NATSURV 7

WATER AND WASTE-WATER MANAGEMENT IN THE RED MEAT INDUSTRY

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PREPARED FOR THE
WATER RESEARCH COMMISSION

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CONSULTING ENGINEERS

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FOREWORD

The need for guidelines to reduce water intake and waste-water discharge by industry is of national concern in view of South Africa's water scarcity.

To establish norms for water intake and waste-water disposal, the Water Research Commission (WRC) in collaboration with the Department of Water Affairs (DWA) contracted Binnie and Partners (now amalgamated with Steffen, Robertson and Kirsten), a firm of consulting engineers, to undertake a National Industrial Water and Waste-water Survey (NATSURV) of all classes of industry. The consultants identified 75 industrial groupings in South Africa, one of which is the red meat abattoir industry. The results obtained in the survey of the red meat abattoir industry form the basis of this Guide on **Water and Waste-water Management in the Red Meat Industry.**

It is expected that this Guide will be of value to the industry itself and to other interested parties such as municipalities, administrators, researchers and consultants in water and waste-water fields.

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Dr OO Hart (Chairman)	Water Research Commission
Mr M Hartmann	Abattoir Corporation
Mr DF Sutton	Department of Water Affairs
Mr P Skivington	Steffen, Robertson and Kirsten Inc

Their contributions to this project and that of Mr AJ Elphinston, are gratefully acknowledged.

SUMMARY

There are 285 red meat abattoirs in South Africa which slaughter some 11 million animals and use some 5,8 million m^3 of water annually. The mean SWI was found to be 1,36 m^3 per water-related cattle unit (wrcu) for A-grade abattoirs and 2,04 m^3/wrcu for other grades.

A target SWI of 1,1 m^3/wrcu for A-grade abattoirs and 1,75 m^3/wrcu for other grades is proposed.

Waste-water volumes are typically 80 - 85% of the water intake, giving an annual waste-water discharge for the industry of approximately 4,9 million m^3.

The average SPL for A-grade abattoirs was found to be 5,2 kg COD/wrcu and 1,6 kg SS/wrcu. For other grades these figures were 8,5 kg COD/wrcu and 1,4 kg SS/wrcu.

Target SPL figures of 4,0 kg COD/wrcu and 1,0 kg SS/wrcu for A-grade abattoirs are proposed. Figures of 5,0 kg COD/wrcu and 1,0 kg SS/wrcu are proposed for other abattoirs.

Extensive analyses of red meat abattoir waste water yielded the relationship 1,0 OA : 11,0 COD.

ABBREVIATIONS

COD	-	Chemical oxygen demand
cu	-	Cattle unit
OA	-	Oxygen absorbed
RO	-	Reverse osmosis
SEV	-	Specific effluent volume
FOG	-	Fats, oil and grease
SPL	-	Specific pollution load
SS	-	Suspended solids
SWI	-	Specific water intake
TDS	-	Total dissolved solids
TKN	-	Total Kjeldahl nitrogen
TS	-	Total solids
UF	-	Ultrafiltration
wrcu	-	Water-related cattle unit

GLOSSARY OF TERMS

CATTLE UNIT

The number of non-bovine species considered equivalent to one bovine animal.

WATER INTAKE

All water entering a premises from municipal and/or other sources e.g. boreholes, river intakes, etc.

SPECIFIC EFFLUENT VOLUME

The waste-water volume generated in a particular period divided by the number of water-related cattle units used in production during the same period.

SPECIFIC POLLUTANT LOAD

The pollutant mass load for a particular period (in terms of any particular pollutant parameter e.g. COD, FOG, TKN, etc.) arising from an industrial unit process divided by the number of water-related cattle units used in production during the same period.

SPECIFIC WATER INTAKE

The water intake for a particular period divided by the number of water-related cattle units used in production during the same period.

SPECIFIC WATER USAGE

The water used in an industrial unit process divided by the number of water-related cattle units processed.

ULTRAFILTRATION

The separation of large molecules or colloidal matter or solid particles by filtration through microporous membranes.

REVERSE OSMOSIS

In this context, the pressurisation of a waste water in order to force water molecules (or other molecules of a similar or smaller size) to pass from the solution through a semi-permeable membrane which will not pass larger molecules such as the majority of complex compounds.

PRE-BREAKER

Item of plant in which large pieces of condemned carcasses are broken down to a size suitable for rendering.

LAIRAGES

Kraals in which animals are received and penned at an abattoir prior to slaughter.

OFFAL

The organs of a slaughtered animal, usually divided into "red offal" (heart, liver, kidneys, ox tongues) and "rough offal" (stomach, intestines, other organs); rough offal requires more intensive cleaning.

RENDERING

Cooking of animal wastes followed by drying in order to produce a proteinaceous meal; melted fat is usually recovered at the same time for tallow production.

STUNNING

Mechanical, electrical or other means of ensuring that an animal is made insensible in an approved humane manner before slaughtering.

STICKING

The slitting of an animal's throat after stunning.

WATER-RELATED CATTLE UNIT

The number of non-bovine species equivalent to one bovine cattle unit in terms of the water usage during processing.

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1 INTRODUCTION

The abattoir industry can be divided into two distinct categories: red meat, which includes the processing of beef, mutton and pork, and white meat, responsible for processing poultry. This guide deals only with the red meat industry.

