final report

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Identification of Nutrient Source Reduction Opportunities and treatment options for Australian Abbatoirs and Rendering Plants

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Foreword

Rust PPK Pty Ltd in association with Taylor Consulting (Aust.) Pty Ltd were contracted by the Meat Research Corporation (MRC) to perform a nutrient audit of three abattoirs, and to incorporate the results from another study of two abattoirs performed by the Chemical Engineering Department of the University of Queensland in association with Australia Meat Holdings Pty Limited (AMH). This work was contracted under the Environmental Issues sub-program of the MRC.

Nutrients in wastewater, namely nitrogen and phosphorus, constitute one of the greatest and most expensive challenges facing abattoir and rendering plant owners in the 1990s. Whether wastewater disposal is to rivers, estuaries or to land, nutrients will determine costs of that disposal as regulators bring in nutrient restrictions. As this report demonstrates, abattoirs generate very significant quantities of both nitrogen and phosphorus.

The outcome of this report is that these nutrients are generated largely in two or three sections of the plant. Furthermore, the capture of these nutrient-rich streams to prevent their release into the wastewater should be possible. In the case of rendering and blood processing waste streams, the captured nitrogen could be added to existing product streams. This not only reduces capital and operating costs in wastewater treatment, but provides a return to the abattoir owner on the investment in capturing the waste stream. Alternatively, there is evidence that equipment selection or redesign (i.e. raw material bins) may greatly reduce nutrient release into wastewater streams.

The reader should also be aware of related projects currently running under the Environmental Issues sub-program of the MRC and dealing with the issue of nutrients in abattoir wastewater.

These include:

- **M.476 The development of a user-friendly irrigation management system for Australia abattoirs.** This project has generated a straightforward manual to help abattoirs dispose of nutrient-rich treated wastewater on to irrigation sites in an environmentally sustainable manner. If your abattoir is irrigating wastewater, this manual is for you!

- **M.478 Development of improved nutrient removal in abattoir wastewater treatment ponds.** A demonstration pond has been constructed on-site at an Australian abattoir to develop a low-cost, but efficient, alternative to more expensive activated sludge systems for removing sizeable quantities of nitrogen and phosphorus from abattoir effluent.

- **M.734 Nutrient minimisation: monitoring and analysis of stickwater evaporation.** A stickwater evaporator has been installed at an Australian abattoir. This has the potential to remove 50% of the nutrients in abattoir wastewater and return them as saleable product. A double win! This project will evaluate such a process.

These projects are all aimed at helping the Australian red meat process industry to minimise environmental-related costs while achieving world best environment practice. Contact the MRC for details.

Executive Summary

This report provides the results of investigations and data collection for five red meat abattoirs. The abattoirs selected cover a range of different operations, climatic conditions and types of animals processed. Data collected includes production levels, fresh water consumptions, wastewater quantities, qualities and treatment systems.

Pollutants considered include organic loading (COD and BOD), nitrogen, phosphorus, oil and grease, suspended solids and sodium. All wastewater pollutants were identified in terms of inputs and outputs of the abattoir process and mass balances were constructed to identify individual source locations.

For comparisons between abattoirs which may vary both in size, operations and type of animals processed the Hot Standard Carcass Weight (HSCW) has been identified as being the most appropriate unit on which to base both fresh water consumption and the generation of pollutant quantities.

Fresh water consumption has been shown to have a major impact in relation to the input of pollutants, wastewater treatment system effectiveness and treated effluent disposal options. Common fresh water supply sources are described in terms of their potential contributions to the total pollutant load. Total fresh water consumptions in addition to a breakdown of consumption by operation have been given both in terms of overall volumes and volumes per unit carcass weight.

Hot water versus cold water consumption has been discussed in terms of potential generation and energy requirements, potential problems for subsequent wastewater treatment and breakdown of usages by production area.

Detailed descriptions of abattoir wastewater treatment systems have been provided to cover the most common treatment processes, typical efficiencies, shortcomings of current practice and options for nutrient removal.

Irrigation has been identified as being the most common disposal method for treated effluent and the impacts of sodium, nitrogen and phosphorus on plant growth and soil quality are discussed.

Wastewater sources in abattoirs and pollutant loadings including the nutrients nitrogen and phosphorus have been determined. Wastewater quantities and qualities are provided for the overall wastewater and final treated effluent and treatment efficiencies evaluated. Each wastewater source is ranked in terms of the potential to contribute pollutant loads to the overall wastewater. Sodium, nitrogen, phosphorus and COD quantities in kg of pollutant per tonne HSCW are compared for all five abattoirs and for all wastewater sources.

The chemical nature of nutrient species and other analytes in abattoir wastewater are explained and quantified both for the overall case and for individual source locations.

The use of recycled effluent has been identified as beneficial for reductions in fresh water usage and associated pollutant inputs (only relevant to sodium in highly saline water supplies). However, the use of recycled effluent does not significantly alter the total mass output of most wastewater pollutants and in fact leads to an increase in the concentration of pollutants in the final effluent due to a reduced volume.

Conclusions of this report include:

That fresh water sodium levels have the greatest impact on the resulting effluent sodium levels and that high effluent sodium levels are more likely in larger inland works processing grass fed stock.

Based on a comparison of feedlot versus grassfed cattle in terms of total quantities of pollutants generated from various wastewater sources, much higher nutrient quantities especially phosphorus were produced from lot fed cattle.

Rendering plants or by-products processing, where in operation, are the single largest source of wastewater contamination for these abattoirs. Individual wastewater sources within rendering plants have been identified and their potential contribution of pollutants have been quantified in terms of kg per 50 tonne HSCW.

Major sources of additional wastewater pollutants include manure and paunch contents, casings processing, and pickling processes (for sodium).

A number of recommendations are made concerning the following areas:

(i) Development of best-practice approach to the management of wastewater pollutants.

(ii) Opportunities to reduce fresh water consumption.

(iii) Opportunities and best-practices to reduce the output of nutrients, sodium and organic loading from an abattoir. Particular attention is given to rendering operations.

By relating pollutant outputs to production levels quick calculations may be undertaken for pollutant loads at any abattoir. However, it is recommended that abattoirs endeavour to obtain site specific data for the quantities of wastewater pollutants generated. The information presented in this report should provide for improved understanding and direction in reducing the output of wastewater pollutants.

Introduction

Rust PPK Pty Ltd in association with Taylor Consulting (Aust.) Pty Ltd were commissioned by the Meat Research Corporation to undertake the Project, "Identification and Nutrient Source Reduction Opportunities and Treatment Options for Australian Abattoirs and Rendering Plants".

The intention of the study is to identify which abattoir and rendering processes contribute the nutrients, nitrogen and phosphorus, to wastewater streams and to identify opportunities and treatment options by which these quantities of waste nutrients can be reduced at source. In addition to nitrogen and phosphorus, the Project also provides recommendations to reduce the usage of water as well as to minimise the generation of sodium, oil and grease and Chemical Oxygen Demand (COD) in wastewater streams.

The overall aims of the Project are to:

- ensure that the industry has access to high quality, current data regarding waste nutrient loads resulting from its operation;
- provide a basis for reducing waste nutrient loads produced by the industry and to recommend improvements to abattoir housekeeping and wastewater management practices to assist in minimisation of nutrient and sodium quantities, and to increase the efficiency of waste treatment and recovery of product; and
- identify opportunities for the development of cleaner technologies or practices.

Objectives identified in the Project Specification were to:

(i) conduct an investigative research program at three red meat abattoirs to determine wastewater nutrient (nitrogen, phosphorus, oil/grease) sources, quantities and nature during the full daily cycle of abattoir operations in varying climatic conditions and different types of abattoir operations;

(ii) incorporate the results of a similar research program being undertaken through The University of Queensland at an additional two abattoirs;

(iii) compare the waste nutrient-generating performance of the most common rendering units in the Australian Meat Industry, including reference to seasonal fluctuations in nutrient load;

(iv) compile recommendations arising from the study for reducing the output of waste nutrients at source;

(v) compile recommendations for residual treatment; and

(vi) disseminate the results of the program and the recommendations to the Australian Meat Industry.

Site investigations involved the measurement and recording of critical water and wastewater streams in addition to both on-site and off-site laboratory analyses. Process flow sheets and mass balances were established for each abattoir for water nutrients, sodium and COD by equating all input sources with measured wastewater quantities.

Results from site investigations included information regarding fresh water supply sources, consumptions and quality concerns, through to final effluent contaminant quantities and disposal problems.

This report represents a detailed summary of the findings and conclusions of the Project. Information is presented in two parts with Part A - Results of Site Investigation encompassing objectives (i) to (iii) above and Part B - Discussion of Results and Recommendations representing the remaining objectives.

It is intended that this report will provide the basis for the dissemination of the results and recommendations to the Australian Meat Industry.

Part A Results of Site Investigations

1. Summary of Abattoirs Investigated

1.1 General

Under the requirements of the Project, results from site investigations, measurements and analyses from five abattoirs have been included in the final report. Limited information obtained from a further two abattoirs has also been included bringing the total number to seven. These abattoirs are referenced sequentially from Abattoir A through to Abattoir G.

The abattoirs chosen for site investigation programs were selected in order to maximise the applicability and usefulness of the information obtained for Australian conditions. Abattoirs have been selected for different species, sizes, extent of operations, in different climatic conditions and catering for different markets.

Fresh water supply sources, wastewater treatment systems and effluent disposal methods also vary significantly for the selected sites.

1.2 Abattoir Operations

The extent of operations and activities on site directly relate to all environmental issues. With respect to the generation of nutrients and other contaminants, abattoir operations will determine the following:

- fresh water consumption;
- wastewater volumes/flowrates;
- quantities of nutrients and contaminants generated;
- size and type of wastewater treatment facilities required; and,
- effluent disposal options.

Table 1.1 presents a summary of Abattoir operations including species processed, product market, climatic zone and generalised abattoir operations which occur on-site. The purpose of this information is to create for the reader an overall picture of the size, location and type of each abattoir as a background for comparison of other abattoirs Australia-wide.

Consideration of the species processed is important as this affects many areas of the water and wastewaters systems and consequently areas of nutrient generation. Some of the impacts associated with differing species include:

- overall water consumption per Unit Product Weight (refer Appendix A for definition);

- varying practices relating to the holding of animals prior to slaughter, for example, overhead wire floored pens for sheep with daily washdown compared with continuous washdown in cattle holding yards;

- quantities of water required for stock drinking;

- quantities of paunch material and wastewater from other slaughter and offal processing practices such as carcass washing;

- feedstock, for example, feedlot animals are typically larger with a higher proportion of fat.

Product market knowledge is useful in assessing such things as total water consumption. Since stricter guidelines on microbial contamination are monitored for export plants, water consumption for uses including sterilisers and cleaning are typically much higher than for domestic market plants.

Climate will determine many factors crucial to abattoir operations, including rainfall patterns and evaporation rates which are critical for effluent disposal requirements and ambient treatment pond temperatures. These affect microbiological reaction rates and wastewater treatment effectiveness. The climatic zones referred to in Table 1.1 have been defined by the Bureau of Meteorology (Reference 1) and are reproduced in Appendix B.

Abattoir operations will for the most part determine the quantity and nature of the various wastewater streams and knowledge of this information is the first step in identifying and reducing the generation of nutrients and other contaminants.

In Table 1.1 'slaughter' incorporates all facets of normal abattoir operations with respect to the receival, holding, slaughter, evisceration, refrigeration and edible offal processing of animals. Additional operations are considered to be Boning Rooms, Casings Plants, Rendering Facilities and skin and hide processing such as Fellmongery and Pickling Plants.

Table 1.1
Summary of Abattoir Operations

	Species			Market		Climatic Zone			Operations						
Abattoir	**Cattle**	**Sheep**	**Pigs**	**Domestic**	**Export**	**Summer Rainfall - Tropical**	**Summer Rainfall - Subtropical**	**Uniform Rainfall - Temperate**	**Slaughter**	**Boning**	**Casings**	**Cont. HT Rendering**	**Batch HT Rendering**	**Fellmongery**	**Pickling**
A		■			■			■	■	■	■	■		■	■
B		■		■				■	■						
C	■	■	■	■				■	■		■				■
D	■			■			■		■	■		■			
E	■				■		■		■	■			■		
F	■				■		■		■	■		■			
G	■				■	■			■	■			■		

1.3 Abattoir Production

Information on production levels for the abattoirs investigated is given in Table 1.2 Summary of Abattoir Production. The information consists of numbers of shifts per day along with production times and daily Hot Standard Carcase Weights (HSCWs) as defined in Appendix A. This data provides the best indication of the size of the operation.

The number of shifts per day is an important consideration for water consumption. It can be assumed that the volume required for cleaning will be independent of production times and hence overall water usage will not double when changing from a one shift to a two shift per day operation. A more realistic increase would be around 50 to 70%. Water consumption is discussed in detail in Section 2.

Production levels are quoted in tonnes per day of HSCW. This is the Unit Product Weight (recorded by most abattoirs) that will be used to set benchmark quantities on water consumption and the generation of nutrients and sodium in this report.

Table 1.2
Summary of Abattoir Production

	Number of shifts/day	Production Times				Production HCSW (Tonnes)		
		Slaughter	Boning	Rendering	Cleaning	Cattle	Sheep	Pigs
Abattoir A	2	16 hrs	16 hrs	24 hrs	8 hrs	-	172	-
Abattoir B	1	8 hrs	-	-	4 hrs	-	27-54	-
Abattoir C	1	9 hrs	-	-	5 hrs	3-20	37-40	20-50
Abattoir D	1	8 hrs	8 hrs	21 hrs	14 hrs	264	-	-
Abattoir E	1	8 hrs	16 hrs	18 hrs	14 hrs	228	-	-
Abattoir F	1	8 hrs	8 hrs	16 hrs	8 hrs	112	-	-
Abattoir G	1	8 hrs	6 hrs	16 hrs	8 hrs	188	-	-

2. Fresh Water Supplies and Consumptions

2.1 General

Abattoirs are typically large consumers of water. Water used in abattoirs is essentially of two types:

(i) Potable (or drinking) quality water obtainable from a variety of sources is the primary supply. Major usages of potable water include:

- all water used on the slaughter floor and other edible production areas, for example, knife sterilisers, handwash basins, carcase washing, viscera tables and cleaning purpose;
- all water used for domestic type purposes, for example, showers and toilets;
- all water used for stock drinking.

Very strict requirements exist for the quality of potable water used in abattoirs with particular emphasis on the potential for microbiological contamination. Fresh water supplies should be regularly monitored as to the quality (even when supply is from town mains) and subsequent treatment including disinfection implemented if required.

(ii) Recycled effluent (wastewater after treatment) is commonly used in most abattoirs for non-potable applications including:

- stockyard washdown;
- initial washing of cattle prior to slaughter (although animals will then require a final wash with potable quality water);
- washdown and cleaning of other areas where permitted, such as outdoor paved surfaces, primary wastewater treatment facilities and some inedible production areas;
- recycled water usage can vary from zero up to 50% of the total water consumption.

Water consumption and its minimisation is arguably the most important factor in reducing the output of nutrients and other contaminants and in the efficient treatment of wastewater. Before beginning on a program for reducing these outputs, all major uses of water should be identified and, if possible, measured. Minimising water usage results in the minimising of wastewater volumes and consequences include:

- smaller and cheaper wastewater treatment systems;
- improved efficiency in existing treatment systems;

- cost savings in the pumping and treating of wastewater;
- easier and cheaper disposal of effluent especially if controlled by an effluent discharge licence to a town sewage treatment plant.

2.2 Measurement of Water Consumptions

Ideally fresh water consumptions for all major uses or plant sections should be monitored. Methods available for collecting this information include:

- town mains supply meters;
- process water meters;
- information based on equipment specifications;
- calculation from pump flowrates and operating times.

An example of water consumption estimation by equipment and process areas is given in Appendix E.

In most areas, water consumption is translatable to wastewater volumes, i.e. water in = water out and vice versa. Hence, measurement of wastewater volumes can be used to estimate water consumptions. Our experience is that wastewater flowrates, in general, are difficult to measure. Methods available range from the high-tech to the very simple and include:

- Open channel weir levels (in which a weir is constructed to precise dimensions and positioned in an open channel such that the overflow level at the weir corresponds to a particular flowrate). Levels can be recorded by ultrasonic sensor or by capacitance probe although the latter method is often not reliable with abattoir wastes due to the high suspended solids and fat content;
- calculation from pump flowrates and operating times;
- calculation from rising levels in sumps, times and sump dimensions;
- many abattoirs have wastewater streams that discharge into a series of large pits. Some of these flows can be estimated using a bucket and stopwatch technique. This should be repeated numerous times at each measurement, with measurements taken throughout the production period.

2.3 Fresh Water Supply Sources

Measurement of nutrient and contaminant **outputs** from abattoirs are often not sufficient to determine what possible reductions can be made in these outputs. It is also important to quantify the nutrient and contaminant **inputs** to the abattoir. One of these inputs is the fresh water supply. To determine the quantities of nutrients and contaminants entering the abattoir via the water supply it is necessary to record both water consumptions (detailed above) and the water quality.

This section deals only with the quality of fresh water sources, recycled water supply quality warrants its own discussion and is incorporated within Section 6 of this report.

Fresh water supplies for abattoirs can be classified into town mains supply, surface waters such as rivers, and creeks and sub-surface waters such as watertable bores (unpressurised) and artesian bores (pressurised).

Town Mains Supply

It can generally be assumed that water from a town mains supply is of potable quality since it must be maintained to meet the drinking water quality standards required by government regulatory bodies.

Microbiological contamination is controlled in most community water supplies by the initial addition of chlorine (disinfection) and the maintenance of a 'residual' of between 0.1 to 0.5 mg/L chlorine in the distribution system. Most abattoirs are likely to be located towards the end of the water distribution system. The chlorine residual, which decays with time, may be negligible in these circumstances.

It is a requirement that abattoirs re-dose incoming water with chlorine, even town mains supply, to ensure satisfactory disinfection. Chlorine is dosed typically as solid calcium hypochlorite or sodium hypochlorite solution. This is good practice for minimising the potential for meat contamination yet it does increase the dissolved solids and sodium levels which eventually appear in the effluent.

Excluding very strict requirements on microbiological and chemical contamination, drinking water regulations are based around general aesthetic qualities. Drinking water should meet the following guidelines.

Table 2.1
Drinking Water Quality Guidelines (Reference 3)

Description	Level
Total coliforms (indicator of microbiological contamination)	None
Turbidity (suspended particles)	5 NTU
Total dissolved solids, TDS	< 500 mg/L good 500 - 1,000 mg/L acceptable > 1,000 causes scaling and corrosion problems - unacceptable tastes
Sodium, Na	> 180 mg/L taste threshold 300 mg/L limit

NTU = Nephelometric turbidity unit(s), a measure of the degree to which light is scattered by suspended materials i.e. aesthetic visibility, clarity.

Table 2.1 represents only a small selection of the guidelines, however, these are of large importance to abattoirs.

Contaminants present in the fresh water supply can represent major contributions to wastewater treatment and disposal problems. Of particular importance are contaminants including Total Dissolved Solids (TDS) and Sodium, which are not reduced in conventional wastewater treatment systems used by abattoirs. TDS and sodium levels given in Table 2.1 are for aesthetic limits only, however, the levels of these pollutants in the final effluent is a major factor in determining land disposal requirements.

Surface Waters

Surface waters used for water supply in abattoirs are generally rivers or lakes. Water drawn from these sources should meet the same guidelines as for drinking water by the time it is used in the abattoir. Often this means an additional facility must be constructed to treat water prior to use in the abattoir. Table 2.2 below details briefly water treatment processes for common surface water contaminants.

Table 2.2
Water Treatment Operations

Common Surface Water Contaminant	Treatment Process
High Turbidity	Filtration
High TDS/Hardness	Chemical Precipitation (typically lime)
Coliforms	Disinfection (typically chlorine)

Surface waters commonly contain higher levels of TDS and sodium than town mains supplies, although since most town supplies in rural areas are also sourced from rivers this difference is often relatively small.

Subsurface Waters

Subsurface or groundwater sources for abattoirs are generally deep artesian bores, in some cases up to 350 metres or more in depth.

Water sourced from bores is typically of a lower standard than surface waters and is characterised by high TDS and sodium levels. Water drawn from subsurface sources often does not comply with the National Health and Medical Research Council (NHMRC) drinking water guidelines for TDS and sodium and in extreme cases is considered unsuitable even for irrigation. This presents a major effluent disposal problem for some operators. TDS levels in the range of 500 to 1,000 mg/L and sodium levels up to 400 mg/L are not uncommon in subsurface waters.

Some groundwater sources may be subject to contamination from surface waters, with underground aquifers or storages (typically shallow) hydraulically connected to nearby surface water sources depending on local geology. For this reason bore water should also be regularly monitored for microbiological and other contaminants for which strict health limits apply for the meat industry.

2.4 Breakdown of Fresh Water Consumptions by Operations

The aim of this section is to present a breakdown of the fresh water consumptions by major operations for the abattoirs investigated. These results and associated discussions should allow the operator of an abattoir to make some very quick approximations as to the distribution of fresh water consumption in their abattoir.

Table 2.3 Summary Fresh Water Supplies indicates total volumes and sources of fresh water for the abattoirs investigated.

Table 2.3
Summary Fresh Water Supplies

	Town Mains Supply (kL/day)	Treated River Water (kL/day)	Bore Water (kL/day)
Abattoir A	915	1,370	-
Abattoir B	180	-	-
Abattoir C	275	-	-
Abattoir D	2200	-	-
Abattoir E	-	-	1140
Abattoir F	1040	-	-
Abattoir G	1888	-	-

The total fresh water consumption can be divided into three major types as follows:

(i) Fresh water supply consumed during normal production times and contributing to the wastewater system from operations including slaughter, evisceration, boning, edible and inedible offal processing, casings and rendering plants and domestic usage.

(ii) Fresh water supply consumed during cleaning and hosedown operations and contributing to the wastewater system.

(iii) Fresh water supply consumptions which do not contribute to the wastewater system from operations including livestock drinking, defrost and condenser make-up water, boiler losses and backwashing streams in water treatment.

Table 2.4 Percentage Breakdown of Fresh Water Consumption by Operations details the recorded water consumptions at the various abattoirs. These figures, taken in conjunction with the information presented in Sections 1.2 and 1.3 and in Table 2.3 above, represent a comprehensive overall picture of these abattoirs and should also provide indicative figures for many other abattoirs.

Table 2.4
Percentage Breakdown of Fresh Water Consumption by Operations

Abattoir	Slaughter, Evisceration and Boning	Inedible and Edible	Casings	Rendering	Chillers	Stock Watering	Stock Yard Washdowns	Domestic Uses	Boiler Losses	Pickle Plant	Fellmongery	Filter Backwash	Make-up, Defrost, Losses etc.	Cleaning and Hosedown Component Where Known *
A	55.6	11.3	9.1	0.2	ND	5.25	n/a	2.4	4	3.7	0.2	6	2.15	25.4
B	52.2	37.9	n/a	n/a	ND	5	ND	5	ND	n/a	n/a	n/a	ND	21.6
C	44.4	19.5	19.7	n/a	2.3	3.6	4.5	4.8	1.2	n/a	n/a	n/a	ND	ND
D	53.0	31.8	n/a	1.7	ND	5	n/a	3.5	ND	n/a	n/a	n/a	ND	≈ 36
E	60.6	7.1	n/a	7.6	ND	5.3	16.1	3.3	ND	n/a	n/a	n/a	ND	29.2

n/a Not Applicable
ND No Data
* Cleaning and hosedown component contributes to many areas and is included in the previous columns

A number of these consumptions can be estimated using the following figures:

Domestic uses	100 litres/employee/day
Stock watering	
- cattle	20 litres/animal/day
- sheep	3 litres/animal/day
- pigs	5 litres/animal/day

It should be noted that these are considered to be good average figures only, and that significant deviations could occur in practice. Important factors to be considered for stock watering consumptions include animal holding times, temperature and drinking apparatus especially for pigs.

