final report

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Water collection and data analysis

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Executive Summary

In November 2007 Teys Bros commissioned a study to collect and collate information on water and waste flows in their Beenleigh meat processing facility and to estimate contaminant loads emitted by the plant. The work was performed under a PIP grant awarded by Meat and Livestock Australia (MLA) by Dr. Mike Johns (Johns Environmental) with the assistance of an undergraduate student Nicole Lucock employed under the Red Meat Industry Undergraduate Program. The willing assistance of Margo Hackett, John Lews, John Coughlan and Tom Maguire among others is also deeply appreciated.

The aim of the project was to obtain sufficient information on waste stream flows and composition to feed into the development of a site strategy for improved efficiencies and sustainability.

A 4-stage approach was used during the summer of 2007/08 which involved sampling and analysis of accessible waste streams for a wide array of parameters and collation and measurement of flows. These two data sets were then used to calculate contaminant loads emitted by 20 waste streams on the site. From this information the relative contributions of each waste stream to the final pollution load sent to the anaerobic pond was determined.

The study found that for each contaminant, three waste streams emit 50% or more of the total contaminant load. This is useful, since it permits these streams to be targeted for source reduction opportunities.

Three streams in particular were found to contain the highest contaminant loads:

- The raw material bin drainage is a low flow (75 kL/day – or only 2.4% of total plant flow) stream but with very high strength. This stream was the worst contributor to nitrogen (32% of total), phosphorus (29%) and chloride (28%) and was a significant emitter of COD. This stream is the priority target for source reduction.

- The tripe processing effluent (370 kL/day or 12% of total flow) also contributed very high loads of oil & grease (almost 2/3rds of total plant emission) as well as significant COD, phosphorus (16%) and 25% or more of salts. This stream was inaccessible to sampling. Given the results, consideration should be given to inserting a sampling point to confirm these findings and assess ways in which source reduction might be applied to this stream.

- Cleaning flows were rich in COD and nutrients – as can be expected. However, the concentration of these contaminants in the water is relatively low and the high volume of cleaning discharge precludes inexpensive approaches at this point in time.

Surprisingly the ante-mortem yards were not as significant contributor as typically seen in the industry. This may be due to difficulties in measuring this flow accurately.

A large number of streams contribute negligible contaminant loads to the WWTP and can be largely ignored in finding significant efficiencies. These are identified in the report.

The Boning Room flow is significant volume (5.5% of total flow) and only lightly contaminated. There is potential for this flow to either bypass treatment (thereby improving retention times), or to be reused in-plant in an appropriate application.

The information arising from the study is not perfect, given the number of streams and their variability in both flow and composition. Nevertheless it provides a reasonable insight into water consumption and source of contaminants in the facility. This will be useful for developing an effective strategy to drive further improvements in sustainability into the future.

Contents

1. Introduction

1.1 Scope

This project comprises the first step in Teys Bros Environmental Innovation Strategy with the aim of further improving the sustainability of the Teys Beenleigh meat processing facility in respect to water consumption. At the time of this project, South East Queensland remained in the grip of one of the worst droughts on record and industrial facilities were required to operate at onerous Level 6 water restrictions.

To assist Teys Bros in this step, joint funding from Australian Meat Processing Corporation (AMPC) and Meat & Livestock Australia (MLA) was obtained in the form of a PIP grant. Further assistance was gained through the employment of Nicole Lucock during the summer vacation under the Red Meat Industry Undergraduate Program run out of MLA.

The project involved the collection of baseline information on water and wastewater flows and contaminant loads in the major flows from the plant. This information then forms the platform upon which further improvements in water efficiency can be launched. A full range of contaminants in the waste streams were studied, including

- organic contaminants (COD, BOD_5),
- gross contaminants Total Suspended Solids (TSS) and Oil & Grease (O&G);
- nutrients nitrogen and phosphorus – normally defined as Total Nitrogen (TN) and Total Phosphorus (TP) by Environmental Agencies in Australia;
- inorganic salts as measured both as individual ionic species (sodium, chloride, etc) and as a lumped measure (electrical conductivity);
- physicochemical parameters such as pH and temperature.

Knowledge of the concentrations of these contaminants and of the multiple forms in which they are present is vital in the selection of appropriate treatment technologies and in identifying reuse opportunities for each stream.

1.2 Objectives

The objectives of the project were:

1. To estimate the flow and contaminant mass loads (kg/day) of major waste streams from the Beenleigh meat processing facility;
2. Use the information to identify the most contaminant-rich (or “dirty”) waste streams;
3. Identify opportunities for source reduction in short, medium and long term.

2. Description of Beenleigh Meat Processing Facility

2.1 Description of Abattoir

Teys Bros. is the largest Australian-owned meat processing company with a total of 7 processing plants throughout Australia. The head office is based in Beenleigh, approx. 30 minutes south of Brisbane.

The Beenleigh meat processing plant is a modern, fully integrated plant, which processes about 1,400 head of cattle/day in a double shift operation running 5 days/week. The plant operates the full suite of operations including:

- Slaughter and boning
- Chilling and freezing
- Byproducts processing using high temperature rendering to produce meat meal and tallow and steam coagulation of blood to produce blood meal.
- Full range of offal processing including intestines, tripe processing and washing and packing of edible and inedible offals.
- Pre-slaughter cattle holding yards.

Large quantities of water are consumed in the manufacturing process, largely to ensure hygienic operation to meet stringent food safety requirements imposed by customers through AQIS.

2.2 Wastewater Treatment Plant

Wastewater generated by the facility undergoes treatment through a variety of physical and biological processes including:

- screening through fine aperture wedgewire rotary and static screens;
- savealls to reduce TSS and O&G;
- anaerobic pond treatment to reduce BOD and COD;
- facultative and maturation ponds to further reduce organic loads and TSS to levels suitable for discharge either to:
    - irrigation of the surrounding property, or
    - sewer (ultimately arriving at Loganholme STP for further treatment).

2.3 Water Efficiency at Beenleigh

Water Efficiency KPIs

The Australian red meat processing industry has measured environmental performance since the mid 1990s. For water, the industry- agreed Key Performance Indicators (KPI) are:

- Raw water consumption (potable): kL/tonne Hot Standard Carcass Weight (HSCW) or kL/head;
- Wastewater emission: kL/tonne Hot Standard Carcass Weight (HSCW) or kL/head;

From Australian-wide environmental surveys of 10 such integrated red meat processing plants conducted in 2003, such operations are known to consume an average 10.6 kL potable water/tonne HSCW and generate 10.0 kL wastewater per tonne HSCW[1].

Water Efficiency at Beenleigh

Whereas the local government sector in Queensland appeared to be surprised by the drought, Teys Bros had achieved significant water efficiency at the Beenleigh plant well beforehand.

Production capacity increased from 864 head per day in 1999 to the current level of 1,428 per day, with a reduction in the overall volume of potable water consumption per day from 3.5 ML to 2.9 ML. This increased production, combined with a reduction in the total volume of potable water, has seen the water efficiency KPI improvements in excess of 40%.

Water consumption at the Beenleigh plant has decreased from a yearly average of 3.3 kL/head or 10.4 kL/tHSCW to the present levels of 2.1 kL per head of potable water or 6.9 kL/tHSCW. This decrease is in order of 34%. The majority of reduction in water consumption occurred prior to 2004, with smaller incremental improvements achieved in the 2004-2007 period.

2.4 Contaminant Loads at Beenleigh

The measurement of contaminant loads in individual waste streams is a technically challenging and expensive business. Sampling is made difficult by the variability in a waste stream with time as various contributing processes switch on/off, ability to access streams and the highly fatty and suspended solids-rich nature of many of the streams. Consequently, until recently, little was known about the distribution of contaminants among the many streams produced in meat plants.

Some detailed work on nutrient emissions in various waste streams had been published for German abattoirs[2] but it was not easy to decipher. A review by Johns[3] summarised existing knowledge at the time.

In 1994, the precursor to MLA – the Meat Research Corporation – conducted a project, which measured nutrient generation in individual waste streams at five Australian abattoirs. This and the output from a PhD study of another large integrated abattoir was published by MLA[4] in November 1995.

Since this time several publications have added to our knowledge of which waste streams are "dirtiest".

However, the contaminant loads of the Beenleigh waste streams have not been determined.

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[1] MLA (2005). "*Industry environmental performance review: integrated meat processing plants*." Prepared by URS Australia, Brisbane, April 2005.

[2] Tritt, W.P. & Schuchardt, F. (1992). *Material flows and possibilities of treating liquid and solid wastes from slaughterhouses in Germany: A review*. Bioresource Technology, 41, pp. 235-245.

[3] Johns M.R. (1995). *Developments in Wastewater Treatment in the Meat Processing Industry: A Review*. Bioresource Technology 54, pp 203-216.

[4] MRC (1995). *Identification of Nutrient Source Reduction Opportunities & Treatment Options for Australian abattoirs and rendering plants*. Project M.445 final report. Meat & Livestock Australia, Sydney.

3. Methodology

A four-stage approach was developed for the work. This involved:

Stage 1: Conducting sampling and analysis of as many of the most important waste streams within the meat processing plant as possible using previous industry data to identify these.

Nicole Lucock was employed under the MLA Red Meat Industry undergraduate program to perform the sampling of these streams during December 2007/January 2008. She was trained by Dr. Mike Johns (Johns Environmental). This involved composite sampling of waste streams to obtain samples as typically representative as possible. The samples were couriered rapidly to ALS Environmental laboratory at Stafford, Brisbane and analysed for a wide range of contaminants. The full range of analyses conducted and the test methods performed are listed in Appendix 1. The results were then evaluated by Dr. Mike Johns.