South Africa's red meat processing is carried out by a total of 285 abattoirs, which provide approximately 60% of the local meat by mass, with poultry providing the remaining 40%[1].

All red meat abattoirs are required to be registered with the Abattoir Commission, who grade each abattoir according to the maximum daily slaughter that their facilities allow. This grading system is indicated below:

Grade	**Maximum daily slaughter allowed (cu/d)**
E	5
D	15
C	50
B	99
A	No limit

N.B. For the purpose of this grading system the Abattoir Commission uses a cattle unit equivalency system by which 3 calves, 15 sheep or goats or 5 pigs are considered to be equivalent to one cattle unit (cu).

Table 1.1 indicates the number of each grade of abattoir operating in the red meat industry and the percentage of total slaughtering for which each grade is responsible.

Table 1:1 **Abattoir size distribution in South Africa[2] (1988)**

Abattoir grade	Number in RSA	% of total RSA slaughter
A	28	80
B	16	7
C	34	6
D	56	3
E	151	4
TOTALS	285	100

Table 1.2 indicates the total number of animals slaughtered in July 1987 to June 1988.

Table 1.2 **Total red meat slaughter in South Africa (1987 - 88)[1]**

Animal	Total slaughter in R S A	Total in cattle units
Cattle	1 852 241	1 852 241
Calves	57 865	28 933
Sheep	6 707 000	1 117 833
Goats	335 000	55 833
Pigs	1 726 000	690 400
TOTALS	10 678 106	3 745 240

The bulk of the slaughter (over 70%) is carried out in areas controlled by the Abattoir Commission. Controlled areas are the Witwatersrand, Pretoria, Kimberley, Bloemfontein, Durban, East London, Port Elizabeth and Cape Town.

The annual water consumption of the red meat industry is in the region of 5,8 million m^3. Waste water from an abattoir will contain the following pollutants: blood, animal trimmings, fat, paunch content, urine and faeces. Each of these contributes to a high organic load as well as a considerable quantity of suspended matter.

The industry discharges approximately 4,9 million m^3 of waste water annually containing about 22 600 t of COD and 7 000 t of SS.

The data presented in this guide have been collected from detailed surveys conducted at 12 separate abattoirs, covering the full range of slaughter capacity. Additional data were collected telephonically from many more abattoirs.

2 PROCESS RÉSUMÉ

The slaughtering process may be considered as a series of unit operations which are generally similar for cattle (and calves), sheep (and goats) and pigs, although these three main species are preferably processed in separate slaughtering areas. A description of the cattle slaughtering process follows, with particular reference to water usage and waste water and by-products generation, and variations for sheep slaughtering and pig slaughtering are noted.

Lairages are the holding areas where animals are quartered species by species and inspected for disease. Retention times are generally a few hours or longer. The lairage structure generally consists of a graded concrete floor with falls to floor drains, sometimes covered with a light roof to provide shade and prevent stormwater from entering the drainage system. Drinking water troughs are supplied, but the animals are not fed unless they spend more than 48 hours while in lairage to minimise the paunch contents to be disposed of after slaughtering. The lairages are cleaned at least once a day. In some abattoirs, the waste water is pumped over screens before being discharged.

Stunning of cattle and large pigs is carried out by a bolt from an air gun or stunning pistol, while sheep and smaller pigs are stunned electrically. At large abattoirs each species is separately stunned, while at smaller abattoirs the same facilities are used on a rotational basis for the different species. In halaal and kosher slaughtering, stunning is not practised.

Sticking consists of slitting the throat over bleeding troughs where the blood is collected and then blown pneumatically to a storage tank for processing. Different bleeding methods are available (Swedish lance, cone) but generally the throat is slit by knife.

Cold wash-down water is used periodically during slaughtering periods, and hot water (85°C) is supplied to small basins where the knives are disinfected periodically by frequent immersion.

Hoof and head removal is carried out manually. After inspection, the tongue is sometimes removed at that stage and conveyed to the red offal washing area. Heads and feet are either sold or conveyed to the rendering plant. In large abattoirs conveyance is by chutes or small stainless steel pans, which are spray-washed en route; in smaller abattoirs the products are conveyed manually in bins. The processing area is hosed down periodically during slaughtering, with the waste water passing to drain.

Hide removal is carried out mechanically by hide pullers in large abattoirs or manually at smaller abattoirs. The hides or skins are trimmed before being sent to tanneries (cattle hides) or fellmongeries (sheep skins) for processing. Trimmings are either sold for gelatine recovery or passed to rendering. After hide removal, the carcass is sprayed by high pressure cold water jets which operate either continuously during slaughtering, or by manual washing.

Dehairing of pig carcasses is accomplished by submergence in a scalding tank containing hot water (80° C, maintained by steam heating coils or live steam) after which the carcass enters a dehairing machine where short rubber strips rotating at high speed flay off most of the hair (bristles). Final hair removal is carried out manually by scraping and singeing. Water from the scalding tank is dumped at the end of each slaughtering period and the bristles are sometimes recovered for brush manufacture or are otherwise dumped to drain.

