumatically conveyed material at the point of destination
- Fly ash removal from grate type boilers – where the particulate emission limit is below 200 mg/Nm^3

Inputs

There are no external inputs, other than the system pressure loss.

Discharge

Material removed from the process gas stream.

G. FABRIC FILTERS

Process and Description

The process gas or airflow passes through a set of fabric filter bags. The filter media removes all but the finest of particles, allowing a cleaned gas flow to exit to the stack. The collected dust is removed from the filter bags on a regular basis – normally with an air pulse – and collected in a hopper beneath the filter bags.

Filter media can be selected to handle gas and air streams at temperatures from ambient to 250^{o}C.

Application

Filters will be used in the following areas:

- Particulate control from dry materials handling and storage, such as meal and dried blood
- Fly ash removal from pulverised fuel fired boilers or in situations where an invisible stack – less than 25 mg/Nm^3 – is required

Inputs

Compressed air is required as part of the filter bag cleaning system on most modern filters.

Discharge

Material removed from the process gas stream.

Effluent irrigation

TABLE OF CONTENTS

Environmental Objectives

- Protection of surface waters
- Protection of groundwater
- Protection of soil integrity / structure

Possible Environmental Impacts

- Nutrient accumulation in soils
- Odour from wet weather storage or excessive applications of inadequately treated effluent
- Surface runoff resulting from over-application, irrigation during rain or poor site
- Impacts on groundwater underlying the irrigation site
- Salinity issues in vulnerable soils with inadequate leaching
- Soil structural damage

Effluent irrigation showing wet weather dam, irrigation area and flooded woodlot

Current Legislation and Regulation

The National Water Quality Management Strategy publication "*Australian Guidelines for Sewerage Systems — Effluent Management*" sets out the basic principles for land application of effluent as:

- the build-up of any substance in the soil should not preclude sustainable use of the land in the long term
- the effluent is not detrimental to the vegetative cover
- any change to the soil structure should not preclude the use of the land in the long term
- any runoff to surface waters or percolation to groundwater should not compromise the agreed environmental values
- no gaseous emissions to cause nuisance odour.

These principals underpin the rules and regulations established by the state agencies for the reuse of effluent for irrigation. However, these rules focus predominantly on the reuse of effluent from sewage treatment plants with an emphasis on public health (pathogens and faecal coliforms). For management of abattoir effluent, the emphasis is on avoiding pollution of surface and groundwater, and ensuring long term sustainable use of the land.

The distinguishing features of systems for effluent irrigation compared to those for municipal effluent are:

- Significantly higher concentrations of plant nutrients and therefore significantly greater potential for environmental harm and consequently the need for larger wet weather storage capacity to manage the environmental risks
- Selection of an appropriate crop to be grown as a function of nutrient uptake capacity rather than water usage or commercial considerations.

The National Water Management Strategy sets the scene for a National approach to effluent irrigation. The detail of policies, licensing and reporting requirements is carried out at the state level with each State having its own regulatory approach and set of minimum standards for effluent irrigation. Table 1 below provides a summary of the relevant state authorities, legislation, acts and guidelines for effluent irrigation.

Further Information

- *If you are unsure about Licensing Requirements, contact your local EPA office (or equivalent) for advice*

Table 1 Summary of State Authorities and Relevant Legislation, Acts & Guidelines

STATE	RELEVENT AUTHOURITY	LEGISLATION, ACTS & GUIDELINES	LICENCES & APPROVALS
National	Department of Environment & Heritage (DEH)	▪ National Water Quality Management Strategy ▪ Australian and New Zealand Guidelines for Fresh and Marine Water Quality (2000) ▪ National Beef Cattle Feedlot Environmental Code of Practice	None
ACT	ACT Environmental Management Authority	▪ Environment Protect Act 1997 ▪ Water Pollution Protection Policy (1999) ▪ ACT Environment and Health Wastewater Reuse Guidelines (1997)	Environmental Protection Agreement
NSW	Department of Environment and Conservation (DEC) Environment Protection Authority (EPA)	▪ Protection of the Environment Operations Act 1997 ▪ Protection of the Environment Operations (General) Regulation 1998 ▪ Environmental Guidelines, Use of Effluent by Irrigation (2004) ▪ Abattoir Industry Guidelines	Environment Protection Licence
NT	Department of Infrastructure, Planning & Development Office of Environment & Heritage	▪ Waste Management & Pollution Control Act (2003) ▪ Water Act (2004)	Environmental Protection Licence Best Practice License Waste Discharge License
QLD	Environmental Protection Agency (EPA)	▪ Environmental Protection Act 1994 ▪ Draft Queensland Guidelines for the Safe Use of Recycled Water (2004) ▪ The Establishment and Operation of Beef Cattle Feedlots (2000)	Registration Certificate Registered activities under Section 619 of the Act
SA	Department of Environment & Heritage Environmental Protection Authority (EPA)	▪ Environment Protection Act 1993 ▪ Environment Protection (Water Quality) Policy 2003 ▪ Reclaimed Water Guidelines, Treated Effluent, 1999	Licence required
TAS	Department of Primary Industries, Water & Environment (DPIWE)	▪ Environmental Management & Pollution Control Act 1994 ▪ Environmental Guidelines for the use of Recycled Water in Tasmania (2002) ▪ Wastewater Management Guidelines for Meat Premises and Pet Food Works	Environmental Agreement
VIC	Environment Protection Authority (EPA)	▪ Environment Protection Act 1970 ▪ Environment Protection (Prescribed Waste) Regulations 1987 ▪ Guidelines for Environmental Management: Use of Reclaimed Water (2002)	Licence or Permit required
WA	Department of Environment (DOE) (incorporates Dept Environment Protection and Water and Rivers Commission) Environmental Protection Authority	▪ Environmental Protection Act 1986 ▪ Environmental Protection Regulations 1987 ▪ Environmental Protection (Abattoirs) Regulations 2001 ▪ Guidelines for the Environmental Management of Beef Cattle Feedlots in WA	Licence Approved Treated Waste Water Irrigation Management Plan

Environmental Best Practice Overview

- **Understanding the site characteristics**: the climate, topography, soil limitations, sensitivity of receiving environment, and consideration of adjoining land uses.
- **Crop Selection and Management** to maximise the removal of nutrients through harvesting and minimise the accumulation of nutrients in the soils to achieve a sustainable site nutrient balance.
- **Effluent Storage and Irrigation Facilities** that include balancing storage and system components designed and managed to suit the site characteristics, climatic conditions and sensitivity of the receiving environment.
- **Irrigation Scheduling and Management** by keeping appropriate records to ensure that the soil is never saturated as a result of irrigation and, adopting an irrigation strategy to balance the water and nutrient requirements according to the effluent strength.
- **An Irrigation Management Plan** (as part of a Site Management Plan) detailing all aspects of the irrigation system, operations, maintenance, monitoring and reporting.
- **Monitoring** the physical condition and operation of the irrigation system and chemical properties including soils, surface and groundwater quality, effluent strength and volume applied.
- **Annual Reporting** on the operational performance of the irrigation system, presentation and interpretation of monitoring data.