Stage 2: Flows for the various streams were determined using methods discussed in Appendix 2. This was conducted as part of the Water Efficiency Management Plan (WEMP)[5] required under Level 6 water restrictions. Where needed, Ms Lucock performed additional measurements of flows.

Stage 3: A spreadsheet mass balance model previously developed by Johns Environmental Pty. Ltd. to describe integrated abattoir operations was used to calculate the overall abattoir and individual stream contaminant mass loads (kg/day) as the product of the average stream flow and composition for each of the 18 – 20 selected waste streams. See equation 1. There are many more individual waste streams that could be sampled further back in the process, but the increasing error associated with both flow and composition measurement make it improbable that the increased cost of doing so would improve the accuracy of the model outputs.

The model results were validated against the actual contaminant loads emitted to the primary wastewater treatment system. A description of the mass balance model is provided in Section 4 of the PRENV.012 report[6].

$$\text{Load}\ \left(\frac{\text{kg}}{\text{day}}\right) = \text{flow}\ \left(\frac{\text{ML}}{\text{day}}\right) * \text{concentration}\left(\frac{\text{mg}}{\text{l}}\right) \qquad \textbf{equation 1}$$

Stage 4: From stage 3 the worst waste streams were identified and opportunities for source reduction activities can be developed.

[5] Hackett M, Coughlan J, Matthewson M, (2007). *Water efficiency management plan*. Gold Coast City Council.
[6] MLA (2003). *A nitrogen management strategy for meat processing plants*. Prepared by Uniquest, Brisbane.

4. Waste Flows

In this section, the water and wastewater stream flows are estimated for the double shift operation. Appendix 2 lays out how each flow was estimated.

4.1 Overall Plant Water Balance

Figure 1 provides a process schematic of water usage in the facility. The diagram was generated from discussions with the engineering and environmental team at Beenleigh. There are two sources of water:

- Recycled treated effluent for ante-mortem yards and cattle wash.
- Town supply for all other uses.

Town supply is used directly for:

- boiler makeup;
- amenities
- cattle troughs
- and hot water makeup.

The town supply is re-chlorinated on-site for supply to:

- the kill floor
- the boning room
- offal processing areas
- byproducts.
- plant cleaning activities.

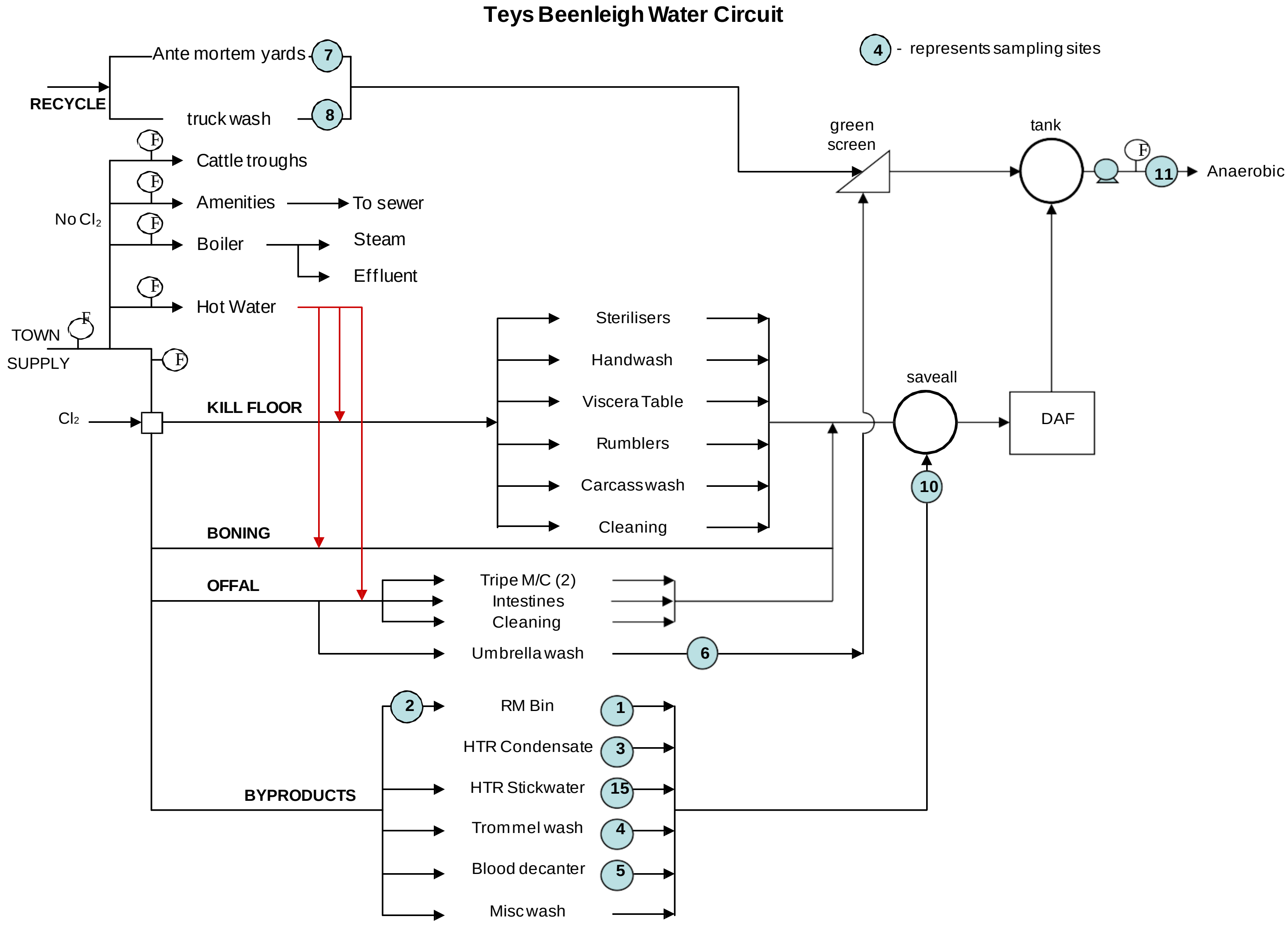
An overall water balance for the Teys Beenleigh abattoir is presented in Table 1. This is a reasonably rigorous balance, in that the following forms of water entering the plant are included:

- Water supplied by utilities;
- Water present in the beef animals, which is liberated through processing and enters the wastewater treatment system.

Table 1. Overall water balance over Beenleigh Abattoir

Source	Flow kL/day	Comments
Water In		
Town water	2,900	Average metered into plant during 2007
Recycled water	200	estimated.
Blood liquid in cattle	8	estimated at approx 6 litres inedible/head @ 1,430 hd/day
Paunch contents	57	estimated as 40 litres/paunch @ 1,430 hd/day
HTR condensate	90	from mass balance over rendering plant.
Raw material bin drainage	75	measured.
Total In	**3,330**	Total liquid entering the plant in all forms.
Water Out		
To Wastewater system	**3,000**	Measured by magnetic flowmeter ex primary system
Water unaccounted for	**330**	Mainly lost in drier exhausts and cooling tower evaporation

Figure 1. Process Schematic of water Use & wastewater Generation at Beenleigh



Of the 2.9 ML/day entering the plant on an average processing day, 3.0 ML/day emerged as wastewater entering the biological wastewater treatment plant. This flow was accurately monitored by an electronic mag flowmeter.

It is more usual to neglect animal-derived moisture inputs when assessing water flows in abattoirs, since they are usually only a small part of the total (only 6.9% from Table 1). The water discharged to the WWTP therefore closely approximates the town supply. The animal-derived moisture largely cancels the unaccounted for losses – probably largely comprised of cooling tower water evaporation which typically consumes about 10% of the total supply.

For the purposes of this report, the total wastewater flow of 3.0 ML/day was used for calculations.

4.2 Individual Waste Stream Flows

In total, 21 waste stream flows are estimated either from direct measurement or from measurements of the potable supply to the facility during WEMP studies in March 2007. These are summarised in Table 2.

Table 2. Estimate of Individual waste stream flows

Waste stream	Flow kL/day	% of total flow	Stream Rank
Kill Floor & Boning			
Kill floor	908	30.3	1
Boning Room	165	5.5	5
Kill floor & Boning Room cleaning	596	19.9	2
Sub-total	*1,669*	(55.7)	
Byproducts			
Raw material bin drainage	72	2.4	
Raw material screw drain	4	0.1	
Trommel wash	150	5.0	
HTR condensate	90	3.0	
HTR Stickwater	46	1.5	
Blood processing stickwater	14	0.5	
Miscellaneous (incl. washdown)	52	1.7	
Sub-total	428	(14.3)	
Offal wash & Yards (green)			
Paunch dry dump	14	0.5	
Umbrella wash	29	1.0	
Tripe processing	371	12.4	3
Intestine processing	75	2.5	
Offal & pet food	76	2.6	
Antemortem yards	165	5.5	4
Truckwash	40	1.3	
Sub-total	770	(25.7)	
Miscellaneous flows			
Human amenities	75	(2.5)	
Chillers	46	1.5	
WWTP	44	1.5	
Miscellaneous (offices, laundry etc)	40	1.3	
Sub-total	130	(4.3)	
Total	**3,000**	**100.0**	

Notes:

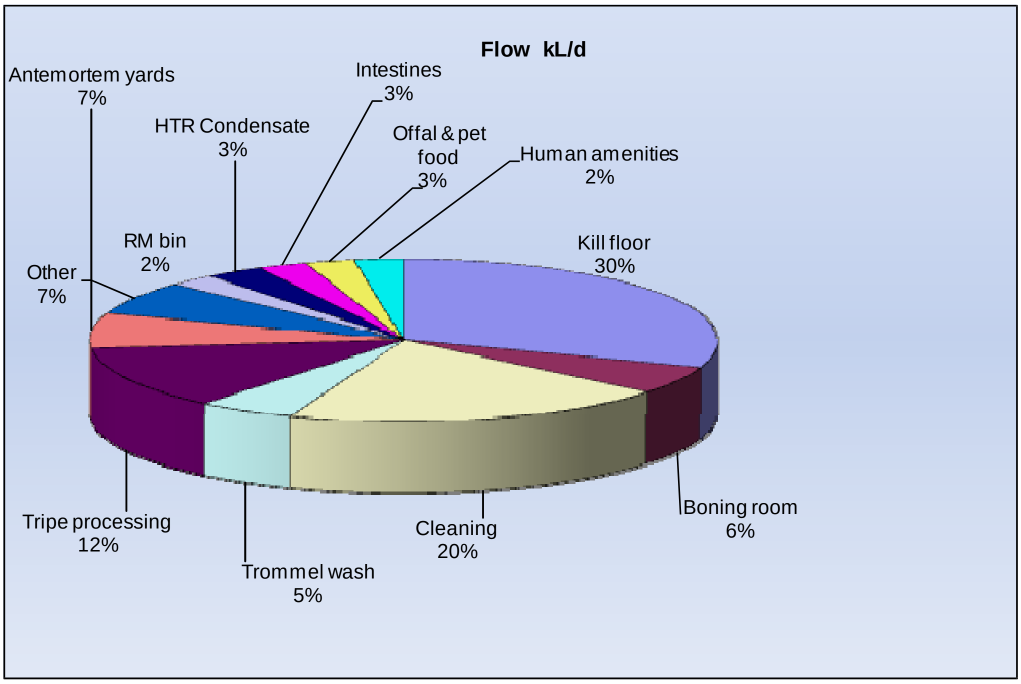
1. Sub-total percentages for each of the plant sections may not accurately equal the sum of the individual waste streams due to rounding error.

The estimated individual stream flows have significant uncertainty since:

- there is a normal daily variability in flow
- in many cases, only the inflows to these parts of the plant are known from flowmeter measurements, rather than effluent outflows;
- in some instances, actual measurements of waste streams could not be performed due to the inaccessibility of the waste stream;

Nevertheless, Table 2 provides the closest possible estimation of flows for each waste stream. The contribution of the individual waste streams to total flow measured into the anaerobic pond are shown in Figure 2.

Figure 2: Waste stream flows, expressed as % of total flow.



4.3 Summary: Flows

The main conclusions from these flow data include:

1. The sum total of individual waste flows is equivalent to the average total wastewater flow of 3.0 ML/day measured into the wastewater treatment plant. This is an excellent overall flow closure and owes much to accuracy of the WEMP flow studies performed by Teys Bros in early 2007.

2. The waste streams contributing the greatest flows are (in order of volume):
   - Kill floor total flow, which accounts for 30% of the total. Unfortunately the lack of access to pipework prevented further disaggregation of this total.
   - Flows from the cleaning shift (20%);
   - Tripe processing flows (12.4%);

- Ante-mortem yard flow (6.8%) including truckwash. This appears to be low relative to other facilities.
- Boning room (5.5%).

3. Traditional allowances for cleaning flows in Australian abattoirs are typically 20 – 30% of total flow. This figure assumes single shift operation – which was normal practice 10 years ago for almost all abattoirs.

4. Wastewater flow from the byproducts plant represented only 9% of the total wastewater generated excluding the trammel wash, which utilised reuse of viscera table water. This is towards the low end for byproducts facilities.

5. Green flows constitute just over a quarter of all wastewater flow from the plant, mainly due to extensive offal processing activities performed on-site and to ante-mortem yard discharge.

6. Miscellaneous flows comprise less than 5% of the total flow from the abattoir and a negligible contaminant load.

5. Waste Stream Composition

5.1 Approach

Sampling of the individual waste streams at Teys Beenleigh was performed for both the morning and afternoon shift. In a sense, this provided duplicate analyses of the same waste stream on the assumption that there was no change in process between shifts. In total, 12 different waste streams were sampled and analysed for 14 physical and chemical parameters. These were:

- Total Chemical Oxygen Demand (TCOD);
- Soluble Chemical Oxygen Demand (SCOD);
- Total Suspended Solids (TSS);
- Oil & Grease (O&G);
- Total Kjeldahl Nitrogen (TKN) – equivalent to Total Nitrogen in raw abattoir streams.
- Ammonia nitrogen (NH_3-N)
- Total Phosphorus (TP)
- Ortho-phosphate phosphorus (FRP)
- Ionic salts (chloride [Cl], sodium [Na], calcium [Ca], magnesium [Mg]).
- pH and electrical conductivity [EC].

5.2 Stream Composition

Table 3 presents the best estimate of stream composition for all 21 waste streams selected for inclusion in the load balance calculations. The raw composition results for both shifts are presented in Appendix 3.

Results for most streams showed reasonable consistency between composited samples taken at different shifts during normal processing. The values for these streams are shown in black in Table 3. For a few streams, it proved extremely difficult to obtain consistent data, despite the use of composite sampling techniques. Troublesome streams included:

- High temperature tallow stickwater
- Raw material bin [inside] particularly for organic components;

For these streams some degree of interpretation was required to eliminate dodgy sample results. Values for these results are shown in red to indicate that interpretation as applied.

A total of 20 waste streams were included in the load modelling calculations. For 8 streams, it was not possible to obtain representative samples for analysis due to lack of access to the drains to retrieve a sample. Previous results from studies by Johns Environmental for similar waste streams at other Australian abattoir sites and results sourced from appropriate MLA publications were used to provide reasonable values for the composition of these waste streams. As above, such data are given in red in Table 3 to indicate that these values are not from measurements taken from Beenleigh samples.

There is considerable uncertainty in these values. Where possible, the degree of closure on the mass load balance (section 6) was used to provide guidance as to the most representative values.

Table 3. Waste stream composition at Beenleigh

Source	Code	TCOD	SCOD	TSS	O&G	TKN	NH_3N	TP	FRP	Cl	Ca	Mg	Na	pH	EC
Units		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	-	
Kill floor															
Kill floor	S12	1,550	685	505	195	100	4	3	1	32	8	3	18		
Boning Room	S9	103.5	71.5	38	35.5	3.4	0.32	0.37	0.10	32	14.5	3	18	7.13	193
Cleaning flow	S14	6,500	1,835	4,430	670	265	10	23	15						
RM Bin (inside)	S1	44,600	23,400	22,400	2,830	3,520	382	387.5	367	1,595	19.5	45.5	1405	6.325	10,315
RM Bin screw (outside)	S2	21,800	10,730	7,500	2,590	1,455	131.6	155.7	144	918	10	22.5	863	6.43	5,015
HTR condensate	S3	526	394	47	148	192	182	0.3	0.0	91.5	0.5	0.5	0.5	9.22	931
Trommel wash	S4	4,400	248	2,635	1,360	62	1.88	7.4	4.0	53.5	13	3.5	34	6.735	295
HT Stickwater	S15	46,000	4,570	13,200	2,580	103	43.4	250	20	44	8	4	44	6.82	673
Blood decanter	S5	42,900	7,990	11,300	29	4,200	121	120	48.7	3,590	8.5	8	2280	8.04	12,550
Misc uses	S16	1,550	685	505	195	100	4	3.0	1.0	32	15	3	18		
Paunch dump dry	S18	55,000	17,900	22,700	2,080	3,400	255	270	125	512	36	21	872		
Umbrella wash	S6	1,240	1,120	3,505	293	276	137	143	102	256	18	11	436	8	3,490
Tripe processing	S17	4,500	425	5,500	7,300	110	5	43	24	256	10	11	436		
Intestines	S13	14,500	1,000	8,500	350	350	10	100	50	256	10	11	436		
Offal & pet food	S24	310	214	114	106	10.2	0.9	1.1	0.31	96	43.5	9	54		
Truckwash	S8	1,880	253	1,440	31	183	136	32	30	120	31	13	114	8	1,750
Chillers	S20	103.5	71.5	38	35.5	3.4	0.319	0.365	0.10	32	14.5	3	18	7.13	193
WWTP use	S25	9,245	3,605	3,980	1,510	198	33	18	12	98	6	5	87	7	866
Miscellaneous	S23	500	300	280	20	50	32	10	6	32	14.5	3	18	7	200
Pre Saveall	S10	9,245	3,605	3,980	1,510	198	33.45	25.9	11.9	97.5	6	4.5	87	6.94	866

5.3 Ranking of Streams by Composition

Table 3 presents the best estimate of stream composition for all 21 waste streams selected for inclusion in the load balance calculations. The raw composition results for both shifts are presented in Appendix 3.

The streams can be grouped into categories based on the contaminant strength.

1. Very strong waste streams. These include:
   - Raw material bin drainage (S1)
   - High temperature stickwater from the tallow polishers (S15);
   - Dry paunch dump liquid (S18) and
   - Blood decanter waste (S5);

   In general, each stream is characterised by very high COD (> 50,000 mg/L), TSS (> 20,000 mg/l), typically high O&G (> 2,000 mg/l) and very high nitrogen (> 3,000 mg/l) and phosphorus (> 200 mg/l), although there is significant variability between streams. It is fortunate that the flow of some of these streams is relatively low.

Photo 1. Raw material bin drainage – a very strong waste stream

Photo 2. Stickwater drain with polisher stickwater entering at top left of drain and occasional tallow tank discharge at top centre. – also very strong waste streams.

2. Medium strength, although there composition was generally wildly variable as a group. These include:
   - Drainage from raw material screw (S2);
   - Tripe processing effluent (S17)
   - Intestine processing stream (S13)
   - Umbrella wash of dry dumped paunches (S6);

   These streams are characterised by high COD (> 10,000 mg/L), high TSS (> 5,000 mg/l), and high nitrogen (> 250 mg/l) and phosphorus (> 100 mg/l), with the exception of the tripe processing stream which has a relatively low TP concentration.

