final report

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Wastewater Treatment for a Small Scale Integrated Abattoir

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Abstract

Wastewater treatment processes in small abattoirs require cost effectiveness and operational ease while still achieving environmental compliance. The abattoir is a typical small, mixed species abattoir whose current wastewater treatment involves primary screening and on-site irrigation. This report explores selecting suitable wastewater treatment units to sustainably support their planned 50% production expansion.

Current wastewater characterisation, irrigation modelling and computer design provided the necessary support information to evaluate options for the abattoir. The proposed wastewater treatment design involves retaining the existing primary screening and adding a new anaerobic pond (naturally crusted but lined), a sequencing batch reactor with disposal of waste sludge and treated effluent to the existing (but enlarged) land irrigation system.

This treatment system is suitable for organic and nutrient removal from wastewater from small scale integrated abattoirs at reasonable capital cost and operational simplicity.

Executive Summary

This project was carried out at a small, mixed species abattoir with on-site render plant located on the Darling Downs, Queensland. Beef, lamb and pig are all processed daily for the domestic market. Currently wastewater is irrigated directly after primary screening. Cropping and vegetation removal from the irrigation area provides nutrient removal. However, the wastewater treatment system requires significant upgrading to provide a sustainable outcome for the planned 50% production expansion over the next 5 years.

Typical meat industry database wastewater compositions are not applicable to the abattoir. Small scale abattoirs produce wastewater that is significantly different to larger scale abattoirs due to several factors including different kill chain arrangements, quite different animal mixes on days during the week and frequently little or no blood segregation and processing

To lay a good foundation for the wastewater upgrade, a wastewater characterisation campaign was undertaken at the abattoir over three typical processing days in June 2013 to measure flowrates and wastewater composition. Final wastewater flows were measured during production and cleaning hours. A non-invasive ultrasonic liquid flow meter measured and recorded the instantaneous flowrates on the final discharge line between the main pit and the irrigation area.

Current average wastewater flows during the production and cleaning hours were 70 and 12 kL/d respectively. Wastewater samples collected from the central collection pit during production and cleaning hours provided composition data. Onsite analysis provided pH, conductivity and temperature data. Laboratory analysis provided BOD_5, COD, O&G, TSS, TN, NH_3 and TP concentrations. Table 1 summarises the overall daily wastewater composition results for the current effluent stream.

Table 1: Summary of Current Effluent Composition

Parameter	Unit	Overall
pH		7.5
pH range		7.0 to 9.0
EC	µS/cm	1,410
Winter Temp	°C	21.4
Summer Temp	°C	29.0
BOD	mg/L	3,600
COD	mg/L	8,160
O&G	mg/L	450
TSS	mg/L	2,300
TN	mg/L	790
NH_3	mg/L	25
TP	mg/L	43

Future wastewater flows are predicted to increase proportionally with the production expansion as the time of operation and floor area increase. Flowrates are calculated to be 92 and 18 kL/d during processing and cleaning periods respectively. The predicted total future wastewater flowrate is estimated to be 110 kL/d. Future effluent is assumed to have approximately the same composition with the current wastewater treatment system.

FSA Consulting was contracted to conduct hydraulic and nutrient balance modelling using current and estimated future wastewater loads on the abattoir's irrigation area. Current irrigation on the 10.3 hectares was found to be unsustainable despite good management practices. A high nitrogen loading was the primary issue.

Three options were explored to assess future sustainable irrigation options.

1. **Purchase more land for irrigation**. Sustainable irrigation of future nitrogen loads (without blood capture) required a total land area of between 75 and 113 hectares. Land areas would approximately halve if blood processing was introduced. Investigations by the abattoir found that purchasing more land was a high cost option.

2. **Blood capture**. Blood contains very high nitrogen levels. Calculations indicated that capturing blood during processing halved nitrogen loadings in the wastewater. However, the residual nitrogen loads remained unsustainable even when irrigating screened wastewater on the extended land area available onsite (~15 hectares).

3. **Blood capture & wastewater treatment to reduce nitrogen**. Sustainable irrigation using the proposed 15 hectares of irrigation land required an upgraded wastewater treatment to achieve nitrogen concentrations of 100 mg/L to 160 mg/L and phosphorus concentrations of 16 mg/L to 26 mg/L.

Improved wastewater treatment after blood capture from the beef and swine processing (Option 3) was chosen as the preferred option to ensure non-odorous, sustainable on-site irrigation.

The proposed wastewater treatment upgrade will involve construction of a new anaerobic pond, a new sequencing batch reactor (SBR) and expansion of the irrigation area. A lined 1ML anaerobic pond will significantly reduce the organic load through a simple, cost effective treatment unit. The downstream SBR will remove nitrogen through a controlled operational cycle to generate treated effluent suitable for sustainable irrigation to land.

The overall wastewater treatment upgrade will require an approximate capital outlay of $320,000 ex GST. This expense will cover the installation of the anaerobic and SBR as HDPE-lined ponds, a 22 kW surface aerator, submersible pump and miscellaneous control instruments and civil works. Annual operating expenses of approximately $45,000 will cover increased labour hours, electricity, maintenance and analytical testing. The above costs do not include blood capture or irrigation area upgrade and operation.

The proposed wastewater treatment upgrade is feasible for a small integrated processing abattoir such as the abattoir. All of the proposed treatment processes are well established in the meat industry. This upgrade will complement the process expansion at the abattoir.

Contents

1.0 Introduction

The project was carried out at a small mixed species abattoir with render plant in Queensland.

The wastewater is currently irrigated after screening. Crops are grown to remove nutrients. The abattoir throughput is continually increasing and it is planned to further expand its operation by an estimated 50% over the next 5 years. The abattoir initiated this project to explore the impact of this increase in operations on the sustainability of its wastewater treatment and land irrigation system.