Best Practice Information

Industry best practice for irrigation of treated effluent requires that the risk of environmental harm be managed at two different time scales:

Day to day management of the "escape" of pollutants by surface runoff:

- directly as a result of over watering or a burst pipe
- indirectly as a result of rainfall runoff immediately after irrigation
- indirectly to groundwater as a result of deep drainage below the root zone.

Year to year management to minimise the potential for:

- degradation of soil by accumulation of phosphorus or salts
- deep drainage that could pollute groundwater.

1.0 SITE CHARACTERISTICS

The characteristics of an effluent irrigation area and its location relative to neighbouring properties, creeks, and groundwater need to be known. Assessment of these characteristics will identify the constraints to effluent irrigation and assist with choosing the irrigation system which best suits the site. The key factors governing the suitability of a site for effluent irrigation are:

- Topography
- Soil considerations
- Proximity of surface and groundwater
- Proximity of neighbours.

Ideally, a site chosen for effluent irrigation has the following qualities:

- a uniform slope of no more than 10%
- permeable, well-drained soil
- adequate depth to groundwater (for increased protection of groundwater)
- is not prone to frequent flooding.

1.1 Topography

The topography of the site will influence the choice of irrigation system that is suitable for the site. For example, on very flat land where the slope is less than 0.1%, flood irrigation would be suitable, whereas, on slopes up to 5%, spray irrigation is more suitable. Also, an undulating site will increase the amount of pumping required and the controls needed to maintain a pressure head for a piped supply system.

Table 2 Irrigation Methods for Use on Different Slopes

Method	Slope (%)
Flood	0 – 0.1
Furrow	0.01 – 1.0
Spray	0.1 – 5
Trickle and Micro	0.1 – 10.0

(Choice of irrigation method is discussed in Section 4.3)

A site with a well-graded, uniform slope will avoid the problems associated with poor drainage and ponding. If effluent is allowed to pond in furrows or hollows, this can cause excess water and nutrients in some locations leading to crop and soil damage. Ponding effluent can also lead to pollution of surface or groundwater caused by ponded effluent runoff to surface waters or drainage to groundwater. Ponded water can also provide increased mosquito / vector breeding sites.

The position of the effluent irrigation area on the landscape can impact the management of the system. The management considerations for different positions on the landscape are as follows:

River Flats – often the river flats are underlain by a local ground water system that is hydraulically linked to the river. An effluent irrigation system needs to be managed so that pollution of the groundwater is prevented.

Steeper Slopes – cultivation or cropping of slopes greater than 2% may require special erosion control practices.

Mid-slope Areas – to fully control the water regime in the irrigation area, run-on from areas up hill needs to be redirected. Effluent irrigation areas should be selected so that this protection from upstream runoff can be easily achieved.

Creeks and Drainage Lines – to protect the adjoining environment from contaminated runoff (from rainfall or excess irrigation) from the effluent irrigation area, it may be necessary to capture runoff from the area which drains directly to the watercourse. Therefore when considering the location of the irrigation area, it may also be necessary to consider siting a tailwater dam to retain the runoff for reuse. This is also discussed in Section 6.4.

Table 3 Landform Limitations for Effluent Irrigation

Property	Limitation			Restrictive Feature
	Nil or slight	Moderate	Severe	
Slope (%)				
Surface	<1	1-3	>3	Excess runoff and erosion risk
Sprinkler	<6	6-12	>12	
Trickle/microspray	<10	10-20	>20	
Flooding	None or rare	Occasional	Frequent	Limited irrigation opportunities
Landform	Crests, convex slopes, plains	Concave slopes and footslopes	Drainage lines and incised channels	Erosion and seasonal water logging
Surface rock and outcrop (%)	Nil	0-5	>5	Interferes with irrigation and cultivation machinery, increases risk of runoff.

Source: NSW Department of Primary Industries (2004)

1.2 Soil Characteristics

The characteristics of the soils will impact on the suitability of the site for effluent irrigation, the irrigation system choice and the management effort required. As the quality of effluent from the meat processing industry is high in nutrients and possibly salts, it is very important that the physical and chemical properties of the soil is analysed to determine the management requirements for protecting against soil degradation which could result in:

- degraded soil structure
- restricted plant growth
- erosion
- salinity
- release of contaminants to surface or ground waters.

1.2.1 Soil Investigations

When assessing potential sites for effluent irrigation, a soil survey or soil investigation should be conducted by a qualified soil scientist. The purpose of a soil survey is to identify and characterise the soil types and assess the limitations of the soil for effluent irrigation. Areas that are not suitable for effluent irrigation are then identified and not included in the system planning and design.

Detailed soil investigations should only be undertaken on sites which are potentially suitable for effluent irrigation. The detailed assessment should be based on the most limiting soil or land characteristic so that the irrigation system can be developed to meet the limitations and therefore reduce risk of pollution resulting from poor management of the limiting condition(s).

1.2.2 Soil Properties

The key soil properties which govern the suitability of a site for effluent irrigation are soil sodicity, soil salinity, saturated hydraulic conductivity, available water holding capacity, pH, cation exchange, dispersion, and soil phosphorus adsorption capacity. These properties are briefly described below.

Soil sodicity – refers to the amount of exchangeable sodium cations (Na^+) and is expressed in terms of exchangeable sodium percentage (ESP). Sodicity occurs when the ESP is greater than 5. This leads to the soil becoming unstable and dispersive, which makes it more susceptible to erosion and reduced soil permeability.

Effluent with a sodium adsorption ratio (SAR) greater than 6 is likely to raise the ESP in non sodic soils and effluent with a SAR less than 3 may lower ESP in sodic soils.

Soil salinity – salinity is the concentration of dissolved salts in the soil solution and is measured by the electrical conductivity EC. The EC is measured by units of dS/m or μS/m or by total dissolved salts (TDS) in mg/L. When salts accumulate in the soil, the soil becomes more saline and as a result, only salt-tolerant plants can be sustained. Therefore, highly saline soils would be unsuitable for effluent irrigation, particularly if the effluent has a high salt content.