3. Weak Streams: The remaining waste streams comprise relatively weak contaminant levels with COD typically in the range 1,500 – 6,000 mg/l, TSS < 2,000 mg/l and nutrients generally low (TN < 250 mg/l; TP < 25 mg/l), although again there is significant variability. These streams contain significant loads only at high flows.

4. The Boning room effluent (S9) was particularly weak.

Photo 3. The Boning Room drain. Although only a trickle at the time of the shot, the excellent quality of this flow is clearly seen and is supported by analytical data.

6. Assessment of Contaminant Mass Loads

6.1 Comment on Reliability of Load Values

Table 4 assesses the accuracy of the modelling approach by assessing the result of the following equation:

$$L_N = C_{N,w} \cdot Q_w = \sum_{i=0}^{i=n} C_{N,i} \cdot Q_i \qquad \textit{equation 2}$$

where:

L_N = Load of contaminant, N (kg/day)

$C_{n,w}$ = Concentration (mg/l) of contaminant N in the total wastewater discharged to the primary treatment system;

Q_w = Estimated flow of the total wastewater discharged to the primary treatment system (ML/day);

$C_{n,i}$ = Concentration (mg/l) of contaminant N in the i*th* waste stream.

Q_i = Estimated flow (ML/day) of the i*th* waste stream.

n = Number of waste streams

Essentially equation 2 states that when we add up the mass (kg/day) of a contaminant across all 20 individual streams (first data row in Table 4) it should equal the mass (kg/day) of that contaminant in the final wastewater stream discharged to the wastewater treatment plant (second data row in Table 4).

Table 4. Contaminant loads: Model estimate vs pre-WWTP measured loads

Load Source	TCOD	SCOD	TSS	O&G	TKN	NH_3N	TP	FRP
Sum of stream loads	16,400	4,715	9,368	4,000	784	106	98	62
Pre-Anaerobic pond	17,489	6,866	5,334	1,032	699	243	113	101
Closure	-6.6%	-45.6%	43.1%	74.2%	10.9%	-128.6%	-15.0%	-62.8%

When this brutal test is applied to the results of the project, the outcomes fall into three categories for the contaminants:

1. Reasonable agreement: COD total, Total Nitrogen (TKN) and Total Phosphorus (TP). For these contaminants the two values of load are within ± 15%. For the inherent error in the measurement or estimation of flow and composition of each stream this is an acceptable result.

   The Beenleigh plant produces:

   - 17.5 tonne COD per day after primary treatment, with 93.5% found in the 20 streams included in the study.
   - 780 kg TN per day ex factory with about 10% removal in the saveälls;
   - 100- 115 kg TP per day ex factory.

2. Reasonable agreement accepting some removal in saveälls: Total Suspended Solids (TSS) and Oil & Grease (O&G). While little can be stated about the accuracy of this result, it would be expected that the primary treatment system would remove of the order of 30 – 60% TSS and 60 –

90% of oil and grease entering from the factory streams. Table 4 indicates that both results are near the mid-point of these ranges.

The Beenleigh plant produces:

- 9.4 tonne TSS per day ex factory, with approximately 43% removal in the savealls.
- 4 tonne O&G per day ex factory with a good removal of about 75% in the primary system.

3. Poor agreement: Soluble COD, Ammonia nitrogen and soluble phosphorus (FRP). For these contaminants closure between the sum of streams and the pre-anaerobic pond loads is poor. It would be expected that removal of these contaminants in the savealls would be negligible.
   - Significant difficulties were experienced with obtaining reliable samples for the soluble COD assay. It required filtering the sample on-site and this was extremely difficult. Consequently, no reliable weight can be put on the sum of streams soluble COD load.
   - Measurement of ammonia loads in the pre-anaerobic stream (S11) gave a figure of 243 kg/day, which is highly reliable, In contrast, over half of the ammonia is missing in the "sum of streams" estimate of 106 kg/day. It is difficult to see why this value is so low: most of the ammonia concentrations recorded in the ammonia-rich streams are consistent with normal industry values.
   - While the proportion of TP in the soluble form (FRP) seems correct for the pre-anaerobic stream, the "sum of streams" FRP load of 62 kg/day is well below the pre-anaerobic value (101 kg/day). Again, FRP levels in most streams were typical of industry values.

   Fortunately, these 3 contaminants are somewhat redundant given the more reasonable closure for the total values of COD, TN and TP.

In summary, the results are reasonable for the effort expended and provide a clear and reasonably consistent picture of the source of major contaminants within the Beenleigh facility.

6.2 Individual Waste Stream Contaminant Loads

Tables 5 and 6 present the best estimate of the load of contaminant (kg/day) in each of the 21 waste streams considered. Table 5 covers organic and nutrients, whereas Table 6 gives information on salt loads in the streams.

Table 7 provides the percentage contribution of each waste stream to the total load of contaminant emitted from the Beenleigh meat processing facility.

Table 5. Total contaminant loads (kg/day) discharged in individual waste streams

Source	TCOD	SCOD	TSS	O&G	TKN	NH_3N	TP	FRP
Kill floor	1,408	622	459	177	91	3.6	2.7	0.9
Boning Room	17.1	11.8	6.3	5.9	0.6	0.1	0.1	0
Cleaning flows	3,871	1,093	2,639	399	158	6	14	9
RM Bin (inside)	3,227	1,693	1,621	205	255	27.6	28.0	26.6
RM Bin screw (outside)	84	41	29	10	5.6	0.5	0.6	0.6
HTR condensate	47	35	4	13	17.3	16.4	0.02	0.00
Trommel wash	659	37	394	204	9.3	0.3	1.1	0.6
HT Stickwater	2,122	211	609	119	4.8	2.0	11.5	0.9
Blood decanter	579	108	153	0	56.7	1.6	1.6	0.7
Miscellaneous uses	81	36	26	10	5.2	0.2	0.2	0.1
Paunch dump dry	787	256	325	30	48.6	3.6	3.9	1.8
Umbrella wash	35	32	100	8	7.9	3.9	4.1	2.9
Tripe processing	1,671	158	2,042	2,710	40.8	1.9	16.0	8.9
Intestine processing	1,092	75	640	26	26.4	0.8	7.5	3.8
Offal & pet food	24	16	9	8	0.8	0.07	0.08	0.02
Truck wash	75	10	58	1.2	7.3	5.4	1.3	1.2
Chillers	4.8	3.3	1.7	1.6	0.2	0.0	0.0	0.0
WWTP use	404	157	174	66.0	8.6	1.5	0.8	0.5
Miscellaneous	20	12	11	0.8	2.0	1.3	0.4	0.2
Total	**16,400**	**4,715**	**9,368**	**4,000**	**784**	**106**	**98**	**62**
Pre-Anaerobic pond	**17,489**	**6,866**	**5,334**	**1,032**	**699**	**243**	**113**	**101**

Notes to Table 5:

1. The Total for some contaminants may comprise the sum of stream loads due to rounding.

6.3 Streams of Little Significance

Of the 20 waste streams assessed, 9 are of little consequence in terms of contaminant loads but are included in the Tables 5 – 7 for the sake of completeness. Streams in this category contained generally less than 6% of total plant load for any single contaminant (< 12% for calcium).

These streams include:

- Boning room effluent (less than 0.3% of any organic or nutrient contaminant)
- Drain from the (outside) raw material bin screw (less than 1% of total);
- Miscellaneous byproducts wash downs (less than 2.5% of any contaminant);
- Paunch dump and umbrella wash;
- Offal & petfood departments;
- Truck wash (less than 5% of any contaminant);

- Chillers, WWTP uses and miscellaneous flows (less than 2.5% of any contaminant);

These flows comprise 510 kL/day, or 17% of the total effluent flow.

Photo 4. Raw material screw drain – although rich in blood, the low and intermittent flow makes it of little overall consequence.

Table 6. Salt loads (kg/day) discharged in individual waste streams

Source	Chloride	Calcium	Magnesium	Sodium
Kill floor red 1	29	7.3	2.7	16
Boning Room	5.3	2.4	0.5	3.0
Kill/Boning clean				
RM Bin (inside)	115	1.4	3.3	102
RM Bin (outside)	3.5	0.0	0.1	3.3
HTR condensate	8.2	0.05	0.05	0.05
Trommel wash	8.0	1.9	0.5	5.1
HT Stickwater	2.0	0.4	0.2	2.0
Blood decanter	48.5	0.11	0.11	31
Miscellaneous wash	1.7	0.75	0.16	0.94
Paunch dump dry	7.3	0.5	0.3	12.5
Umbrella wash	7.3	0.5	0.3	12.5
Tripe processing	95	3.7	3.9	162
Intestine processing	19	0.8	0.8	33
Offal & pet food	7.3	3.3	0.7	4.1
Truck wash	5	1	1	5
Chillers	1	1	0	1
WWTP use	4	0	0	4
Miscellaneous	1	1	0	1
Total	**406**	**29.7**	**15.5**	**417**
Pre-Anaerobic pond	**394**	**15.0**	**15.0**	**517**

Table 7. Waste stream load as percentage of total "sum of streams" load.