Evisceration is carried out by mechanically cleaving the carcass and allowing the stomach, intestines and internal organs to fall onto a pan conveyor kept clean by continuous mist sprays. After evisceration, the head and feet conveyor, the carcass conveyor and the viscera conveyor are synchronised to pass an inspection point where all the component parts of a single animal are inspected simultaneously to determine the suitability of the animal for human consumption. If the animal is condemned at this point, all the parts are transferred to a condemned room for subsequent rendering in the by-products plant (if provided) or incinerated (if not). If the animal is approved, the carcass is forwarded for halving while the viscera are sorted and conveyed to the various offal processing areas. Condemned carcasses and viscera are processed separately to by-products.

Red offal (hearts, lungs, kidneys and livers) requires only some cold water washing to remove blood etc., before storage, with the small amount of waste water generated being passed to drain.

Rough offal processing comprises opening up of paunches and intestines for washing, carried out in two stages namely a primary cold water wash to remove loose dirt followed by secondary hot water washing to clean the offal to the requisite standards for human consumption. Water usage is higher than in any other single abattoir operation. The paunches and intestines contain large quantities of suspended solids, and the organic strength of paunch contents and associated wash waters is very high. Waste water from the rough offal processing room is usually screened separately prior to discharge to drain.

Carcass halving consists of mechanically splitting the carcass down the backbone to allow easier handling. Trimming is carried out manually to remove loose pieces of fat or meat before manually washing the carcass using high pressure cold water jets.

Cold storage facilities must be provided by Grade A, B and C abattoirs. Carcasses must be stored at low temperatures typically 0 to 5°C, and maintaining the required temperature in cold rooms includes the widespread use of evaporative cooling towers where large quantities of water are evaporated to achieve the desired cooling effect. Small quantities of cleaning water are used in the cold rooms. Cooling coils can be defrosted either electrically, by hot gas or by water.

By-products handling at red meat abattoirs includes the disposal of condemned meat, blood and carcass trimmings. The most attractive route is rendering to produce a marketable by-product for animal feed manufacture. The capital cost of rendering plants restricts their economically viable application to the larger abattoirs, which sometimes also handle wastes from smaller neighbouring abattoirs. By-products include carcass meal, blood meal, tallow and lard. Water is used for steam raising (for the cookers), plant cleaning and vapour condensation for odour control. Waste water is generated as condensates and floor washings.

3 SOURCES OF SOLID WASTE AND WASTE WATER

3.1 Lairages

The major pollutants from the lairage area are urine and faecal matter. Solid matter is collected and removed to a midden and the floors washed down at least once a day.

3.2 Stunning, sticking and bleeding

Blood accounts for approximately 4% by weight of an animal.[4,5] Although most of the blood is caught in a collection trough, some is inevitably lost. This blood is subsequently washed down and constitutes a major pollutant, in terms of oxygen demand, to leave an abattoir. Where no on-site blood drying facilities are available, blood from the collection trough may be drained and collected for processing or disposal by burial or subsequent discharge to a sewer, increasing local COD concentrations dramatically.

3.3 Carcass processing

After bleeding, the head, ankles, hide and viscera are removed. These are relatively clean operations which, however, do give rise to solid matter. After screening the waste water from this area is discharged to drain.

Pig hair is removed immediately after bleeding, using a scalding process. The hair collected in the scalding tank is continuously recovered using a small screen, and the bristles are recovered for brush manufacture or are rendered.

At the end of each day the water from the scalding tank, containing blood, loose hair and other dirt, is discharged to drain after screening.

3.4 Offal handling

3.4.1 Rough offal

Unopened stomachs are conveyed with animal intestines from the slaughter floor to the rough offal processing area. Here they are cut open and the contents removed. The waste water from this operation is extremely high in suspended matter - mostly semi-digested grass - and is usually screened prior to discharge to drain. Disposal of screened solids causes major problems.

3.4.2 Red offal

Waste water from the red offal handling area is comparatively clean and low in volume. It contains small quantities of blood washed from the various organs, but this does not present a significant organic load when compared with other waste water.

3.5 By-products processing

Any meat which is classified unfit for human consumption, as well as blood and the various trimmings removed from the carcass after slaughter, must be disposed of. The most attractive means of disposal for each of these wastes is rendering, since this produces a marketable by-product used in the manufacture of animal feeds. The capital cost of the necessary processing plant, however, restricts the recovery of such by-products to only the largest abattoirs, who usually also handle wastes from several smaller abattoirs in their vicinity.

The principal operating features of various by-products recovery plant are outlined below.

3.5.1 Condemned meat processing - carcass meal

Condemned meat is macerated in a "breaker" and charged into a cooker. Jacketed steam is used to heat the cookers and maintain the temperature at about 60°C for approximately two hours. The carcass meal is then withdrawn and centrifuged to remove tallow and other fats. Vapours from the cookers are condensed to reduce bad odours before being discharged to drain.

3.5.2 Blood handling - blood meal

Blood from the bleeding stage is a rich source of protein and at large abattoirs it is dried to solid blood meal. Live steam is injected into a precooker where the blood is coagulated; the congealed matter is separated and sterilised in a cooker for a two hour period before being removed, sieved and bagged.