In situations where water treatment prior to the abattoir is required the filter backwash stream can represent a considerable volume of water, which ideally should have its own treatment and recycle systems.

Typically filter backwash volumes are around 5 to 10% of the total throughput. A system which does not treat and recycle this backwash volume is not only operating inefficiently but also creating an additional wastewater disposal problem.

The cleaning and hosedown component of the total supply is difficult to evaluate. A relatively simple method for approximating this usage requires only the measurement of the final effluent volumes over the twenty-four hour period. The cleaning and hosedown volume is then approximated by subtracting the effluent volumes during production times from the total daily effluent volume. The component (percentage) of the total fresh water supply is simply this calculated volume divided by the total fresh water supply (usually metered).

2.5 Fresh Water Consumption Per Unit Product Weight

In the development of a system in which the water consumption of one abattoir can be compared against that of another, a standard must be defined which is applicable to the industry as a whole.

An appropriate standard for this is the water consumption (kL) per tonne of Hot Standard Carcass Weight.

Average figures for the abattoirs investigated are given in Table 2.5.

Table 2.5
Total Fresh Water Consumption Per Unit Product Weight

Abattoir	Fresh Water Consumption (kL/tonne HSCW)
A	13.8
B	4.0
C	3.3
D	8.3
E	5.0
F	9.3
G	10

From Table 2.5 an operator would compare their abattoirs total fresh water consumption with those investigated. Taking this one step further, the fresh water consumption breakdown in Table 2.4 can be manipulated to represent the fresh water consumption per unit product weight by abattoir operation. In other words, water consumption by operation and independent of production throughput. This is shown in Table 2.6.

Table 2.6
Breakdown of Fresh Water Consumptions by Operators
(kL/tonne HSCW)

Abattoir	Slaughter, Evisceration and	Offal Processing	Casings	Rendering	Chillers	Stock Watering	Stock Yard Washdowns	Domestic Uses	Boiler Make-Up	Pickle Plant	Fellmongery	Filter Backwash	Make-up, Defrost, Losses etc.	Cleaning and Hosedown Component Where Known
A	7.39	1.5	1.21	0.03	ND	0.7	n/a	0.32	0.52	0.49	0.03	0.8	0.29	3.37
B	2.1	1.52	n/a	n/a	ND	0.2	ND	0.2	n/a	n/a	n/a	n/a	ND	0.90
C	1.50	0.7	0.67	n/a	0.08	0.12	0.15	0.16	0.04	n/a	n/a	n/a	ND	ND
D	4.42	2.65	n/a	0.14	ND	0.42	n/a	0.29	ND	n/a	n/a	n/a	ND	3.0
E	3.03	0.36	n/a	0.38	ND	0.27	0.81	0.17	ND	n/a	n/a	n/a	ND	1.46

n/a Not Applicable
ND No Data

Some significant results are as follows:

Slaughter, Evisceration and Boning - percentage breakdown figures varied from 44.4% to 55.6% of the total consumption. As percentages there is a relatively small range in the results, whereas independent of production, Abattoir A consumes around three to four times the amount of water compared to Abattoirs B and C and around two and half times that of Abattoirs D and E.

Offal Processing - percentage figures varied from 7.1% to 37.9% with all sites significantly different. Results independent of production show Abattoirs A, B and D at around the same levels from 1.5 to 1.9 with Abattoirs C and E lower at 0.7 and 0.34 kL/tonne HSCW respectively.

Cleaning and Hosedown Component - on a percentage of total consumption Abattoirs A and B were 21.6% and 25.4% respectively, whereas independent of production and similar to slaughter, evisceration and boning, Abattoir A uses around four times the volume of water compared to Abattoir B. The most likely explanation for this would be in total surface areas available for cleaning since Abattoir B is a very small and compact plant.

2.6 Hot Water Versus Cold Water Consumption

Hot water (greater than 83°C) is required for overflowing sterilisers and plant sanitation. Hot water consumption is usually taken as approximately 30% of the fresh water consumption. It is typically generated by either:

- use of a steam fed heat exchanger; or
- condensation of rendering vapour.

Rendering vapour amounts to around 50% of the total raw materials processed, with each kg of vapour condensed generating approximately 7.5 litres of hot water at 83°C. With adequately insulated storage capacity this should be sufficient to support operations.

Without a continuous rendering process it is usually necessary to provide a steam fed heat exchanger to supply hot water to allow operations to commence before rendering begins.

Where hot water is generated in excess of the works requirements, it is usually due to excessive use of water in the conveying of raw materials (e.g. in blow conveyor systems, or in the use of pumps to transfer gut to the raw materials bin). This is ultimately extremely inefficient in energy consumption.

Excessive production of hot water is not only very costly but also contributes to problems in the wastewater treatment system. At temperatures above around 35°C fats and greases will exist as liquids and will not be effectively removed through primary treatment systems such as screens. This situation simply transfers the problem downstream to secondary treatment processes often representing a considerable increase in wastewater loadings.

Although the separation of fatty layers from water occurs more rapidly at higher temperatures this is not always true for abattoir wastes. Fats, oils and greases in abattoir wastes often exist in a colloidal state or as an emulsion at higher temperatures. In either state, natural physical separation will not occur to any significant degree and more elaborate treatment processes such as Dissolved Air Flotation (DAF) units are required.

At only one of the sites investigated was information obtainable concerning hot water versus cold water consumption.

Abattoir C at which an extensive water metering program was implemented, yielded a complete breakdown of water consumption data. Abattoir C also has a separate warm water system (approximately 45 to 50°C) for handwash basins supply although consumption of warm water represents only about 2% of the total. Table 2.7 Summary of Water Consumptions - Abattoir C, presents the results obtained.

Table 2.7
Summary of Water Consumptions - Abattoir C

Operations Area	Cold Water (% of Total)	Warm Water (% of Total)	Hot Water (% of Total)	Total Fresh Water (% of Total)
Sheep Slaughter Floor	12.7	0.4	4.5	17.5
Pig Slaughter Floor	16.4	0.9	5.1	22.4
Beef Slaughter Floor	2.0	0.1	2.5	4.6
Offal Processing	14.9	0.5	4.2	19.6
Casings Plant	19.7			19.7
Chillers	0.2		2.1	2.3
Cattle Yards Washdown	1.6			1.6
Sheep and Pig Pens Washdown	2.8			2.8
Inedible Offal Areas Washdown	0.5			0.5
Bulk Bin Area Washdown	0.2			0.2
Cattle Drinking Troughs	0.4			0.4
Sheep and Pig Stock Watering	3.2			3.2
Boiler Make-Up	0.4			0.4
Amenities	4.9			4.9
Totals	**79.9**	**1.9**	**18.4**	**100.00**

Hot water consumption in Abattoir C represents 18.4% of the total fresh water consumption. Hot water usages exist only on the slaughter floors and offal processing areas, individual percentage consumptions in these areas is shown in Table 2.8.

Table 2.8
Percentage Hot Water Consumption by Operations

Operation Area	Hot Water Usage (%)
Sheep Slaughter Floor (SF)	26
Pig SF	23
Beef SF	54
Offal Processing	21

Major uses of hot water in abattoirs are typically:

(i) Continuous overflow sterilisers.

(ii) Hot water taps/hoses used during cleaning operations.

(iii) Pig scald tanks (although these normally receive a cold water supply and heat via live steam injection).

(iv) Boiler losses.

Abattoirs with higher steriliser usage such as those having export licenses would have a significantly greater use of hot water on the slaughter floor than shown above.

Abattoirs with a higher water consumption for cleaning purposes would also be expected to use a greater proportion of hot water.

3. Wastewater Systems

3.1 Summary Abattoir Wastewater Systems

Various detailed discussions and papers concerning current levels of waste treatment and emerging issues/developments in the Australian Meat Industry are readily available through the Meat Research Corporation (Reference 2, 4). One of the valid points raised in the Cooper Report (Reference 5) was that generally abattoirs were found to have significantly increased their operations over time without subsequent increases in the capacity of the wastewater treatment system.

The intent of this section is to represent a summary only, of the common unit operations of wastewater treatment systems utilised in abattoirs. Where considered important, operations which are not common practice yet relevant to the subject i.e. nutrient removal, are also mentioned.

Wastewater treatment unit operations are classified as being either Primary, Secondary or Tertiary processes, although many modern processes often combine or overlap these traditional classifications. In primary treatment, physical operations, such as screening and sedimentation, are used to remove the floating and settleable material as well as fats found in wastewater.

In secondary treatment, biological and chemical processes are used to remove most of the organic matter, this includes both anaerobic and aerobic treatment systems.

Tertiary treatment, incorporating processes such as filtration (to remove suspended solids, residual COD and algae), disinfection and additional operations to remove the nutrients nitrogen and phosphorus is not generally used by abattoirs. Without disinfection, the final effluent can be a medium for the transfer of bacteria and viruses including salmonella where cattle and sheep are grazed on irrigation areas.

Modern wastewater treatment processes often incorporate nutrient removal in the secondary treatment stage.

Abattoir wastewater differs from other wastewaters such as sewage in that they are of a high strength, highly degradable and at elevated temperature, and that the waste products can be economically recovered.

Abattoir wastewater treatment systems in Australia typically comprise a combination of the following treatment processes:

Primary Treatment

(i) Screening - static screen
- vibrating screen
- rotary screen.

(ii) Primary Sedimentation Tanks (PST) or Saveall.

(iii) Dissolved Air Flotation (DAF).

Efficient primary treatment is the key to a good wastewater system. Removal of suspended solids, settleable material and floatables such as fats in the primary treatment stage will not only significantly reduce the loading on the secondary treatment facilities but if managed correctly can return a high yield of renderable material such as proteins and fats.

Secondary Treatment

(i) Anaerobic Ponds.

(ii) Aeration Tanks (mechanically aerated).

(iii) Facultative Ponds (anaerobic/aerobic surface layer).

(iv) Maturation Ponds (natural aeration).

Following secondary treatment the effluent is normally disposed of without further treatment. Disposal methods common to abattoirs include:

(i) Spray irrigation.

(ii) Disposal to sewer.

(iii) Disposal to inland waters.

(iv) Tidal waters.

(v) Effluent recycle.

(vi) Nil discharge evaporative basins.

The choice of effluent disposal method will reflect the quality requirements for the wastewater following secondary treatment. This in turn will control the level of treatment required.

Table 3.1 Summary of Abattoir Wastewater Systems presents the unit operations which comprise the wastewater systems at all seven abattoirs considered.

The following points summarise the wastewater systems for these abattoirs:

- The most common choice for screening is the rotary screen for abattoir waste and static screens for paunch manure. Rotary screens in general give much better performance than static and vibrating screens. Many variations of rotary screens are currently available with aperture sizes typically ranging from 0.1 to 2.0 mm.

  The smaller the aperture size the greater the removal of suspended solids, fats and COD. However, small apertures are also more likely to block because of fat accumulation. A suggested minimum aperture size is 0.4 mm (Reference 4).

- All abattoirs utilised pond treatment systems. The use of Anaerobic ponds as the first step in secondary treatment was standard. Abattoirs A through D incorporated mechanical aeration to oxidise remaining organic material after anaerobic treatment, through aerobic bacteria. In most cases, the application of this technology did not allow for the best possible treatment efficiencies. Systems were generally undersized and the removal of sludge build up and prevention of the carry-over of suspended solids to further treatment ponds not given adequate consideration. Aeration system capacities were not matched to potential oxygen demand and in some cases serve primarily only as a mixer.

- Most abattoirs employed effluent recycle for the supply of non-potable water.

- The most common method of effluent disposal is by spray irrigation.

- None of the abattoirs considered employed nutrient removal processes in their wastewater treatment systems to reduce the total nitrogen and phosphorus concentrations in the final effluent.

- In no case did the plants visited conduct step-by-step testing which would allow for the evaluation of removal efficiencies in the pond system.

- Sampling methods are crude (one-off grab sampling) so that results are unreliable. Analysis was not carried out for nutrients (nitrogen and phosphorus), or for other factors crucial to effluent disposal (sodium, total dissolved solids and conductivity).

Table 3.1
Summary of Abattoir Wastewater Systems

		Primary Treatment					Secondary Treatment					Effluent Disposal			
Abattoir	Total Daily Effluent Flow (KL)	Static Screen	Vibrating Screen	Rotary Screen	Saveall	Dissolved Air Flotation	Anaerobic Ponds	Facultative Ponds	Mechanically Aerated Ponds	Natural Aeration/Maturation Ponds	Irrigation Holding Ponds	Effluent Recycle	Sewer	River or other Watercourse	Spray Irrigation
A	2150	■		■			■		■	■	■	■			■
B	130		■				■		■			■			■
C	270		■				■		■	■	■	■			■
D	1700			■	■	■	■		■	■	■	■		■	
E	1080			■	■		■	■			■				■
F	900			■	■	■	■	■		■	■				■
G	1300			■	■		■	■			■			■	■

3.2 Treatment Pond Efficiencies

The use of anaerobic ponds as the first step in biological treatment of abattoir wastewaters is almost universal. For this reason, information gathered during site investigations regarding the physical characteristics, history, operation and treatment efficiencies is presented in Table 3.2. It is intended that these results could be useful for comparison with other pond systems or for incorporation into future research in this area.

These ponds are favoured by the industry due to their cheap construction, extremely low operating costs, and ability to remove up to 95% or greater of the organic loading of the wastewater. Potential drawbacks of a pond system include the requirement of considerable land area and the possibility for nutrient contamination of groundwater sources in areas of highly permeable soil types.

The following factors often lead to poor pond performances:

- Poor design of ponds can include pond shape, depth, size and inlet and outlet structures. Ponds are often constructed very deep and end up resembling a cone or inverted pyramid in shape. This contributes to a more rapid build up of sludge and ineffective flow distribution which reduces the effective volume.

- Lack of pond maintenance, documented operation and monitoring of parameters such as sludge accumulation rates can lead to pond failure after a long period of declining efficiency.

- Hydraulic and organic overload of systems which have not been expanded at an appropriate rate compared with increased production.

- Poor primary treatment can affect pond performance, especially in deposits of excess sludge and organic overload.

- Short-circuiting of ponds, which can greatly reduce the effective volume, could occur for various reasons. Most commonly, the ponds shape contributes to the occurrence of large hydraulic “dead zones” e.g. square ponds with the wastewater traversing a diagonal path leaving “dead zones” in the remaining corners. Another major cause of short-circuiting is the "buoyancy effect" with warmer, lighter influent rising above the cooler, heavier pond contents, flowing across the top of the pond directly to the outlet.

Of significance in Table 3.2 are the very high efficiencies reported from Abattoirs F and G. Although the data is not extensive enough to provide for firm conclusions the following points should be considered:

- both Abattoirs F and G had their anaerobic ponds desludged less than three years ago. Abattoir D's anaerobic pond was desludged in 1993, however, hydraulic retention in this pond is very short;

- ponds at Abattoirs F and G are quite deep with large detention times. Short-circuiting is minimised since both ponds are rectangular in shape with length more than double the width;

- anaerobic processes tend to favour stronger wastes and this could also be a factor in the high efficiencies from Abattoirs F and G since their influents contain around 40% higher levels of COD than the other ponds investigated;

- Abattoirs F and G have sub-tropical and tropical climates respectively, it is expected that ambient pond temperatures would be higher (which favour anaerobic treatment) than for Abattoirs A, B and C which have temperate climates;

- high inlet temperatures (greater than 30°C) are near optimum for anaerobic processes but hinder efficient fat recovery.

Table 3.2
Anaerobic Pond Descriptions and Efficiencies

Abattoir	Pond Operation	Inlet COD (mg/L)	Outlet COD (mg/L)	Most Recent Desludging	Estimated Age (years)	Inlet	Outlet	Depth	Theoretical Hydraulic Retention	Treatment Efficiency %
A	2 in series	4500	1125	Never	6	Above Surface	Surface Weir	6	9	75
B	1 only	3400	714	Never	5	Submerged Pipe	Submerged Pipe	6.5	20	79
C	1 only	3500	630	Never	3	Submerged Pipe	Submerged Pipe	7	13.5	82
D	2 in series	3000	600	1993	No information	Above Surface	Submerged Pipe	4.6	6	84
E	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
F	1 only	6000	150	1992	20	Above Surface	Submerged Pipe	8.6	16	97.5
G	1 only	5000 +	300	1992	34	Above Surface	Submerged Pipe	8	30	94

ND = No Data available for Abattoir E

3.3 Nutrient Removal in Wastewater

3.3.1 Legislative Requirements - Disposal

It is unlikely that abattoirs will be allowed to continue to dispose of wastewater to watercourses including creeks and rivers. Discharge to tidal waterways may still be allowed, however, they will continually attract more specific conditions than present requirements. The increasing requirements and monitoring by the regulatory authorities mean that abattoirs are limited in their effluent disposal options. Available options generally only include either spray irrigation or disposal to sewer. Other methods such as effluent recycle and evaporative techniques (concentrated wastes only) will serve to reduce the overall effluent volume, however, the remainder must still be satisfactorily disposed of.

Disposal to Sewer

As many abattoirs now realise, disposal of wastewater to the local sewerage system can be an extremely expensive exercise. At present, many authorities operating sewage treatment plants around Australia do not charge their trade waste customers on a **user pays** basis. Changing legislation and trends in privatisation of these authorities will lead to the introduction of these charges at the least for economic reasons, since residential customers will strongly object to subsidising the treatment of trade wastes.

As an example, the charges for disposal of treated[1] effluent from a typical abattoir to sewers operated by either Sydney or Hunter Water Corporations would be well in excess of $1 Million per annum. The major components of this charge would be penalties for acceptance of very high nitrogen and phosphorus quantities.

Spray Irrigation

Spray irrigation can be used to dispose of higher levels of nitrogen and phosphorus. However the associated long return times are often the controlling criteria and can require large areas of land for irrigation. Successful application of effluent to the land as a long term solution requires much initial investigation. None of the abattoirs investigated has a formal site management plan. Irrigation is still not the perfect solution, limitations including available land area and the need to harvest the crop to prevent nutrients ultimately impacting on the environment, may mean that to satisfactorily dispose of all the effluent, nutrient levels must be reduced. Impacts of nutrients on wastewater used for irrigation is discussed in more detail in Section 3.4. In addition, the regulatory authorities require large storages to cover prolonged wet periods during which irrigation is not possible.

3.3.2 Available Treatment Technologies

This section is aimed at providing a brief summary of available nutrient removal technologies as applied to abattoir wastewaters. The following assumptions have been made.

1 *Typical treatment might include primary screening, DAF unit, anaerobic and aerobic pond system*

(i) In considering nutrient removal techniques for wastewater treatment it is assumed that all major avenues for source reduction have been investigated.

(ii) Effluent disposal options must be fully investigated to determine either

(a) the maximum receival capacity of the land for spray irrigation, or

(b) a detailed economic analyses has been completed where treatment facility capital and operating costs are compared against ongoing disposal charges.

Options for nitrogen removal are summarised in Table 3.2 Nitrogen Removal Options.

Options for phosphorus removal include biological and physio-chemical methods. These methods are summarised in Table 3.3 Phosphorus Removal Options.

Abattoir wastewater treatment facilities, when compared to similarly loaded facilities in other industries, are greatly under capitalised.

The previous practice of constructing low cost earth lined ponds as the "standard" treatment system, although appropriate in the past, has left the industry unprepared for the relatively high costs of nutrient removal and other higher treatment technologies.

The end result is that treatment facility augmentation and upgrading works are often delayed until forced by regulatory pressure.

Table 3.3
Nitrogen Removal Options

Method	Description	Advantages	Disadvantages
Biological Nitrogen Removal	1. Nitrification. Microbiological oxidisation of ammonia to nitrates. 2. Denitrification. Conversion of nitrates to nitrogen gas. Generally achievable by an activated sludge process	• Can achieve very good quality final effluents; • Very high level of process control available (for skilled labour).	• Require large degree of aeration, high power costs; • Requires concrete lined tank or equivalent; • Requires skilled labour.
Artificial Wetlands	Effluent is passed through plants in a man-made wetlands in which nitrogen is removed biologically and taken up by plants. Some phosphorus may also be removed. Process only successful so far for low strength wastes such as municipal sewage	• Low capital cost; • Low operàting costs; • Good quality effluent.	• Not proven technology for high strength wastes; • Plants must be regularly harvested; • Large area requirement for high volume/high strength waste; • Very little control over system
Air Stripping of Ammonia	Ammonium ions in the wastewater are converted to ammonia gas by raising the pH (approximately 98% at pH 11) Ammonia is removed by stripping with air, usually accomplish in a packed tower fitted with an air blower.	• Following anaerobic treatment most nitrogen exists as ammonium ions.	• Very large quantities of lime or caustic and acid are required to alter wastewater pH; • Lime will produce large quantity of sludge; • Only nitrogen in the form of ammonia is removed; • Large quantity of air required; • Ammonia laden air may need to be further treated.

Table 3.4
Phosphorus Removal Options

Method	Description	Advantages	Disadvantages
Biological Phosphorus Removal	Usually occurring simultaneously to nitrogen removal in modified activated sludge process. Phosphorus is removed by incorporation into cell tissue and subsequent wasting of accumulated sludge.	• Much cheaper than physio-chemical treatment; • Treatment combined with nitrogen removal; • Abattoir waste typically undergoes anaerobic treatment prior to this stage which is beneficial to the process due to low nitrate nitrogen levels; • Resulting sludge can contain high percentage of phosphorus, good fertiliser if properly treated. (Saleable product).	• Most research and operations to date are for municipal sewage with much lower phosphorus levels (10 - 15 mg/L); • Sludge from this process must be continuously removed and dewatered as phosphorus can be released back into solution under anaerobic conditions; • Since technology is still not fully recognised as being reliable, especially without highly skilled operators, often needs to be backed up by physio-chemical facilities to ensure results.
Physio-chemical phosphorus removal	Involves the addition of cationic (positively charged) metal salts (aluminium or iron) to wastewater to form insoluble phosphate precipitates, removal of the precipitate from the wastewater via flocculation and settling and disposal of the settled sludge.	• Chemical costs are becoming increasingly cheaper; • Can successfully use ferrous chloride if dosing into aeration tank - cheaper chemical; • Very well understood tried and true process. Very widely used in many industries.	• High chemical consumption especially due to high phosphorus levels in effluent; • Creates a sludge treatment and disposal problem; • Can lower the pH of wastewater requiring lime of caustic addition.

3.4 Impact of Nutrients on Irrigation

Phosphorus, nitrogen and sodium in the wastewater disposed of by irrigation can have a detrimental impact on the vegetation, soil structure, groundwater resources if the soil is overloaded with one or all of these nutrients. The potential impact each of these nutrients can have is discussed below.