Saturated hydraulic conductivity (Ksat) – (soil permeability) is a measure of the movement of water through the soil, expressed in mm/hour. Ksat is an important soil property for determining the suitability for irrigation and for identifying possible limitations to effluent irrigation. The permeability of a soil will influence the irrigation method, application rates and degree of management needed to control runoff.

Soils with very high Ksat (e.g. sand) may allow nutrient and salt from effluent to quickly enter the groundwater, while soils with very low Ksat (typically unstructured clayey soils) are prone to waterlogging. Ksat also varies through the soil profile, therefore soil assessments need to investigate the hydraulic conductivity of soil layers within the top 1 metre of soil to determine the layer with the lowest permeability. As shown in Table 4, soils with a very low or a very high Ksat require a greater management effort when used for effluent irrigation.

Table 4 Soil Requirements for Effluent Irrigation

Property	**Limitation**			**Restrictive Feature**
	Nil or slight	Moderate	Severe	
Sodicity, ESP (0-40cm)	<5	5-10	>10	Structural degradation and water logging [F]
Sodicity, ESP (40-100 cm)	<10	>10	-	Structural degradation and water logging
Salinity, EC (dS/m) [H]	<2	2-4	>4	Excess salt restricts plant growth
Depth to top of seasonal high water table (m) [G]	>3 [A]	0.5-3 [A]	<0.5	Wetness, risk to groundwater
Depth to bedrock, hardpan (m)	>1	0.5-1	<0.5	Restricts plant growth, excess runoff, waterlogging
Saturated hydraulic conductivity, Ksat (mm/hr)	20-80	5-20 >80	<5	Excess runoff, waterlogging, risk to groundwater
Available water capacity, AWC (mm/m)	>100	<100	-	Little plant available water in reserve, risk to groundwater
Bulk Density (g/cm^3)				Restricts root growth
Sandy loam	<1.8	>1.8	-	
Loam and clay loam	<1.6	>1.6	-	
Clay	<1.4	>1.4	-	
Soil pH (surface layer)	6.0-7.5	3.5 [B]-6.0 >7.5	<3.5 [B]	Reduces optimum plant growth
Effective cation exchange capacity ECEC, cmol(+)/kg	>15	3 [C]-15	<3 [C]	Unable to 'hold' plant nutrients
Emerson aggregate test	4,5,6,7,8	2,3	1	Poor structure
Phosphorus sorption (kg/ha)	>6000 [D]	2000-6000 [E]	<2000 [E]	Unable to immobilise any excess P

Source: NSW Department of Primary Industries (2004)

A. Often impossible to excavate to 3 m, hence local knowledge and lack of evidence of watertable to sampling depth (1 m) is used.

B. Where effluent is alkaline or lime is available, opportunities exist to raise the pH. If acid sulphate soil is present, land levelling may not be appropriate.

C. This can be overcome by adding soil amendments such as bio-solids or liming agents.

D. Assuming the sorption strength is higher than 20% of the sorption capacity. If this is not the case, a higher sorption capacity is required to immobilise excess phosphorus.

E. These limitations exist only if there is a sensitive groundwater source.

F. Overcome by gypsum application.

G. Quality and potential impacts on groundwater should also be considered.

H. Plants vary in their sensitivity to salt.

Available water holding capacity (AWC) – refers to the moisture content of the soil which is the maximum amount of plant-available water that the soil can hold. This is expressed in terms of the depth of available water (mm) per metre depth of soil. Sandy soils and some clayey soils (with low cation exchange capacities) typically have very low water holding capacities.

Knowledge of available water holding capacity is important when designing an irrigation system, calculating water balance for the site and for irrigation scheduling to maximise water use efficiency or minimise the risk of polluting surface and groundwater.

Soil pH - is a measure of the concentration of hydrogen ions in the soil and indicates the availability of plant macro and micro nutrients. For most plants a pH range of between 6 and 7.5 (measured in calcium chloride) maximises the availability of plant nutrients and hence the potential for plant growth.

Cation exchange and exchangeable cations - The cation exchange capacity (CEC) of a soil is the total quantity of exchangeable cations it can retain on its adsorption complex at a given pH. Exchangeable cations in soil include Ca^{2+}, Mg^{2+}, K^+, Na^+ (exchangeable bases), and H^+ and Al^{3+} (exchangeable acidity). The effective cation exchange capacity (ECEC) is a measure of the concentration of the five most abundant cations in the soil.

As shown in Table 4, soils with high CEC are more suitable for effluent irrigation as they are able to ‘hold’ nutrients. Soils with a low CEC can be improved by adding organic matter (which typically has a high CEC) or use of a green manure crop (which will also increase the soils organic matter content).

Emerson Aggregate Test (EAT) - measures the structural stability of a soil and classifies soils according to their stability in water. Table 5 provides a summary of the soil properties associated with the EAT Class.

Table 5   Emerson Aggregate Test Soil Properties

EAT Class	Description
1	Highly Dispersive Soils with the least stable structure
2 & 3	Moderately Dispersive Soil has some potential to slake and disperse
4 - 8	Low Dispersibility Indicates stable soils Class 8 soil can be so stable that it cannot be penetrated by plant roots

As shown in Table 5 Class 4-8 soils are more suitable for effluent irrigation and will require less management against soil erosion. The structural stability of dispersive soils can be improved by adding gypsum, lime or organic matter to the soil.

Soil phosphorus adsorption – is a measure of the ability of the soil to immobilise phosphorus expressed in kg of phosphorus per hectare. As indicated in Table 4, a low phosphorus adsorption indicates that any excess phosphorus applied to the site (in excess of plant uptake) has the potential to move through the soil, contaminating groundwater.

Acidic soils with a high clay content that have formed in situ have a very high capacity to adsorb phosphorus while sandy soils have a very low capacity. Sites that have been receiving high levels of phosphorus fertilisers or waste products over a number of years may have a reduced phosphorus adsorption capacity.

1.3 Surface and Groundwater

The location of surface water and groundwater systems in relation to the effluent irrigation area needs to be identified. As indicated in Table 4, where the groundwater is shallow (less than 0.5 m below surface) then effluent irrigation is generally not possible due to the very high risk of contamination of the groundwater.