The primary source of waste water in by-products processing is the water used to wash out the cookers after the rendered charge has been removed. Although low in volume this waste water can contain a high pollution load. Another source of waste water from this area is from the condensers used to condense malodorous vapours leaving the cookers.

3.6 Miscellaneous waste waters

A large volume of waste water is generated at the end of each day when an intensive wash down programme is instituted. Process areas are given special attention, with all fittings and floor areas being washed, sanitised and then rinsed using sanitisers, detergents and/or enzymatic cleaning systems.

Other waste water derives from laundries, boot washing - a requirement for entry to the slaughter floor during processing - and from knife sterilising basins. Hot water, slightly

Several abattoirs produce secondary products on-site to increase the market value of the meat. Examples of this are the manufacture of patties, sausages and polonies. This usually entails the mincing of deboned meat and the subsequent addition of, for example, chopped onions, various spices, flavourings and preservatives.

Water usage is limited to essential cleaning of machinery and floors for hygiene reasons.

4 SUMMARY OF SURVEY RESULTS

4.1 Introduction

To enable direct comparisons to be made between abattoirs where more than one animal species is slaughtered, calves, sheep and goats, and pigs are counted in terms of cattle units. Cattle units form the basis of comparison throughout the abattoir industry and must therefore be clearly defined. There are several ratios in use, the one chosen in any particular instance depending upon the purpose of the calculation being performed. Those in most frequent use are based on:

(a) cost through the abattoir;
(b) cost through the slaughter floor;
(c) hanging space requirements;
(d) animal mass; and
(e) water use.

Since the ratios for sheep, for example, vary from 5 animals per cu to 15 animals per cu, it is clear that the correct ratio must be established before fair comparison can be made. None of the ratios mentioned above are wholly relevant to water usage, so that to compare the water efficiency of various abattoirs, a new definition of cattle unit has had to be determined during this survey. Detailed work at abattoirs where the same staff slaughter each species strictly by rotation has led to the derivation of cattle units based on water usage. These are compared with other cattle unit ratios in general use in Table 4.1. Tariff units are periodically adjusted on a cost basis in consultation with the Abattoir Commission, subject to approval by the Minister of Agricultural Economics and Marketing.

Table 4.1 <u>Comparison of cattle units</u>

Basis	Water usage (animals/cu)	Slaughter units[5] (mass) (animals/cu)	Chiller[6] units (animals/cu)	Tariff units (animals/cu)
Cattle	1	1	1	1
Calves	2	3	2	2,25
Sheep/goats	6	15	6	8
Pigs	2,5	5	2	2

4.2 Water intake

4.2.1 Specific water intake

The SWIs of several abattoirs are listed in Table 4.2. These have been calculated using wrcu as defined earlier.

It is proposed that,for the purposes of this Guide, A-grade abattoirs be considered separately from the other grades. The reason for this is the very marked difference in output and water consumption between A-grade abattoirs and the other grades.

The weighted average SWI for A-grade abattoirs is 1,36 m^3/wrcu. The weighted average SWI for other grade abattoirs was found to be 2,04 m^3/wrcu. It can be seen that, on average, large abattoirs are more water-efficient than small ones, but it is also interesting to look at the range of SWI found for the two groups. For A-grade abattoirs, the range of SWI was found to be 0,71 to 2,88 m^3/wrcu, while for the other grades the range was found to be 0,70 to 4,71 m^3/wrcu. It is important to consider that small abattoirs often operate on a stop/start basis and do not have the personnel available for intensive water management exercises. Also they are dealing with much smaller volumes of water which understandably do not warrant the close attention given by larger abattoirs.

Table 4.2 **Specific water intakes for red meat abattoirs**

Grade	Animals slaughtered (wrcu/d)	Water intake (m^3/d)	SWI (m^3/wrcu)
A	3087	3449	1,12
A	1525	2618	1,72
A	808	766	0,95
A	509	565	1,11
A	491	1414	2,88
A	319	346	1,09
A	275	194	0,71
A	241	644	2,67
A	237	208	0,88
A	211	292	1,38
A	171	194	1,14
B	68	102	1,49
B	67	83	1,25
B	66	109	1,64
B	62	112	1,81
B	57	167	2,92
B	42	132	3,15
C	29	46	1,59
C	28	29	1,01
C	21	99	4,64
C	13	27	2,07
D	29	55	1,92
D	26	18	0,70
D	17	46	2,75
D	14	24	1,74
D	12	54	4,35
D	11	29	2,64
D	9	10	1,13
D	9	40	4,71
D	5	10	1,78
E	7	20	2,72
E	7	9	1,37
E	6	8	1,31
E	5	5	1,10
E	3	12	4,19
E	2	6	2,78
E	1	4	2,91
E	1	5	3,83

For abattoirs in general, the utilisation of abattoir capacity is an important factor influencing SWI and this probably has greater impact for A-grade abattoirs than for other grades. An A-grade abattoir will still use considerable amounts of water for essential operations, such as cleaning, even if it is operating at below its design capacity. This will obviously tend to push up the average SWI for the abattoir. Smaller abattoirs with lower levels of sophistication will generally not encounter this problem and at times of very low throughput can often close down completely for a period of time, which large abattoirs cannot do so easily.