Sodium

Salt applied to land by the irrigation of wastewater or water with high sodium content can result in three consequences.

(1) *Osmotic effect*

With the increasing soil salinity in the root zone as a result of the irrigation, the plant expends more of its available energy on adjusting salt concentration within its tissue (osmotic adjustment) to obtain the water it needs from the soil. This leaves less energy for the plant to use for growth. Once the salinity levels reach a threshold for a particular species, as the salt level increases past this threshold there will be a progressive reduction in yield until the plant will cease to grow.

(2) *Specific ion toxicity*

Growth depressions can result from excessive concentrations of specific ions including sodium.

(3) Poor physical conditions

The stability of the soil depends on electrostatic forces on the soil particles and the ions in the soil solution. When clay particles are surrounded by calcium particles aggregates are formed (flocculated). These permeable aggregates allow water to move through the profile without affecting the aggregates.

By introducing wastewater which contains sodium ions, the sodium ions are exchanged for the calcium in the clay particles, which destroys the electrostatic forces binding the clay particles together. Deflocculation of the clay particles occurs when water is added to the soil, and the water molecules force their way between clay particles and cause them to fall apart. Under these conditions the soil particles disperse, surface sealing of the topsoil may occur and restrictive layers may develop within the profile. Decreased infiltration rates and air movement impeded through the soil result for the deterioration in the soil structure.

Phosphorus

Phosphorus removal in wastewater irrigated to land is accomplished by plant uptake and fixation in the soil matrix. Due to adsorption and precipitation reactions in the soil profile the level of soluble phosphorus declines rapidly with time, and it tends to be attached to the soil particles, in particular clay particles. Once the phosphorus sorption capacity of the soil has reached its limit, and plant uptake cannot utilise all the phosphorus available, it builds up in the profile.

When the soil becomes overloaded with phosphorus, the control of surface runoff and the prevention of soil erosion off site becomes extremely important. The reason for this is that phosphorus is a limiting factor in the eutrophication of surface waters.

Nitrogen

Nitrogen in the form of nitrates (oxidised nitrogen) is very important when considering the impact nitrogen can have on the environment. Being an anion, nitrates are not absorbed by the negatively charged clay particles, and its solubility in water is high. Thus nitrates are susceptible to leaching through the plant root zone into the deep soil layers and inevitably percolate into the groundwater resources, where it causes pollution of the resource.

In acid soils with a pH < 5.5 - 6 or in the presence of amorphous minerals of volcanic origin, positively charged ions capable of absorbing nitrates are prevalent and nitrate leaching decreases.

Nitrogen uptake by plants vary through the season, the highest uptake during certain physiological stages, such as when the growth rate is highest.

Harvesting

Since the nutrients, nitrogen and phosphorus, are taken up in plants, harvesting the crop provides the most direct method of removing nutrients from the site. Crops to be grown need to be carefully selected, particularly with regard to the salinity of the irrigation waters. The practice of grazing stock on irrigation areas as opposed to harvesting essentially achieves only the recycling of nutrients back to the soil via manure and to the abattoir and not off-site as desired.

4. Wastewater Sources, Quantities and Qualities

4.1 Summary of Wastewater Sources

For the purposes of this study wastewater sources within abattoirs have been categorised under standard titles relating to generalised operational areas or distinct wastewater types such as manure.

The following list of wastewater sources in Table 4.1 is extensive and consequently will not be relevant to all abattoirs. This list is designed to encompass from the very largest abattoir to the smallest. For smaller operations which may only identify perhaps three or four of these general sources, it may be necessary to sub-divide these areas to create a more meaningful set of wastewater sources.

Table 4.1
Wastewater Sources in Abattoirs

1. Slaughter and evisceration
2. Offal processing (typically edible offal)
3. Chillers
4. Boning rooms
5. Casings Processing
6. Paunch contents and manure
7. Rendering plants
8. Stock yards
9. Amenities
10. Fellmongery Processes
11. Pickling Processes.

A preliminary list of wastewater sources for any particular abattoir should be based on what can reasonably be measured or analysed.

Site investigations have concluded that wastewater arising from rendering processes is a major contributor to the total wastewater loadings presented to the treatment system.

Rendering plant wastewater has been further sub-divided into five sources as follows:

7.1 Raw materials bin drainage;
7.2 Tallow processing;
7.3 Blood processing;
7.4 Cooker condensate;
7.5 Scrubber effluent.

4.2 Overall Wastewater Quantity, Quality and Treatment Performance

Final treated effluent volumes in the abattoirs measured consist of between 80 to 95% of the fresh water consumptions. Total raw wastewater quantities are greater due to the addition of up to 50% of the fresh water consumption volume as recycled effluent.

As detailed in Section 2, the wastewater flows in most areas can be approximated by the fresh water consumptions in these areas. Where appropriate, typical values can be taken from Table 2.5 for the total consumption on Table 2.6 for individual areas. The main exceptions to this are paunch emptying and rendering operations, both of which release significant wastewater for which the source is the processed animal.

Tables 4.2 and 4.3 below present a summary of the quantity and quality of the overall raw (untreated) wastewater and final treated effluent per tonne of HSCW processed for each abattoir investigated.

Table 4.2
Quantity and Quality of Overall Raw Wastewater

Abattoir	Wastewater Volume (kL)/tonne HSCW	Mass Pollutant (kg)/tonne HSCW					
		COD	TSS	TN	TP	O&G	Na
A	12.5	66.52	ND	3.09	0.53	12.43	4.03
B	3.2 to 6.3	15.93	13.12	1.78	0.29	2.76	1.17
C	2.5 to 4.5	11.87	4.41	1.09	0.11	1.87	0.56
D	10.2 to 12.1	48.89	14.50	2.41	0.43	ND	1.70
E	4.82	28.27	12.10	1.06	0.10	ND	3.89

ND = No Data Available

Table 4.3
Quantity and Quality of the Final Treated Effluent

Abattoir	Effluent Volume (kL)/tonne HSCW	Mass Pollutant (kg)/tonne HSCW					
		COD	TSS	TN	TP	O&G	Na
A	11.0	6.5	ND	2.24	0.53	0.56	3.78
B	3.0 to 6.0	2.38	0.84	1.28	0.21	2.25	1.01
C	2.3 to 4.3	0.54	0.32	0.96	0.14	0.02	0.77
D	6.4	0.88	0.35	0.19	0.27	ND	1.61
E	4.82	ND	ND	ND	ND	ND	ND

ND = No Data Available

Table 4.2 and Table 4.3 represent pollutant quantities before and after the abattoir treatment systems and hence, allows for treatment performances to be evaluated. Table 4.4 contains the percentage removal of wastewater pollutants for each abattoir.

Table 4.4
Percentage Removal of Pollutants in Abattoir Wastewater Treatment Systems

Abattoir	Percent Removal of Pollutant					
	COD	TSS	TN	TP	O&G	Na
A	90.2	ND	27.5	0	95.5	6.2
B	85.0	93.6	28.1	27.6	18.5[2]	13.7
C	95.5	92.7	11.9	0	98.9	-37.5[3]
D	98.2	97.6	92.1[1]	37.2	ND	5.3
E	ND	ND	ND	ND	ND	ND

ND = No Data Available

Notes:

1. As indicated on Table 3.1 Abattoir D has an extensive wastewater treatment system achieving nitrification by high powered aeration followed by denitrification. High percentage removals are required for effluent disposal to river.

2. Abattoir B exhibits a low percentage Oil and Grease (O&G) removal for two reasons (i) the untreated wastewater O&G content is relatively low, and (ii) the treatment system consists of only one anaerobic and one low-powered aeration pond hence reducing the likelihood of removing floating O&G achievable through progressive submerged outlets in multiple pond systems.

3. Although some increase in soluble pollutants is theoretically possible due to evaporation from the pond system it is unlikely to account for this amount. This increase in most likely due to abnormally low sodium levels recorded in the untreated wastewater tested.

Generally, removal rates for chemical oxygen demand, suspended solids and oil and grease are in excess of 90%, however, for soluble pollutants including the nutrients nitrogen and phosphorus and sodium, removal rates are typically less than 30%.

The various forms or speciation in which nitrogen and phosphorus exist in wastewater is discussed in the following section.

4.3 Chemical Nature of Nutrient Species and Other Analytes

Phosphorus

Phosphorus in abattoir wastewater exists almost solely in the form of phosphates. These are further classified as ortho and other polyphosphates and as organically bound phosphates. The only form of phosphate which can be determined by analysis directly is orthophosphate, other forms require pre-treatment for conversion to orthophosphate for analysis. There are three main tests:

- Relative Phosphorus - essentially a measure of orthophosphates (Ortho-P).
- Acid Hydrolyzable Phosphorus (Acid-P) - conversion of condensed phosphate (Cond-P) forms (meta -, pyro -, or other polyphosphates) to orthophosphates before analysis. Organic phosphates are not converted in this process, hence, the "acid hydrolyzable" phosphate results are primarily a measure of inorganic phosphorus.
- Total Phosphorus (TP) - phosphates in organic and condensed inorganic forms are converted to orthophosphates before analysis. Organic phosphorus (Org-P) is simply total less acid hydrolyzable forms.

Phosphorus analyses can be summarised as follows:

TP = Org-P + Acid-P
Acid-P = Cond-P + Ortho-P

All these forms of phosphorus, ortho, condensed and organic can exist in both the dissolved and suspended fractions of the wastewater. Analysis results indicate that typically, greater than 75% of the total phosphorus exists as soluble orthophosphates. The remainder being condensed and organic phosphate forms.

Nitrogen

Nitrogen can exist in the organic, ammonic and oxidised forms. Analytically, organic nitrogen (Org-N) and ammonia (NH_3-N) can be determined together and have been referred to as "Kjeldahl Nitrogen" (TKN). Organic nitrogen includes natural materials as proteins, peptides, nucleic acid and urea and numerous synthetic organic materials.

Total oxidised nitrogen (NO_x-N) is the sum of nitrate and nitrite nitrogen.

Nitrogen analyses can be summarised as follows:

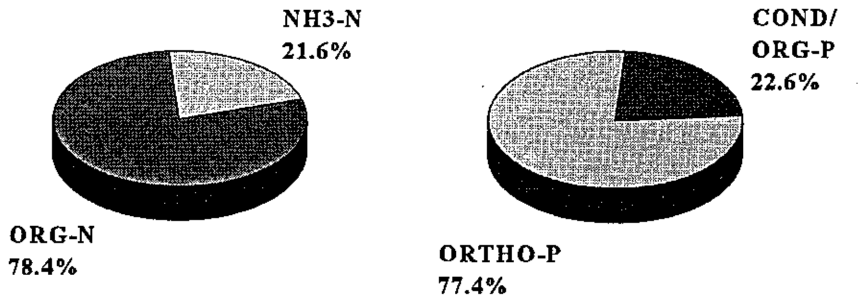
TKN = Org-N + NH_3-N
NO_x-N = NO_2-N + NO_3-N

Organic nitrogen can exist in both the dissolved and suspended fractions of the wastewater whereas both ammonia and oxidised nitrogen forms exist only in the dissolved fractions. Analysis results indicate that ammonia percentages of the total nitrogen in untreated wastewater are widely variable depending on the source with values typically between 15 to 50%. Ammonia percentages following anaerobic treatment increase to generally greater than 80% through the conversion of the organic nitrogen. Oxidised nitrogen levels in abattoir wastewaters are normally less than 1% of the total nitrogen content.

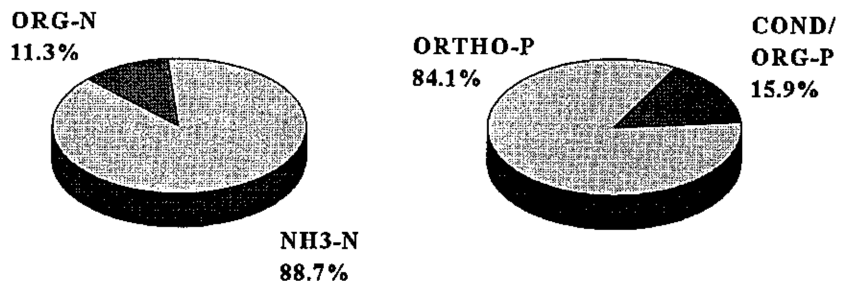
Nutrient speciation (nitrogen and phosphorus) data for the overall raw wastewater, post anaerobic treatment and final effluent is shown in Figure 4.1.

Figure 4.1
Nutrient Speciation in Abattoir Wastewater and Treated Effluents

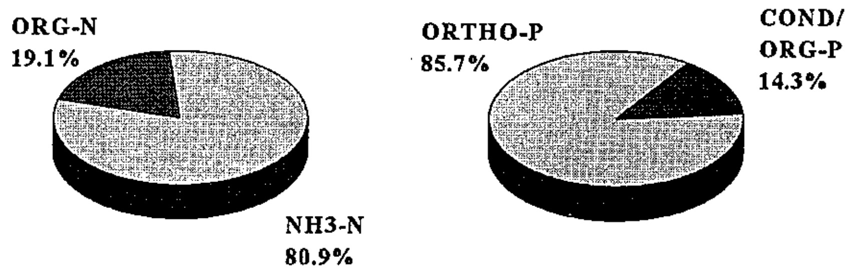
1. Overall Raw Wastewater



2. Post Anaerobic Treatment



3. Final Treated Effluent



Chemical Oxygen Demand (COD)

COD is used as a measure of the oxygen equivalent of the organic matter content of a sample that is susceptible to oxidation by a strong chemical oxidant. For samples from a specific source COD can be related empirically to the Biological Oxygen Demand (BOD) which is simply a measure of the oxygen utilised during a specific time period for the biochemical degradation of organic material. Both BOD and COD of wastewater will decrease with time, however, COD decreases proportionally less than BOD, and thus, was more appropriate for determination of mass balance relationships across an abattoir required in the Project.

The ratio of COD to BOD varies greatly on the source and age of the wastewater with values in the range of 1.3 to 3.7:1 recorded.

Sodium

Sodium is an indicator of the total salinity of the wastewater. Salt in the soil solution has important consequences for plant growth and land degradation. Sodium exists as a "dissolved solid" in ionic form. For effluent disposal investigations the sodium to total cation ratio (generally calcium plus magnesium) is also important.

4.4 Typical Quantities and Qualities of Wastewater Sources

This section presents detailed descriptions of the wastewater sources identified in Section 4.1 in the following general manner:

A. Wastewater type and description.

B. Measured or estimated daily volumes.

C. Wastewater quality, including physical characteristics such as temperature, solids content and pH. Analysis results (mg/L) and calculated ranges of daily masses of major contaminants, nutrients and sodium expressed as kilograms per tonne HSCW. In addition, nutrient speciation data is supplied for each wastewater source where available.

D. Typical raw material sources including:

- fresh water inputs;
- recycle water inputs;
- blood, fat and other animal sources.

Summary worksheets for each abattoir investigated, containing averaged values for effluent analyses, calculated daily masses and daily masses per tonne hot standard carcass weight are contained in Appendix E.

1. Slaughter and Evisceration

A. Sources for this wastewater include all activities relating to the slaughter and evisceration of animals up to production of the hot dressed carcase. Major contributions by volume are from overflowing sterilisers and cleaning.

B. Wastewater volumes from this area can be approximated by the corresponding water consumptions. From Table 2.6 volumes range from 1.5 to 7.39 kL/tonne HSCW with four of the five abattoirs between 1.5 and 3.53.

Volumes will depend upon:

- number of sterilisers;
- water use by viscera table(s);
- water used during cleaning, related to method and surface area.

- degree to which carcass washing is employed;

Where high pressure/sanitising carcass washing is used, this is likely to represent a considerable water consumption. The use of hot water and/or acetic acid in the sprays will also significantly increase the wastewater loadings in this area.

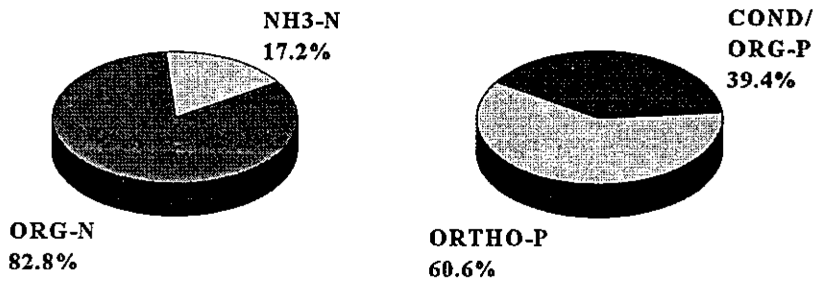
Wastewater from slaughter and evisceration account for around 40 to 60% of the total wastewater volume.

C. This wastewater is generally of good quality relative to other abattoir waste streams. It is characterised as being warm to hot, mostly clear to a pale red in colour. Typical pollutant levels are as follows:

Table 4.5
Typical Pollutant Levels and Daily Masses
In Wastewater From Slaughter and Evisceration

Analyte	Typical Range (mg/L)	Minimum Recorded Value (mg/L)	Range of Daily Masses (kg/tonne HSCW)
Total Suspended Solids (TSS)	400 - 800	420	0.7 to 1.2
Total Phosphorus	< 10	2.5	0.003 to 0.07
Total Nitrogen	< 300	68	0.08 to 1.0
Chemical Oxygen Demand (COD)	1000 - 3000	972	1 to 6.5
Sodium	< 1100	34	0.17 to 1.34
Oil and Grease (O&G)	< 350	27	0.1 to 0.6
Temperature	19 to 65°C	19	-
pH	7 - 8.5	N/A	-

Figure 4.2
Nutrient Speciation in Wastewater from Slaughter and Evisceration



D. Due to the large fresh water volume used in this area, a significant proportion of the daily mass of sodium could be from this source. Major source of pollutants in the wastewater are blood, meat scraps and fat particles.

2. *Offal Processing*

A. Wastewater sources in offal processing are primarily due to washing operations in inedible and edible offal and pet food areas. In most cases this includes the cutting and emptying of paunches and runners, however, paunch or manure effluent has been excluded in this case and treated separately (see 6 below).

B. Wastewater volumes can be approximated by corresponding water consumptions. From Table 2.6, volumes range from 0.34 to 1.9 kL/tonne HSCW with the five abattoirs investigated well spread over this range. Volumes will depend upon:

- equipment selections and operating practices;
- water used for cleaning.

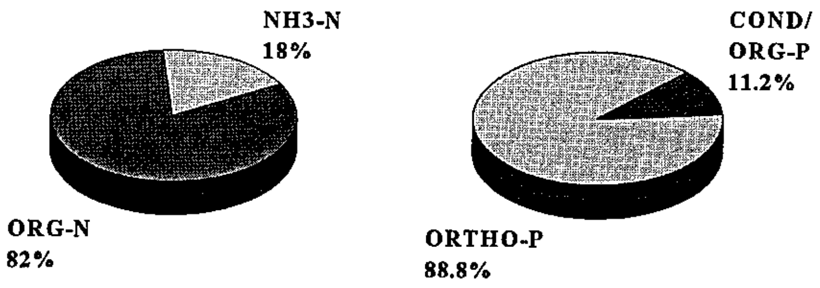
Wastewater from offal processing accounts for around 10 to 40% of the total wastewater volume.

C. Offal processing wastewater is of highly variable quality due to the many varied operations which occur in these areas. It is characterised as being cold to warm and a pale to deep watery red colour. The appearance of manure or paunch contents in this waste (characterised by yellow and brown colours) will contribute to a general degradation in wastewater quality. Typical pollutant levels are as follows:

Table 4.6
Typical Pollutant Levels and Daily Masses In Wastewater From Offal Processing

Analyte	Typical Range (mg/L)	Minimum Recorded Value (mg/L)	Range of Daily Masses (kg/tonne HSCW)
TSS	600 - 2600	660	0.2 - 1.3
Total Phosphorus	15 - 100	15	0.01 - 0.08
Total Nitrogen	100 - 500	120	0.1 - 0.5
COD	2000 - 7500	1900	0.9 - 7.0
Sodium	150 - 800	32	0.02 - 0.3
O&G	100 - 1300	100	0.1 - 1.0
Temperature	20 to 35°C	21°C	-
pH	5.4 - 8.1	N/A	-

Figure 4.3
Nutrient Speciation in Wastewater from Offal Processing



D. A significant proportion of the daily mass of sodium could be due to the input water supply. Any use of recycled effluent could greatly increase the output masses of all contaminants. Major pollutants are blood, meat and fat in greater quantities than slaughter and evisceration wastewater.

3 and 4. ***Chillers and Boning Rooms***

A. These two areas have been combined since as sources of effluent they are very similar and need only be covered once. Wastewater from chillers only occurs during cleaning and hosedown operations. Although there is generally some flow from boning rooms during production times, the majority of wastewater is also created during cleaning and hosedown operations.

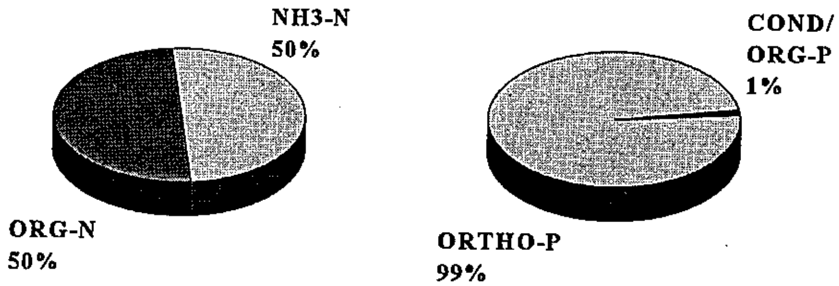
B. Wastewater volume is equivalent to water consumption in these areas with boning room production volumes around 0.06 to 1.1 kL per tonne HSCW. Cleaning usages in these areas have not been isolated, however, it is expected to be at least equivalent to the production volumes.

C. This wastewater is similar to quality to that from slaughter and evisceration areas, and hence relatively of a higher quality than other abattoir streams. Typical pollutant levels are as follows.

Table 4.7
Typical Pollutant Levels and Daily Masses
In Wastewater From Chillers and Boning Operations

Analyte	Typical Range (mg/L)	Minimum Recorded Value (mg/L)	Range of Daily Masses (kg/tonne HSCW)
TSS	50 - 200	52	< 0.5
Total Phosphorus	< 10	0.2	< 0.001
Total Nitrogen	< 300	8	< 0.17
COD	300 - 800	308	< 0.46
Sodium	30 - 70	28	0.003 - 0.03
O&G	300 - 900		< 0.07
Temperature	Hot water used for cleaning	15	-
pH	5.1 - 8.7	N/A	-

Figure 4.4
Nutrient Speciation in Wastewater from Chillers and Boning Operations



D. Major contributions to pollutant levels consist of meat and fat scraps collected during cleaning.

5. *Casings Processings*

A. Casings processing occurred at only two of the five abattoirs investigated. Wastewater is produced from the final washing, grading and packing of runners.