This report presents the outcomes of the project which included sampling results from the existing wastewater treatment system, an irrigation loading analysis and proposed upgrade to process increased loads produced by future expansion.

2.0 Background

2.1 Site Description

The abattoir is located approximately 1 kilometer from the township. Figure 1 highlights the abattoir, irrigation area and township.

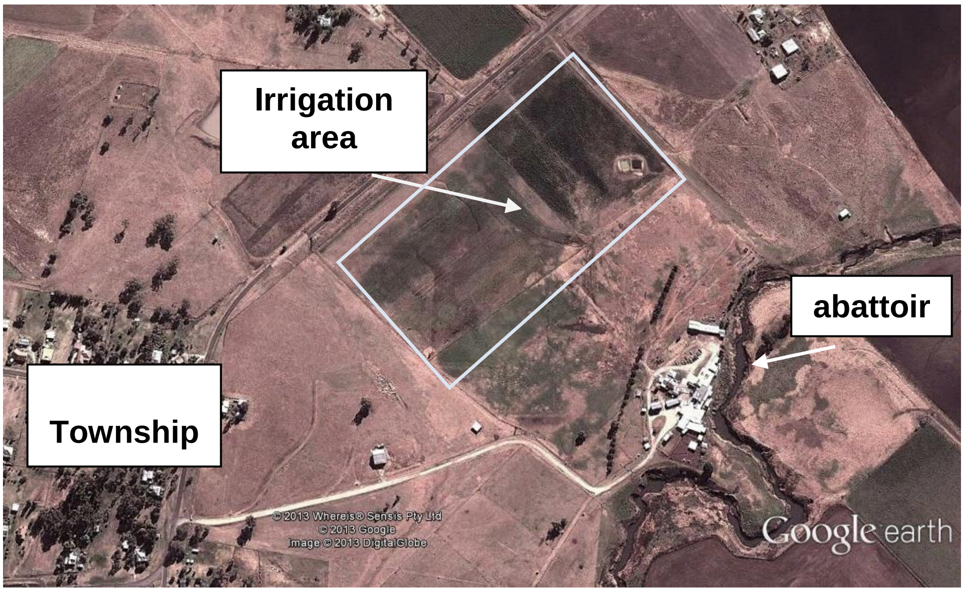


Figure 1: The Abattoir locality. Google Earth Jul 2013 (image date 7/5/11)

The total land area owned by the company is 36.07 ha. The land consists of a number of portions, as listed in Table 2. Irrigation land covers 12.65 ha of this property area and is instrumental in the overall wastewater treatment strategy.

Table 2: Real Property Description

Lot No	Plan No	Area (ha)
5	RP 218122	6.073
2	RP 166646	12.428
196	D342	8.903
197	D342	8.903
Total		36.307

2.2 Climate Data

Climatic information needed to estimate treatment process operating temperatures was sourced from Bureau of Meteorology. The data covers the period from 1994 until present. The mean max summer air temperature is 31.9°C (January) and mean max winter temperature is 19.6°C (July). These temperatures are important for the design of biological treatment plants.

2.3 Process Description

Beef, lamb and pig are all processed daily for the domestic market. Table 3 shows the median current weekly production from the 2012/13 financial year and project defined current and future production numbers. Operation is single shift 5 days per week, 260 days per year. Production typically starts at 5am and concludes at 3pm to 4pm. Rendering continues to run to approximately 10pm until the daily material is processed.

Table 3: Production Numbers

Species	Units	Median 2012/13	Project Current	Project Future
Beef	head/wk	377	360	540
Lamb	head/wk	1423	1300	1950
Pig	head/wk	399	360	540

High temperature rendering, consisting of 2 batch cookers and associated processing equipment processes onsite waste organic material from the abattoir. Blood processing is not currently conducted on-site.

Other processing includes:

- Cattle hides are shipped off-site in green condition.
- Sheep pelts are dry salted on-site. Hide salting waste brine is collected separately and sent to evaporation pond. Brine does not enter the wastewater stream.
- Human wastes are collected separately and treated through an on-site septic system and adsorption trench.

2.4 Existing Wastewater Treatment System

Wastewaters from the stock holding pens and kill floor pass are pumped to an overhead collection tank (Photo **1**), and gravity fed to a rotary screen (Photo 2) and then into the central collection pit (Photo 3).

The by-products plant wastewater is pumped intermittently from a separate pit into the central collection pit. The contents of the central collection pit are pumped directly to the irrigation area through travelling irrigators (Photo 4). Nutrients are removed from the irrigation site through vegetation cropping.

Photo 1: Wastewater Treatment area showing overhead tanks

Photo 2: Rotary Screen

Photo 3: Central Collection Pit

Photo 4: Travelling Irrigator

3.0 Wastewater Flow

This section presents wastewater flow analysis as measured during sampling campaign from the 4th to the 6th June 2013. Flows were validated against water usage data.

3.1 Methodology

Instantaneous flow rate of the final wastewater discharge was measured over 3 production days from the 4th to the 6th June 2013. A non-invasive GE Panametrics PT878 Ultrasonic liquid flow meter was installed on the final discharge line between the final collection pit and the irrigation area. This device recorded the instantaneous flowrate within the pipe every minute.