There are some circumstances where a very high level of protection is required and runoff from the irrigation area needs to be captured and prevented from entering the surface water system. For example, if the local creek or groundwater system form part of a drinking water supply catchment, then the restrictions on runoff and infiltration will be severe.

Groundwater bore protected against cattle damage

Generally, however, stormwater runoff capture is not required if the receiving environment is less sensitive, particularly if the creek is flowing full and the potential for contamination is very small.

To minimise the risk of runoff from the effluent irrigation area, it is good practice to ensure that:

- irrigation systems in close proximity to surface waters are well-designed and managed
- the nutrient loading is appropriate for the soil and plants being irrigated so that contaminants are not mobilised; and
- an adequate buffer zone is provided between the irrigation area and any surface water body.

1.4 Buffers and Adjoining Landuse Considerations

When selecting a site for effluent irrigation, it is fundamental to consider the compatibility with and potential impacts on surrounding land uses and sensitive environments. These include neighbouring properties, public roads, surface and groundwater as well as sensitive areas of native vegetation. Table 6 below identifies some of the more obvious sensitive receptors and the general impacts of concern, but this list is by no means an exhaustive.

Table 6 Sensitive Receptors of Effluent Irrigation Schemes

Sensitive Area	**Impacts of Concern**
Natural water bodies (eg rivers, lakes)	Water quality, aquatic ecosystems, relevant beneficial uses
Other waters: eg artificial waters with beneficial uses, drainage channels, small streams, intermittent streams, farm dams	Water quality, aquatic ecosystems, relevant beneficial uses
Domestic well used for household water	Water quality and public health
Town water supply bore	Water quality and public health
Houses, schools, playing fields, public roads, public open space	Odour, noise, water quality
Environmentally sensitive areas: eg drinking water catchments, wetlands, stands of native vegetation	Water quality, ecosystems, soil and water nutrient status, biodiversity
Livestock and crops	Pathogens, heavy metals, organic compounds

Source: *Environmental Guidelines: Use of Effluent by Irrigation* NSW DEC (2004)

Management of sensitive receptors can be achieved by developing specific management strategies within a plan of management for the site and by providing appropriate buffer zones.

When considering the size of a buffer zone, it worth bearing in mind:

- the sensitivity of the receiving environment
- the strength of the effluent (level of effluent treatment)
- irrigation system choice
- impact mitigation or management strategies
- irrigation management practices such as scheduling

- **Soil sampling and investigations are best undertaken by a Soil Scientist**
- **Testing of soil and water samples should be undertaken by a NATA registered laboratory**
- **Groundwater assessment and bore installations should be undertaken by Groundwater Specialists (Geologist/Hydrogeologist)**

Well vegetated buffers
minimise spray drift

2.0 CLIMATE

The climatic setting for the effluent irrigation area is an important factor in the design of the system and the storage requirements for wet weather. The regional climate, and annual water deficit (the difference between rainfall and evaporation) are used to determine the irrigation requirement and the wet weather storage requirements.

2.1 Irrigation Requirement

Climatic rainfall patterns vary greatly from one end of the country to the other, and can depend on proximity to the coast. The evaporation also varies significantly depending on the season and the regional location. For example the average monthly evaporation in northern Queensland and Northern Territory is fairly constant throughout the year, where as in the southern states, evaporation is highest in summer and lowest in winter.

A useful guide to the irrigation requirement is the annual difference between rainfall and evaporation. However during periods when the evaporation is lower than the rainfall, this does not necessarily mean that irrigation will not occur. A large amount of rainfall could fall over a very short period of time, that is, it may be intense storm bursts with extended dry periods in between when irrigation can occur. Therefore, when assessing the irrigation requirement the difference between the annual evapotranspiration and rainfall provides a useful guide. However, more detailed analysis at the daily scale is far more effective in seeing the true irrigation requirement.

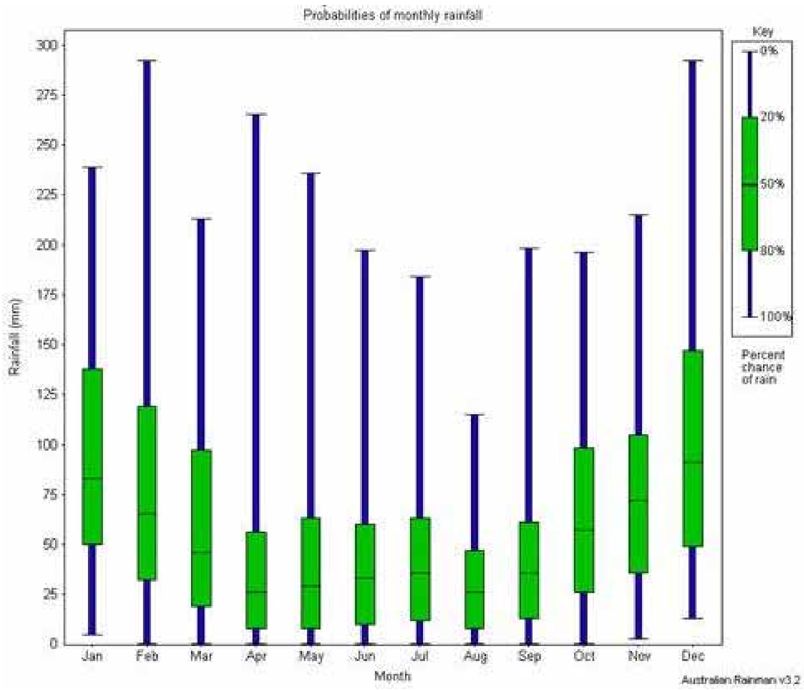
2.2 Water Balance

The annual average rainfall and evaporation provides an indication of the annual irrigation requirement, and the wet weather (balancing) storage needs for an effluent irrigation area. Wet weather storage is discussed in more detail later in Section 4.1.

A water balance calculation includes rainfall, evaporation and irrigation scheduling strategy at a daily scale to calculate the irrigation requirement and the optimal balancing storage.

There are a number of commercially available tools to assist with water balance calculations:

- Effluent Irrigation Reuse Model (ERIM)
- WATMOD
- Perfect
- MEDLI
- WASTLOAD



A spreadsheet can also be used for simple water balance calculations. However, advice from a qualified agricultural agronomist is desirable.

Further Information

- *Climate data can be obtained from the Bureau of Meteorology, website www.bom.gov.au*
- *Advice on Water Balance and Irrigation Requirements should be from Agricultural Agronomists or Irrigation Specialists*

3.0 SUSTAINABILITY

A sustainable effluent irrigation management system will achieve a balance between the use of effluent for irrigation with the nutrient requirements of the crop while protecting the environment from potential pollution. Additionally, the amenity of the surrounding environment and meeting the needs on a social and ecological level are important considerations in sustainability.