Other points to note when considering Table 4.2 are:

a) Even within the A-grade abattoir category there is a difference of eighteen times the production throughput between the largest and smallest abattoir considered in this study so, although the water management principles are the same for all abattoirs, it must be remembered that some principles may be more appropriate for the very large abattoirs than for the smaller ones.

b) There can be significant variations in day to day production and water intake in the industry so figures given in Table 4.2 are averages.

c) It is interesting to note that even for abattoirs with very similar production throughput there are considerable differences in SWI. This is true for all grades, but is of greatest significance for A-grade abattoirs where much larger volumes of water are involved. These differences in SWI for abattoirs with similar production rates are a clear indication of major differences in the efficiency of water management of various plants and shows that, within any particular abattoir grade, there is considerable room for improvement in water management practices.

4.2.2 Breakdown of water use

Table 4.3 below shows the breakdown of water use for a typical red meat abattoir. The SWI breakdown is shown for the A-grade abattoir weighted average.

Table 4.3 <u>Breakdown of water intake in A-grade red meat abattoirs</u>

Area	Operations	Range of % encountered	Aver. %	Breakdown of SWI for an A-grade abattoir
Processing	Lairages	5 - 12	10	0,14
	Slaughter and carcass dressing	13 - 33	20	0,28
	Offal handling	11 - 60	25	0,34
Utilities	Hot water	14 - 36	25	0,34
	Cooling and refrigeration	5 - 11	8	0,11
	Steam raising	2 - 9	5	0,06
Services	Ablutions, laundry & general washing	1 - 12	7	0,09
			100	1,36

Note: (a) These figures were calculated from surveys at A-grade abattoirs listed in Table 4.2.

(b) As was mentioned in 3.4.1, rough offal washing, which has a considerably greater water demand than clean offal washing, is performed in two stages. The wide range of water use indicated in the table for this operation may be partially explained by the fact that some abattoirs only perform rough offal washing whereas others conduct both rough and red offal washing operations.

4.3 Waste water

4.3.1 Specific parameters

Composite samples of the waste water leaving each of the abattoirs visited were collected over a 24-h period. Table 4.4 summarises the results from the analyses performed on these samples. Table 4.5 indicates the variation in specific pollution loads based on these analyses.

Table 4.4 Waste water quality data from red meat abattoirs

	WATER INTAKE (m^3/d)	WASTE-WATER DISCHARGE (m^3/d)	% DISCHARGE	DETERMINAND				
				pH	COD	SS	TDS	TKN
					(mg/ℓ)	(mg/ℓ)	(mg/ℓ)	(mg/ℓ)
Range A-grade	194-3 449	170-2 830	75 - 94	5,7-8,4	3 300-8 942	534-3 330	780-2 570	71 -17
Other grade	27-167	21-157	79 - 94	7,1-7,7	2 380-5 060	189-1 400	595-2 805	24 - 10
Mean A-grade	1 195	978	82	7,4	5 000	1 500	1 530	11
Other grade	81	70	86	7,4	4 160	740	1 620	5

Table 4.5 Specific pollution loads for red meat abattoirs

	ANIMALS SLAUGHTE-RED (wrcu/d)	WASTE-WATER DISCHARGE (m^3/d)	COD (kg/ wrcu)	SS (kg/ wrcu)	TDS (kg/ wrcu)	TKN (kg/ wrcu)	SEV (m^3/ wrcu)
Range A-grade	240-3 090	170-2 830	2,4-8,5	0,3-3,4	1,1-2,2	0,07-0,22	0,6-2,2
Other grade	11-67	21-157	5,1-11.5	0,5-2,2	0,6-4,9	0,07-0,17	1,0-3,7
Mean A-grade	906	978	5,2	1,6	1,5	0,12	1,1
Other grade	34	70	8,5	1,4	3,7	0,11	2,2

From Tables 4.4 and 4.5, the following have been calculated:

Mean waste water discharge :

a) for A-grade abattoirs = 978 m^3/d

b) for other grade abattoirs = 70 m^3/d

Mean number of animals slaughtered :

a) for A-grade abattoirs = 906 wrcu/d

b) for other grade abattoirs = 34 wrcu/d

Therefore the weighted average SEV is 1,1 m^3/wrcu for A-grade abattoirs and 2,2 m^3/wrcu for other grade abattoirs.

The mean water intake is 1 195 m^3/d for A-grade abattoirs and 81 m^3/d for other grade abattoirs. This gives a weighted average percentage waste-water discharge of 82% for A-grade abattoirs and 86% for other grades.

Both SEV and percentage waste-water figures indicate that water is used differently in A-grade abattoirs as compared with other grades.

Water may be used excessively in some smaller abattoirs giving a larger proportion discharged to drain but it must also be considered that domestic water used in boilers and cooling circuits (which is often evaporated rather than discharged to drain), is generally greater in A-grade abattoirs than in other grades. Neither of these categories of water use generate waste water which would be discharged to an industrial sewer under normal circumstances.