Waste Stream	TCOD	SCOD	TSS	O&G	TKN	NH_3N	TP	FRP	Cl	Ca	Mg	Na
Kill floor												
Kill floor	8.6	13.2	4.9	4.4	11.6	3.4	2.8	1.5	7.1	24.5	17.6	3.9
Boning Room	0.1	0.3	0.1	0.1	0.1	0.0	0.1	0.0	1.3	8.1	3.2	0.7
Cleaning	23.6	23.2	28.2	10.0	20.1	5.6	14.0	14.4	0.0	0.0	0.0	0.0
Byproducts												
RM Bin drain (inside)	19.7	35.9	17.3	5.1	32.5	26.0	28.6	42.9	28.4	4.8	21.3	24.4
RM Bin screw (outside)	0.5	0.9	0.3	0.2	0.7	0.5	0.6	0.9	0.9	0.1	0.6	0.8
HTR condensate	0.3	0.8	0.0	0.3	2.2	15.4	0.0	0.0	2.0	0.2	0.3	0.0
Trommel wash	4.0	0.8	4.2	5.1	1.2	0.3	1.1	1.0	2.0	6.6	3.4	1.2
HT Stickwater	12.9	4.5	6.5	3.0	0.6	1.9	11.8	1.5	0.5	1.2	1.2	0.5
Blood decanter	3.5	2.3	1.6	0.0	7.2	1.5	1.7	1.1	11.9	0.4	0.7	7.4
Miscellaneous wash	0.5	0.8	0.3	0.3	0.7	0.2	0.2	0.1	0.4	2.5	1.0	0.2
Offal processing												
Paunch dump dry	4.8	5.4	3.5	0.7	6.2	3.4	3.9	2.9	1.8	1.7	1.9	3.0
Umbrella wash	0.2	0.7	1.1	0.2	1.0	3.7	4.2	4.7	1.8	1.7	1.9	3.0
Tripe processing	10.2	3.3	21.8	67.8	5.2	1.7	16.3	14.4	23.4	12.5	25.2	38.8
Intestine processing	6.7	1.6	6.8	0.7	3.4	0.7	7.7	6.1	4.7	2.5	5.1	7.9
Offal & pet food	0.1	0.3	0.1	0.2	0.1	0.1	0.1	0.0	1.8	11.1	4.4	1.0
Ante-mortem yards	1.2	2.3	0.7	0.1	5.0	27.8	4.5	5.5	9.0	12.8	5.9	4.9
Truck wash	0.5	0.2	0.6	0.0	0.9	5.1	1.3	2.0	1.2	4.2	3.4	1.1
Chillers	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4	2.2	0.9	0.2
WWTP use	2.5	3.3	1.9	1.6	1.1	1.4	0.8	0.8	1.0	0.9	1.3	0.9
Miscellaneous	0.1	0.3	0.1	0.0	0.3	1.2	0.4	0.4	0.3	2.0	0.8	0.2

Colour code: Cell colour: Red – identifies stream with highest contribution to a given contaminant load

Yellow – second highest contribution; White: 3rd highest contribution; Blue – 4th highest contribution

Green – background only.

7. The "Dirtiest" Streams

7.1 Identifying the Worst Streams

Table 8 identifies the waste streams containing the greatest loads of each contaminant. The three streams that dominate the list are:

- Raw material bin drainage (2.4% of total flow);
- Tripe processing discharge (12.4% of total flow)
- Cleaning flows (20% of flow).

The surprise omission from this list is the ante-mortem yards, which typically rank as a high contaminant source for Australian abattoirs. This may be due to the low flow measured by Nicole Lucock during the survey. If the yards flow was larger than 5.5% of total flow (as is likely), the yards may be ranked higher.

Some caution is needed with rankings for soluble COD, ammonia nitrogen, soluble P, calcium and sodium in view of the poor mass balance closures.

Table 8. Dirtiest waste streams by contaminant.

Contaminant	1st	2nd	3rd	4th
Total COD	Cleaning	RM Bin	HT stickwater	-
Soluble COD	RM Bin	Cleaning	Kill floor	-
Suspended Solids	Cleaning	Tripe processing	RM Bin	-
Oil & Grease	Tripe processing	Cleaning	-	-
Total Nitrogen	RM Bin	Cleaning	Kill floor	-
Ammonia-N	Ante-mortem yards	RM Bin	HTR condensate	-
Total Phosphorus	RM Bin	Tripe processing	Cleaning	HT stickwater
Soluble phosphorus	RM Bin	Cleaning, Tripe processing	-	-
Chloride	RM Bin	Tripe processing	Blood decanter	-
Calcium	Kill floor	Ante-mortem yards	Tripe processing	Offal & petfood
Magnesium	Tripe processing	RM Bin	Kill floor	-
Sodium	Tripe processing	RM Bin	-	-

Notes to Table 8:

- The rankings are based on the proportion of total contaminant mass load in any stream.

Table 9 estimates the fraction of total contaminant emission in the top dirtiest streams and contrasts this with the corresponding proportion of flow represented by the top 3 dirty streams. In all cases, 50% or more of the contaminant load is released in the top 3 dirtiest streams. In most cases this comprised only one third of the total flow.

These are typical findings for Australian plants.

It is interesting to note that after the three most contaminant-rich streams, there was daylight to other waste streams. It was rare for there to be a fourth stream exceeding 10% of contaminants.

Consequently, these dirty streams are the natural targets for source reduction.

Table 9. Impact of “dirtiest” waste streams by contaminant.

Contaminant	% Total emission in top 3 streams	% Total flow in top 3 streams
Total COD	56	24
Soluble COD	72	53
Suspended Solids	67	35
Oil & Grease	78	32
Total Nitrogen	64	53
Ammonia-N	69	11
Total Phosphorus	59	35
Soluble phosphorus	72	35
Chloride	64	15
Calcium	50	38
Magnesium	64	46
Sodium	78	15

7.2 Distribution of Contaminants among Waste Streams

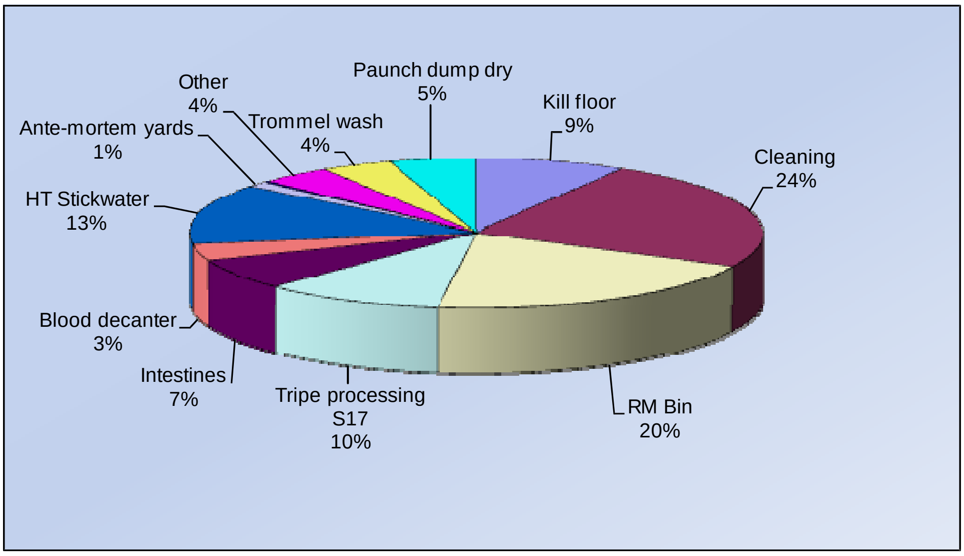
Figures 3 – 8 present the distribution of contaminants (on a percent of total load basis) among the most contaminated 10 – 12 waste streams.

7.2.1 COD

COD emissions are dominated by organic loads discharged in the:

- raw material bin drainage,
- cleaning flows,
- tallow polisher (HT)stickwater and
- tripe processing.

Figure 3. Percentage contribution of COD from significant waste streams.



The nature of the COD in each case are probably quite different.

- For example, raw material bin COD appears to be highly soluble (SCOD/TCOD ratio is about 0.5), whereas that from the stickwater is largely insoluble (SCOD/TCOD ratio of 0.1). This affects treatment options.

- Whereas raw material bin COD is high, oil and grease levels are moderate (O&G/COD ~ 0.06). This contrasts with tripe processing effluent with very high oil & grease levels (O&G/COD ~ 1.6).

7.2.2 Total Nitrogen

Approximately half of the plant's TN discharge comes from two sources (Fig. 4):

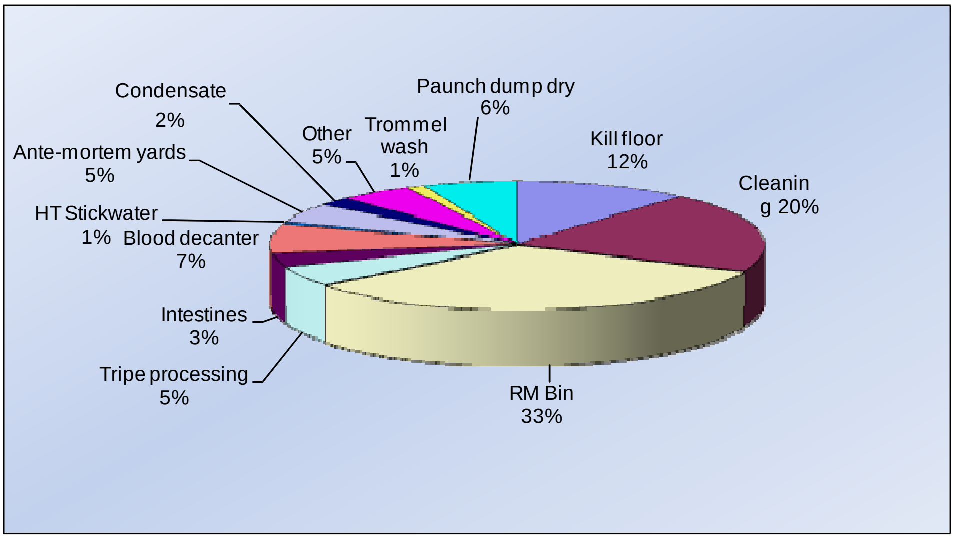
- The raw material bin
- Cleaning flows.