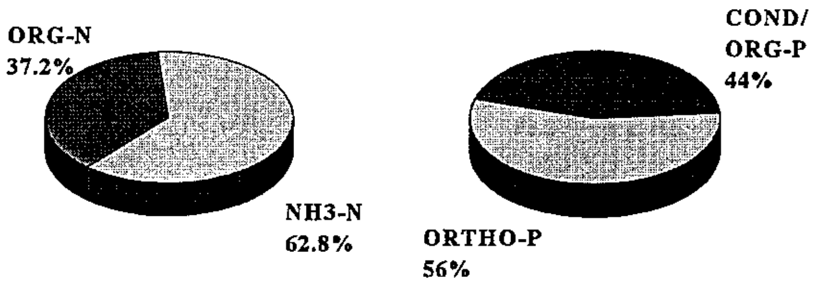
B. Wastewater volumes are equivalent to fresh water consumptions with measurements ranging from 0.67 to 1.21 kL/tonne HSCW. This represents around 10 to 20% of the total water consumption.

C. Wastewater is characterised by its white, opaque colouring and large quantity of intestine lining material from the final washing. Casings wastewater should be screened to remove this solid material. This wastewater can be a major source of sodium since after washing and grading, runners are packed in salt which accumulates on the floor and can be carried into the wastewater system. Typical quantity ranges and daily masses are as follows:

Table 4.8
Typical Pollutant Levels and Daily Masses In Wastewater From Casings Processing

Analyte	Typical Range (mg/L)	Minimum Recorded Value (mg/L)	Range of Daily Masses (kg/tonne HSCW)
TSS	500 - 1000	690	0.4 - 0.6
Total Phosphorus	10 - 70	8.1	0.01 - 0.05
Total Nitrogen	200 - 450	240	0.05 - 0.30
COD	500 - 800	610	0.4 - 0.62
Sodium	400 - 600	460	0.3 - 0.52
O&G	< 150	16	0.01 - 0.07
Temperature	Cold - Warm	35°C	-
pH	-	7.04	-

Figure 4.5
Nutrient Speciation in Wastewater from Casings Processing



D. Major contributions to pollutant levels are from casings contents (not completely removed at the offal processing stage in the abattoir), solid material in the form of casings linings, fat and salt.

6. Paunch Contents and Manure

A. The source of this wastewater is in the cutting and emptying of paunches, usually completed with the addition of large volumes of water. Other contributions to this waste might include stock yard washdowns and amenities wastewater. Paunch contents and manure wastes are a major load on the treatment system and a significant source of nutrients, COD and sodium.

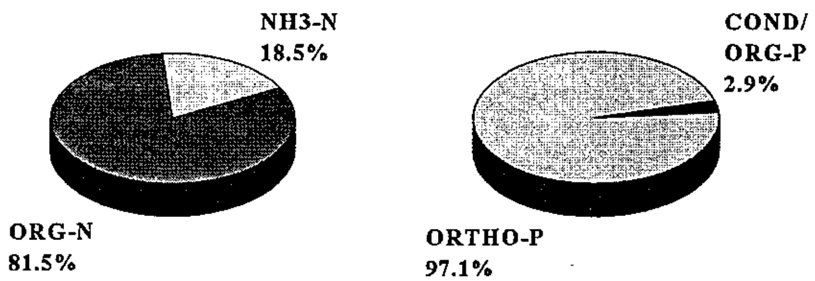
B. Wastewater volumes measured in this study vary from 0.13 up to 2.82 kL/tonne HSCW. Large flows result from the practice of 'Wet Dumping' of paunches where washwater and paunch contents are combined in the wastewater. Manure streams can represent up to 25% by volume of the total wastewater flow.

C. This wastewater typically has a high degree of suspended material, a high COD and often the highest sodium levels of the abattoir waste steams. This waste is characterised by its colour with hues of yellow and brown.

Table 4.9
Typical Pollutant Levels and Daily Masses
In Wastewater Containing Manure and Paunch Contents

Analyte	Typical Range (mg/L)	Minimum Recorded Value (mg/L)	Range of Daily Masses (kg/tonne HSCW)
TSS	800 - 4500	824	0.8 - 2.3
Total Phosphorus	80 - 140	81	0.02 - 0.35
Total Nitrogen	90 - 320	89	0.06 - 0.73
COD	3000 - 13500	3310	2.7 - 13.7
Sodium	300 - 750	320	0.14 - 1.61
O&G	600 - 1500	670	0.6 - 4.3
Temperature	Cold - Warm	31°C	-
pH	6.8 - 7.9	N/A	-

Figure 4.6
Nutrient Speciation in Wastewater Containing
Manure and Paunch Contents



D. Major contributions to these pollutant levels are the contents of paunches consisting of partly digested feed and soluble proteins. The type of feed will impact on the levels of nutrients and sodium obtained.

7. *Rendering Plant*

Wastewater from rendering plants representing a combination of the major individual components was sampled and analysed, however, the results exhibited large variations even from identical sampling points. The most likely explanation for this is in the wide variations in quality of the individual component streams and the intermittent or cyclical flow variations of these streams.

For this reason it is more appropriate to only present the results of the individual component streams. The combined effluent quality can then be assumed from the addition of these outputs.

Rendering plant wastewaters contain very high concentrations of most wastewater contaminants, a high proportion of which is recoverable as saleable product. Implications in the loss of nitrogen can be estimated in terms of loss of revenue from meal production as follows:

Nitrogen (N)		x 6.25≈ Protein
Protein	x 2	≈ Meal equivalent
Therefore	N x 12.5	≈ Potential loss in meal production

7.1 *Raw Materials Bin Drainage*

A. This is wastewater produced from the rendering raw materials or bulk storage bin, mostly due to surplus water introduced to the bin with the raw materials. Wastewater is typically collected in a sump underneath the bin and intermittently pumped into the wastewater system.

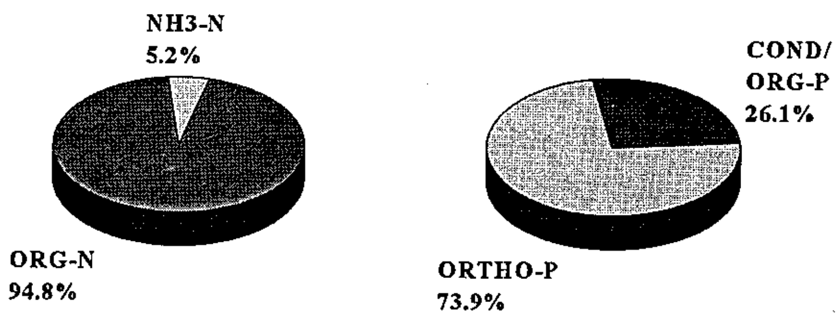
B. Flowrates will vary according to the amount of water introduced and the total load in the bin. Greater quantities of material in the bin will result in higher pressures acting on material near the bottom of the bin, squeezing out more water. Very high quantities of fat are extruded with this flow. Numbers and sizes of drainage holes in the bottom of the bin will also control wastewater flows. A common source of surplus water is in the transfer of raw materials to the bin. Measured volumes varied from as low as 0.7 up to 36 kL/day.

C. Drainings from the raw materials bin is characterised as being a very deep red colour (blood), with a very high degree of solid material including floatable fat. Typical quality and quantities are given below. Large ranges in daily masses resulted from the extremely low flowrate at Abattoir E. To represent the data more clearly the daily mass from Abattoir E is shown in parenthesis. It is important to note that wastewater qualities were of the same order regardless of volume.

Table 4.10
Typical Pollutant Levels and Daily Masses
In Wastewater From Raw Materials Bin Drainings

Analyte	Typical Range (mg/L)	Minimum Recorded Value (mg/L)	Range of Daily Masses (kg/tonne HSCW)
TSS	6000 - 14500	6400	0.9 - 1.0 (0.04)
Total Phosphorus	300 - 700	300	0.040 - 0.05 (0.002)
Total Nitrogen	3000 - 5500	3130	0.35 - 0.50 (0.03)
COD	40000 - 65000	41900	5.5 - 6.5 (0.14)
Sodium	1300 - 1900	1300	0.05 - 0.15 (0.005)
O&G	up to 100,000	-	up to 10
Temperature	Cold - Warm	28°C	-
pH	6.38 - 7.5	-	-

Figure 4.7
Nutrient Speciation in Wastewater from
Raw Materials Bin Drainings



D. Major pollutant sources are blood, fat and proteins leached from rendering raw materials. Exclusion of water from the raw materials is seen as a means of reducing fuel usage. Bins are almost exclusively designed by the machinery manufacturer.

7.2 *Tallow Processing*

A. Wastewater from tallow processing is produced from the separation of water and tallow in the refining processes. Wastewater flows will depend upon equipment type, common flows include water removed continuously as a heavy 'bottoms' layer and an intermittent stream generated by the purging of the centrifuge both of which flow directly to the wastewater system.

B. Flowrates for these streams will depend primarily on the equipment type, amount of water in the tallow stream from the cooker(s) and control settings for the centrifuge. Large differences in flowrates were recorded from the different abattoirs with measured values ranging from 2 up to 103 kL/day.

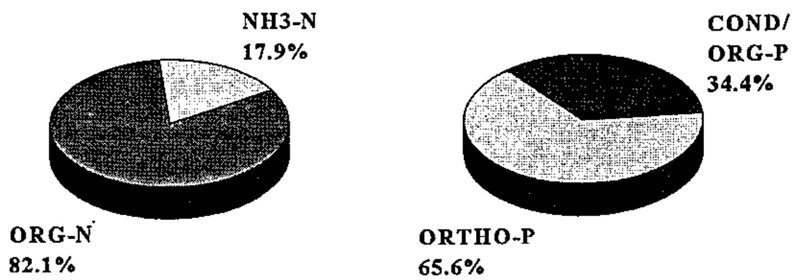
C. Wastewater from tallow processing is characterised as a very hot (90°C) and very oily, golden brown liquid. As with previous streams, much lower flowrates distort the daily mass ranges, Abattoir A in this case. Values for Abattoir A are quoted separately in parenthesis. However, unlike the raw materials bin drainages the lower flowrate from Abattoir A appears to be a more concentrated waste stream by a factor of approximately four.

Typical wastewater quality and quantities arising from tallow processing are given below.

Table 4.11
Typical Pollutant Levels and Daily Masses In Wastewater from Tallow Processing

Analyte	Typical Range (mg/L)	Minimum Recorded Value (mg/L)	Range of Daily Masses (kg/tonne HSCW)
TSS	20,000 - 35,000	22,100	5 - 10
Total Phosphorus	70 - 120 (1150)	69	0.012 - 0.051 (0.014)
Total Nitrogen	250 - 400 (1050)	259	0.05 - 0.16 (0.013)
COD	50,000 - 70,000 (200,000)	53,450	12 - 24 (2.38)
Sodium	60 -450	67	0.03 - 0.10 (0.004)
O&G	up to 50,000	-	up to 30
Temperature	Very Hot	90°C	-
pH	6.4 - 8.5	-	-

Figure 4.8
Nutrient Speciation in Wastewater from Tallow Processing



D. Pollutant sources are obviously wasted amounts of tallow and soluble proteins from the rendering process.

7.3 *Blood Processing*

A. Blood is fed through a coagulator supplied with live steam. Blood solids are separated and the remainder becomes wastewater.

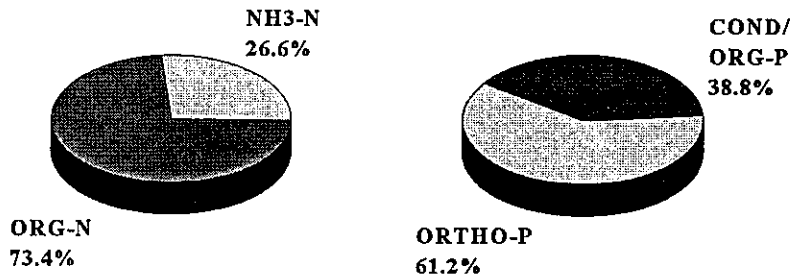
B. Wastewater volumes will depend upon the volume of blood processed. Measured daily volumes ranged from 11 to 43 kL per day.

C. Wastewater from blood processing is characterised as a light brown to grey, very hot (90°C) and frothy liquid. This wastewater has very high sodium, nitrogen and COD levels. Typical quality ranges and daily masses are given below.

Table 4.12
Typical Pollutant Levels and Daily Masses In Wastewater From Blood Processing

Analyte	Typical Range (mg/L)	Minimum Recorded Value (mg/L)	Range of Daily Masses (kg/tonne HSCW)
TSS	2000 - 20,000	1760	0.3 - 0.78
Total Phosphorus	75 - 150	75	0.03 - 0.13
Total Nitrogen	1200 - 8500	1230	0.13 - 0.32
COD	15,000 - 100,000	14,650	2.60 - 3.66
Sodium	500 - 2,500	550	0.06 - 0.20
O&G	up to 500	-	up to 0.2
Temperature	Very Hot	90°C	-
pH	7.4 - 8.9	7.4	-

Figure 4.9
Nutrient Speciation in Wastewater from Blood Processing



D. Pollutant sources are from inefficient coagulation and separation of blood solids.

7.4 Cooker Condensate

A. During the cooking process in rendering approximately 50% by weight of the raw materials is driven off as a vapour. This vapour is subsequently cooled through a condenser with the resulting condensate joining the wastewater system. The condensate contains protein breakdown and degradation products due to localised over heating. Fatty aerosols and entrained fine particles are normally removed by an entrainment trap via a water sealed screw, non-condensibles are typically disposed of by use of either after-burner, biofilter or boiler incineration.

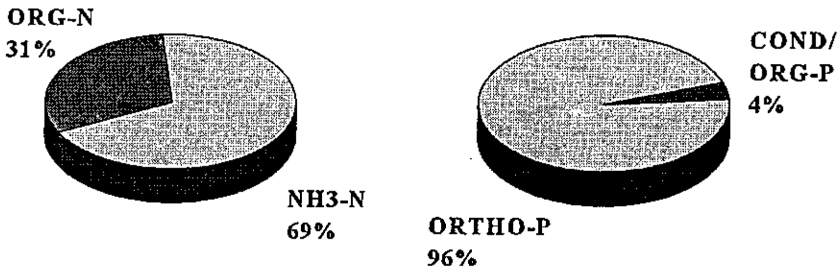
B. Condensate volumes will depend primarily on the quantity of material rendered and secondly on the amount of surplus water introduced to the cookers. Measured daily volumes ranged from 36 to 120 kL per day.

C. Wastewater produced from the cooker condensate is typically a clear to slightly cloudy liquid. Temperature is around 90°C. This waste stream is not as concentrated as some of the other rendering wastewaters yet is significant because of the high volumes generated. Typical quality and daily masses are given below.

Table 4.13
Typical Pollutant Levels and Daily Masses
In Wastewater Produced From Cooker Condensate

Analyte	Typical Range (mg/L)	Minimum Recorded Value (mg/L)	Range of Daily Masses (kg/tonne HSCW)
TSS	< 200	31	< 0.1
Total Phosphorus	< 25	0.2	< 0.013
Total Nitrogen	200 - 400	209	0.03 - 0.18
COD	700 - 3600	725	0.07 - 1.8
Sodium	< 200	1.25	< 0.08
O&G	< 100	67	< 0.05
Temperature	Very Hot	90°C	-
pH	7.7 - 8.9	7.7	-

Figure 4.10
Nutrient Speciation in Wastewater produced from Cooker Condensate



D. Pollutant source is from rendered material entrained in the vapours and subsequently removed as wastewater. High nitrogen levels indicate a loss of proteins from the cooker.

7.5 *Scrubber Effluent*

A. Scrubber effluent is the name commonly given to what is actually the overflowing water from the entrainment trap and is often a major and uncontrolled source of odorous emissions from the rendering plant.

B. Measured daily volumes for this study were 22 and 24 kL/day.

C. Wastewater quality will depend upon the amount of condensate taken up and the quantity of airborne particulates removed in the scrubber. Sources of odour within rendering plants includes:

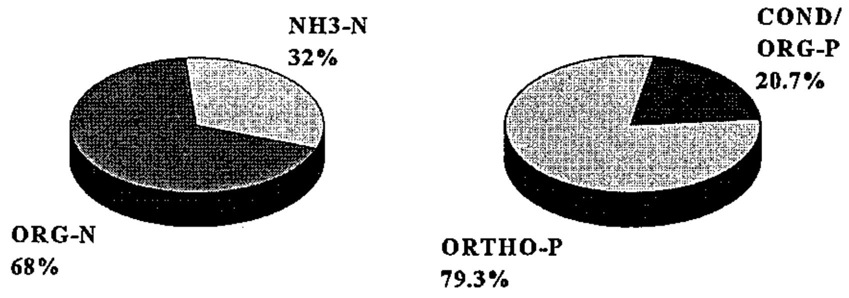
- degradation or decomposition of raw materials awaiting processing;
- direct emissions from open batch cookers during loading and unloading.
- emissions from driers including ring dryers do not contribute except when a shelf type scrubber is used;

Typical scrubber wastewater quality and daily quantities are given below.

Table 4.14
Typical Pollutant Levels and Daily Masses
In Wastewater Produced from Scrubber Effluent

Analyte	Typical Range (mg/L)	Minimum Recorded Value (mg/L)	Range of Daily Masses (kg/tonne HSCW)
TSS	500 - 2500	560	0.05 - 0.18
Total Phosphorus	< 30	2.5	< 0.003
Total Nitrogen	50 - 450	48	0.005 - 0.026
COD	900 - 2000	900	0.08 - 0.15
Sodium	170 - 560	170	0.017 - 0.035
O&G	-	-	-
Temperature	Cold - Warm	-	-
pH	-	8.2	-

Figure 4.11
Nutrient Speciation in Wastewater produced from Scrubber Effluent



D. Pollutant sources for this wastewater are too varied to be individually identified apart from the general sources listed in part C.

8. *Stock Yards*

A. Wastewater is produced from the washdown operations in stock holding or ante-mortem yards. In smaller facilities this is a once or twice daily operation, however, in larger facilities, especially for cattle, ante-mortem yards are washed almost continuously throughout production times. Since this is a non-potable water use, recycled effluent is often used. Greater water usage on feedlot cattle is apparent.

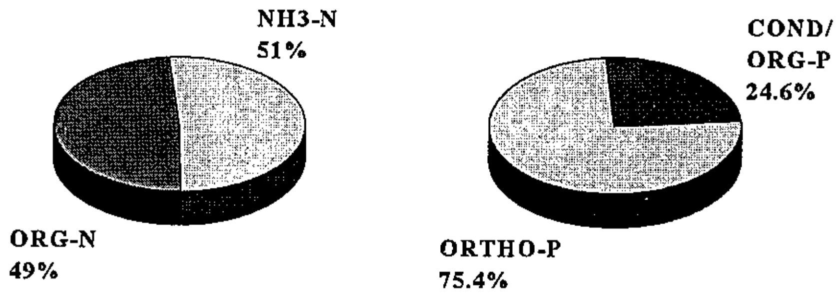
B. Due to the nature of this wastewater and the manual requirements for hosedown, resulting volumes can differ widely from day to day at the same abattoir. Measured daily volumes from abattoirs with stock yards (D and E) varied from 184 to 252 kL per day.

C. Wastewater from stock yards will mostly contain animal urine and faeces. The use of recycled effluent will result in an increase of pollutant levels, especially sodium, nitrogen and phosphorus which are not reduced through treatment. The following values are typical of this type of wastewater from a beef processing facility, data from both grass and grain fed cattle is included. Grain fed cattle will generally contribute to higher pollutant levels in this area than grass fed.

Table 4.15
Typical Pollutant Levels and Daily Masses In Wastewater From Stock Yard Washdowns

Analyte	Typical Range (mg/L)	Minimum Recorded Value (mg/L)	Range of Daily Masses (kg/tonne HSCW)
TSS	300 - 1500	284	0.3 - 0.7
Total Phosphorus	45 - 60	46	0.03 - 0.05
Total Nitrogen	100 - 400	106	0.11 - 0.24
COD	1000 - 2200	1030	0.98 - 1.41
Sodium	250 - 650	255	0.20 - 0.42
O&G	-	-	-
Temperature	Cold	-	-
pH	8.3 - 8.4	8.3	-

Figure 4.12
Nutrient Speciation in Wastewater from Stock Yard Washdowns



D. Pollutant sources as mentioned are mostly animal urine and faeces. Urine contributes around a half to three quarters of the nitrogen as ammonia whilst the faeces is responsible for most of the COD levels. Large amounts of dirt (inorganic materials) is also collected by this wastewater leading to higher suspended solids levels.

9. Amenities

A. Wastewater from amenities is produced by:

- toilet flushing;
- showers and handwashing;
- kitchen wastes;
- laundering of uniforms;
- general cleaning.

B. Wastewater volumes for amenities were not measured in this study. However, volumes will be approximately equivalent to the water consumption which has been estimated at 100 L/employee/day.

C. Amenities wastewater was not analysed in this study. It is assumed that this wastewater will resemble domestic sewage in quality. Typical values are as follows:

Table 4.16
Typical Pollutant Levels For Wastewater From Amenities as Domestic Sewage

Analyte	Typical Range (mg/L)
TSS	300 - 350
Total Phosphorus	10 - 15
Total Nitrogen	40 - 50
COD	450 - 600
Sodium	Dependent on source water
O&G	20 - 50
Temperature	Cold - Warm
pH	6.5 - 8.0

D. Major sources of pollutant in this wastewater are urine, faeces and other organic matter, soaps and detergents. Amenities wastewater is not a major contributor relative to the total wastewater load.

10 and 11. Fellmongery and Pickling Processes

These processes relating to the further treatment of animal skins are not common abattoir operations. Only Abattoir A of the five abattoirs investigated in this study operated both Fellmongery and Pickle Plants. For this reason the results quoted below may not be typical, but only indicative, of Fellmongery and Pickle Plants.

Table 4.17
Indicative Quality and Quantity of Wastewater From Fellmongery and Pickle Plants

	Daily Volume (KL)	COD (mg/L)	Sodium (mg/L)	Total Nitrogen (mg/L)	Total Phosphorus (mg/L)
Fellmongery	4	24000	12000	250	21
Pickle	85	5000	1400	450	16

In both major fellmongery processes, high sodium levels can be expected in the wastewater. Sodium source is either sodium hydroxide and salt (sodium chloride) or sodium sulphide.

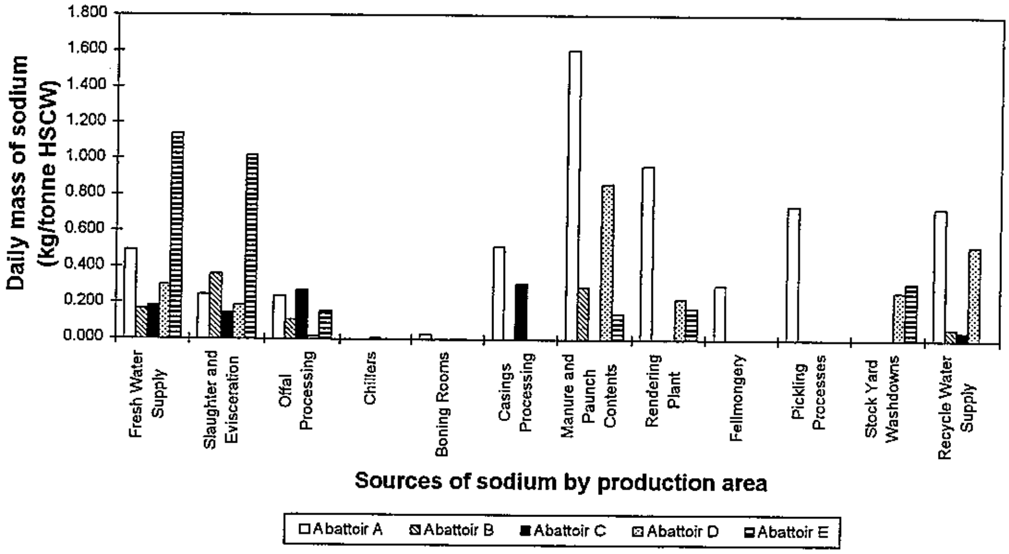
Fellmongered skins are then sent to the pickle plant where they are agitated in a brine (salt) mixture. Major pollutant is the wasting of used brine.