From Table 4.5 the mean SPL figures reveal some interesting trends. For COD and TDS the results indicate lower pollution loads per water-related cattle unit for A-grade abattoirs which is expected as they would tend to have more sophisticated waste-water management programmes in operation than other grades. The SPL for TKN (which is related to protein content in the waste water) is approximately the same for all grades while the SPL for SS is higher for A-grade abattoirs than for other grades. These are surprising results as many A-grade abattoirs operate rendering and protein recovery plants which should result in markedly lower levels of TKN and SS pollution loads. A combination of factors may have influenced these results including the extreme variability in the waste water discharged by small abattoirs which do not have any balancing effect due to size of reticulation system, as is the case in large abattoirs. Another point worth considering is that very high levels of staff training are required if by-products recovery plants are to operate efficiently. Management must ensure that staff are taking all the necessary steps to ensure that all the waste materials which should be directed to these plants, are doing so and are not sometimes being discharged directly to drain.

Within the range of sizes found for A-grade abattoirs no significant trends related to SPL were found except that SPLs for abattoirs slaughtering over 1 500 wrcu/d were generally lower than for smaller A-grade abattoirs. The mean COD-related SPL was 4,6 kg COD/wrcu for these larger abattoirs compared with 5,4 kg COD/wrcu for A-grade abattoirs slaughtering less than 1 500 wrcu/d.

4.3.2 Breakdown of specific pollution load*

The main areas of the abattoir responsible for pollution load have been identified as the offal processing area, the slaughter floor and the lairages.

In terms of final waste water COD load the offal processing area is responsible for about 68% of the COD load, the slaughter floor for 15% and the lairages for 7%.

In terms of final waste-water volume the order is the same with the offal processing area contributing 39%, the slaughter floor 27% and the lairages 13%. These results indicate that in a waste water management programme the offal processing area in particular is deserving of considerable attention.

4.4 Waste water parameter ratios

From the large number of chemical analyses carried out during this survey the relationship 1,0 OA : 11,0 COD is suggested for red meat abattoir waste water.

4.5 Solid wastes and by-products

Operation of a red meat abattoir gives rise to a number of by-products, as detailed in Table 4.6.

Table 4.6 **Materials from the processing of animals**[4,5]

Item	% Weight		
	Cattle	Sheep	Pigs
Carcass	55	50	75
Hide/skin	7	12	-
Blood	4	5	5
Offal	9	10	7
Paunch contents	15	13	10
Other wastes	10**	10*	8*
TOTAL	100	100	100
Average live mass (kg)	400	35	65

Notes * includes head, feet and fat

** includes hair, feet, fat, horn and trimmings

(a) Hides and skins

These are sent to a preserving facility and then to a tannery or fellmongery for processing into leather.

(b) Blood

Large abattoirs usually render blood on site. Smaller ones either send it to a central facility for rendering or dispose of it by incineration, burial or discharge with the waste water. Disposal of the blood can be a problem. If it is buried, ensuring hygiene can be difficult.

If the blood is incinerated, odour problems can occur and discharging blood to drain leads to high waste-water tariff charges by local authorities.

(c) Paunch contents

This is usually disposed of by burial or alternatively it may be composted.

(d) Other wastes

Included under this heading are condemned material, heads, feet and other animal trimmings. Hooves are often removed and sent for gelatine recovery; heads are either sold as a low grade meat or else, as at larger abattoirs, rendered. Remaining wastes are either sent for rendering or buried. Animals dead on arrival, still-born animals and unborn embryos can be rendered for animal feeds, incinerated or buried.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Water intake

Red meat abattoirs in South Africa have a range of SWI between 0,71 and 2,88 m^3/wrcu for A-grade abattoirs and 0,70 and 4,71 m^3/wrcu for other grades.

Abattoir size is clearly a factor influencing SWI as illustrated by the weighted average SWI figures for A-grade and other grade abattoirs which were found to be 1,36 and 2,04 m^3/wrcu respectively. It is interesting to compare these figures with that given by Squires and Cowan (1986)[12]. The SWI at that time was given as 3,0 m^3/cu which can be corrected to about 2,2 m^3/wrcu using the water-related cattle units defined in this guide. It is clear that the industry has made some commendable efforts at reducing its SWI since Squires and Cowan's survey which was carried out in 1983.

Target SWI figures based on reasonably achievable figures are proposed as 1,1 m^3/wrcu for A-grade abattoirs and 1,75 m^3/wrcu for other grades. The minimum legal requirement for water use in red meat abattoirs is 0,9 m^3/per cu (slaughter unit)[13].

5.2 Recommendations for reducing water intake

The variation in SWI for all grades of abattoirs indicates that opportunities exist for improved water management in the industry. As most of the production (over 80%) and most of the water intake (over 70%) is carried out at the A-grade abattoirs it is mainly in these larger plants that implementations of improved water management programmes will have a significant impact on the red meat abattoir industry's national water use.

Methods of reducing water intake include:

(a) Water used for general washing should be pressurised. Equipment is available for mixing a water jet and a compressed air stream close to the exit nozzle of hand held sprays. This produces an effective spray which may be used for washing of carcasses and also floor washing.

(b) All hoses should be fitted with self-closing nozzles to prevent wastage when not in use. Where the hoses are in frequent use, pistol grips should be used, whereas pressure sensitive rubber nozzles are advisable for hoses used only intermittently.

(c) Teat-like drinking water dispensers should be used in preference to ballcock regulated drinking troughs in animal lairages. Ballcocks tend to become damaged or jammed, resulting in overflow from troughs.