In both streams, the nitrogen is present mainly as organic nitrogen (proteins etc).

The raw material bin comprises less than 3% of total flow. For a facility like Beenleigh, reducing the raw material bin nitrogen load will have immense payback in deferred or eliminated capital cost if a biological nitrogen removal plant is ever needed. The measured flow of 75 kL/day is significant.

Relatively little can be done to minimise nitrogen in cleaning flows beyond good housekeeping.

Figure 4. Percentage contribution of Total Nitrogen from significant waste streams.



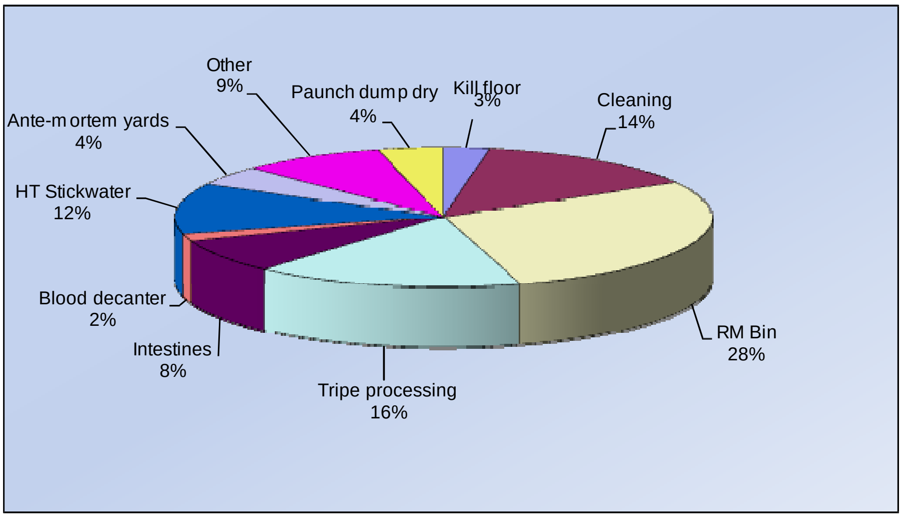
7.2.3 Total Phosphorus

Approximately half of the plant's TP discharge comes from the raw material bin and offal processing (Fig. 5. The use of dry paunch dumping ensures that this process contributes reasonably negligible amount (4%) to the total TP load.

Phosphorus from raw material bin drainage contributes a quarter of all phosphorus, again in less than 3% of the flow. Further the vast majority is highly soluble (FRP/TP ratio > 0.95).

Tripe and intestine processing contribute an additional quarter of all phosphorus. This is evenly split between organic and soluble forms.

Figure 5. Percentage contribution of Total Phosphorus from significant waste streams



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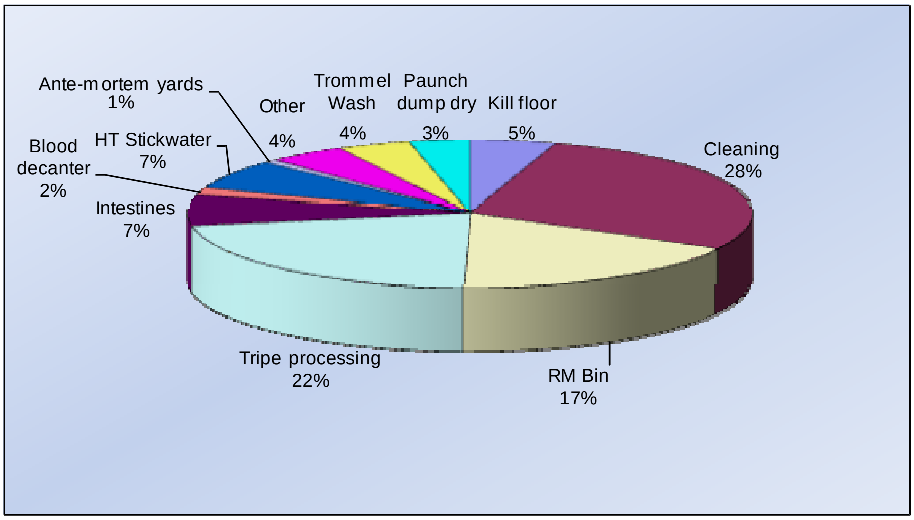
7.2.4 Total Suspended Solids

The raw material bin and tripe processing figure significantly in TSS emissions (~ 40% of total). A substantial quantity of organic nitrogen and phosphorus are tied up with these and is removed in primary treatment. Cleaning flows contribute a large portion, as can be expected.

Figure 6. Percentage contribution of Total Suspended Solids from significant waste streams



7.2.5 Oil & Grease

Tripe processing dominates in the release of oil & grease form the factory (Figure 7). Some care is needed with interpreting this outcome, since the tripe processing effluent could not be directly sampled and analysed. Consequently the results are based on industry averages for composition of this stream.

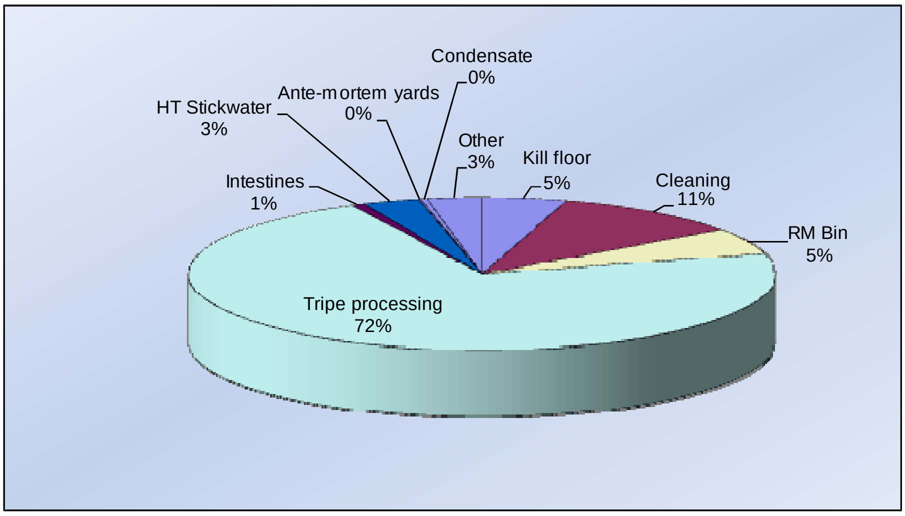
Given the contribution of tripe processing to contaminant loads in this study, however, it may be sensible to tap into the discharge lines to allow direct sampling of tripe effluent composition. I am not aware of this being done anywhere in Australia (or overseas). This would allow the accuracy of the outcomes of this study to be better assessed.

Recovery of oil and grease from this stream is made difficult by:

- A very high temperature – especially during scalding – which can emulsify the fat;
- Associated high levels of suspended solids. A hydrocyclone technology kit might be well suited to this application but would require careful pre-treatment using a baleen filter, for example.

At current oil & grease prices it may be worthwhile looking at fat recovery once a more definitive study of tripe effluent composition and variability is completed to ensure that the payback is better known.

Figure 7 Percentage contribution of Oil & Grease from significant waste streams



7.2.6 Salts – particularly Chloride

There have been relatively few studies of salts in meat processing effluent. I am aware of a study some time ago at Rockdale (NSW) where such a study was performed.

Salt balance closure was not marvellous during this project, but the chloride and magnesium balances seem reasonable. Chloride serves as a useful guide.

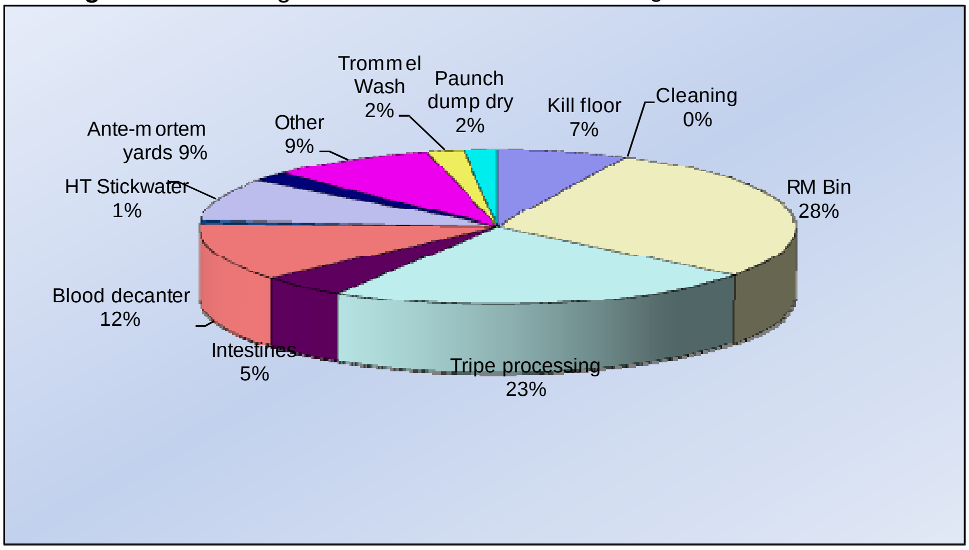
It might be thought that salts would be relatively dispersed across the waste streams given their high solubility in water, but this is definitely not the case for any of the salts. Figure 8 outlines the contribution of different streams to chloride discharge. Amazingly more than half the chloride is emitted from two streams comprising less than 15% of total flow:

- The raw material bin
- Tripe processing.

The blood decanter waste also makes a strong contribution (12% of total chloride from only 0.5% of flow!). A common feature appears to be cattle blood, which is rich in chloride ions (~ 3.5 g Cl/litre).