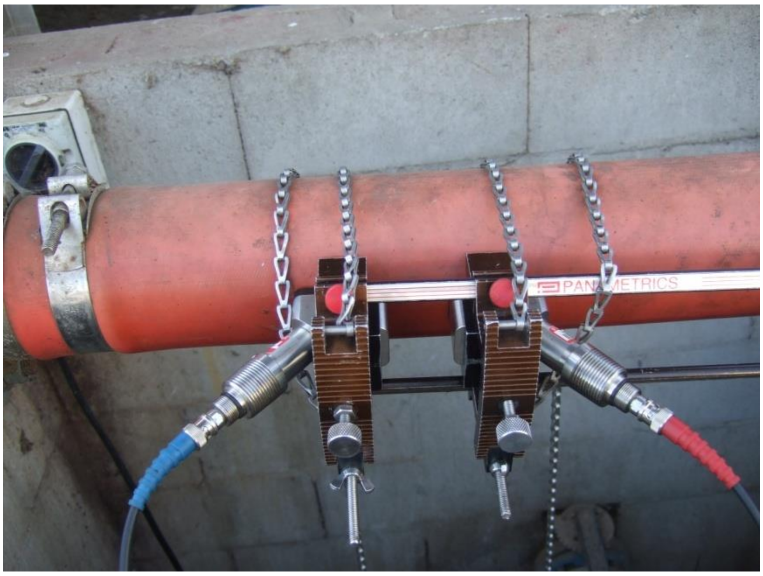


Photo 5: Flow meter installed on final discharge line

3.2 Daily wastewater flow results

Figure 2 shows the hourly wastewater volume pumped to the irrigation area over the production day. Wastewater flow is concentrated between the production hours of 6am and 6pm. Zero values during production hours were due to a flowmeter malfunction on the 4th June and an effluent pump malfunction on the 6th June. Further smaller flows until 11pm are due to on-site cleaning.

Table 4 and Table 5 present the production number and hours of processing during the investigation period. Whilst the production numbers were variable they were within the typical current range presented in Table 3.

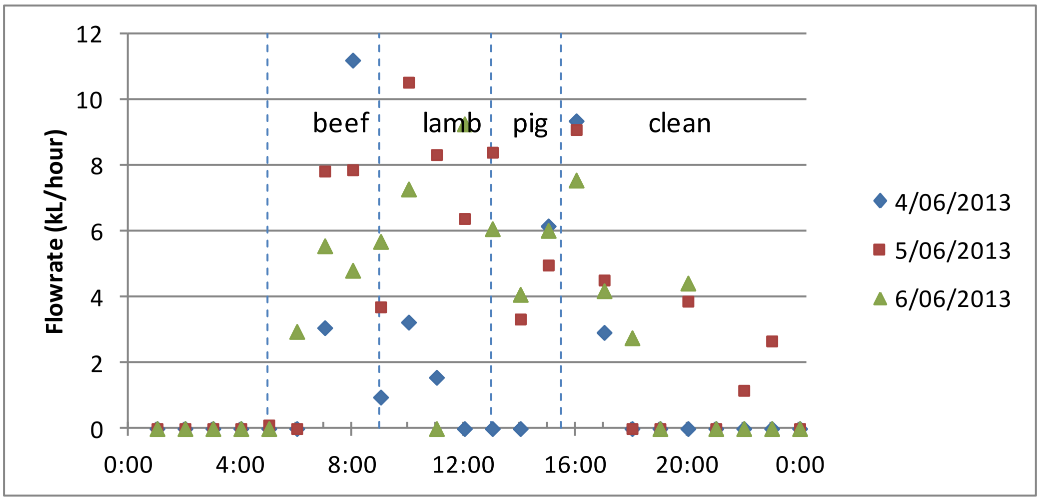


Figure 2: Hourly Wastewater Flow to Irrigation Area

Table 4: Production Numbers during Investigation Period

Date	Beef No	Lamb No	Pig No
4/06/2013	89	386	39
5/06/2013	101	266	134
6/06/2013	84	239	121

Table 5: Processing Times during Investigation Period

Date	Beef start	Beef end	Lamb start	Lamb end	Pig start	Pig end
4/06/2013	5:00	9:10	9:15	13:24	13:42	14:44
5/06/2013	5:00	9:17	9:15	11:38	12:10	15:33
6/06/2013	5:29	9:27	9:33	12:14	12:52	15:55

Table 6 presents the measured wastewater flows. The hours of production were used to estimate the portion of wastewater produced by each of the species processed. Due to missing flow data, beef and lamb wastewater volumes on the 4th June were calculated using water efficiencies from 5th & 6th June. The daily production wastewater volume was proportional to the production number of each species while the daily cleaning wastewater volume was relatively constant.

Table 6: Measured Wastewater Flows during Investigation Period

Species	unit	4/06/13	5/06/13	6/06/13
Beef	kL	22.2	22.2	22.7
Lamb	kL	46.3	22.6	19.0
Pig	kL	6.2	25.8	17.7
Cleaning	kL	12.3	12.2	11.4
Total	kL	87.0	82.9	70.8

Note: values in red represent calculated volumes

The current and future wastewater volumes are presented in Table 7. Wastewater production for each species is calculated from the current and future production numbers in Table 3.

Current cleaning volumes are the average of the measured values. Cleaning volumes are assumed to increase proportionally to floor area as the number of stock holding pens and processing areas to clean increase. Production wastewater volumes are assumed to increase proportionally to processing numbers.

Table 7: Summary of Current and Future Wastewater Flows

Species	Units	Current	Future 50% expansion
Beef	kL/d	24	35
Lamb	kLd	34	41
Pig	kL/d	12	16
Cleaning	kL/d	12	18
Total	kL/d	82	110

4.0 Wastewater Composition and Loads

This section summarises the composition of the wastewater discharged to the irrigation area.

4.1 Methodology

The central collection pit provided a single, well mixed location for representative sampling of the final wastewater effluent. The effluent was sampled both manually and using an autosampler over 3 production days using 3 sampling techniques.