3.1 Nutrient Balance

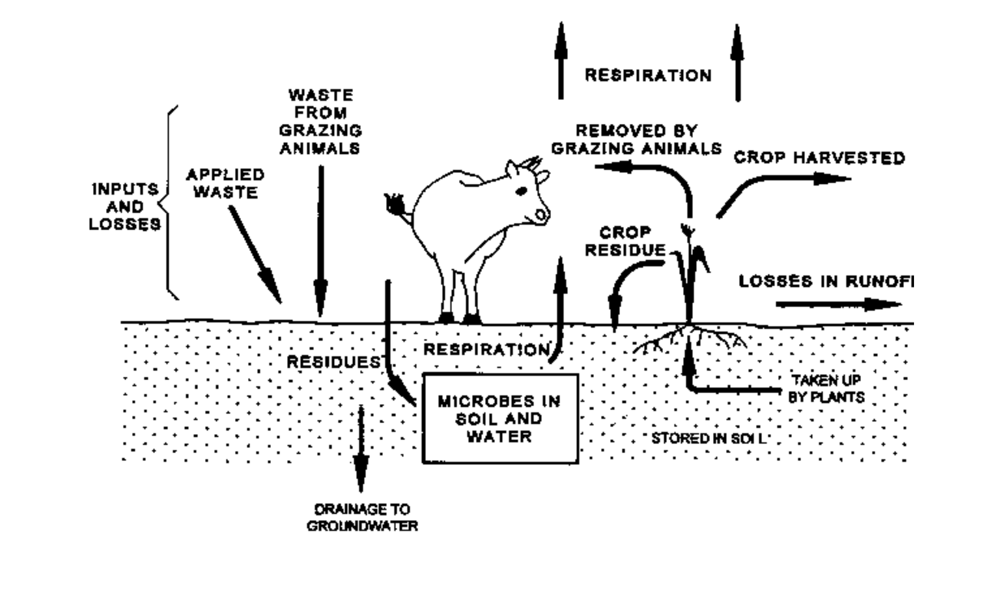
Abattoir effluent contains high levels of nitrogen and phosphorus. Abattoir effluent typically has 130 – 250 mg/L of nitrogen, ie 300 mm of irrigation will provide 450 kg/ha/year of nitrogen. Most crops and pastures have a limit to the amount of nitrogen that can be taken up by plants, therefore, often the main issue is to manage the amount of nitrogen, not the amount of water.

3.1.1 Nutrient Uptake and Cycling

Nutrients can undergo a number of transformations in the soil (see Figure 1) these include:

- Absorption of soluble forms and nutrient uptake by plants
- Breakdown and incorporation into soil organic matter by soil organisms. Further breakdown into gases, which may enter the atmosphere, or soluble form, which enter the soluble pool
- Leaching of soluble forms below the root zone potentially into the groundwater
- Removal by erosion
- Fixation to exchange sites
- Formation of insoluble compounds
- Release to atmosphere from plants.

Figure 1 Nutrient Cycle in Plant Soil System



Effectively, the desirable outcome is to manage the crop and irrigation scheduling so that on balance there is no excess of nutrients in the soil which could leach to groundwater or runoff the site during wet periods.

Soils have a high capacity for immobilising phosphorous and salts, but nitrogen remains in soluble forms (nitrate and nitrite) and is the nutrient most likely to be lost from the site though leaching to groundwater or runoff. Therefore effective nutrient management is required, usually with a focus on nitrogen.

3.1.2 Nitrogen Management

A mass-balance approach to nitrogen management includes consideration of:

- Nitrogen content within the soil
- Nitrogen content within the irrigation water
- Losses due to volatilisation
- Crop type, uptake and harvesting
- Impact of grazing animals.

Effective management of nitrogen requires that the monitoring and recording of nitrogen inputs and outputs occur so that the annual mass-balance returns a zero net increase in nitrogen for the site.

Ultimately, the nitrate concentrations below the root zone of the reuse area provide the best indication of the sustainability of the nitrogen content of the irrigation system. Once nitrogen has moved below the root zone, it is no longer available for plant uptake. Therefore, comparing the nitrogen level with the soils that have not received effluent irrigation (eg under fence-line, or results prior to irrigation) can provide an indication of the sustainability of effluent (and nitrogen) application.

Nitrogen can be safely managed by:

- Knowing how much is added and removed as plant material each year;
- Ensuring that nitrogen removed by crops grown over the year is equal to the nitrogen added in effluent;
- Avoiding saturated soil conditions which might cause the movement of nitrogen; and
- Monitoring residual nitrogen in the soil.

Flood irrigation producing lucerne

3.2 Crop Selection

Choice of the crop to be grown in an effluent irrigation area involves considering the following factors:

- Characteristics of the site (soil type, topography, climate)
- The effort needed to manage the irrigation area
    - level of management of irrigation application
    - cultivation, planting, and harvesting operations
    - management of grazing stock
    - marketing of agricultural products
    - weed control
    - machinery requirements and costs
- Possible need for tolerance to high nutrient levels or salinity
- Ability to accumulate nutrients – if nutrient loads are high then crops capable of using these nutrients are preferred
- Water requirements – crops with higher water use may not necessarily be the best because water is often in short supply compared with the amount of nutrients to be used

- Financial considerations – capital costs, operating costs.

There are five cropping activities which are generally suitable for effluent irrigation:

- pastures
- annual crops
- woodlots
- special horticultural crops
- turf farming.

Further Information

- *There are a number of software applications (with varying levels of input required) to assess site Nutrient Balance, eg ERIM, WASTLOAD, MEDLI*
- *Advice on Crop Selection can be sought from an Agricultural Agronomist, also refer to the Effluent Irrigation Manual (1995)*

3.3 Irrigation Management

Sustainable management of the irrigation system will involve a management plan which includes the operation, monitoring, and reporting for the system. Larger operations formalise this into an Environmental Management Plan for the whole of the abattoir operation which would include sub-plans for different sections of the processing and operations.

Annual review of the performance of the irrigation management system from data collected on operation and environmental performance will assist with identifying areas of risk potential improvements to the system.

3.4 Social Considerations

Consideration of the surrounding community through effective communication regarding the meat processing facility and associated effluent irrigation system will assist with developing a mutually beneficial relationship with the local community.