Unfortunately measurements were not taken of cleaning flows to monitor salt concentrations in these streams, particularly from the use of chloride-containing chemicals. Consequently the impact of cleaning on chloride (and other salts) remains unknown.

Figure 8 Percentage contribution of Chloride from significant waste streams



8. Conclusions

1. The Teys Bros. Beenleigh meat processing plant generates an average flow of 3.0 ML/day wastewater containing about 17.5 tonne COD, 780 kg nitrogen and 100 – 115 kg phosphorus per day. Significant quantities of total suspended solids and oils & greases are also produced, but the primary treatment plant appears to reduce these considerably.

2. The five largest waste streams were:
   - Kill floor stream: 30% of daily flow
   - Cleaning flows: 20% " " "
   - Tripe processing 12.5% " " "
   - Ante-mortem yards and boning room flows at 5.5% each. "

   Other individual waste streams generally form less than 5% of total daily flow.

3. The streams containing the greatest proportion of contaminants by mass load were:
   - Raw material bin drainage (2.4% of total flow);
   - Tripe processing discharge (12.4% of total flow)
   - Cleaning flows (20% of flow).

   The ante-mortem yards waste stream is also a significant stream, but appears to be a surprisingly low flow during the measurements taken over summer 2007/08.

4. A large number of waste streams (9) are of little consequence in terms of mass contaminant loads relative to the above. They generally comprise either streams containing weak concentrations, or strong streams of low flow.

   One of these is the dry paunch dump stream, which typically contributes high phosphorus loads. However, the dry dumping system at Beenleigh generally works well and the dry paunch stream is estimated to contribute only 4% TP, which is an excellent result. There is little value in pursuing these streams for further efficiencies.

5. For all contaminants, at least 50% - and in some cases more than 67% - of the contaminant load was emitted in the top 3 "dirtiest" waste streams with contributions from other streams being very small. This seems typical of meat processing plants. The streams in the top 3 tended to vary according to the contaminant.

6. The waste stream carrying the richest mass load of contaminants was the 75 kL/day average flow from the Raw Material Bin in the Byproducts. This is a very high strength, very low flow stream which contributed:
   - 20% of all COD generated by the facility;
   - 32% of the total nitrogen
   - Almost 30% of total phosphorus
   - And approx. 25% of salt loads, especially chloride and sodium.

   All of this in only 2.4% of average daily flow! Raw material bin drainage is known to be a major contaminant source in Australian integrated meat plants and Beenleigh seems no exception.

   In terms of reducing contaminant loads to the WWTP – and especially if nutrient removal becomes important – this is the key stream to target. Options might include:
   - Looking at ways to reduce the wetness, or added water, to the raw material particularly if blow systems are used.
   - Consider conveying systems which minimise water addition;

- Consider installation of equipment to capture and process the drainage to value-added product.

7. The tripe processing flow is a large (370 kL/day) stream containing very high mass loads of contaminants. Unfortunately the inability to sample this stream meant that average industry composition values were used to estimate loads, so there is considerable uncertainty about the outcomes. Nevertheless, the estimated loads suggest that this stream emits:
   - 68% of total oil & grease from the facility, which is a huge result.
   - 22% of the TSS
   - 16% of the total phosphorus, and
   - More than 25% of all salts.

   These results merit:
   - A small program to tap into the tripe processing waste stream to allow actual sampling to confirm the above numbers.
   - Assessment of ways in which the high oil and grease concentrations in this stream might be recovered – for example using baleen/hydrocyclone combinations.

   Both the high contaminant mass loads and the large water volume attributed to tripe processing make this stream a valuable target for work.

8. Cleaning and kill floor flows both contribute significant loads, but the water volume is high, which makes it difficult to target these streams inexpensively.

9. The Boning Room waste stream is only lightly contaminated. Given it is over 5% of the plant flow, it could be considered for either:
   - Bypassing the treatment system direct to either sewer or irrigation, and/or.
   - Reuse for some appropriate purpose.

10. The measurements and monitoring of the 20 waste streams in the abattoir appears to provide reasonable results, despite the high degree of variability in stream composition in many cases and the difficult nature of these raw samples. However, some streams remain poorly characterised (tripe and cleaning flows for example), and in some instances – particularly ante-mortem yard flows – the flow may have been under-estimated. If required, these can be assessed in the future.

The project appears to have been successful. It is hoped these data will provide further incentive for developing and implementing new strategies to further reduce resource consumption and waste generation during meat processing.

The excellent work on the site by Ms. Nicole Lucock collecting stream samples and analysing the results during her University vacation period working under the Red Meat Industry Undergraduate Program is gratefully acknowledged.

Abbreviations

AMPC	=	Australian Meat Processor Corporation
AN	=	Ammonia Nitrogen (mg/l)
BOD_5	=	Biochemical Oxygen Demand (measured in 5 days at 20°C) (mg/l).
COD	=	Chemical Oxygen Demand (mg/l)
DAF	=	Dissolved Air Flotation
EC	=	Electrical conductivity
EPA	=	Environmental Protection Agency
FRP	=	Filterable Reactive Phosphorus
tHSCW	=	tonne Hot Standard Carcase Weight
HTR	=	high temperature rendering
LTR	=	low temperature rendering
ML	=	Megalitre
MLA	=	Meat and Livestock Australia
MRC	=	Meat Research Council
NH_3-N	=	Ammonia-Nitrogen concentration (mg/l)
O&G	=	Oil and Grease (mg/l)
Org N	=	Organic Nitrogen (mg/l)
PO_4-P	=	ortho-phosphate concentration (mg/l)
RM	=	raw materials
SBR	=	Sequencing Batch Reactor
SCOD	=	Soluble Chemical Oxygen Demand (mg/l)
STP	=	Sewage Treatment Plant
TCOD	=	Total Chemical Oxygen Demand (mg/l)
TKN	=	Total Kjeldahl nitrogen (mg/l)
TN	=	Total Nitrogen concentration (mg/l)
TP	=	Total Phosphorus concentration (mg/l)
TSS	=	Total Suspended Solids (mg/l)
WBP	=	World Best Practice.
WEMP	=	Water Efficiency Management Plan
WWTP	=	Wastewater Treatment Plant

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Appendix 1: Test Methodology.

Test Methods

Samples were collected and tested for the range of parameters indicated in Table A1.1.

Temperature, pH, EC (Electrical conductivity) and ORP (redox potential) were measured directly from the sample in the field using a calibrated HACH HQ40d multiparameter meter (Johns Environmental). Where sample temperature exceeded the limit of the HQ40d sensors (~ 60^{o}C), the temperature was measured using a Davis & Waddell digital thermometer probe and other parameters were measured once the sample had cooled. The Hach instrument logs the readings to memory by sample ID and sampler ID and they are subsequently downloaded to computer as excel-compatible file.

Other parameters were analysed by ALS Environmental laboratories, which is NATA accredited for these tests. Table A1.1 indicates the method used by ALS with comments on the method. Table A1.2 records the limit of reporting. ALS Environmental is routinely used by Johns Environmental for the testing of high and low strength meat processing/rendering samples and it has an excellent track record in handling the samples. Full documentation - including Chain-of-Custody and QC forms – is held for the testing.

Table A1.1. Analytical Analysis Methods.

Water Analysis	ALS Code	Method	Comment
COD total	EP026	APHA 5220 B	-
COD soluble	EP026F	APHA 5220 B	Generally too difficult to filter samples.
Oil & Grease	EP020	APHA 5220 B	n-hexane extraction
TSS	EA025	APHA 2540 D	GFC 1.2 um filter gravimetric
Total Kjeldahl Nitrogen (TKN)	EK061	APHA 4500-Norg-D	Acid digestion & FIA
Ammonia -nitrogen	EK055A	APHA 4500 NH3+-H	FIA method
Total phosphorus	EK067	APHA 4500 P-H	Acid digestion & FIA
Orthophosphate (PO_4^{3-})	EK071F	APHA	FIA method
Elements Na, Ca, Mg	ED093F	APHA 3120	ICPAES method
Chloride	ED045-P	APHA 4500	Automated titration
Electrical conductivity	EA010-P	APHA 2510	Field measurement used
pH	EA005-P	APHA 4500H+ B	Field measurement used

Note: APHA refers to 21st edition.

Sampling Methods

Wastewater characteristics for each waste stream were determined by sampling and subsequent analysis off-site. Composite sampling was performed for all waste streams due to the inherent variability associated with waste streams close to source.

There are two shifts at Beenleigh, one from 5am-2pm and then 2pm-10pm. The morning shift samples were taken between 8-11am and afternoon shift between 3-5pm. On average, 2-3 streams were sampled per day.

Composite sampling method: To obtain a composite sample, four grab samples (at least 3-5 litres each) were taken of the effluent stream over 5 - 10 minutes of normal operation and mixed together. After mixing this total volume thoroughly, samples were withdrawn for analysis

The sample was distributed into labelled bottles provided by ALS Environmental and cooled immediately on ice to achieve 4^{o}C prior to packing into eskis packed with ice bricks for transport to the lab. Samples were couriered to the laboratory by a third party courier.

Where possible, samples were filtered for soluble COD determination using syringe filters supplied for this purpose by ALS Environmental. In many instances, the oil & grease levels in the sample prevented accurate determination of this parameter.

Table A1.2. Limits of Reporting (LoR).

Parameter	ALS Code	LoR	Units
CODt	EP026	5	mg/L
CODs	EP026F	5	mg/L
TSS	EA025	1	mg/L
O&G	EP020	0.01	mg/L
TKN	EK061	0.1	mg/L
NH_3N	EK055A	0.01	mg/L
TP	EK067	0.01	mg/L
FRP	EK071F	0.01	mg/L
Cl	ED045	1	mg/L
Ca	EDO93F	1	mg/L
Mg	EDO93F	1	mg/L
Na	EDO93F	1	mg/L
pH	EA005	0.01	pH unit
EC	EA01010	1	µs/cm

Appendix 2: Wastewater Stream Flow Estimation

Table A2.1 below identifies how individual waste stream flows were estimated.