(d) Loose dirt should be swept dry from lairages prior to subsequent hosing down. This will also effect a reduction in the quantity of solid matter entering the final waste water.

(e) Paunch contents should be removed from the paunch without the use of water; the dry content can be removed to a skip by screw conveyor or compressed air systems. From here they should be dewatered.

(f) Blood soiled areas, such as those around the bleeding trough, should be washed first with cold water, since hot water causes blood to congeal, making cleaning difficult. It is economically desirable to prevent blood from entering the abattoir waste-water and dry cleaning should be implemented wherever possible.

(g) Water meters should be installed at all of the major water using areas in the abattoir, and read regularly to monitor use.

(h) Staff should be trained to increase their awareness of water saving methods.

(i) Condensate recovery should be encouraged.

Recently, savings in energy and service water have been introduced at several abattoirs. Hot water is required at several temperatures; 82°C for use in sterilising basins, 60°C in pig scalding baths, and 40°C for use for hand washing and other general washing. Historically boilers have been used to meet these requirements. By careful adjustment of water flows, however, it is possible to generate sufficient 45°C water in tube-in-shell heat exchangers to meet the abattoir demand. A fraction of this water may then be drawn off and heated to 82°C either directly in an electrically heated geyser or indirectly by heat exchange with a pressurised, electrically heated hot water circuit. In this way evaporative losses from refrigerant condensers are reduced and boiler blowdown is reduced. The decision to use such a system is obviously based both on energy considerations and water savings.

An important consideration when examining areas of water saving in the abattoir industry is that the water required at the various processing stages need not necessarily all be of potable quality. For example, the water quality necessary for lairage washdown is different from the quality required when handling finished or semi-finished product. It is estimated that about 25% of a typical abattoir's water requirements could be met by recycled water[9]. These could include lairage washdown, vehicle and yard washing. At least one abattoir operates a lairage flushing system in which screened and aerated waste water is pumped to an overhead tower throughout processing hours. This water is released at the end of the day to remove faecal matter and other dirt from the lairages prior to a more thorough hose down.

Facilities exist for dosing this flush water with chlorine to prevent spread of disease. It is essential that water recovery plants are carefully monitored so that water quality complies with regulations laid down by the various authorities and that reserve supplies of water should be available in the event of the quality of recycled water becoming unacceptable for a period of time. Typically the authorities judge each case on its own merits.

5.3 Waste water

It has been found that for an A-grade abattoir the mean SEV is 1,1 m^3/wrcu and the percentage waste-water discharge is 82%. For other grade abattoirs the SEV was found to be 2,2 m^3/wrcu and the percentage waste-water discharge was 86%.

As for water intake considerable variation in these parameters was found indicating that opportunities for improved waste-water management also exist. For all grades of abattoirs the variation in SEV was 0,6 to 3,7 m^3/wrcu and the variation in percentage waste-water discharge was 75 to 94%.

Similar variations were found in the SPL figures obtained and these are given below:

Table **5.1** **Mean specific pollution loads for various abattoir grades in the RSA**

Mean specific pollution load		Range	
A-grade	Other grades	A-grade	Other grades
5,2 kg COD/wrcu	8,5 kg COD/wrcu	2,4 to 8,5 kg COD/wrcu	5,1 to 11,5 kg COD/wrcu
1,6 kg SS/wrcu	1,4 kg SS/wrcu	0,3 to 3,4 kg SS/wrcu	0,5 to 2,2 kg SS/wrcu
1,5 kg TDS/wrcu	3,7 kg TDS/wrcu	1,1 to 2,2 kg TDS/wrcu	0,6 to 4,9 kg TDS/wrcu
0,12 kg TKN/wrcu	0,11 kg TKN/wrcu	0,07 to 0,22 kg TKN/wrcu	0,07 to 0,17kg TKN/wrcu

Target figures for SPL are proposed as 4,0 kg COD/cu and 1,0 kg SS/wrcu for A-grade abattoirs. The corresponding figures for other grade abattoirs are 5,0 kg COD/cu and 1,0 kg SS/wrcu.

On a national basis it is estimated that the red meat abattoir industry discharged approximately 4,9 million m^3 of waste water between July 1987 and June 1988. This effluent would have contained approximately 23 000 t of COD, 7 000 t of SS, 8 200 t of TDS and 375 t of TKN.

5.4 Recommendations for reducing pollution loads at red meat abattoirs

The primary pollutants in abattoir waste waters are blood, paunch content, liquors from rough offal washing, fat, loose meat trimmings, urine and faecal matter from the lairages. Blood presents particular problems for the waste-water treatment facilities due to its intractable nature.

The most effective means of reducing pollution load from an abattoir is preventing the pollutant from entering the waste water in the first place. Certain process areas merit particular attention, and these are listed below:

(a) Lairages: The suspended matter in lairage washdown water can be dramatically reduced by sweeping dry dirt from the area before hosing the area. The suspended solids load can be further reduced by segregating the waste-water stream and passing it over screens before allowing it to mix with the final waste water leaving the abattoir.

(b) Slaughter floor: Waste water from this area with a COD of greater than 110 000 mg/l has been sampled. The quantity of blood entering the waste-water system can be reduced by extending blood collection troughs to allow animals to drip for a sufficient length of time. Alternatively the following options[10] may be worthy of consideration:

(i) A flat sticking knife equipped with a collection vessel at the base may be used. Blood is drained into the vessel and removed by vacuum.