5. Sodium, Nutrient and COD Sources

5.1 Sources of Sodium

Sources of sodium have been identified in all five abattoirs investigated. For each abattoir, daily masses (kg/tonne HSCW) were calculated for each of the wastewater sources or production areas identified in Section 4. Results are presented in Figure 5.1.

Figure 5.1
Sodium Sources In Five Abattoirs Investigated



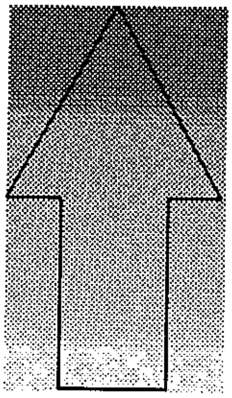
The following points help to illustrate several of the major conclusions which can be drawn from Figure 5.1:

- Sodium sources in the fresh water supply will appear proportionally in all areas of fresh water consumption. This is particularly evident in areas of high consumption such as slaughter and evisceration and offal processing. High sodium levels in the fresh water supply directly translate to high sodium levels in the abattoir wastewater. Example is Abattoir E with high fresh water sodium levels and corresponding high slaughter and evisceration levels.

- Since sodium levels are not generally reduced in typical abattoir wastewater treatment systems, high sodium levels in the wastewater directly translate to high sodium levels in the final effluent. Recycling of this effluent often creates very high sodium levels in some areas. Examples are Abattoirs A and D, both use recycled effluent in inedible offal areas which contributes to the very high sodium quantities in the manure and paunch contents wastewater.

Production area sources have been ranked in order of perceived importance or impact according to their potential contribution to the total abattoir output. Other factors which influence the importance given to the ranking of these sources include the extent of opportunities which exist to reduce sodium outputs at the source and the degree to which particular problems at these abattoirs are considered likely to be applicable to abattoirs in general.

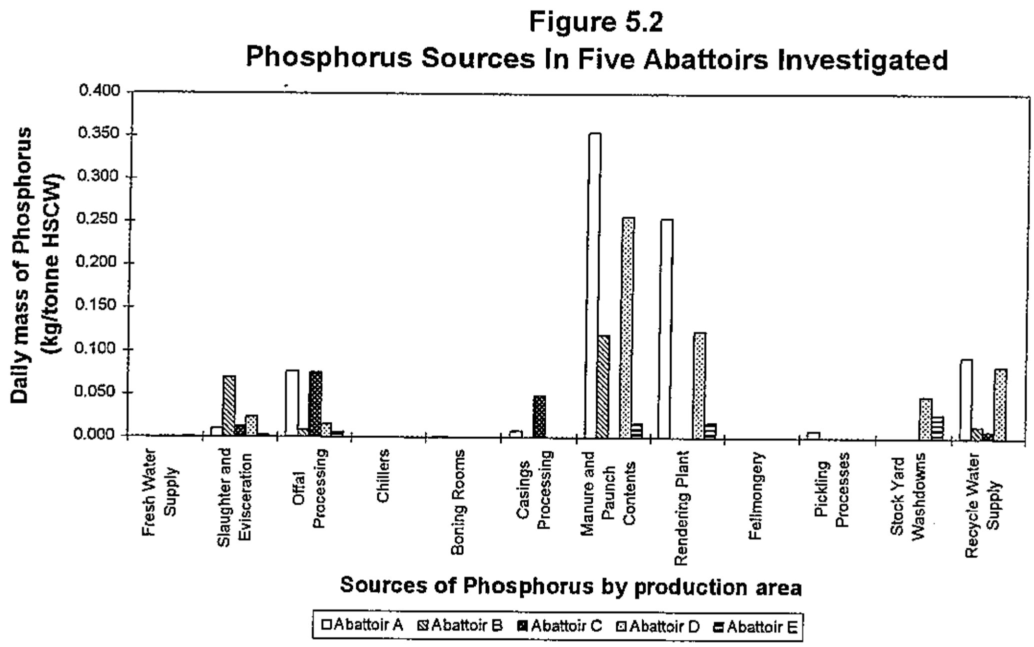
Sodium sources are ranged as follows from those likely to have the most impact at the top then in order of decreasing importance:



- Fresh water supply;
- Recycled effluent;
- Manure and paunch contents;
- Pickling processes;
- Casings processing;
- Rendering plant;
- Stock yard washdowns;
- Fellmongery;
- Offal processing;
- Slaughter and Evisceration;
- Chillers and boning rooms.

5.2 Sources of Phosphorus

Similarly as for sodium, phosphorus sources have been identified and daily masses (kg/tonne HSCW) calculated for each of the wastewater sources or production areas identified in Section 4. Results are presented in Figure 5.2

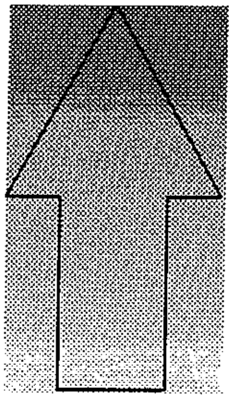


The major sources of phosphorus in abattoirs are manure, paunch material and blood. The following points illustrate the main conclusions from Figure 5.2.

- wastewater which contains manure and paunch contents is the major source of phosphorus.
- the rendering plant is the second highest source of phosphorus. Sources within the rendering plant primarily consist of blood processing, raw materials bin drainings and tallow processing.
- unless the wastewater treatment includes means for phosphorus removal then high levels will be returned to the abattoir with the recycled effluent.

Production area sources have been ranked in order of perceived importance or impact according to their potential contribution to the total abattoir output. Other factors which influence the importance given to the ranking of these sources include the extent of opportunities which exist to reduce the output of phosphorus at the source and the degree to which particular problems at these abattoirs are considered likely to be applicable to abattoirs in general.

Phosphorus sources are ranged as follows from those likely to have the most impact at the top then in order of decreasing importance:

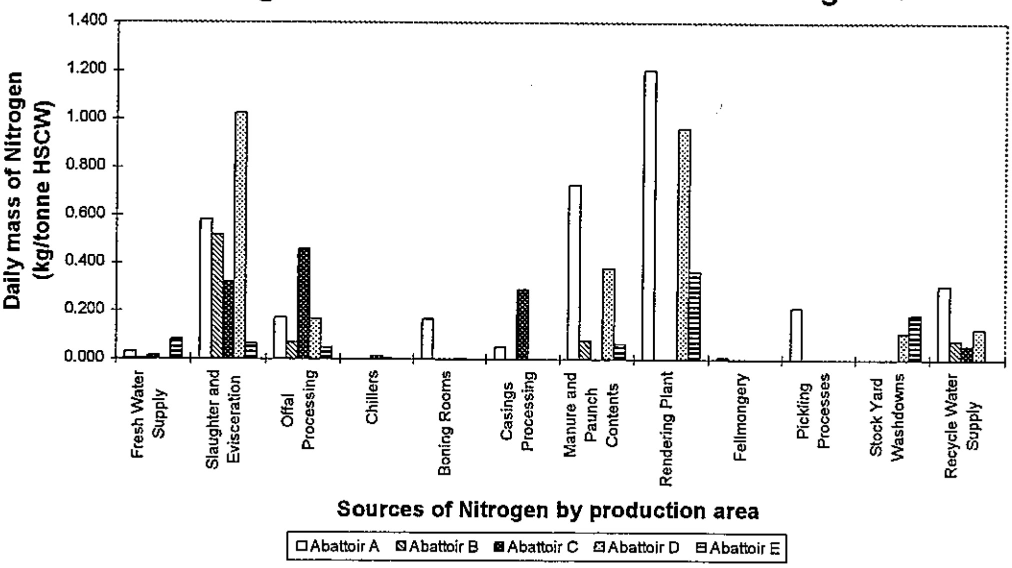


- Manure and paunch contents;
- Rendering plant;
- Recycled effluent;
- Stock yard washdowns;
- Offal processing;
- Casings processing;
- Slaughter and Evisceration;
- Pickling processes;
- Chillers and boning rooms.
- Fellmongery;
- Raw water source.

5.3 Sources of Nitrogen

Nitrogen sources within the five abattoirs investigated have been identified. For each abattoir the daily masses (kg/tonne HSCW) have been calculated for each of the wastewater sources or production areas identified in Section 4. Results are presented in Figure 5.3.

Figure 5.3
Nitrogen Sources In Five Abattoirs Investigated



The single major source of nitrogen in abattoirs is blood. Other sources include nitrogen in the form of ammonia from animal urine and as amino groups in proteins. The major conclusions which can be drawn from Figure 5.3 are as follows:

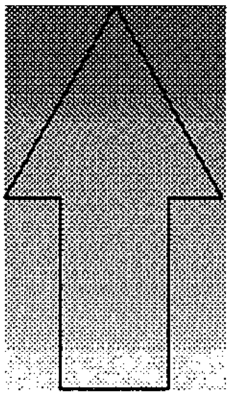
- largest source of nitrogen in abattoirs with a rendering plant is from the raw materials bin drainings. Blood and tallow processing are also significant nitrogen sources.

- slaughter and evisceration wastewater in the second largest contributing area where inefficient blood capture would be primarily responsible.

- to a lesser degree, manure and paunch contents and offal processing wastewaters are also significant problem areas.

Production area sources have been ranked in order of perceived importance or impact according to their potential contribution to the total abattoir output. Other factors which influence the importance given to the ranking of these sources include the extent of opportunities which exist to reduce the output of nitrogen at the source and the degree to which particular problems at these abattoirs are considered likely to be applicable to abattoirs in general.

Nitrogen sources are ranged as follows from those likely to have the most impact at the top then in order of decreasing importance:

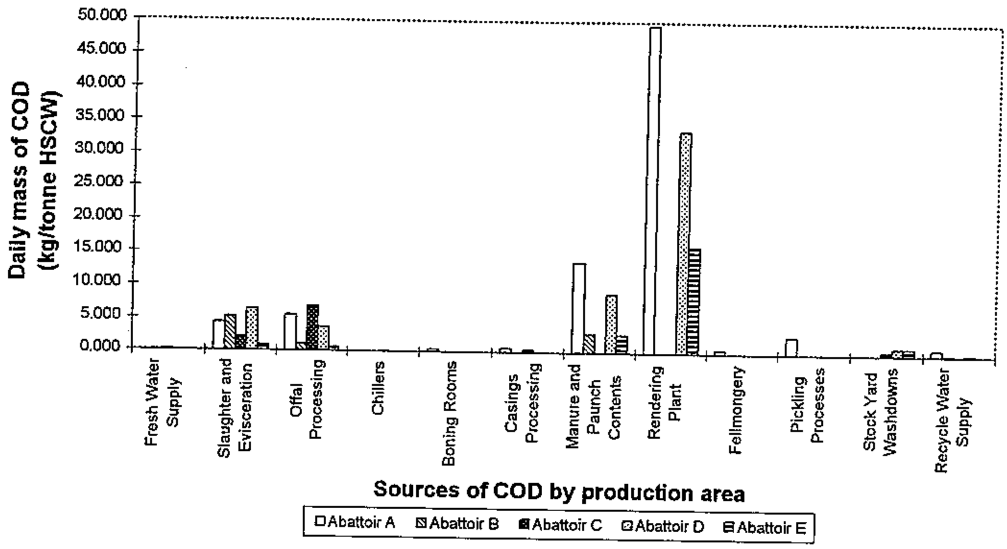


- Rendering plant;
- Slaughter and Evisceration;
- Manure and paunch contents;
- Offal processing;
- Casings processing;
- Recycled effluent;
- Stock yard washdowns;
- Pickling processes;
- Chillers and boning rooms.
- Raw water source;
- Fellmongery.

5.4 Sources of COD

In a similar manner as for sodium and nutrients, COD sources from the five abattoirs investigated have been identified. Daily masses (kg/tonne HSCW) for each wastewater source have been calculated with the results presented in Figure 5.4.

Figure 5.4
COD Sources In Five Abattoirs Investigated

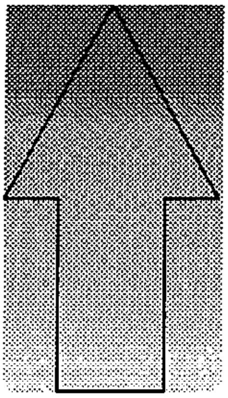


These results very clearly indicate that the vast majority of the organic load in the wastewater is due to the rendering process. The following points can be made.

- Within the rendering plant the main areas of concern are tallow processing, raw materials bin drainings and, to a lesser degree blood processing.
- Neither the fresh water supply or recycled effluent represented a significant COD contribution.
- Manure and paunch contents were the second largest source of COD followed closely by slaughter and evisceration and offal processing.

Production area sources have been ranked in order of perceived importance or impact according to their potential contribution to the total abattoir output. Other factors which influence the importance given to the ranking of these sources include the extent of opportunities which exist to reduce the output of COD at the source and the degree to which particular problems at these abattoirs are considered likely to be applicable to abattoirs in general.

COD sources are ranged as follows from those likely to have the most impact at the top then in order of decreasing importance:



- Rendering plant;
- Manure and paunch contents;
- Slaughter and Evisceration;
- Offal processing;
- Pickling processes;
- Stock yard washdowns;
- Casings processing;
- Recycled effluent;
- Fellmongery;
- Chillers and boning rooms.
- Raw water source.

Part B Discussion of Results and Recommendations

6. Discussion of Results

6.1 Fresh Water Source

As shown in Section 5, high sodium levels in the fresh water supply are a main concern and contribute to high levels of sodium in all areas of fresh water consumption and ultimately in the final effluent.

High sodium content in the wastewater presents special difficulties, since the resulting effluent may not be irrigable unless applied over large areas with long return times, or some alternative source of water (shallow bore or stored stormwater) is available for dilution.

Where ion exchange is used to produce water suitable for use in boilers or condensers, each litre produced results in the simultaneous production of an equivalent volume at around twice the strength of the feedwater source. Disposal of this high salinity waste may add additional cost to the system.

High sodium content is primarily a problem of inland works, where the water source is river or bore water, these problems are likely to increase due to the following:

- trends for the integration of beefworks and feed lots is towards a smaller number of larger works;
- the location of feed lots is oriented to feed sources, and favours inland locations;
- the preference for the coastal location of beef only export plants appears to be declining;
- the number of coastal plants is being reduced, and new plants have been built in inland locations in line with these trends.

6.2 Recycled Effluent

The following impacts have been observed regarding the recycling of treated effluent:

- recycling is an obvious means of reducing fresh water consumption in non-potable use areas;

- since sodium, nitrogen and phosphorus are not reduced through typical abattoir wastewater systems, the greater the use of recycled effluent the greater will be the final effluent concentration of these contaminants;

- anaerobic treatment converts nearly all nitrogen to its ammonic form. High concentrations resulting through the use of recycle could have detrimental effluent disposal impacts since nitrogen in this form is toxic to most life forms;

- high pollutant concentrations typical of recycled effluent raise health concerns which need to be considered in design and operation of any reuse schemes;

- in the case of high sodium content fresh water, recycling may significantly reduce the total mass output of this contaminant;

- high concentrations of effluent sodium and TDS can affect crop growth and will ultimately kill most plants;

- reuse of steriliser overflow in inedible offal washing and other non-potable applications warrants investigation since this would negate many of the detrimental affects of effluent recycle and warrants further investigation.

6.3 Rendering

Rendering plants, where installed, are the largest overall single source of wastewater contamination. The combined wastewater from rendering contains approximately 60% of the total COD output whilst being typically around only 5 to 10% of the total volume. The rendering plant wastewater also contains between 20 to 40% of the total outputs of sodium, phosphorus and nitrogen.

There appears to be a good case for the separate evaluation and treatment of the rendering wastewater since it is relatively very high in COD and nitrogen content.

Evaporation/concentration of this stream could produce a feedstock for reincorporation into the rendering raw material stream. This appears to be a promising area for further work.

The alternative loss of this material to the wastewater treatment system not only represents a greatly increased treatment load, but a significant loss of otherwise saleable protein material.

Wastewater contaminant sources from individual areas within a rendering plant have been determined and are presented in Figure 6.1 below. This figure contains some very significant results for nutrient source reduction opportunities as follows:

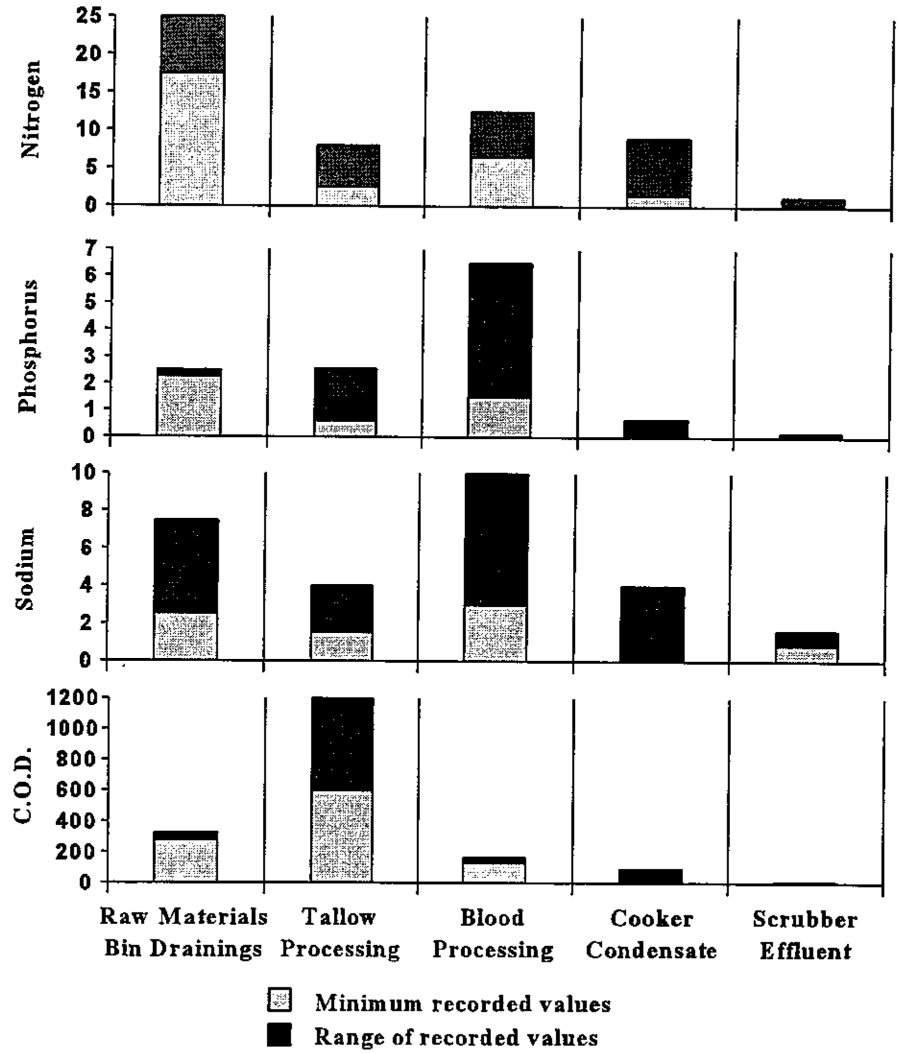
- Approximately 50% of the nitrogen from rendering is sourced from the raw materials bin drainings (RMBD). Blood processing contributes approximately another 25%. The scrubber effluent in comparison is negligible.

- Blood processing contributes 25 to 50% of the total rendering phosphorus output. RMBD and tallow processing each contribute approximately 20 to 30%. Cooker condensate and scrubber effluent in comparison are negligible.

- Sodium sources are more evenly spread with blood processing 37%, RMBD 25%, tallow processing and cooker condensate each 15% and scrubber effluent approximately 5 to 10%.

- Tallow processing accounts for approximately 67% of the total COD output from rendering. This corresponds to around 40 to 50% of the total abattoir output! Other COD sources are RMBD 18%, blood processing 9%, cooker condensate 5%. The Scrubber effluent does not significantly contribute to the COD output from rendering.

Figure 6.1
Wastewater Contaminant Sources in Rendering Plants (kg / 50 tonne HSCW)



The mass loadings for contaminants from rendering in Figure 6.1 have been calculated on a per 50 tonne of HSCW basis. This is to allow for quick approximate calculations based on particular production levels. For example, RMBD nitrogen is approximately 20 kg per 50 tonne HSCW. If daily production was 130 tonnes HSCW then the total RMBD nitrogen would be approximately 52 kg. (Using the equation from Section 4 this equates to around 650 kg/day meat meal). It should be noted that these figures are based on kill, bone and freeze operations as apart from kill and chill (carcase) operations, since this may affect expected wastewater loadings from rendering plants.

Individual contaminant sources in rendering are discussed in more detail below:

Raw Materials Bin Drainings

Raw material bins are designed to give adequate surge storage, and are usually provided with drainage holes along the base of the screw conveyor as designed by the manufacturer. Water is often added to facilitate the transport of the raw materials to the bin (e.g. where gut material is pumped or blow pots are used).

The water washes blood off the raw material, and collects small particles of fat, meat scrap, hair, etc. In large bins, the weight of the material presses water and blood out of the lower layers.

The drainings from the raw materials bin can thus represent a large loss of nitrogen compounds (and hence of protein) from the rendering department.

The design rationale in draining bins has been to reduce the water content of the feedstock, and hence to conserve energy by minimising evaporation. The affect of the raw materials drainings on the wastewater system and loss of product, appears not to have been considered, thus this appears to be a mistaken effort.

Choice of Tallow Refining Equipment

Where polishing centrifuges are used, the choice of machine type is critical. The older type full discharge machines lose a large amount of oil and grease to the wastewater system. Partial discharge machines appear to lose less product.

Manual washing results in high wastewater loads and high fat losses to the wastewater system.

Continuous and Batch High Temperature Rendering

There is little apparent difference between the two systems, since both rely on evaporation of the bulk of the water content of the raw material and its subsequent condensation.

Because of the greater probability of localised overheating in batch processing, and the fluctuating loads it places on the condensing system, it seems likely that batch cooking will produce more non-condensible material. The wastewater streams appear to be similar in quality. Further detailed investigation is necessary to identify differences in waste generation of the various high temperature rendering units.

6.4 Manure and Paunch Contents

Wastewater containing paunch contents, and arising from the washing of inedible offal contains the highest sodium and phosphorus quantities in addition to significant nitrogen and COD. This waste stream should be considered second in importance, after rendering, of abattoir waste sources. The following observations are made:

- Paunch and manure waste should ideally be kept separate from the general abattoir wastewater. The main reason for this is to keep this material out of the rendering process as this can lead to discolouration and/or degradation of the tallow quality and to unacceptable levels of fibre in meal.

- Paunches should be dry dumped with the contents kept separate from the washings wastewater. This is to limit the quantity of pollutants entering the wastewater systems. Despite the repetition of this recommendation in many previous publications it was not practised at any of the five abattoirs investigated.