Strategies to employ include:

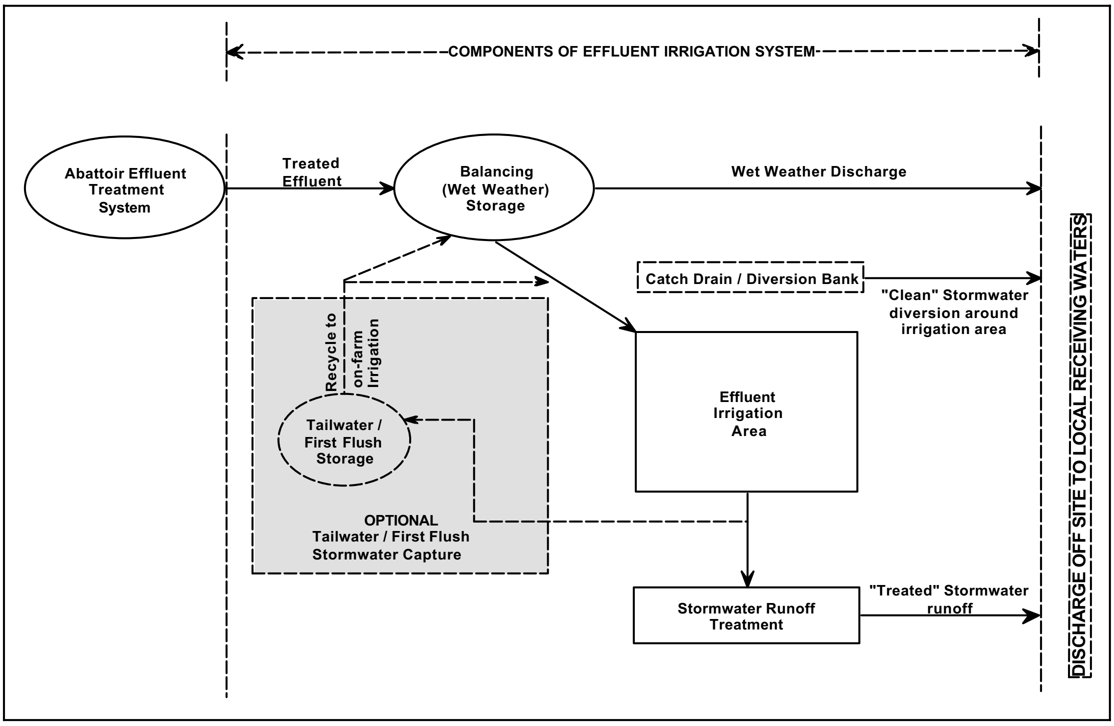
- Open, two way communications through consultative committees
- Maintain communication and feed back in both normal and abnormal times
- Meat processing plant as the first point of complaints (not EPA)
- Fast and co-operative reporting and feedback procedures for complaint handling
- Including a complaint verification procedure in the irrigation management plan
- Data base for complaint assessment.

4.0 IRRIGATION SYSTEM COMPONENTS

The components of an effluent irrigation system are shown in Figure 2 and include:

- Wet weather or balancing storage
- Diversion of "clean" stormwater runoff away from the effluent irrigation area
- Irrigation system including pumps, controls etc
- Stormwater runoff "treatment" (and Tailwater Capture if necessary)
- Wet weather discharge.

Figure 2 Effluent Irrigation System Components



4.1 Balancing (Wet Weather) Storage

Due to the variation in climate and weather patterns, there will be periods of wet weather when irrigation is not possible. To achieve zero discharge of treated effluent from the site, during periods of wet weather effluent needs to be stored in a balancing or wet weather storage until conditions are suitable for irrigation.

As discussed in Section 2.2 a water balance calculation is a useful method of sizing a wet weather storage. This method can also assess the frequency of discharges that might occur based on the historical climatic record.

The wet weather storages needs to be sized to match the rate of effluent produced and the regional climatic setting of the site. Some states (eg NSW) set a wet weather discharge frequency limit such as: "*discharge can only occur during a 75th percentile or 90th percentile rainfall year*". In such cases, the storage needs to be designed to hold the volume of effluent such that this frequency of "overflow" or discharge limit can be met.

Further Information

- *More detail on the design and operation of Balancing (Wet Weather) Storage is in the Effluent Irrigation Manual (1995)*

4.2 "Clean" Runoff Diversion

Where the irrigation area is located mid-slope, run-on from areas up hill needs to be redirected. Catch drains, diversion drains or low bunding can be used to separate the effluent irrigation area from upslope runoff areas. This will ensure that the water management in the irrigation area is well controlled, and reduces the possibility of contaminated stormwater runoff from leaving the site.

50 ML wet weather storage dam

4.3 Effluent Irrigation System

The choice of effluent irrigation system depends on the following:

- Site characteristics, slope (see 1.1)
- Soil characteristics (see Section 1.2)
- Crop type (see Section 3.2)
- Capital costs
- Operating costs
- Precision and control of application

There are three basic groupings of the irrigation methods: spray, surface irrigation and micro as outlined in Table 7 below.

Table 7 Irrigation Methods

Irrigation Method	System Types
Spray irrigation	Hand move sprinkler Side roll sprinkler Travelling gun Centre pivot Travelling Lateral
Surface irrigation	Furrow Border check Levelled bays Contour bays Wild flooding
Micro irrigation	Drip Mini sprinkler

The irrigation system should provide for uniform application of the effluent and at a rate less than the permeability of the soil. Table 2 provided an overview of the irrigation methods suitable for different slopes, and Table 8 below outlines the advantages and disadvantages for each system.