1. Three manual samples were collected each day with during the processing period of each species. These results are represented by the red square, green triangle and purple circle for the 4th, 5th and 6th June results respectively in the figures below.
2. An auto sampler collected 11 individual samples over the production day and cleaning hours on the 4th June. These results are represented as the blue diamonds in the following figures. The flow averaged concentration calculated from these results and the process shift flow are represented by the grey bar to the left of each figure.
3. An auto sampler collected a composite flow proportional sample over the production day and cleaning hours on the 5th and 6th June. The blue and orange bar to the left of each figure represents these results.

The physical parameters pH and conductivity were also analysed onsite with a HACH HQ40d. Off site laboratory analysis delivered further information on the wastewater organic, nutrient and other properties.

A tinytag temperature monitoring device logged wastewater temperature in the central collection pit over 3 days in June 2013 and 6 days in March 2014 to obtain design wastewater temperatures for the design of biological treatment.

4.2 Physical Parameters Results

4.2.1 pH

pH data collected from onsite analysis is presented in Figure **3**. Most of the pH results for the primary-treated wastewater were within the range of 6.5 to 8.0 with the composite values being between 7.3 and 7.6. This pH range is suitable for biological treatment.

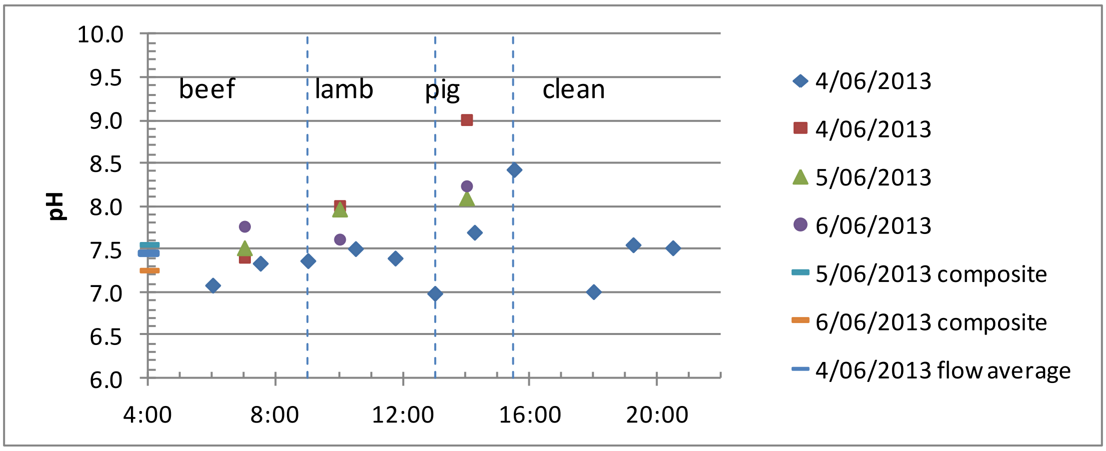


Figure 3: Onsite pH results

4.2.2 Electrical Conductivity

Electrical conductivity data collected from onsite analysis is presented in Figure 4. The electrical conductivity is approximately 1,600 µS/cm during production hours but drops to low values during cleaning. The composite values were consistent over the three process days with a median value of 1,450 µS/cm. This electrical conductivity will not be problematic for future biological treatment.

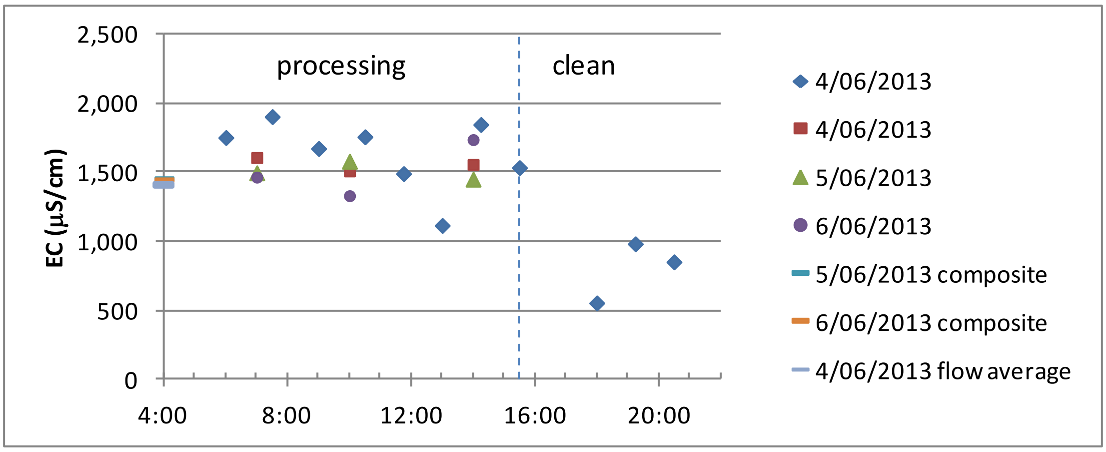


Figure 4: Onsite Electrical Conductivity Results

4.2.3 Temperature

Wastewater temperature in the central collection pit is presented in Figure 5 and Figure 6 for winter and summer respectively. The temperature was quite variable day to day with an average production day flow weighted value of 21.4°C in winter and 29.0°C in summer. This is a low temperature range compared to larger export meat processing facilities which usually produce effluent in the range 30 – 40°C).

The low temperature will affect the rate of treatment for any future biological wastewater treatment units.