- Paunch contents should be separately treated. This waste can be concentrated further by pressing or, if suitable, combined with other waste for composting. In some cases, direct disposal by land spreading may be possible.

- The paunch material contains a high proportion of used seeds. These may be sterilised by temperatures attained in composting, otherwise this may become a route for the dissemination of weeds.

Further investigation should be carried out to determine the reasons why the practice of dry-dumping is not more commonly employed to reduce waste outputs.

Wastewater resulting from tripe washing operations, although typically part of the manure and paunch contents stream, needs to be separately considered. Wastewater from tripe washing is distinct from other abattoir wastes in that it contains very high quantities of both manure and fat. Recovery of the saleable component of this wastewater is complicated in that where manure contains a high loading of pea fats which can represent a considerable dollar loss it is likely to be contaminated with manure and may reduce the value of the recovered fats.

Tripe washing produces a considerable load on the treatment system which can be reduced by improved equipment selection. Older generation tripe cleaning machines consume large amounts of hot water whereas a number of newer design machines use considerably less water and also process a wider range of material e.g. bibles.

6.5 Feedlot vs Grassfed

The following comparisons between lot fed and grass fed cattle were noted:

- conditions under which lot fed animals are kept results in coating of the belly with dried, ingrained manure. These cattle require washing with high pressure water to dislodge these deposits before slaughter. This practice contributes to the very high water usage in ante-mortem yards;

- for lot fed animals, higher levels of nutrients particularly phosphorus were recorded for the ante-mortem yards. This indicates much greater quantities of manure voided in this area;

- associated with these high levels in the ante-mortem yards were comparatively lower levels recorded in inedible offal washing;

- conversely, grass fed cattle reported proportionally higher nutrient levels in inedible offal washing compared to ante-mortem yards;

- overall, much higher nutrient quantities, especially phosphorus, was produced from lot fed cattle;

- it is expected that grass fed animals (cattle/sheep) particularly those from saline and inland pastures would exhibit much higher levels of sodium in the paunch contents.

6.6 Pickling Processes

Pickle plant wastewater is a significant sodium source.

Concentrated brine solutions from pickling processes should not be entering the wastewater system. Investigations should be carried out on a site by site basis to evaluate:

- opportunities to re-use or recycle used brine solutions;

- appropriate methods to treat used brine solutions to a level suitable for reuse including coagulation of protein and filtering hair and dirt;

- in conjunction with treatment and reuse, methods for appropriate wastewater disposal may include concentration or evaporation techniques.

6.7 Casings Processing

Casing plants can be significant contributors of sodium, nitrogen and phosphorus. The major sodium source is salt used to preserve the casings and to act as a dehydratant. Nutrient sources are generally small amounts of casings contents and significant amounts of mucous membranes and slimes from emptying and cleaning processes.

Sources of sodium include:

- *Salt table.* This is the main sodium source within the plant.

- *Centrifuge.* The water that exists in the centrifuge has a high content of sodium. This is a result of the salt dissolving into the water of the product after salting. Thus as water is removed from the casings in the centrifuge salt is also removed in a soluble form.

- *Soaking tanks.* Small amounts of sodium are generated from these tanks.

- *Emptying machine.* The water leaving the machine has sodium present both in the water (soluble) and absorbed into the mucous/slime material itself (insoluble).

Taking into account these sources, any new design or modification to a casing factory should consider the following operational procedures:

- soaking and the cleaning processes generate minimal amounts of sodium when compared to the salt table and centrifuge.

- washing down of salt laden containers and the disposal of salt solutions can be a major contributor if not managed by appropriate means.

The following is a summary of the most appropriate design of a casings operation.

The plant should be segregated into two sections. One section for the low sodium producing processes and the other for the high sodium producing processes. The sections should ideally:

- be divided by a wall.

- have sloping floors towards the middle of each section. This would eliminate spillage's in areas which are not divided by the wall, e.g. in area where dams/containers are required for a number of processes are placed. Sloping floors also allow for better drainage.

- have separate collection (drainage) systems coming from each section to separate disposal facilities.

For example, the wastewater generated in the salt processing side, may be drained to a brine tank. This water has an extremely high sodium content and should be periodically pumped out and removed off-site or treated similar to pickling wastes.

Investigations have illustrated that, if operational procedures in relation to housekeeping, are appropriate and adhered too, then it may be possible to achieve sodium levels below 100 mg/L in the wastewater leaving the casings factory without treatment. However if procedures are not followed then this figure can increase five or six fold.

General housekeeping operations that require specific attention are:

- the washing down of drums/containers which have salt residual on the outside of the containers should be carried out in the salt processes side of the factory.
- salt solutions should be emptied and disposed of on the salt processing side.

Casings processing produces a range of slimes, mucosa, serosa and other wastes that add considerably to the BOD and nutrient loading of the effluent. Further treatment of the casings effluent should be considered before it enters the main abattoir waste stream. Screening of the waste, for example by a rotary screen, reduces the BOD loading, and the products from the screens are recoverable and can be transferred over to the plant to produce a saleable by-product.

7. Recommendations

The following recommendations are made for abattoirs to identify nutrient and other contaminant sources and quantities and to guide the management of nutrient and wastewater issues.

- That abattoirs conduct a sampling program to quantify their contaminant outputs from major sources. Results of this project should be used to guide point source reduction efforts and to minimise overall sampling and measurement requirements.

- Sampling should include not only the final effluent but also regular sampling through a cross-section of the treatment system to evaluate efficiencies and monitor performance. Total wastewater volumes should also be recorded on a continuous basis. This data then forms the basis for evaluating the effectiveness of source reduction programs.

- That all monitoring and source reduction programs be part of an overall waste minimisation and site management plan. This type of approach is well regarded, and in some instances required, by licensing authorities.

- Abattoirs need to record total water consumption figures and to evaluate potential water consumption minimisation opportunities especially for major usage areas. This is particularly important in cases of high fresh water sodium and TDS levels.

- Primary treatment facilities should be optimised to give maximum solids and fat removal. This will result in a minimum secondary treatment load and hence reduced treatment costs, especially for nutrient removal. Where possible, solids should be returned to a rendering process.

- Effluent disposal, reuse and recycle options need to be evaluated to determine the necessary final effluent quality requirements and disposal limitations. This information should be used to set optimum final effluent contaminant concentrations.

- Possible upgrading and augmentation works for wastewater treatment systems should be designed based on the wastewater loading **after** the implementation of waste minimisation procedures and to meet the final effluent quality required to optimise disposal, reuse and recycle options.

The following recommendations are made to reduce the consumption of water and to reduce the generation of the nutrients nitrogen and phosphorus, COD and sodium.

Water

- Implement treated effluent recycle for use in non-potable areas where possible to reduce the overall fresh water consumption. Ensure that the recycle effluent has been satisfactorily treated to meet health requirements. Consider the effect of concentration of final effluent contaminants with respect to effluent disposal and/or further reuse.

- Better cleaning practices including an initial dry clean and use of high pressure/low flow nozzles on hoses should be implemented and monitored to reduce water consumptions during cleaning times.

- Avoid the generation of excess hot water, that is, minimise the quantity of water added to the raw materials for rendering. This avoids wastage, saves energy, helps to reduce wastewater contaminants in other areas and may improve primary treatment efficiencies such as screening.

- Avoid too high flows in sterilisers since this can represent a considerable wastage of water. Steriliser flows should be measured and adjusted to match health guidelines.

Nutrients, COD and Sodium

- The main source of nitrogen in wastewater is blood either from the slaughter floor or rendering operations. It is essential to maximise the blood capture on the slaughter floor.

- The RMBD contain high levels of all contaminants considered, particularly nitrogen. RMBD should be returned to the rendering process as this wastewater stream can represent a considerable amount of lost product.

- Wastewater from blood processing contains high levels of phosphorus, nitrogen and sodium. Blood processing should be optimised either through new technologies or improvements in existing equipment to maximise the blood solids removal whilst minimising the resultant wastewater loadings.

- Abattoirs should immediately inspect and evaluate their tallow processing operations with respect to the quantity and quality of the resultant wastewater. High wastewater loads equate to lost product, so there are definite economic advantages to improving this area of operations. Water washing is extremely wasteful and centrifuging is a more efficient process. Care must be exercised in the selection of centrifuge type to ensure minimum wastage. Partial discharge types appear to be the more appropriate option.

- The possibility to separately treat or concentrate the rendering wastewater should be investigated. Concentrated waste could be returned to the process, treated, composted or removed off-site.

- Manure and paunch contents, ideally should be kept separate from the wastewater system i.e. dry dumping. This material can be treated, stored or composted on-site prior to either on-site disposal by suitable methods or removal off-site due to land disposal limitations. It should be considered that ultimately nutrients, especially nitrogen, will need to be continually removed from the site (e.g. crop harvesting) and that it may be more appropriate and easier to remove concentrated material (e.g. paunch contents) off-site in the first instance.

The recommendations for manure and paunch contents are even more critical for phosphorus or sodium reduction since this wastewater accounts for around 50% of the total outputs of these contaminants.

- High sodium generating processes such as casings, fellmongery and pickling should be investigated to determine best practice options to reduce outputs. In these instances minimising contaminants entering the wastewater system and recycle should be prioritised.

- Generally, nutrient loads in the final effluent are in excess of the ability of available land to absorb and abattoirs will need to look towards more elaborate treatment to reduce these quantities.

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Appendix A

Unit Product Weight

Appendix A

Unit Product Weight

In the development of a system in which the water consumption and pollutant quantities of one abattoir can be compared with that of another, which may process different animals, a standard must be defined which is applicable to the different types of animals and acceptable to the industry as a whole.

The Food and Agriculture Organisation of the United Nations (Reference 6) consider that:

> "The relating of polluting water and matter to the number of cattle units slaughtered is considered to be a more satisfactory procedure than tonnage of meat slaughtered as the average weight of animals varies from country to country and regionally, particularly in developing countries. Obviously, two or more smaller type animals still require the same individual dressing procedure and therefore more processing water than the equivalent weight of one larger animal".

This approach, however, does not allow for comparison between different species.

Past studies in Australia have measured water use on a cattle kill equivalent (CKE) basis. This basis has several serious shortcomings as:

(i) it does not account for weight differences between animals. This is particularly marked with the comparison between various types of cattle (refer table below);

(ii) mixed species operations are difficult to accurately account for. Methods for equating animals (e.g. 1 cow = 6 sheep = 2.5 pigs = 2.5 calves) produce distorted results in comparing water use.

The NSW Meat Industry Authority uses a different system, under which all animals are reduced to sheep kill equivalents (SKE). The system of conversion of the various species to SKEs differs from that listed above.

These systems are not uniform. It was therefore considered more rational for this study to adopt an objective system which allows direct and accurate comparison between plants and between species based on a recognized unit which is recorded by most abattoirs. This is the Hot Standard Carcass Weight (HSCW) defined as follows:

HSCW = Animal - (head + feet + hide + blood + eviscera)

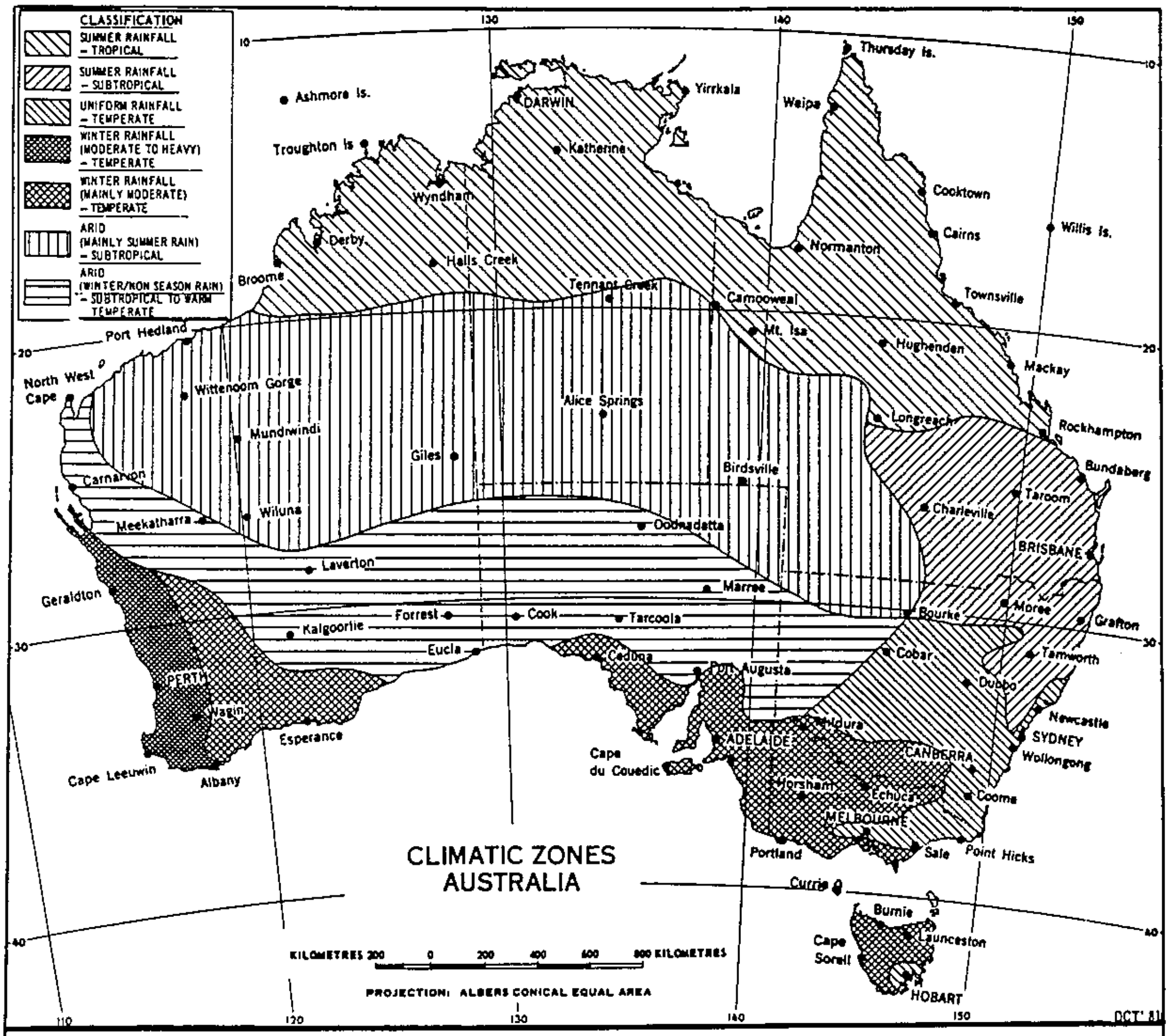
Initial investigations included edible eviscera in the unit product weight, however, since many smaller operations do not record offal weights on a regular basis this component has been excluded. Investigations have shown that the proportion of the total weight which represents the offal is similar regardless of the species (Reference 7). Hence, the exclusion of this component in order to maximise the usefulness of the defined unit product weight should not adversely affect comparisons between species.

Indicative industry average carcass weights for various species is as follows:

Cattle	-	Cows	230 kg
	-	Grassfed Ox	300 kg
	-	Grainfed Ox	325 kg
Sheeps	-	Light	15 kg
	-	Heavy	24 kg
	-	Lambs	18.5 kg
Pigs			70 kg
Sows			150-155 kg

Appendix B

Climatic Zones of Australia



CLASSIFICATION	SEASONAL CHARACTERISTICS SUMMER	WINTER
Summer Rainfall – Tropical	Heavy periodic rains (heavier in coastal & highland areas) Hot generally Humid in coastal areas	Generally rainless Mild to warm Dry
Summer Rainfall – Subtropical	Heavy periodic rains (heavier in coastal & highland areas) Mainly hot Humid in highlands & coastal areas	Some significant rain Mild
Uniform Rainfall – Temperate	Mainly reliable rain Warm to hot	Mainly reliable rain Cool to cold
Winter Rainfall (moderate to heavy) – Temperate	Irregular rain, mostly light Warm to hot	Reliable rain (moderate to heavy) Cool to mild
Winter Rainfall (mainly moderate) – Temperate	Mostly light irregular rain Warm to hot	Reliable rain (mainly moderate) Cool to cold
Arid (mainly summer rain) – Subtropical	Variably rain Hot to extreme Very dry	Mainly irregular light rain Mild to warm Dry
Arid (winter or non-seasonal rain) – Warm Temperate to Subtropical	Very irregular rain Hot to extreme Very dry	Variable rain, mainly light Cool to mild Dry

Appendix C

Effluent Sampling and Analyses

- Sampling Methods
- Sample Collection and Pre-Treatment
- Sample Analyses: Accuracy and Recommendations

Appendix C

Sampling Methods

The following methods were used for determining the concentrations of sodium, nutrients and COD.

Analytical Analysis Methods

Analyte	**On-Site (Abattoir)**	**Off-Site (Laboratory)**
Sodium	n/a	APHA 3030E.3111B
Reactive Phosphorus	HACH 8178/8114	APHA 4500 - P.E
Acid Hydrolyzable P	HACH 8180	n/a
Total Phosphorus	HACH 8190	APHA 4500 - P,B(5), E
NO_x-N	HACH 8039	APHA 4500 NO_3-F
NH_3-N	HACH 8155	Skalar Method 22125
TKN	HACH 8075	APHA 4500 Norg A, B
COD	n/a	APHA 577OC

On-site analyses were conducted with HACH portable laboratory equipment including the DR2000 spectrophotometer and Digesdahl digestion apparatus.

Appendix C

Sample Collection and Pre-Treatment

Due to the large variabilities in abattoir waste streams, a sample collection methodology was developed to ensure that, as far as possible, the sample collected was representative of the wastewater streams sampled from.

Main factors of methodology included:

- Collection of samples over the full production times of the abattoir.
- Collection of multiple samples at either regular or random times. Composite daily samples are then prepared from individual samples.
- Collection of samples during breaks in production (e.g. lunch times, smoko, etc) and washdown operations was avoided where possible.
- Duplicate samples were collected for both on-site and off-site analyses.

Prior to transport for off-site analyses, wastewater samples were preserved to minimise any degradation in quality. Pre-treatment is summarised in the table below:

Sample Pre-Treatment and Storage Times

Analyte	Pre-Treatment	Holding Time
COD	Cool to 4° C add H_2SO_4, pH < 2	28 days
TKN, TP and NO_x	Cool to 4° C add H_2SO_4, pH < 2	28 days
Oil and Grease	Cool to 4° C add H_2SO_4, pH < 2	28/14 days
Sodium	add H_2SO_4, pH < 2	6 months
Dissolved Solids	Cool to 4° C	7 days
Suspended Solids	Cool to 4° C	7 days

Appendix C

Sample Analyses: Accuracy and Recommendations

Accuracy of Sample Analyses

Abattoir wastewaters are typified as containing very high levels of pollutants including organic loading (COD and BOD), suspended solids, oil and grease, and nutrients (nitrogen and phosphorus). Analytical techniques for the determination of these pollutant loads generally require dilution (up to 100:1) and filtration of the sample prior to analysis. Both the inconsistency within the samples and the degree of pretreatment required inherently decreases the accuracy of abattoir wastewater analyses as described below:

Accuracy of Off-Site Analyses

Off-site analyses were completed by a NATA registered wastewater analysis laboratory. The main factors affecting accuracy of the analysis results using the listed methods are:

- Due to the extremely high grease content of some samples (which separates and solidifies due to sample chilling) it is often difficult to ensure that a representative portion of the entire sample is taken for analyses. This also applies for a high solids content.

- Most abattoir wastes are very high in COD and nutrient levels. At these high levels, particularly for COD, the accuracy of the analyses diminishes due to the necessity to dilute the sample, or use smaller quantities for analyses. In both cases it is again difficult to ensure that the analysis volume is representative of the entire sample.

- Laboratory results are often rounded up or down to accurately report the uncertainty of physical measurement with respect to significant figures. For instance, a COD analysis result of 1200 mg/L could be the result of rounding any number from 1150 to 1249 according to 2 significant figures.

Table C1 summarises the expected accuracy for analysis of highly polluted wastewater from abattoirs.

Table C1
Accuracy of Laboratory Analysis

ANALYTE	ACCURACY RANGE	MAJOR FACTORS AFFECTING ANALYSES RESULT
COD	Normally ± 10%	• Accuracy will be lower for increasing COD levels due to the necessity to dilute the sample and use less sample volume.
O&G	Normally at least ± 20%	• Due to high grease contents of samples, the small sample required and since most grease exists as a solids mean that errors could be much higher.
NO_x	Normally ± 10%	• Samples are checked against standards* and must be within 10%. • Samples are filtered prior to analyses.
TKN	Normally ± 10%	• Samples are checked against standards and must be within 10%. • Normally start with 100 ml of sample, however, for very high levels (>1000), start with 50 ml.
TP	Normally ± 10%	• Samples are checked against standards and must be within 10%
Sodium	Normally ± 10%	• Samples are checked against standards and must be within 10%
Conductivity	Normally ± 10%	• Large variations can result due to temperature effects, it is important to measure conductivity at normal temperature (i.e. 20-25 ° C).

* When samples are checked against standards this can be done in two ways:

1. A sample of known analyte concentration is tested alongside (i.e. same methodology) the actual sample and result must be within 10% of known concentration.
2. A duplicate sample is given an induced 'spike' (i.e. a known amount of analyte is added) and the difference between the original and duplicate sample must be within 10% of the added 'spike'.

Accuracy of On-Site Analyses

With the exception of Total Phosphorus (TP) and Total Kjeldahl Nitrogen (TKN) analyses, on-site analyses of abattoir wastewater using the methods and equipment listed was not very successful. Problems occurred mostly due to the wastewater sample quality. Limited resources to effectively overcome these problems attributed to difficulties.

As mentioned, effluent samples typically contain high levels of oil and grease (O& G), suspended solids (SS) and nutrients leading to difficulties as follows:

- High levels of SS creates interference in spectrophotometric analysis by obstructing the light path and must be reduced in order to achieve correct results. SS content can be reduced by filtration (recommended for very high SS content) or by sample dilution (recommended only for lower SS content).

- High O&G levels interfere with spectrophometric analysis by obstruction of the light path and can also interfere with reactions (for example, coating of the cadmium catalyst for oxidised nitrate reaction). O&G also coats glassware and other apparatus such as pH and conductivity electrodes making cleaning very difficult. O&G may be reduced through sample dilution or removed via solvent extraction. It should be noted that if the sample is cooled allowing the grease to solidify then significant reductions in grease levels can be achieved through filtration alone.

- High nutrient levels in the effluent samples makes it necessary to dilute the sample until the nutrient level is within the measurement range of the spectrophotometer. This can often be a trial and error operation resulting in repetition of analyses. Very few analyses could be completed without some degree of sample dilution and these were limited to some TKN and TP analyses of steriliser wastewater. It was necessary to dilute samples up to 100:1 for some analyses and great care must be taken during such large dilutions to minimise errors. Dilutions from 50:1 to 100:1 should be completed in stages such that the initial sample volume is large enough to be representative of the whole sample.

Obtaining accurate results for on-site analysis is linked to successfully overcoming the problems of poor effluent quality and the subsequent effects on analysis. However, some analysis methods are inherently more able to give accurate results with poor effluent quality. The following points summarise the issues and difficulties in obtaining accurate analysis results.

- On-site analysis that incorporate a digestion process, such as TP and TKN, which results in greatly reduced SS and O&G concentrations generally produce accurate results.