A centre pivot irrigator

Table 8 Irrigation System Advantages and Disadvantages

Irrigation Method	Advantages	Disadvantages
Surface Systems	▪ Good control of tail water, ▪ Potential to recirculate tail water ▪ High efficiency and uniformity on appropriate soils ▪ Potential to control stormwater runoff ▪ Minimal pumping costs	▪ Most systems apply a “minimum” unit of 40 mm – 80 mm of water at a time ▪ Furrow erosion if not well-designed ▪ Deep percolation losses on light soils if poorly designed ▪ Leakage from channels and drains if not well maintained ▪ Could require substantial land forming works on uneven land ▪ Effect of above ground works (eg access tracks) on external overland flows
Spray Systems	▪ Frequent application and small quantities can be applied ▪ Little or no tailwater ▪ Diffuse stormwater runoff ▪ Control of depth of application reducing deep percolation ▪ No water losses from supply channel ▪ Minimal impact on overland flows ▪ High pumping costs	▪ No control or reuse of tailwater or stormwater runoff ▪ Water and dissolved nutrients carried off site by spray drift ▪ Requires almost complete clearing of trees ▪ Uncontrolled runoff on heavy soils and/or steep slopes ▪ Poor uniformity of watering if sprinklers not well maintained ▪ Labour intensive
Micro Irrigation	▪ Minimal wind effects ▪ Good water use efficiency ▪ Good irrigation control – no tailwater and little deep percolation ▪ Low pumping costs	▪ Poor performance if system not well designed or operated ▪ Requires a high level of monitoring maintenance and scheduling ▪ Effluent needs to be filtered ▪ High capital cost

4.3.1 Surface Irrigation

These systems account for nearly 80% of irrigation in Australia. They are popular because they:

- are suitable for clay soils
- require minimal equipment to operate
- have minimal or no pumping costs

The drawbacks however for effluent irrigation relate mainly to the environmental risks due to surface runoff. Surface systems need to be well operated and maintained so that tailwater is effectively collected and controlled. Deep percolation is prevented and uniform coverage achieved by careful grading of the site. Proper maintenance of the transport and collector channels and drains will ensure that seepage losses do not occur.

4.3.2 Spray irrigation

Spray irrigation systems provide the most flexibility for irrigators and are generally suitable for abattoir effluent irrigation. The main advantages are:

- the ease of operation when well designed and set up
- suitability for a wide range of crop and soil types
- the ability to provide a high level of control for uniformity and depth of watering
- avoid the need for a tailwater collection system.

4.3.3 Micro Irrigation

Micro irrigation systems are generally less suitable for use with effluent. This is because drippers and micro sprays are easily blocked when there is a high load of suspended solids as would be expected from abattoir effluent. The high nutrient loads also increase algal growth around outlet nozzles, also causing blockage.

Therefore, micro-irrigation is only applicable in specialist situations where a higher water quality (ie low concentrations of salts, nutrients and suspended solids) of effluent is available and specialist skills are available to manage the system.

4.4 Stormwater Runoff Considerations

One of the key objectives of managing an effluent irrigation system is to protect the environment from harm caused by contaminants in the effluent. Therefore, best industry practice is to ensure that surface drainage from the irrigation area does not contaminate surface waters. Strategies for managing stormwater runoff should also consider:

- the proximity of surface waters to the irrigation area
- the water quality objectives of surface waters
- flow characteristics of the receiving water (ie lake, intermittent or perennial stream).

The stormwater runoff management strategy will also depend on the irrigation system in place:

Surface irrigation systems include tailwater capture and reuse for irrigation. The tailwater storage can be sized to capture a desired runoff volume and provide storage of "first flush" runoff.

Spray irrigation systems are designed to provide uniform irrigation coverage without runoff therefore, tailwater is not captured. Therefore, managing stormwater to provide "treatment" of stormwater is a good practice as discussed below.

Appropriate site management practices to avoid the need for a first flush storage include:

- Schedule irrigation to meet the moisture demand
- Providing contour banks on steeper slopes to disperse runoff and minimise erosion
- Provide a well-maintained grassed buffer strip along the down-slope boundary or between the irrigation area and a watercourse
- Convert an irrigation tailwater dam into a wetland
- Direct runoff into a woodlot or runoff disposal area that is maintained with a good grass cover.

Maintaining a grass riparian filter strip between the paddock and the watercourse is good farming practice whether or not effluent is used for irrigation. The desirable filter width is calculated from a range of factors which include rainfall intensity, soil erosivity, slope and the paddock area. By trapping fine sediments, grassed filter strips are also an effective means of trapping contaminants (suspended solids and nutrients) before they reach surface waters.

Further Information

- *Guidelines for Riparian Filter Strips for Queensland Irrigators* [8]
- *National Policy and Regulatory Stormwater Review* [12]

4.5 Wet Weather Discharge

Not all effluent irrigation systems are capable of using 100% of the effluent as it is produced, particularly during periods of extended wet weather. Therefore, a balancing or wet weather storage is usually an essential component of the effluent irrigation system (see Section 4.1) unless the effluent quantity is small relative to the size of land available (sometimes the case for very small abattoirs).

Wet weather discharge from a site is defined as the discharge of effluent from the property boundary. Therefore, during wet weather if discharge from the balancing storage is necessary, it is preferable that it occurs in a controlled and organised manner. Ideally, during wet weather, a steady discharge at a uniform depth across the upper section of the property is usually considered. Effluent will be treated and diluted as it passes through vegetation to lower reaches of the property so that "clean" runoff leaves the site at the boundary.

- **Wet weather discharge allowances vary between States, and will depend on the sensitivity of the receiving waters.**
- **Advice should be sought from the local EPA office (or equivalent)**

Travelling irrigator

5.0 OPERATION AND MANAGEMENT

Developing an irrigation management plan which forms part of an overall site operation or management plan is an important aspect of industry best practice in effluent irrigation. Outlined below are the specific operational management areas which need to be considered when formulating the irrigation management plan.

5.1 Operation Manual

An important aspect of the operation and management of the irrigation system is a well documented operation manual. The system operation manual should specify:

- the correct way to operate all equipment and installations
- scheduling methods and crop water requirements
- how the system should work and its optimal operating range
- protocols for operating the system safely
- how the system handles natural extreme events such as floods and storms
- how the system's operation will be monitored
- how environmental impacts will be monitored
- emergency procedures.

The operation manual can also provide the basis for training staff in the management of the effluent irrigation system.

5.2 Maintenance Manual

A system maintenance manual should include:

- A service manual and parts book.
- A schedule of maintenance and replacement that specifies the frequency of inspection and service for all elements of the irrigation system.

5.3 Irrigation Scheduling

Irrigation scheduling of effluent is dependant on three main factors:

- the quality of the effluent and the impact it will have on the nutrient balance for the site
- the moisture content of the soil and the amount of water needed to water the root zone
- weather considerations – wind rainfall and temperature.

As outlined in Section 3.1, the limiting factor for most sites is the nutrient load applied to the site. The most appropriate strategy where higher strength effluent is used to maintain a soil water deficit. This aims to stress the crops at specific stages in the growth cycle and maintains a high yield ensuring that the soils and the cropping regime have the capacity to use available nutrients.

Irrigation scheduling also needs to consider the soil moisture store of the soil. If the soil moisture store is thought of as a tank, then when the store is full (ie the soil saturated) then excess water will spill (to deep drainage / groundwater or pond on the surface).