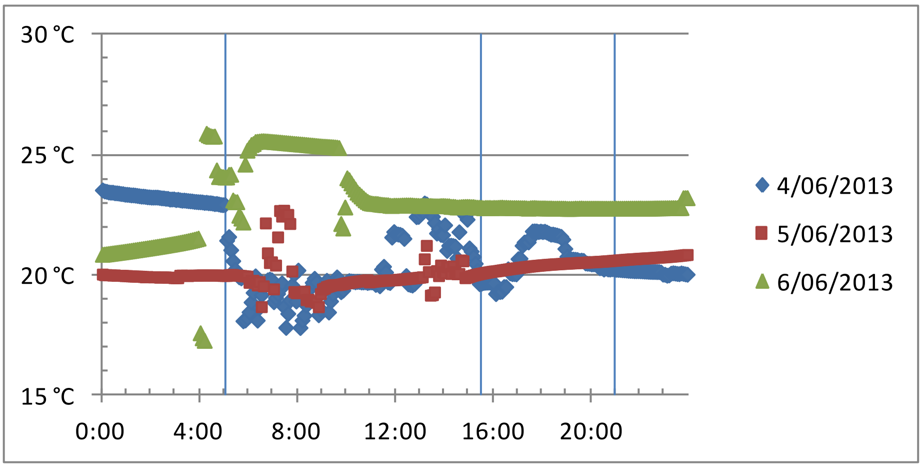


Figure 5: Winter Onsite Temperature Results

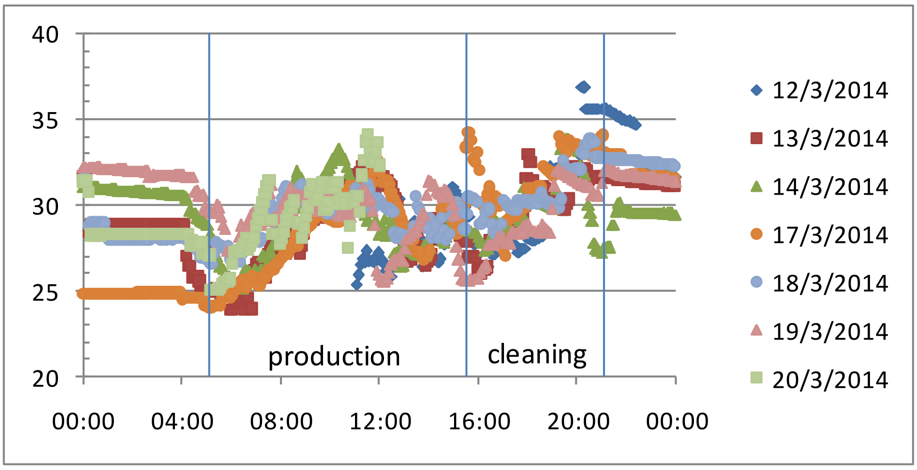


Figure 6: Summer Onsite Temperature Results

4.2.4 Physical properties value and load summary

Table 8 summarises the mean values of physical properties measured for the processing and cleaning shifts. The flow weighted values for current and future are also included in Table 8. For pH and temperature, the range of values will also be considered in the design.

Table 8: Median values of physical parameters

	pH	pH range	Conductivity (µS/cm)	Temperature (°C) Winter	Temperature (°C) Summer
Processing	7.7	7.0 to 9.0	1,580	21.4	28.8
Cleaning	7.5	7.6 to 8.2	800	21.3	30.3
Flow weighted median value	7.45	1,410	1,410	21.4	29.0

4.3 Organic Constituent Results

4.3.1 BOD_5 concentrations

BOD concentrations in the wastewater display a wide range of values during each sampling day as shown in Figure 7. BOD is generally higher in the morning during the beef processing shift. Lower values were found during lamb processing, lower again during pig processing and a further reduction during cleaning. The daily BOD values are relatively similar for the 3 processing days with a median value of 3,600 mg/L. The median BOD during the processing and cleaning periods was 4,150 mg/L and 420 mg/L respectively.

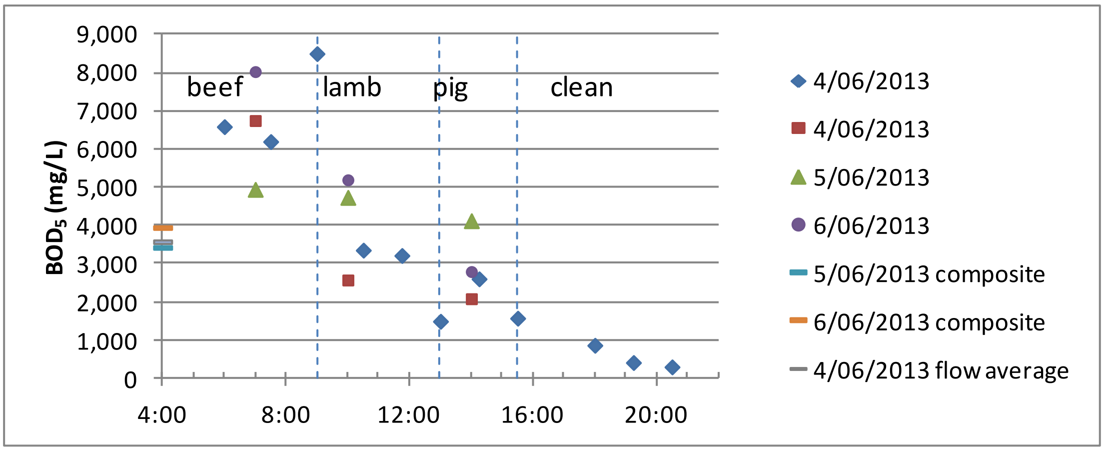


Figure 7: BOD results

4.3.2 COD concentrations

COD values are shown in Figure 8. These values also reduced considerably across the processing day with the highest during the beef processing and the lowest during the cleaning. The median daily COD concentration was 8,700 mg/L. The median COD during the processing and cleaning periods was 9,300 mg/L and 1,500 mg/L respectively.