- On-site analysis for substances dissolved in the aqueous phase of the effluent such as NO_x, RP and NH_3 may be improved by filtration to remove SS and reduce O&G or solvent extraction to remove O&G. Abattoir effluents generally would require some degree of treatment before these analyses were attempted as poor results are otherwise obtained.

Recommendations

The experience gained through this project has led to the conclusion that abattoir wastewater analyses should be completed at a NATA registered off-site laboratory unless appropriate resources are available on-site. To enable accurate suspended and dissolved solids analyses samples should not be acidified on-site as part of the sample pre-treatment. For this project many wastewater samples were simply frozen (e.g. pet food freezer) before transport to the laboratory.

In terms of both accuracy and cost effectiveness it is best to only collect and pre-treat samples on-site before transport to the laboratory.

Appendix D

Effluent Quality

- Analyses Results
- Daily Masses
- Masses Per Unit Product Weight

Eff kgperday

Summary of Abattoir Effluent Qualities

ABATTOIR A

Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Biochemical Oxygen Demand, BOD (kg/day)	Chemical Oxygen Demand, COD (kg/day)	Total Suspended Solids, TSS (kg/day)	Total Dissolved Solids, TDS (kg/day)	Sodium (kg/day)	Chlorice (kg/day)	Flouride (kg/day)	Nitrite/Nitrate Nitrogen, NOX (kg/day)	Ammonia Nitrogen, NH3 (kg/day)	Total Kjeldahl Nitrogen, TKN (kg/day)	Orthophosphate Phosphorus, OP (kg/day)	Total Phosphorus, TP (kg/day)	Sulphates, SO4 (kg/day)	Oil and Grease, O&G (kg/day)	pH	Temperature - April
		Results of Effluent Analyses															
Fresh Water Supply	2285					79.061					4.7985						
Slaughter and Evisceration	620		682			39.68					93		1.612		16.74		
Offal Processing	125		868.75			38.75			7.5		27.5		12.25		162.5		
Chillers																	
Boning Room Effluent	95		73.15			4.655					26.6		0.1615				
Casings Processing	150		99			82.5			106.5		7.95		1.215		2.4		
Manure (Paunch) Effluent	485		2182.5			257.05			29.1		116.4		56.745		679		
Rendering Plant:	110		7920			154			23.1		192.5		40.7		2420		
Raw Material Bin Drainage	14		910			18.2			0.56		59.5		7.21		1540		
Tallow Processing	2		380			0.7					2.14		2.26		98		
Blood Processing	14		518			30.8					20.3		2.1		4.9		
Cooker Condensate	80		58			0.1			1.6		29.6		0.052		5.36		
Scubber Effluent																	
Fellmongery	4		96			48					1		0.084				
Pickle Plant	85		425			119					34		1.36				
Stock Yard Washdowns																	
Amenities	55																
Final Effluent	2150		10642.5			645			473		494.5		83.85		1988.75		
Post Primary Treatment:																	
Static Screen																	
Vibrating Screen																	
Rotating Screen																	
Saveall																	
DAF																	
Post Secondary Treatment:																	
Anaerobic	2150		2150			623.5			86	408.5	494.5		107.5		322.5		
Facultative																	
Mechanically Aerated	2150		1182.5			623.5			64.5	430	430		98.9		88.15		
Natural Aeration/Maturation	2150		752.5			279.5			129	430	430		101.05		53.75		
Irrigation Holding Pond	2150		1462			688			107.5				96.75		101.05		
Recycle Water Supply	260		143			117			8.32		49.4		15.08				

Eff kgperday

Summary of Abattoir Effluent Qualities

ABATTOIR B

Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Results of Effluent Analyses															
		Biochemical Oxygen Demand, BOD (kg/day)	Chemical Oxygen Demand, COD (kg/day)	Total Suspended Solids, TSS (kg/day)	Total Dissolved Solids, TDS (kg/day)	Sodium (kg/day)	Chlorice (kg/day)	Flouride (kg/day)	Nitrite/Nitrate Nitrogen, NOX (kg/day)	Ammonia Nitrogen, NH3 (kg/day)	Total Kjeldahl Nitrogen, TKN (kg/day)	Orthophosphate Phosphorus, OP (kg/day)	Total Phosphorus, TP (kg/day)	Sulphates, SO4 (kg/day)	Oil and Grease, O&G (kg/day)	pH	Temperature - April
Fresh Water Supply	180		1.8			6.12					0.09						
Slaughter and Evisceration	63		189	39.69	168.21	13.23					18.9		2.52		20.79		
Offal Processing	21		39.9	13.86	27.3	3.99					2.52		0.315		2.1		
Chillers																	
Boning Room Effluent																	
Casings Processing																	
Manure (Paunch) Effluent	31		105.4	71.3	55.8	10.54				0.465	2.759		4.34		20.77		
Rendering Plant:																	
Raw Material Bin Drainage																	
Tallow Processing																	
Blood Processing																	
Cooker Condensate																	
Scubber Effluent																	
Fellmongery																	
Pickle Plant																	
Stock Yard Washdowns																	
Amenities																	
Final Effluent	171		581.4	478.8	256.5	35.91			94.05	3.249	32.49	8.721	10.431		42.75		
Post Primary Treatment:																	
Static Screen	171		581.4	188.1	256.5	42.75			32.49	46.17	64.98		9.234		100.89		
Vibrating Screen																	
Rotating Screen																	
Saveall																	
DAF																	
Post Secondary Treatment:																	
Anaerobic	171		126.54	34.2	188.1	73.53			8.55	44.46	47.88		8.379		27.36		
Facultative																	
Mechanically Aerated	171		87.21	32.49	188.1	41.04			10.26	39.33	44.46		8.208		87.21		
Natural Aeration/Maturation																	
Irrigation Holding Pond																	
Recycle Water Supply	10		5.4			2.3					2.9		0.49				

Eff kgperday

Summary of Abattoir Effluent Qualities

ABATTOIR C

Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Results of Effluent Analyses: Biochemical Oxygen Demand, BOD (kg/day)	Chemical Oxygen Demand, COD (kg/day)	Total Suspended Solids, TSS (kg/day)	Total Dissolved Solids, TDS (kg/day)	Sodium (kg/day)	Chlorice (kg/day)	Flouride (kg/day)	Nitrite/Nitrate Nitrogen, NOX (kg/day)	Ammonia Nitrogen, NH3 (kg/day)	Total Kjeldahl Nitrogen, TKN (kg/day)	Orthophosphate Phosphorus, OP (kg/day)	Total Phosphorus, TP (kg/day)	Sulphates, SO4 (kg/day)	Oil and Grease, O&G (kg/day)	pH	Temperature - April
Fresh Water Supply	270		10.8		75.6	14.58					1.08		0.0135				
Slaughter and Evisceration	124.7		162.11	56.115	168.345	11.5971					25.5635		0.9976		21.199		
Offal Processing	74.8		540.056			21.692					36.652		5.984				
Chillers	9.6		6.24	2.016	6.432	0.6528				0.6336	0.912		0.0672		5.568		
Boning Room Effluent																	
Casings Processing	54		32.94	37.26	156.6	24.84			3.24	14.58	23.22		3.942		5.94		
Manure (Paunch) Effluent																	
Rendering Plant:																	
Raw Material Bin Drainage																	
Tallow Processing																	
Blood Processing																	
Cooker Condensate																	
Scubber Effluent																	
Fellmongery																	
Pickle Plant																	
Stock Yard Washdowns	8		40.8														
Amenities	13																
Final Effluent	270		945	351	594	44.55			270	10.8	86.4	7.83	8.91		148.5		
Post Primary Treatment:																	
Static Screen																	
Vibrating Screen																	
Rotating Screen																	
Saveall																	
DAF																	
Post Secondary Treatment:																	
Anaerobic	270		140.4	45.9	297	59.4			10.8	81	89.1	9.99	11.88		67.5		
Facultative																	
Mechanically Aerated																	
Natural Aeration/Maturation	270		45.9	29.7	297	64.8			162	67.5	81	9.45	13.5		23.22		
Irrigation Holding Pond	270		54	27	297	78.3			116.1	78.3	81		11.61		1.35		
Recycle Water Supply	15		2.55	1.35	16.5	3.6				4.05	4.5		0.645				

Eff kgperday

Summary of Abattoir Effluent Qualities

ABATTOIR D

Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Results of Effluent Analyses: Biochemical Oxygen Demand, BOD (kg/day)	Chemical Oxygen Demand, COD (kg/day)	Total Suspended Solids, TSS (kg/day)	Total Dissolved Solids, TDS (kg/day)	Sodium (kg/day)	Chlorice (kg/day)	Flouride (kg/day)	Nitrite/Nitrate Nitrogen, NOX (kg/day)	Ammonia Nitrogen, NH3 (kg/day)	Total Kjeldahl Nitrogen, TKN (kg/day)	Orthophosphate Phosphorus, OP (kg/day)	Total Phosphorus, TP (kg/day)	Sulphates, SO4 (kg/day)	Oil and Grease, O&G (kg/day)	pH	Temperature - April
Fresh Water Supply	2200					72.6											
Slaughter and Evisceration	691	1029.59	1520.2	290.22		44.915	55.28	4.837		19.348	245.996	3.3168	5.8044	2.073			
Offal Processing	120	415.2	871.2	312		3.84	85.08	13.2		9	39.96	3	3.72	1.44			
Chillers	4	1.484	2.72	0.248		0.192	0.168	0.0172		0.0068	0.22	0.0036	0.0032	0.01			
Boning Room Effluent	29	3.335	8.932	1.45		0.812	1.914	0.203		0.1798	0.232	0.029	0.0058	0.058			
Casings Processing																	
Manure (Paunch) Effluent	648	1056.24	2144.88	533.952		207.36				13.608	91.368	64.152	61.56				
Rendering Plant:																	
Raw Material Bin Drainage	36	1022.4	1508.4	230.4			30.42	14.04		7.92	112.68	5.4	10.8	0.36			
Tallow Processing	103	6828.9	5505.35	2276.3		6.901	7.519	1.133		11.124	39.037	11.536	12.154	0.2472			
Blood Processing	43	373.24	629.95	75.68		23.65		1.075		21.93	52.89	2.107	3.225	1.161			
Cooker Condensate	119	82.11	428.4	22.372		19.278	1.309	4.165		23.8	24.871	0.119	2.975	0.238			
Scubber Effluent	24	44.64	21.6	13.44		4.08	5.184	0.096		3.048	1.152	0.528	0.672	0.264			
Fellmongery																	
Pickle Plant																	
Stock Yard Washdowns	252	922.32	259.56	71.568		64.26	46.872	9.576		18.396	26.712	7.308	11.592	3.024			
Amenities																	
Final Effluent																	
Post Primary Treatment:																	
Static Screen																	
Vibrating Screen																	
Rotating Screen																	
Saveall	1440	2664	5184	1627.2		349.92	204.48	36		82.08	316.8	72	79.2	7.2			
DAF	2700		6588	3051		426.6	337.5	45.9		229.5	577.8	135		13.5			
Post Secondary Treatment:																	
Anaerobic	2700		945	351						345.6		108					
Facultative																	
Mechanically Aerated	2700		472.5	256.5						78.3		97.2					
Natural Aeration/Maturation	2700		367.2	145.8						62.1		97.2					
Irrigation Holding Pond																	
Recycle Water Supply	500		50			125					30		20				

Summary of Abattoir Effluent Qualities

ABATTOIR E

Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Results of Effluent Analyses															
		Biochemical Oxygen Demand, BOD (kg/day)	Chemical Oxygen Demand, COD (kg/day)	Total Suspended Solids, TSS (kg/day)	Total Dissolved Solids, TDS (kg/day)	Sodium (kg/day)	Chlorice (kg/day)	Flouride (kg/day)	Nitrite/Nitrate Nitrogen, NOX (kg/day)	Ammonia Nitrogen, NH3 (kg/day)	Total Kjeldahl Nitrogen, TKN (kg/day)	Orthophosphate Phosphorus, OP (kg/day)	Total Phosphorus, TP (kg/day)	Sulphates, SO4 (kg/day)	Oil and Grease, O&G (kg/day)	pH	Temperature - April
Fresh Water Supply	1100	5.5	20.9	11		433.4					30.8	0.22	0.33				
Slaughter and Evisceration	345.4	156.466	335.729	259.05		386.848				6.2172	23.4872	0.55264	0.8635				
Offal Processing	78.1	139.799	252.263	89.034		60.137				2.4211	17.963	2.4211	2.4992				
Chillers																	
Boning Room Effluent																	
Casings Processing																	
Manure (Paunch) Effluent	77	515.9	1031.8	319.55		54.208				5.698	24.178	5.621	6.237				
Rendering Plant:																	
Raw Material Bin Drainage	0.7	20.23	40.25	9.94		1.302				0.1197	3.675	0.455	0.4655				
Tallow Processing	72	3258	4932	2260.8		29.88				1.368	18.648	1.8	4.968				
Blood Processing	11	638	1052.7	224.4		22.55				11	93.5	0.66	1.155				
Cooker Condensate	36	18	27.864	1.116		0.324				5.328	12.6	0.0144	0.0072				
Scubber Effluent	22	3.388	44	52.8		12.32				1.276	10.01	0.044	0.055				
Fellmongery																	
Pickle Plant																	
Stock Yard Washdowns	184	143.52	404.8	257.6		119.6				23.184	70.288	9.2	10.488				
Amenities																	
Final Effluent	1100	2860	5170	8470		533.5				64.9	286	15.4	16.5				
Post Primary Treatment:																	
Static Screen																	
Vibrating Screen																	
Rotating Screen																	
Saveall																	
DAF																	
Post Secondary Treatment:																	
Anaerobic																	
Facultative																	
Mechanically Aerated																	
Natural Aeration/Maturation																	
Irrigation Holding Pond																	
Recycle Water Supply																	

Eff kgperHSCW

Summary of Abattoir Effluent Qualities

ABATTOIR A

Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Results of Effluent Analyses: Biochemical Oxygen Demand, BOD (kg/tonne HSCW)	Chemical Oxygen Demand, COD(kg/tonne HSCW)	Total Suspended Solids, TSS (kg/tonne HSCW)	Total Dissolved Solids, TDS (kg/tonne HSCW)	Sodium (kg/tonne HSCW)	Chlorice (kg/tonne HSCW)	Flouride(kg/tonne HSCW)	Nitrite/Nitrate Nitrogen, NOX (kg/tonne HSCW)	Ammonia Nitrogen, NH3 (kg/tonne HSCW)	Total Kjeldahl Nitrogen, TKN (kg/tonne HSCW)	Orthophosphate Phosphorus, OP (kg/tonne HSCW)	Total Phosphorus, TP (kg/tonne HSCW)	Sulphates, SO4 (kg/tonne HSCW)	Oil and Grease, O&G (kg/tonne HSCW)	pH	Temperature - April
Fresh Water Supply	2285					0.49413					0.02999						
Slaughter and Evisceration	620		4.2625			0.248					0.58125		0.01008		0.10463		
Offal Processing	125		5.42969			0.24219			0.04688		0.17188		0.07656		1.01563		
Chillers																	
Boning Room Effluent	95		0.45719			0.02909					0.16625		0.00101				
Casings Processing	150		0.61875			0.51563			0.66563		0.04969		0.00759		0.015		
Manure (Paunch) Effluent	485		13.6406			1.60656			0.18188		0.7275		0.35466		4.24375		
Rendering Plant:	110		49.5			0.9625			0.14438		1.20313		0.25438		15.125		
Raw Material Bin Drainage	14		5.6875			0.11375			0.0035		0.37188		0.04506		9.625		
Tallow Processing	2		2.375			0.00438					0.01338		0.01413		0.6125		
Blood Processing	14		3.2375			0.1925					0.12688		0.01313		0.03063		
Cooker Condensate	80		0.3625			0.00063			0.01		0.185		0.00033		0.0335		
Scubber Effluent																	
Fellmongery	4		0.6			0.3					0.00625		0.00053				
Pickle Plant	85		2.65625			0.74375					0.2125		0.0085				
Stock Yard Washdowns																	
Amenities	55																
Final Effluent	2150		66.5156			4.03125			2.95625		3.09063		0.52406		12.4297		
Post Primary Treatment:																	
Static Screen																	
Vibrating Screen																	
Rotating Screen																	
Saveall																	
DAF																	
Post Secondary Treatment:																	
Anaerobic	2150		13.4375			3.89688			0.5375	2.55313	3.09063		0.67188		2.01563		
Facultative																	
Mechanically Aerated	2150		7.39063			3.89688			0.40313	2.6875	2.6875		0.61813		0.55094		
Natural Aeration/Maturation	2150		4.70313			1.74688			0.80625	2.6875	2.6875		0.63156		0.33594		
Irrigation Holding Pond	2150		9.1375			4.3			0.67188				0.60469		0.63156		
Recycle Water Supply	260		0.89375			0.73125			0.052		0.30875		0.09425				

Summary of Abattoir Effluent Qualities

ABATTOIR B

Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Results of Effluent Analyses: Biochemical Oxygen Demand, BOD (kg/tonne HSCW)	Chemical Oxygen Demand, COD(kg/tonne HSCW)	Total Suspended Solids, TSS (kg/tonne HSCW)	Total Dissolved Solids, TDS (kg/tonne HSCW)	Sodium (kg/tonne HSCW)	Chlorice (kg/tonne HSCW)	Flouride(kg/tonne HSCW)	Nitrite/Nitrate Nitrogen, NOX (kg/tonne HSCW)	Ammonia Nitrogen, NH3 (kg/tonne HSCW)	Total Kjeldahl Nitrogen, TKN (kg/tonne HSCW)	Orthophosphate Phosphorus, OP (kg/tonne HSCW)	Total Phosphorus, TP (kg/tonne HSCW)	Sulphates, SO4 (kg/tonne HSCW)	Oil and Grease, O&G (kg/tonne HSCW)	pH	Temperature - April
Fresh Water Supply	180		0.04932			0.16767					0.00247						
Slaughter and Evisceration	63		5.17808	1.0874	4.60849	0.36247					0.51781		0.06904		0.56959		
Offal Processing	21		1.09315	0.37973	0.74795	0.10932					0.06904		0.00863		0.05753		
Chillers																	
Boning Room Effluent																	
Casings Processing																	
Manure (Paunch) Effluent	31		2.88767	1.95342	1.52877	0.28877				0.01274	0.07559		0.1189		0.56904		
Rendering Plant:																	
Raw Material Bin Drainage																	
Tallow Processing																	
Blood Processing																	
Cooker Condensate																	
Scubber Effluent																	
Fellmongery																	
Pickle Plant																	
Stock Yard Washdowns																	
Amenities																	
Final Effluent	171		15.9288	13.1178	7.0274	0.98384			2.57671	0.08901	0.89014	0.23893	0.28578		1.17123		
Post Primary Treatment:																	
Static Screen	171		15.9288	5.15342	7.0274	1.17123			0.89014	1.26493	1.78027		0.25299		2.76411		
Vibrating Screen																	
Rotating Screen																	
Saveall																	
DAF																	
Post Secondary Treatment:																	
Anaerobic	171		3.46685	0.93699	5.15342	2.01452			0.23425	1.21808	1.31178		0.22956		0.74959		
Facultative																	
Mechanically Aerated	171		2.38932	0.89014	5.15342	1.12438			0.2811	1.07753	1.21808		0.22488		2.38932		
Natural Aeration/Maturation																	
Irrigation Holding Pond																	
Recycle Water Supply	10		0.14795			0.06301					0.07945		0.01342				

Summary of Abattoir Effluent Qualities

ABATTOIR C

Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Results of Effluent Analyses: Biochemical Oxygen Demand, BOD (kg/tonne HSCW)	Chemical Oxygen Demand, COD(kg/tonne HSCW)	Total Suspended Solids, TSS (kg/tonne HSCW)	Total Dissolved Solids, TDS (kg/tonne HSCW)	Sodium (kg/tonne HSCW)	Chlorice (kg/tonne HSCW)	Flouride(kg/tonne HSCW)	Nitrite/Nitrate Nitrogen, NOX (kg/tonne HSCW)	Ammonia Nitrogen, NH3 (kg/tonne HSCW)	Total Kjeldahl Nitrogen, TKN (kg/tonne HSCW)	Orthophosphate Phosphorus, OP (kg/tonne HSCW)	Total Phosphorus, TP (kg/tonne HSCW)	Sulphates, SO4 (kg/tonne HSCW)	Oil and Grease, O&G (kg/tonne HSCW)	pH	Temperature - April
Fresh Water Supply	270		0.13568		0.94975	0.18317					0.01357		0.00017				
Slaughter and Evisceration	124.7		2.03656	0.70496	2.11489	0.14569					0.32115		0.01253		0.26632		
Offal Processing	74.8		6.78462			0.27251					0.46045		0.07518				
Chillers	9.6		0.07839	0.02533	0.0808	0.0082				0.00796	0.01146		0.00084		0.06995		
Boning Room Effluent																	
Casings Processing	54		0.41382	0.46809	1.96734	0.31206			0.0407	0.18317	0.29171		0.04952		0.07462		
Manure (Paunch) Effluent																	
Rendering Plant:																	
Raw Material Bin Drainage																	
Tallow Processing																	
Blood Processing																	
Cooker Condensate																	
Scubber Effluent																	
Fellmongery																	
Pickle Plant																	
Stock Yard Washdowns	8		0.51256														
Amenities	13																
Final Effluent	270		11.8719	4.40955	7.46231	0.55967			3.39196	0.13568	1.08543	0.09837	0.11193		1.86558		
Post Primary Treatment:																	
Static Screen																	
Vibrating Screen																	
Rotating Screen																	
Saveall																	
DAF																	
Post Secondary Treatment:																	
Anaerobic	270		1.76382	0.57663	3.73116	0.74623			0.13568	1.01759	1.11935	0.1255	0.14925		0.84799		
Facultative																	
Mechanically Aerated																	
Natural Aeration/Maturation	270		0.57663	0.37312	3.73116	0.81407			2.03518	0.84799	1.01759	0.11872	0.1696		0.29171		
Irrigation Holding Pond	270		0.67839	0.3392	3.73116	0.98367			1.45854	0.98367	1.01759		0.14585		0.01696		
Recycle Water Supply	15		0.03204	0.01696	0.20729	0.04523				0.05088	0.05653		0.0081				