(ii) A perforated tube attached to the sticking knife may be forced into the incision with suction being applied to remove blood.

Bins should be provided on the slaughter floor so that loose fat and meat trimmed from the carcasses can be collected instead of being dropped to the floor and washed down the drain. Adequate grids should be installed to prevent loose fat and meat entering the drains.

(c) Offal washing: Waste-water from the washing of rough offal is liable to contain gross quantities of suspended matter if care is not exercised. It is preferable for the initial removal of paunch contents to be made without the use of water. The comparatively dry matter removed at this stage can be conveyed directly to a skip or blow tank. Water should only then be used to complete the primary washing stage.

(d) By-products: Special care should be taken to ensure that cookers are not overcharged. Waste-water strengths as high as 25 000 mg/1 COD have been encountered flowing from the condensers of overcharged cookers.

5.5 Waste-water treatment

5.5.1 Preliminary treatment[10]

The placing of vibratory and self cleaning screens in the areas mentioned above will drastically reduce the solids load of the final waste water from an abattoir. The screened waste water, however, will still have a high dissolved and colloidal organic content and efforts should be made to reduce this.

FOG removal facilities positioned upstream of any waste-water treatment facility will greatly improve the effectiveness of the subsequent treatment process. Balancing of abattoir waste water which has previously passed through screens and FOG removal facilities is recommended. It does, however, require technical supervision and should be viewed as a resource recovery process. It is especially important to consider if further on-site treatment such as that described below will be effective. Abattoir waste water fluctuates enormously in quality and quantity and balancing of this waste water for an appropriate period of time gives rise to waste water of much more consistent quality than could otherwise be achieved. As well as benefiting any on-site treatment, there are obviously advantages for a municipal treatment works.

5.5.2 Membrane processes[7]

To render abattoir waste water suitable for recycle and selective reuse, further treatment is required. Considerable work has been carried out to determine the applicability of membrane separation, in particular ultrafiltration (UF) and reverse osmosis (RO), for this duty.

A major consideration in these processes is membrane fouling which results in a reduced flow of liquid through the membrane. The rate of flow of liquid through the membrane is termed flux, and is measured in units of $l/m^2.h$ for a given driving pressure. Flux levels are monitored throughout operation and, when the flux falls to a predetermined level, a cleaning agent (such as a hot alkali solution) is flushed through the system to restore the flux once more.

Membranes are manufactured from a number of materials including cellulose acetate, polyamides and polysulphonates. They can only be selected for a particular duty after pilot plant work has been conducted to identify which type is suited best and what cleaning agent should be used to restore flux. Pilot plant results indicated that product water from these processes may be recycled after chlorination to selected areas within an abattoir. The concentrate stream can be recovered at 10 to 15% solids for forwarding to rendering facilities.

5.6 Subsequent uses of waste water and solids materials

5.6.1 Disinfection

Abattoir waste waters may contain pathogenic microorganisms. It is important to consider the destination of the waste water when considering disinfection. For example use of waste water for irrigation of feed crops should first involve disinfections of the waste water. Survival times for Salmonella in various soils have been reported as 35 to more than 280 days[11]. Waste waters are most commonly disinfected using chlorine components or ozone. Any subsequent use of abattoir waste waters should be cleared with the relevant authorities.

5.6.2 Centralised rendering facilities

At many of the smaller abattoirs, especially those situated in rural areas, disposal of blood and other by-products such as trimmings and meat classified unfit for human consumption, is problematic.At large abattoirs these by-products are sent for rendering in an adjacent rendering plant which may also receive by-products from smaller abattoirs situated close by. Often small abattoirs in rural areas have no alternative but to discharge blood and other by-products to the local waste-water treatment works. This obviously puts considerable strain on what is probably a small works and results in high costs for both the abattoir and the municipality.

With the provision of a centralised rendering facility where geographically feasible, these problems would be largely obviated to the benefit of both abattoir and municipality. The abattoir would benefit financially as the blood and other by-products are of considerable value, in addition to saving on waste-water disposal costs.

5.6.3 Protein recovery[10]

As the major portion of the organic matter in abattoir waste waters is proteinaceous in nature, several methods of protein recovery have been developed:

(a) adjustment to low pH and protein precipitation with lignosulphonate or sodium hexametaphosphate;

(b) use of cellulose based ion-exchange resin to recover protein;

(c) maximisation of biomass yield in activated sludge followed by protein recovery in the form of the generated biomass;

(d) use of ultrafiltration to separate large molecular weight proteins from waste water.

5.7 Waste segregation[10]

Many of the treatment methods and options for reuse of second grade waters mentioned earlier can be applied more easily if waste-water streams of different characteristics are segregated. For example:

(a) Lairage wastes which are high in suspended solids but incompatible with streams containing fats and grease. High levels of fats and grease tend to hamper solids removal by screening.

(b) The quantity of blood allowed to reach the drain should be minimised.

(c) Fats and grease-bearing waste waters from process areas such as cutting, rendering and meat processing should be segregated for fats and grease recovery; by, for example, bubble aeration.

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