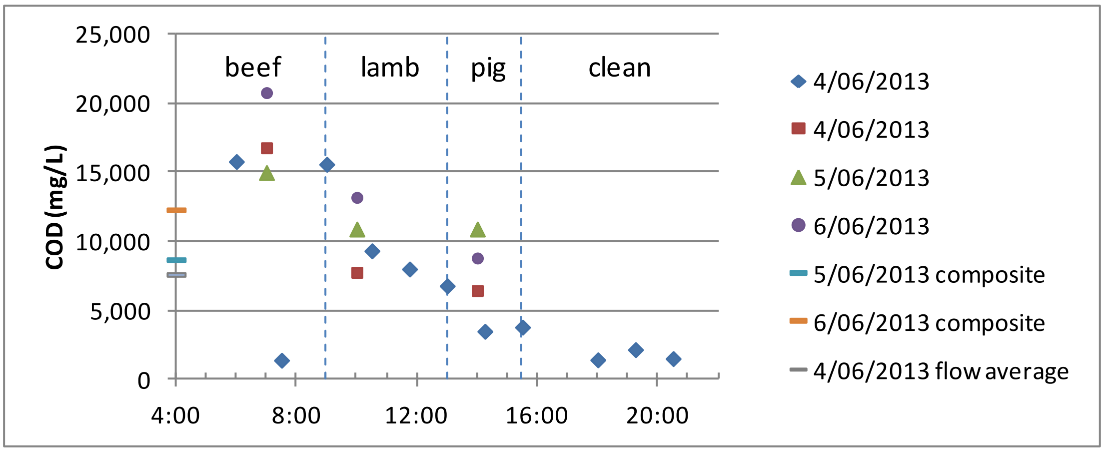


Figure 8: COD results

4.3.3 Oil and grease concentrations

Oil and grease values, shown in Figure 9, were generally very low. There was an unusually high concentration reported in the one grab sample and for the overall daily composite on the 6th June 2013. It is likely that little oil and grease is entrained in the wastewater due to the cold water temperatures. The oil and grease value from the 5th June daily composite of 450 mg/L is chosen as the representative value. This value is still higher than all the other grab samples.

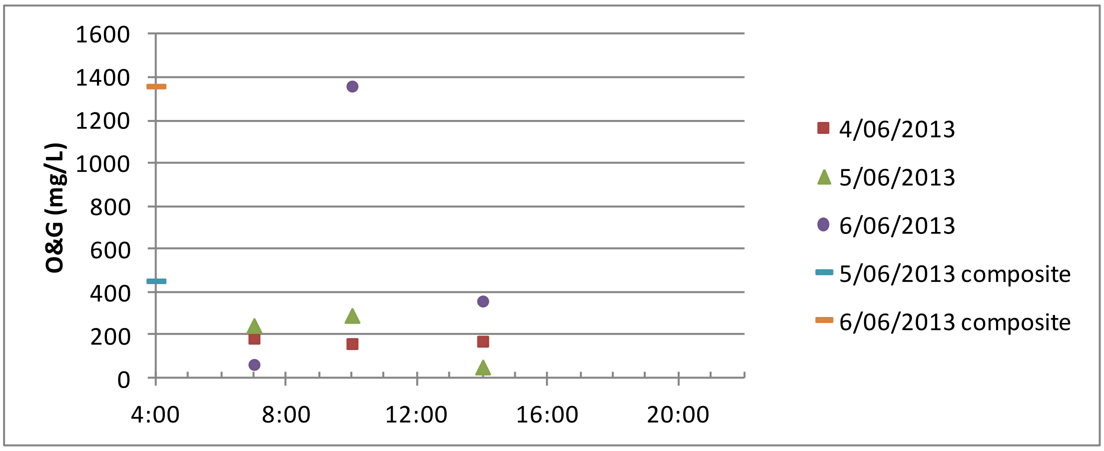


Figure 9: Oil and grease results

4.3.4 TSS concentrations

Total suspended solids levels, shown in Figure 10, are highly variable. There appears to be a peak in the TSS concentration in the period of pig processing. The median daily TSS concentration was 3,150 mg/L (median of daily composite values). The median TSS concentration (grab and individual sample values) during the processing and cleaning periods were 2,500 mg/L and 1,100 mg/L respectively.

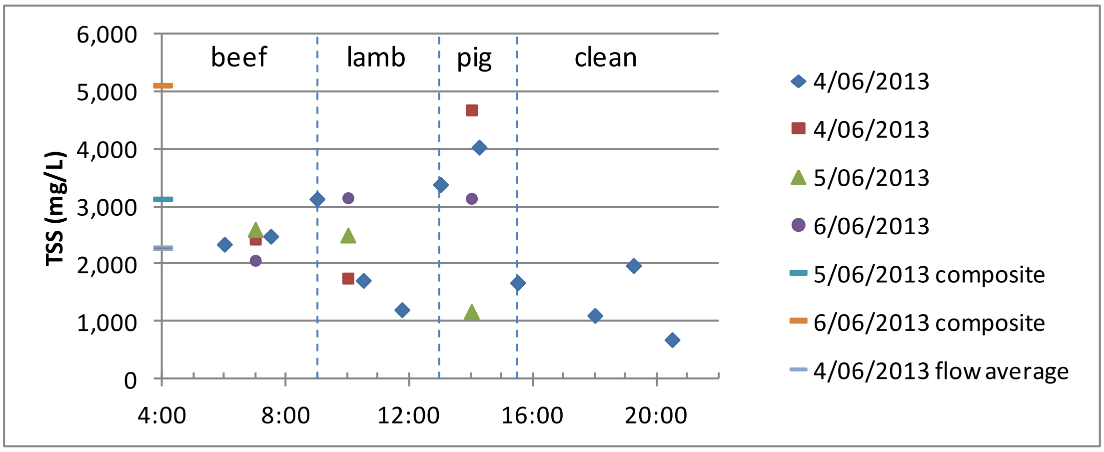


Figure 10: Total suspended solids results

4.3.5 Organic constituents load and concentration

Table 9 summarises the organic constituent design concentrations and the corresponding daily loads. The current loads were calculated using the current processing and cleaning flows from Table 7. The future loads are assumed to increase proportionally with production. While wastewater flows may not increase proportionally due to water efficiency saving, the wastewater composition is likely to increase in concentration.