Flow measurement of some streams was straightforward and used fill time for a bucket timed with a stopwatch. If the stream had a variable flow then many (10 – 12) measurements were taken to permit a more accurate average value. A sample was taken for up to a minute, or with some slow flow rates, over a period of 10 - 30 minutes.

Some flow rates were gathered from the Water Efficiency Management Plan (WEMP) which was published in April 2007 and the data was collected in March. The WEMP considers water inputs rather than flow outputs, but in most cases there is reasonable correspondence since little water enters the product. Allocation of water inputs to waste streams is provided in Table A2.2.

The final wastewater flow to the wastewater plant (ex DAF) was measured by electronic magnetic flow meter, as was town supply into the facility. The average 2007 water use was used for this report.

Table A2.1. Flow Analysis Methods.

Code	Stream	Flow source
S1	Main raw material bin	Measured by NL
S2	Raw material screw drain	Measured by NL
S3	HTR condensate	Calculated from 1,430 head/day.
S4	Trommel wash	Measured by NL
S5	Blood decanter	Measured by NL
S6	Umbrella wash	Calculated estimate
S7	Ante-mortem yards	WEMP
S8	Truck wash	WEMP
S9	Boning room	WEMP
S10	Saveall	Not measured
S11	Into anaerobic pond	Flow metered
S12	Kill floor	WEMP
S13	Intestine processing	WEMP
S14	Cleaning (all flows)	WEMP
S15	Polisher stickwater	Measured by NL
S16	Miscellaneous byproducts	Calculated estimate
S17	Tripe room	WEMP
S18	Dry paunch dump	Calculated estimate
S19	Amenities	WEMP
S20	Side chillers	WEMP
S21	Boiler blowdown	WEMP
S22	Laundry	WEMP
S23	Miscellaneous	WEMP
S24	Offal & pet food	WEMP
S25	WWTP use	WEMP

Table A2.2. Water Flows from WEMP (2007) and allocation to waste stream

General area	Cold water (L)	Warm water (L)	Hot water (L)	Total water (L)	Allocation
Receival yards	40 000	0	0	40 000	Truck wash S8
Undercover yards	164 700	0	0	164 700	antemortem S7
Maintenance workshop No.1	2356	0	0	2356	Misc S23
Maintenance workshop No.2	780	0	80	860	Misc S23
Hook room	1338	384	5453	17175	Kill floor S12
Offal room	25588	12266	12960	50814	Offal S24
Tripe room	214954	25512	130800	371266	Tripe S17
Intestine room	55968	8764	10560	75292	Intestines S13
Pet food room	23040	0	2000	25040	Offal S24
Slaughter floor anteroom	1130	9816	24120	35066	Kill floor S12
Slaughter floor	366949	192038	296847	855834	Kill floor S12
Sides chillers	0	0	51000	51000	Chillers S20
Boning room anteroom	0	16068	89800	105868	Boning room S9
Boning room	0	16416	3264	19680	Boning room S9
Frozen packing	120	2394	1936	4450	
Vacuum bagging	0	272	0	272	Boning room S9
CL testing	0	204	0	204	
Vacuum packing	0	144	39312	39456	Boning room S9
Load out	23138	247	0	23385	
Engine room	129900	0	0	133500	Cooling towers
Boilers	44000	0	0	44000	not included
Saveall	31410	0	12270	43680	WWTP S25
Rendering	0	36	91655	91691	Split S16 & S15
Main office	2087	0	0	2087	Misc S23
Production office No.1	4532	0	0	4532	Misc S23
Production office No.2	705	0	0	705	Misc S23
Male amenities	17570	2880	0	20450	Amenities S19
Male lunch room	6741	0	8300	15041	Amenities S19
Female amenities	10080	720	0	10800	Amenities S19
Female lunch room	2820	0	0	2820	Amenities S19
Laundry	800	0	25200	26000	Amenities S19
Canteen	1260	0	0	1260	Misc S23
Engineering office	94	0	0	94	Misc S23
Training room	164 700	0	0	164 700	
Laboratory	2045	0	0	2045	Misc S23
HR office	483	0	0	483	Misc S23
Security	0	0	0	0	Misc S23
Self insurance	41	0	0	41	Misc S23
AQIS	1596	0	0	1596	Misc S23
Foreman's lunch room	1065	0	0	1065	Misc S23
Cleaners	595600	0	0	595600	Cleaning S14
Totals	**1,772,905**	**288,161**	**805,557**	**2,870,223**	

Appendix 3: Stream Composition

Tables A3.1 and A3.2 present results of measurements performed by N Lucock on-site (temperature and pH) and the results of analyses of stream samples performed by ALS Environmental. To obtain the stream concentrations for Table 3, the average value from the morning and afternoon shifts was calculated on the presumption that they formed a set of duplicates. Where the calculated average was outside typical industry values, only the more appropriate set was used. This judgement was done on a contaminant by contaminant basis.

Where no entries exist for a waste stream it is because it was not possible to obtain samples for analysis for that stream. Table 3 (in text) concentrations for these streams was obtained from industry waste stream database held by Johns Environmental.

Table A3.1 Morning Shift Stream concentrations

Source	Code	TCOD	SCOD	TSS	O&G	TKN	NH_3N	TP	FRP	Cl	Ca	Mg	Na	pH	EC	Temp
Units		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	-	µS/cm	^oC
Kill floor																
Kill floor red 1	S12															
Boning Room	S9	142	92	55	49	5.4	0.056	0.29	0.005	33	15	3	18	7.21	177	45.4
Kill/Boning clean	S14															
RM Bin (inside)	S1	55,000	10,700	22,400	2,830	3,780	447	424	406	1,910	23	50	1,780	6.37	11,100	24.2
RM Bin (outside)	S2	27,200	9,660	10,000	1,490	1,740	202	265	243	1,240	8	32	1,330	6.55	7,230	29.6
HTR condensate	S3	583	426	52	211	621	211	0.25	0.067	93	0.5	0.5	0.5	9.08	1,000	36.5
Trommel wash	S4	2,080	335	3,450	1,010	58.9	1.67	8.84	2.77	45	14	4	35	6.95	283	56.3
HT Stickwater	S15	7,040	4,570	3,000	1,810	103	43.4	30.8	7.41	68	10	4	49	7.46	730	67.6
Blood decanter	S5	58,500	9,010	11,100	21	5,600	111	127	68.2	3,420	10	8	2,260	8.50	11,300	62.4
Misc wash	S16															
Paunch dump dry	S18	55,000	17,900	22,700	2,080	3,400	255	270	125	292	38	20	404			
Umbrella wash	S6	364	398	670	471	273	79.2	136	84.2	146	19	10	202	7.47	1,850	33.2
Tripe processing	S17															
Intestines	S13															
Offal & pet food	S24															
Antemortem yards	S7	1,190	304	424	30	216	167	29.8	23.5	127	22	8	107	8.48	2,080	27.8
Truckwash	S8	1,880	253	1,440	31	183	136	31.7	30.4	120	31	13	114	8.29	1,750	25.1
Miscellaneous	S23															
Anaerobic pond	S11	5,790	3,450	1,530	281	222	80.8	37.5	33.6	133	5	6	160	7.45	1,520	40.4
Pre Saveall	S10	6,590	3,700	2,660	1,220	198	23.6	25.9	14.2	115	7	4	108	7.14	810	48.9

Table A3.2 Afternoon Shift Stream concentrations

Source	Code	TCOD	SCOD	TSS	O&G	TKN	NH_3N	TP	FRP	Cl	Ca	Mg	Na	pH	EC	Temp
Units		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	-	µS/cm	°C
Kill floor																
Kill floor red 1	S12															
Boning Room	S9	65	51	21	22	1.4	0.582	0.44	0.199	31	14	3	18	7.05	209	39.8
Kill/Boning clean	S14															
RM Bin (inside)	S1	34,200	23,400	4,700	214	3,260	317	351	329	1,280	16	41	1,030	6.28	9,530	25.3
RM Bin (outside)	S2	16,400	11,800	5,000	3,690	1,170	61.2	46.3	45.4	595	12	13	396	6.31	2,800	27.6
HTR condensate	S3	469	361	41	84	192	153	<0.01	0.01	90	0.5	0.5	0.5	9.36	862	38.2
Trommel wash	S4	6,720	160	1,820	1,710	64.7	2.09	5.88	5.19	62	12	3	33	6.52	308	53.2
HT Stickwater	S15	46,000	288	13,200	2,580	72.5	32.5	11.5	8.93	44	8	4	44	6.82	673	66.2
Blood decanter	S5	27,300	6,970	11,500	37	2,800	131	113	29.1	3,760	7	8	2,300	7.58	13,800	66.8
Miscellaneous wash	S16															
Paunch dump dry	S18															
Umbrella wash	S6	1,240	1,120	6,340	114	278	194	150	119	366	17	11	670	7.91	5,130	29.3
Tripe processing	S17															
Intestine processing	S13															
Offal & pet food	S24															
Ante-mortem yards	S7	1,150	987	408	27	258	191	23.8	17.9	318	24	3	141	8.90	355	27.1
Truck wash	S8	1,430	367	548	32	128	45.5	32.7	7.83	222	57	32	140	7.80	3,020	25.3
Misc	S23															
Anaerobic pond	S11	5,850	1,120	2,020	406	243	121	58.9	50.4	129	<1	4	184	6.98	2,250	37.6
Pre Saveall	S10	11,900	3,510	5,300	1,800		43.3	10.2	9.72	80	5	5	66	6.74	921	46.7