5.3.1 Irrigation Strategy

The irrigation strategy needs to suit the water requirements of the crop while meeting the nutrient balance of the site. Generally the preferred strategy for effluent irrigation is a “deficit” irrigation strategy, however, the strategy chosen will be dependant on:

- Irrigation system - a “deficit irrigation” strategy requires a high level of control of the quantity of water used. This is difficult to achieve using a surface irrigation system
- Soil water holding properties – will impact on the frequency of watering
- Crop choice – crops which are stress tolerant can be used to achieve high yields using a deficit strategy
- Crop management – knowing when to apply stress to achieve the desired crop outcome.

5.3.2 Soil Moisture

Where soil saturation during irrigation poses a high risk of environmental damage caused by deep drainage to groundwater, or ponding and surface runoff, a higher standard of irrigation management is necessary. Monitoring soil moisture can be a useful tool in assisting with irrigation management to prevent soil saturation.

Further Information

- *Advice from an Agricultural Agronomist can be sought to establish simple rules for maximum irrigation rates depending on the season and when not to irrigate*
- *For details of Deficit Irrigation refer to the Effluent Irrigation Manual*

5.3.3 Weather

When scheduling irrigation, it is important to consider the current and future weather conditions. Weather impacts include

- rainfall – impacts on soil moisture and the amount of irrigation required,
- wind – impact on odour and spray,

- temperature impacts on evaporation and odour - may be more effective to irrigate at night

Weather impacts the frequency of irrigation, therefore maintaining a weather record can be a useful tool to assist with irrigation scheduling. Some sites will achieve this through installing an automatic weather station, however, at a minimum, rainfall records should be maintained.

5.4 Management of Salinity & Leaching

Salinity in the soil can be a serious problem when additional salt is being delivered through irrigation. Plants have differing tolerance to salt and accumulation of salt in the root zone can have a negative impact on plant growth.

Management of soil salinity in many areas of Australia is vital to maintaining vigorous growth in crops. The key elements to managing soil salinity are:

- regular soil monitoring to identify changes in salinity
- regular monitoring of effluent to account for salt added to the irrigation area
- monitoring of groundwater levels
- controlled leaching to “wash out” accumulated salt from soils

During the wet season, salt leaching can be expected therefore leaching by applying irrigation application is usually not necessary. Salt leaching by applying additional irrigation needs to be a planned and managed activity undertaken when the nitrate level in the soil is at a minimum.

Further Information

- *If the annual soil salinity monitoring shows increases in salinity, seek advice from a Soil Scientist or Agricultural Agronomist for appropriate strategies to promote soil leaching*

5.5 Odour Management

Odour becomes an issue when complaints occur. The majority of odour complaints arise from the meat processing and the effluent treatment process rather than effluent irrigation. However, potential exists for low-level odour to be released from irrigation with inadequately treated effluent or effluent containing insufficient dissolved oxygen.

Strategies for managing odour arising from effluent irrigation include:

- reducing spray drift through choice of big droplet spray emitter
- vegetated buffer zones to separate the irrigation area from neighbours
- irrigating at night
- careful consideration of prevailing wind direction and strength before scheduling irrigation.

6.0 MONITORING AND REPORTING

Keeping track of the effluent irrigation system is an important aspect of meeting environmental requirements as well as satisfying licence conditions. Annual reporting is a statutory requirement of most effluent irrigation schemes.

6.1 Monitoring and Record Keeping

Monitoring of the effluent irrigation system can be broken down into two key areas:

1. Operational performance
2. Environmental performance

6.1.1 Operational Monitoring

On the operational side, data needs to be collected to assist with day to day decisions regarding:

- irrigation scheduling
- system management during irrigation to prevent over watering
- maintenance of the irrigation system, ie regular checking for leaks, blockages, pressure testing etc.

Record keeping is also necessary to keep track of operational activities as they occur and of the nutrient balance for the site, ie crop type, mass harvested and removed, stocking rates where applicable.

6.1.2 Environmental Performance Monitoring

Monitoring environmental performance requires the systematic collection of data to quantify the levels of potential pollutants in the receiving environment. This data provides essential information regarding environmental performance. Non-conformance triggers the review management strategies to ensure that environmental objectives are met.

Effluent quality and quantity may change with time as a result of the seasonal nature of some industries or changes to production or treatment processes. Adjustments to irrigation, vegetation, soil or stock management may then become necessary.

To ensure that remedial action can be taken early, the following sampling and records are recommended:

- flow monitoring (from wastewater system to irrigation system)
- effluent quality monitoring (from wastewater system to irrigation system)
- soil monitoring
- groundwater monitoring (where applicable)
- climate – rainfall.

The frequency of monitoring will vary depending on:

- the size of the irrigation system
- the proximity of environmentally sensitive receptors, ie depth to groundwater, location of water supply bores, drinking water catchments, neighbours
- strength of effluent
- soil characteristics.

A flood irrigation scheme showing contours to direct effluent

Analysis of soil and water samples should be undertaken by a NATA registered laboratory. NATA accreditation provides formal recognition to competent testing facilities and indicates that the test, calibration or inspection data supplied by the laboratory are accurate and reliable.

The methods used for the collection, handling, storage and transportation of samples need to be well-documented, and staff trained in sampling procedures. This will ensure that sampling occurs at the right location and are less likely to be inconsistent due to poor handling and storage. The analysing laboratory can provide guidance on developing sampling procedures.

Alternatively, employing a third party to undertake the sampling can provide the benefit of consistency in the sampling procedure, and improved confidence in the results.

Further Information

- *A list of NATA registered laboratories can be found at: www.nata.asn.au*
- *Advice on the parameters to be monitored and frequency should be sought from the local EPA office*

6.2 Reporting

Where an effluent irrigation scheme is licensed by a State authority, one of the conditions of the licence will usually be the return of an annual report. The annual report will provide details of the performance of the irrigation system during the reporting period and include all relevant events which have the potential to impact on the receiving environment. In some states, the annual report also needs to be independently verified to ensure that the collection, use and interpretation of information is correct.

To achieve an "independently verified" report, some facilities choose to have the report prepared by a third party. This can ensure that the preparation and presentation of information is consistent, and reduces the likelihood of bias in the reporting. This, however, will depend on the size of the scheme and the level of detail required by the regulatory authority.

Smaller facilities will generally prepare their own annual reports using a structure and minimum reporting methods provided by the regulating authority.

7.0 REFERENCES

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