Table 9: Summary of organic constituent load and composition.

	Flow (kL/d)	BOD (mg/L)	COD (mg/L)	O&G (mg/L)	TSS (mg/L)
Processing	70	4,150	9,300		2,500
Cleaning	12	420	1,500		1,100
Overall	82	3,600	8,160	450	2,300
Current production day load (kg/d)		300	670	35	190
Future production day load (kg/d)		**440**	**1,000**	**55**	**280**

4.4 Nutrient Results

4.4.1 TN concentrations

Total nitrogen results are shown in Figure 11. Nitrate and nitrite concentrations were undetected or insignificant in all samples. Total nitrogen was very high during the morning beef processing shift. This is likely to be due to the large volume of blood that enters the wastewater during this period. The average total nitrogen concentration is 790 mg/L.

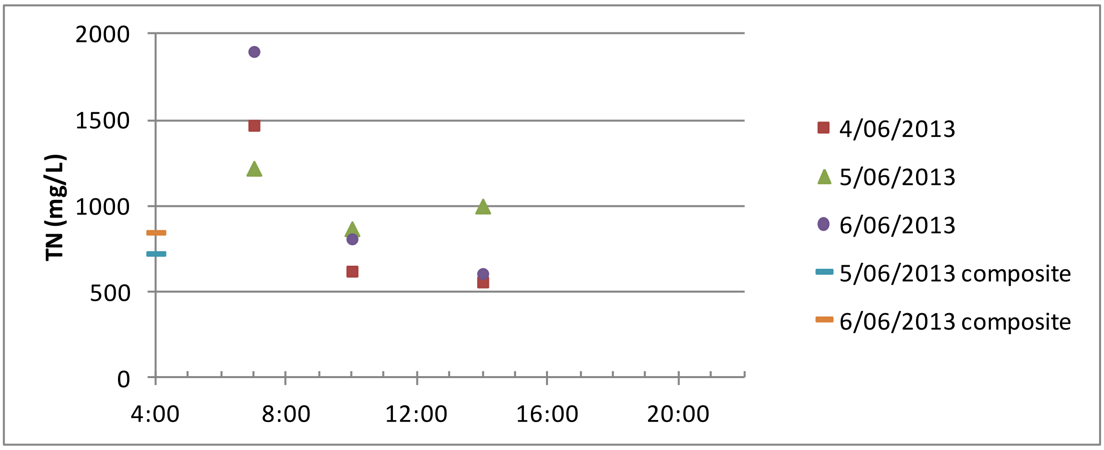


Figure 11: Total Nitrogen Results

4.4.2 Ammonia concentrations

Ammonia concentrations were low as shown in Figure 12. The composite result collected on the 5th June of 25 mg/L seem to be the most representative value.

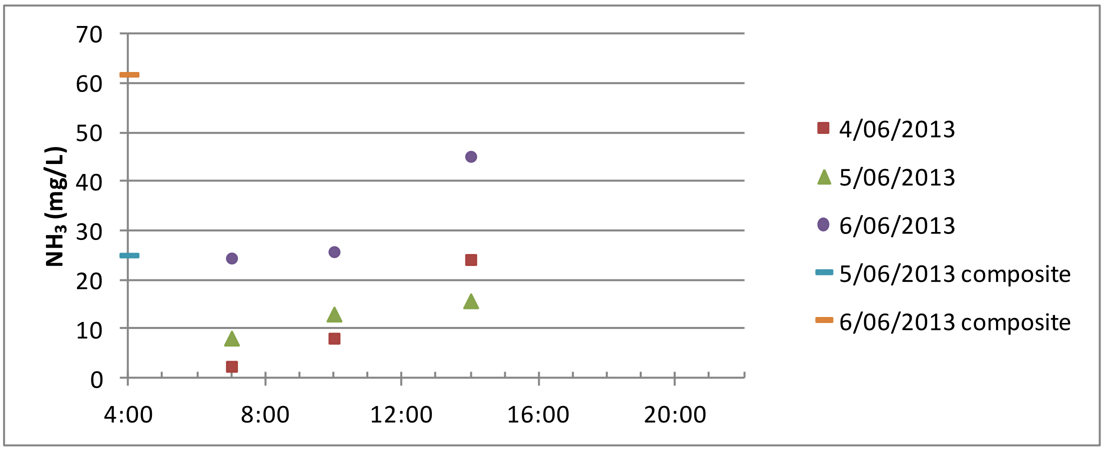


Figure 12: Ammonia Results

4.4.3 TP concentrations

Total phosphorus concentrations, shown in Figure 13, were fairly consistent over each production day. The average total phosphorus concentration was 43 mg/L