Summary of Abattoir Effluent Qualities

ABATTOIR D		Results of Effluent Analyses															
Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Biochemical Oxygen Demand, BOD (kg/tonne HSCW)	Chemical Oxygen Demand, COD(kg/tonne HSCW)	Total Suspended Solids, TSS (kg/tonne HSCW)	Total Dissolved Solids, TDS (kg/tonne HSCW)	Sodium (kg/tonne HSCW)	Chlorice (kg/tonne HSCW)	Flouride(kg/tonne HSCW)	Nitrite/Nitrate Nitrogen, NOX (kg/tonne HSCW)	Ammonia Nitrogen, NH3 (kg/tonne HSCW)	Total Kjeldahl Nitrogen, TKN (kg/tonne HSCW)	Orthophosphate Phosphorus, OP (kg/tonne HSCW)	Total Phosphorus, TP (kg/tonne HSCW)	Sulphates, SO4 (kg/tonne HSCW)	Oil and Grease, O&G (kg/tonne HSCW)	pH	Temperature - April
Fresh Water Supply	2200					0.275											
Slaughter and Evisceration	691	3.89996	5.75833	1.09932		0.17013	0.20939	0.01832		0.07329	0.9318	0.01256	0.02199	0.00785			
Offal Processing	120	1.57273	3.3	1.18182		0.01455	0.32227	0.05		0.03409	0.15136	0.01136	0.01409	0.00545			
Chillers	4	0.00562	0.0103	0.00094		0.00073	0.00064	6.5E-05		2.6E-05	0.00083	1.4E-05	1.2E-05	3.8E-05			
Boning Room Effluent	29	0.01263	0.03383	0.00549		0.00308	0.00725	0.00077		0.00068	0.00088	0.00011	2.2E-05	0.00022			
Casings Processing																	
Manure (Paunch) Effluent	648	4.00091	8.12455	2.02255		0.78545				0.05155	0.34609	0.243	0.23318				
Rendering Plant:																	
Raw Material Bin Drainage	36	3.87273	5.71364	0.87273			0.11523	0.05318		0.03	0.42682	0.02045	0.04091	0.00136			
Tallow Processing	103	25.867	20.8536	8.62235		0.02614	0.02848	0.00429		0.04214	0.14787	0.0437	0.04604	0.00094			
Blood Processing	43	1.41379	2.38617	0.28667		0.08958		0.00407		0.08307	0.20034	0.00798	0.01222	0.0044			
Cooker Condensate	119	0.31102	1.62273	0.08474		0.07302	0.00496	0.01578		0.09015	0.09421	0.00045	0.01127	0.0009			
Scubber Effluent	24	0.16909	0.08182	0.05091		0.01545	0.01964	0.00036		0.01155	0.00436	0.002	0.00255	0.001			
Fellmongery																	
Pickle Plant																	
Stock Yard Washdowns	252	3.49364	0.98318	0.27109		0.24341	0.17755	0.03627		0.06968	0.10118	0.02768	0.04391	0.01145			
Amenities																	
Final Effluent		44.6192	48.8682	14.4986		1.69655	0.8854	0.18311		0.48621	2.40575	0.36932	0.42618	0.03362			
Post Primary Treatment:																	
Static Screen																	
Vibrating Screen																	
Rotating Screen																	
Saveall	1440	10.0909	19.6364	6.16364		1.32545	0.77455	0.13636		0.31091	1.2	0.27273	0.3	0.02727			
DAF	2700		24.9545	11.5568		1.61591	1.27841	0.17386		0.86932	2.18864	0.51136		0.05114			
Post Secondary Treatment:																	
Anaerobic	2700		3.57955	1.32955						1.30909		0.40909					
Facultative																	
Mechanically Aerated	2700		1.78977	0.97159						0.29659		0.36818					
Natural Aeration/Maturation	2700		1.39091	0.55227						0.23523		0.36818					
Irrigation Holding Pond																	
Recycle Water Supply	500		0.18939			0.47348					0.11364		0.07576				

Summary of Abattoir Effluent Qualities

ABATTOIR E

Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Biochemical Oxygen Demand, BOD (kg/tonne HSCW)	Chemical Oxygen Demand, COD(kg/tonne HSCW)	Total Suspended Solids, TSS (kg/tonne HSCW)	Total Dissolved Solids, TDS (kg/tonne HSCW)	Sodium (kg/tonne HSCW)	Chlorice (kg/tonne HSCW)	Flouride(kg/tonne HSCW)	Nitrite/Nitrate Nitrogen, NOX (kg/tonne HSCW)	Ammonia Nitrogen, NH3 (kg/tonne HSCW)	Total Kjeldahl Nitrogen, TKN (kg/tonne HSCW)	Orthophosphate Phosphorus, OP (kg/tonne HSCW)	Total Phosphorus, TP (kg/tonne HSCW)	Sulphates, SO4 (kg/tonne HSCW)	Oil and Grease, O&G (kg/tonne HSCW)	pH	Temperature - April
		Results of Effluent Analyses															
Fresh Water Supply	1100	0.0191	0.07257	0.03819		1.50486					0.10694	0.00076	0.00115				
Slaughter and Evisceration	345.4	0.54329	1.16573	0.89948		1.34322				0.02159	0.08155	0.00192	0.003				
Offal Processing	78.1	0.48541	0.87591	0.30915		0.20881				0.00841	0.06237	0.00841	0.00868				
Chillers																	
Boning Room Effluent																	
Casings Processing																	
Manure (Paunch) Effluent	77	1.79132	3.58264	1.10955		0.18822				0.01978	0.08395	0.01952	0.02166				
Rendering Plant:																	
Raw Material Bin Drainage	0.7	0.07024	0.13976	0.03451		0.00452				0.00042	0.01276	0.00158	0.00162				
Tallow Processing	72	11.3125	17.125	7.85		0.10375				0.00475	0.06475	0.00625	0.01725				
Blood Processing	11	2.21528	3.65521	0.77917		0.0783				0.03819	0.32465	0.00229	0.00401				
Cooker Condensate	36	0.0625	0.09675	0.00388		0.00113				0.0185	0.04375	0.00005	2.5E-05				
Scubber Effluent	22	0.01176	0.15278	0.18333		0.04278				0.00443	0.03476	0.00015	0.00019				
Fellmongery																	
Pickle Plant																	
Stock Yard Washdowns	184	0.49833	1.40556	0.89444		0.41528				0.0805	0.24406	0.03194	0.03642				
Amenities																	
Final Effluent	1100	9.93056	17.9514	29.4097		1.85243				0.22535	0.99306	0.05347	0.05729				
Post Primary Treatment:		17.0097	28.2719	12.1017		3.89086				0.19657	1.05955	0.07288	0.09399				
Static Screen																	
Vibrating Screen																	
Rotating Screen																	
Saveall																	
DAF																	
Post Secondary Treatment:																	
Anaerobic																	
Facultative																	
Mechanically Aerated																	
Natural Aeration/Maturation																	
Irrigation Holding Pond																	
Recycle Water Supply																	

Summary of Abattoir Effluent Qualities

ABATTOIR A

Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Results of Effluent Analyses: Biochemical Oxygen Demand, BOD (kg/tonne HSCW)	Chemical Oxygen Demand, COD(kg/tonne HSCW)	Total Suspended Solids, TSS (kg/tonne HSCW)	Total Dissolved Solids, TDS (kg/tonne HSCW)	Sodium (kg/tonne HSCW)	Chlorice (kg/tonne HSCW)	Flouride(kg/tonne HSCW)	Nitrite/Nitrate Nitrogen, NOX (kg/tonne HSCW)	Ammonia Nitrogen, NH3 (kg/tonne HSCW)	Total Kjeldahl Nitrogen, TKN (kg/tonne HSCW)	Orthophosphate Phosphorus, OP (kg/tonne HSCW)	Total Phosphorus, TP (kg/tonne HSCW)	Sulphates, SO4 (kg/tonne HSCW)	Oil and Grease, O&G (kg/tonne HSCW)	pH	Temperature - April
Fresh Water Supply	2285					0.49413					0.02999						
Slaughter and Evisceration	620		4.2625			0.248					0.58125		0.01008		0.10463		
Offal Processing	125		5.42969			0.24219			0.04688		0.17188		0.07656		1.01563		
Chillers																	
Boning Room Effluent	95		0.45719			0.02909					0.16625		0.00101				
Casings Processing	150		0.61875			0.51563			0.66563		0.04969		0.00759		0.015		
Manure (Paunch) Effluent	485		13.6406			1.60656			0.18188		0.7275		0.35466		4.24375		
Rendering Plant:	110		49.5			0.9625			0.14438		1.20313		0.25438		15.125		
Raw Material Bin Drainage	14		5.6875			0.11375			0.0035		0.37188		0.04506		9.625		
Tallow Processing	2		2.375			0.00438					0.01338		0.01413		0.6125		
Blood Processing	14		3.2375			0.1925					0.12688		0.01313		0.03063		
Cooker Condensate	80		0.3625			0.00063			0.01		0.185		0.00033		0.0335		
Scubber Effluent																	
Fellmongery	4		0.6			0.3					0.00625		0.00053				
Pickle Plant	85		2.65625			0.74375					0.2125		0.0085				
Stock Yard Washdowns																	
Amenities	55																
Final Effluent	2150		66.5156			4.03125			2.95625		3.09063		0.52406		12.4297		
Post Primary Treatment:																	
Static Screen																	
Vibrating Screen																	
Rotating Screen																	
Saveall																	
DAF																	
Post Secondary Treatment:																	
Anaerobic	2150		13.4375			3.89688			0.5375	2.55313	3.09063		0.67188		2.01563		
Facultative																	
Mechanically Aerated	2150		7.39063			3.89688			0.40313	2.6875	2.6875		0.61813		0.55094		
Natural Aeration/Maturation	2150		4.70313			1.74688			0.80625	2.6875	2.6875		0.63156		0.33594		
Irrigation Holding Pond	2150		9.1375			4.3			0.67188				0.60469		0.63156		
Recycle Water Supply	260		0.89375			0.73125			0.052		0.30875		0.09425				

Summary of Abattoir Effluent Qualities

ABATTOIR B

Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Results of Effluent Analyses															
		Biochemical Oxygen Demand, BOD (kg/tonne HSCW)	Chemical Oxygen Demand, COD(kg/tonne HSCW)	Total Suspended Solids, TSS (kg/tonne HSCW)	Total Dissolved Solids, TDS (kg/tonne HSCW)	Sodium (kg/tonne HSCW)	Chlorice (kg/tonne HSCW)	Flouride(kg/tonne HSCW)	Nitrite/Nitrate Nitrogen, NOX (kg/tonne HSCW)	Ammonia Nitrogen, NH3 (kg/tonne HSCW)	Total Kjeldahl Nitrogen, TKN (kg/tonne HSCW)	Orthophosphate Phosphorus, OP (kg/tonne HSCW)	Total Phosphorus, TP (kg/tonne HSCW)	Sulphates, SO4 (kg/tonne HSCW)	Oil and Grease, O&G (kg/tonne HSCW)	pH	Temperature - April
Fresh Water Supply	180		0.04932			0.16767					0.00247						
Slaughter and Evisceration	63		5.17808	1.0874	4.60849	0.36247					0.51781		0.06904		0.56959		
Offal Processing	21		1.09315	0.37973	0.74795	0.10932					0.06904		0.00863		0.05753		
Chillers																	
Boning Room Effluent																	
Casings Processing																	
Manure (Paunch) Effluent	31		2.88767	1.95342	1.52877	0.28877				0.01274	0.07559		0.1189		0.56904		
Rendering Plant:																	
Raw Material Bin Drainage																	
Tallow Processing																	
Blood Processing																	
Cooker Condensate																	
Scubber Effluent																	
Fellmongery																	
Pickle Plant																	
Stock Yard Washdowns																	
Amenities																	
Final Effluent	171		15.9288	13.1178	7.0274	0.98384			2.57671	0.08901	0.89014	0.23893	0.28578		1.17123		
Post Primary Treatment:																	
Static Screen	171		15.9288	5.15342	7.0274	1.17123			0.89014	1.26493	1.78027		0.25299		2.76411		
Vibrating Screen																	
Rotating Screen																	
Saveall																	
DAF																	
Post Secondary Treatment:																	
Anaerobic	171		3.46685	0.93699	5.15342	2.01452			0.23425	1.21808	1.31178		0.22956		0.74959		
Facultative																	
Mechanically Aerated	171		2.38932	0.89014	5.15342	1.12438			0.2811	1.07753	1.21808		0.22488		2.38932		
Natural Aeration/Maturation																	
Irrigation Holding Pond																	
Recycle Water Supply	10		0.14795			0.06301					0.07945		0.01342				

Summary of Abattoir Effluent Qualities

ABATTOIR C

Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Results of Effluent Analyses															
		Biochemical Oxygen Demand, BOD (kg/tonne HSCW)	Chemical Oxygen Demand, COD(kg/tonne HSCW)	Total Suspended Solids, TSS (kg/tonne HSCW)	Total Dissolved Solids, TDS (kg/tonne HSCW)	Sodium (kg/tonne HSCW)	Chlorice (kg/tonne HSCW)	Flouride(kg/tonne HSCW)	Nitrite/Nitrate Nitrogen, NOX (kg/tonne HSCW)	Ammonia Nitrogen, NH3 (kg/tonne HSCW)	Total Kjeldahl Nitrogen, TKN (kg/tonne HSCW)	Orthophosphate Phosphorus, OP (kg/tonne HSCW)	Total Phosphorus, TP (kg/tonne HSCW)	Sulphates, SO4 (kg/tonne HSCW)	Oil and Grease, O&G (kg/tonne HSCW)	pH	Temperature - April
Fresh Water Supply	270		0.13568		0.94975	0.18317					0.01357		0.00017				
Slaughter and Evisceration	124.7		2.03656	0.70496	2.11489	0.14569					0.32115		0.01253		0.26632		
Offal Processing	74.8		6.78462			0.27251					0.46045		0.07518				
Chillers	9.6		0.07839	0.02533	0.0808	0.0082				0.00796	0.01146		0.00084		0.06995		
Boning Room Effluent																	
Casings Processing	54		0.41382	0.46809	1.96734	0.31206			0.0407	0.18317	0.29171		0.04952		0.07462		
Manure (Paunch) Effluent																	
Rendering Plant:																	
Raw Material Bin Drainage																	
Tallow Processing																	
Blood Processing																	
Cooker Condensate																	
Scubber Effluent																	
Fellmongery																	
Pickle Plant																	
Stock Yard Washdowns	8		0.51256														
Amenities	13																
Final Effluent	270		11.8719	4.40955	7.46231	0.55967			3.39196	0.13568	1.08543	0.09837	0.11193		1.86558		
Post Primary Treatment:																	
Static Screen																	
Vibrating Screen																	
Rotating Screen																	
Saveall																	
DAF																	
Post Secondary Treatment:																	
Anaerobic	270		1.76382	0.57663	3.73116	0.74623			0.13568	1.01759	1.11935	0.1255	0.14925		0.84799		
Facultative																	
Mechanically Aerated																	
Natural Aeration/Maturation	270		0.57663	0.37312	3.73116	0.81407			2.03518	0.84799	1.01759	0.11872	0.1696		0.29171		
Irrigation Holding Pond	270		0.67839	0.3392	3.73116	0.98367			1.45854	0.98367	1.01759		0.14585		0.01696		
Recycle Water Supply	15		0.03204	0.01696	0.20729	0.04523				0.05088	0.05653		0.0081				

Summary of Abattoir Effluent Qualities

ABATTOIR D

Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Biochemical Oxygen Demand, BOD (kg/tonne HSCW)	Chemical Oxygen Demand, COD(kg/tonne HSCW)	Total Suspended Solids, TSS (kg/tonne HSCW)	Total Dissolved Solids, TDS (kg/tonne HSCW)	Sodium (kg/tonne HSCW)	Chlorice (kg/tonne HSCW)	Flouride(kg/tonne HSCW)	Nitrite/Nitrate Nitrogen, NOX (kg/tonne HSCW)	Ammonia Nitrogen, NH3 (kg/tonne HSCW)	Total Kjeldahl Nitrogen, TKN (kg/tonne HSCW)	Orthophosphate Phosphorus, OP (kg/tonne HSCW)	Total Phosphorus, TP (kg/tonne HSCW)	Sulphates, SO4 (kg/tonne HSCW)	Oil and Grease, O&G (kg/tonne HSCW)	pH	Temperature - April
		Results of Effluent Analyses															
Fresh Water Supply	2200					0.275											
Slaughter and Evisceration	691	3.89996	5.75833	1.09932		0.17013	0.20939	0.01832		0.07329	0.9318	0.01256	0.02199	0.00785			
Offal Processing	120	1.57273	3.3	1.18182		0.01455	0.32227	0.05		0.03409	0.15136	0.01136	0.01409	0.00545			
Chillers	4	0.00562	0.0103	0.00094		0.00073	0.00064	6.5E-05		2.6E-05	0.00083	1.4E-05	1.2E-05	3.8E-05			
Boning Room Effluent	29	0.01263	0.03383	0.00549		0.00308	0.00725	0.00077		0.00068	0.00088	0.00011	2.2E-05	0.00022			
Casings Processing																	
Manure (Paunch) Effluent	648	4.00091	8.12455	2.02255		0.78545				0.05155	0.34609	0.243	0.23318				
Rendering Plant:																	
Raw Material Bin Drainage	36	3.87273	5.71364	0.87273			0.11523	0.05318		0.03	0.42682	0.02045	0.04091	0.00136			
Tallow Processing	103	25.867	20.8536	8.62235		0.02614	0.02848	0.00429		0.04214	0.14787	0.0437	0.04604	0.00094			
Blood Processing	43	1.41379	2.38617	0.28667		0.08958		0.00407		0.08307	0.20034	0.00798	0.01222	0.0044			
Cooker Condensate	119	0.31102	1.62273	0.08474		0.07302	0.00496	0.01578		0.09015	0.09421	0.00045	0.01127	0.0009			
Scubber Effluent	24	0.16909	0.08182	0.05091		0.01545	0.01964	0.00036		0.01155	0.00436	0.002	0.00255	0.001			
Fellmongery																	
Pickle Plant																	
Stock Yard Washdowns	252	3.49364	0.98318	0.27109		0.24341	0.17755	0.03627		0.06968	0.10118	0.02768	0.04391	0.01145			
Amenities																	
Final Effluent		44.6192	48.8682	14.4986		1.69655	0.8854	0.18311		0.48621	2.40575	0.36932	0.42618	0.03362			
Post Primary Treatment:																	
Static Screen																	
Vibrating Screen																	
Rotating Screen																	
Saveall	1440	10.0909	19.6364	6.16364		1.32545	0.77455	0.13636		0.31091	1.2	0.27273	0.3	0.02727			
DAF	2700		24.9545	11.5568		1.61591	1.27841	0.17386		0.86932	2.18864	0.51136		0.05114			
Post Secondary Treatment:																	
Anaerobic	2700		3.57955	1.32955						1.30909		0.40909					
Facultative																	
Mechanically Aerated	2700		1.78977	0.97159						0.29659		0.36818					
Natural Aeration/Maturation	2700		1.39091	0.55227						0.23523		0.36818					
Irrigation Holding Pond																	
Recycle Water Supply	500		0.18939			0.47348					0.11364		0.07576				

Summary of Abattoir Effluent Qualities

ABATTOIR E

Effluent Sampling Locations	Total Daily Effluent Flow (kL)	Biochemical Oxygen Demand, BOD (kg/tonne HSCW)	Chemical Oxygen Demand, COD(kg/tonne HSCW)	Total Suspended Solids, TSS (kg/tonne HSCW)	Total Dissolved Solids, TDS (kg/tonne HSCW)	Sodium (kg/tonne HSCW)	Chlorice (kg/tonne HSCW)	Flouride(kg/tonne HSCW)	Nitrite/Nitrate Nitrogen, NOX (kg/tonne HSCW)	Ammonia Nitrogen, NH3 (kg/tonne HSCW)	Total Kjeldahl Nitrogen, TKN (kg/tonne HSCW)	Orthophosphate Phosphorus, OP (kg/tonne HSCW)	Total Phosphorus, TP (kg/tonne HSCW)	Sulphates, SO4 (kg/tonne HSCW)	Oil and Grease, O&G (kg/tonne HSCW)	pH	Temperature - April
		Results of Effluent Analyses															
Fresh Water Supply	1100	0.0191	0.07257	0.03819		1.50486					0.10694	0.00076	0.00115				
Slaughter and Evisceration	345.4	0.54329	1.16573	0.89948		1.34322				0.02159	0.08155	0.00192	0.003				
Offal Processing	78.1	0.48541	0.87591	0.30915		0.20881				0.00841	0.06237	0.00841	0.00868				
Chillers																	
Boning Room Effluent																	
Casings Processing																	
Manure (Paunch) Effluent	77	1.79132	3.58264	1.10955		0.18822				0.01978	0.08395	0.01952	0.02166				
Rendering Plant:																	
Raw Material Bin Drainage	0.7	0.07024	0.13976	0.03451		0.00452				0.00042	0.01276	0.00158	0.00162				
Tallow Processing	72	11.3125	17.125	7.85		0.10375				0.00475	0.06475	0.00625	0.01725				
Blood Processing	11	2.21528	3.65521	0.77917		0.0783				0.03819	0.32465	0.00229	0.00401				
Cooker Condensate	36	0.0625	0.09675	0.00388		0.00113				0.0185	0.04375	0.00005	2.5E-05				
Scubber Effluent	22	0.01176	0.15278	0.18333		0.04278				0.00443	0.03476	0.00015	0.00019				
Fellmongery																	
Pickle Plant																	
Stock Yard Washdowns	184	0.49833	1.40556	0.89444		0.41528				0.0805	0.24406	0.03194	0.03642				
Amenities																	
Final Effluent	1100	9.93056	17.9514	29.4097		1.85243				0.22535	0.99306	0.05347	0.05729				
Post Primary Treatment:		17.0097	28.2719	12.1017		3.89086				0.19657	1.05955	0.07288	0.09399				
Static Screen																	
Vibrating Screen																	
Rotating Screen																	
Saveall																	
DAF																	
Post Secondary Treatment:																	
Anaerobic																	
Facultative																	
Mechanically Aerated																	
Natural Aeration/Maturation																	
Irrigation Holding Pond																	
Recycle Water Supply																	

Appendix E

Example Water Consumption Estimation by Equipment and Process Area

Appendix E

Example Water Consumption Estimation by Equipment and Process Area

The following information is provided to assist operators in generating similar information on water consumptions by equipment and process areas. Sources of information consists of equipment specifications, queries to manufacturers and direct measurement.

Estimated water consumptions for 400 cattle/day abattoir:

			Volume in litres
(a)	**Beef Floor**		
		Knife sterilizer x 28	11,550
		Hand wash x 28	8,820
		Hand wash x 28	5,250
		Saw sterilizers	9,000
		Viscera table sprays	52,920
		Carcase wash auto	11,340
		Implement sterilizers	4,200
		Drop hose and intermediate washdown	11,200
			114,280
(b)	**Ground Floor to Slaughter Floor**		
		Paunch table spigot	22,400
		Hand spray	3,200
		Tripe room: tripe washer	21,000
		Spray to table	4,040
		Drop gun	840
		Edible offal sinks x 4	7,200
		Pet food: Spray to holding drums	5,040
		Slinks	4,480
		Sterilisers to ground floor 10 off:	
		Knife steriliser	4,125
		Hand basins	3,150
			75,475
(c)	**Yard Wash Down**		
		Cattle wash primary wash - spray	81,000
		Potable wash	24,000
		Yard wash down cattle	10,200
		Stock Truck wash down	5,200
			120,400

			Volume in Litres
(d)	**Hand and Apron Wash Areas**		
		Boot wash	4,600
		Hand wash	4,200
		Apron wash	5,800
			14,600
(e)	**Defrost Freezer (recycle)**		
		Chillers (hot gas) potable	3,240
(f)	**Boning Room**		
		Knife steriliser - 10 off	4,124
		Hand basins	3,150
		Shrink cabinets (recycle potable)	500
			7,775
(g)	**Wash Down**		
		Beef slaughter floor	48,000
		Ground floor	25,600
		Chillers	12,800
		Boning room	42,000
		Meat truck wash area	9,600
		By-products	28,000
			169,000
(h)	**By-products Process Effluent**		64,000
(i)	**Amenities and Office**		15,200