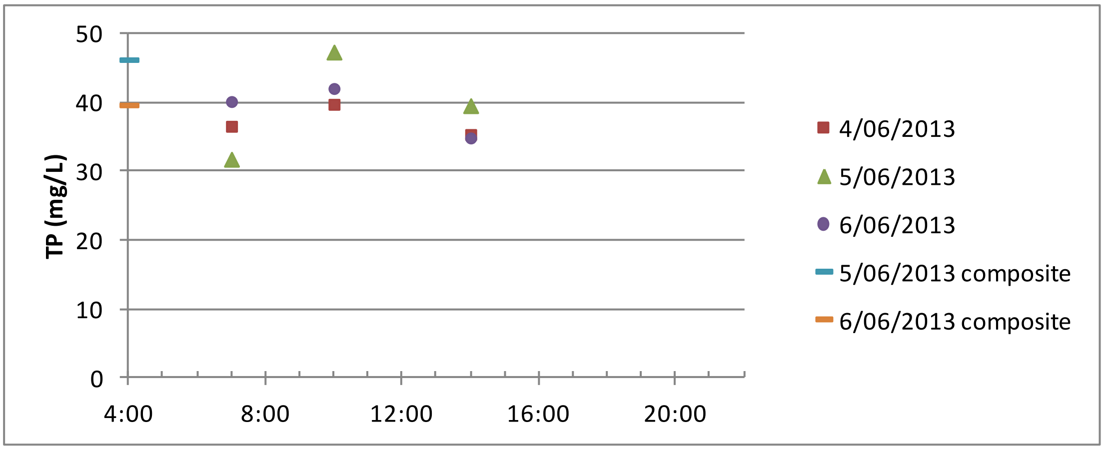


Figure 13: Total Phosphorus Results

4.4.4 Nutrient concentration and loads

Table 10 summarises the nutrient concentrations and the daily loads. The current loads were calculated using the current wastewater flow from Table 7. The future loads were assumed to increase proportionally with production (multiply the current loads by 1.5).

Table 10: Summary of organic constituent load and composition.

	Flow (kL/d)	TN (mg/L)	NH_3 (mg/L)	TP (mg/L)
Overall	82	790	25	43
Current production day load (kg/d)		**65**	**2.0**	**3.5**
Future production day load (kg/d)		**100**	**3.1**	**5.3**

4.5 Miscellaneous Parameter Results

Selected cation and anion concentrations were also measured in the composite samples collected on the 6th June. Table 11 presents these concentrations.

Table 11: Cation, anion and alkalinity results

Parameter	Units	6th June 2013
Sulphate	mg/L	5
Chloride	mg/L	179
Total Alkalinity	mg/L	433
Calcium	mg/L	169
Magnesium	mg/L	27
Sodium	mg/L	167
Potassium	mg/L	64

4.6 Current and Future Wastewater Composition Summary

The wastewater flows and organic and nutrient loads are summarised in Table 12. The current daily wastewater flow 82 kL/day is based on a throughput of cattle, lamb and pig of 360, 1300 and 360 head/week respectively. The future wastewater flow of 110kL/day was calculated from the current flow and a proportional increase with production.

Table 12: Summary of current and future wastewater flow and loads

Parameter	Unit	Current	Future
Flow	kL/d	82	110
pH		7.5	7.5
Temperature	^oC	21 to 29	21 to 29
COD	kg/d	670	1,000
BOD_5	kg/d	300	440
O&G	kg/d	35	55
TSS	kg/d	190	280
TN	kg/d	65	100
TP	kg/d	3.5	5.3

5.0 Irrigation Modelling

Justin Galloway of FSA Consulting was engaged to undertake hydraulic and nutrient balance modeling using current and future wastewater loads on the abattoir irrigation area. Justin is thoroughly familiar with the site and performed the original assessment for the abattoir in 2004. The MEDLI model incorporating the soil data for the site, climate data, the latest soil sampling data and current irrigation management practices formed the basis of the sustainability assessment. The full irrigation report is provided in Appendix A.

5.1 Irrigation Area

The current effluent irrigation area at the abattoir is approximately 10.3 hectares on the new northern paddock that has been used for irrigation since early 2011. Crops are baled and removed from site to facilitate nutrient removal.

It is possible for the future irrigation land size to be increased by 50% with expansion into the top half of the former southern paddock. This would provide a total land area of 15 hectares nominal.

5.2 Irrigation Loading of Current and Future Wastewaters

Irrigation modeling of current and future wastewaters with the current wastewater treatment used the parameters listed in Table 13. Future irrigation area assumed the use of the full 15 hectares available, increased wastewater flow and the same nutrient concentration and irrigation scheduling as current.

Table 13: Current and future wastewater irrigation inputs (existing wastewater treatment)

Parameter	Unit	Current Value	Future Value
Irrigation area	ha	10.3	15
Wastewater flow	kL/d	82	110
Nitrogen concentration	mg/L	790	790
Phosphorus concentration	mg/L	43	43
Irrigation Schedule		daily	daily

Irrigation modeling found that neither the current nor the future effluent loading is sustainable with the existing wastewater treatment. Table 14 presents the modeling results along with recommended ranges for nitrogen and phosphorus loading. Note that these recommended ranges are appropriate to the abattoir site and should not be applied to other sites in Australia without expert advice.

The current irrigation is unsustainable. Despite excellent irrigation practices, both nitrogen and phosphorus are significantly above recommended irrigation loading rates. Nitrogen poses the greatest challenge being more than 5 times the recommended loading rate.

Future irrigation is also unsustainable even with the greater irrigation land area (15 ha).

Table 14: Current and Future Irrigation Loading (existing wastewater treatment)

Parameter	Units	Recommended	Current	Future
N Loading	kg/ha/yr	200 to 300	1,643	1,514
P loading	kg/ha/yr	30 to 50	89	82

5.3 Investigation Options to Achieve Sustainable Irrigation Loading

Three options to reduce irrigation loading to acceptable ranges were investigated. The basis was operation at the proposed future throughputs. The options were:

1. Capture of beef and swine blood.
2. Increase irrigation area
3. Reduce nutrient concentrations through upgraded wastewater treatment.

Wastewater parameters and modeling results are presented in Table 15 for each of the above options using wastewater flows and composition for the future expansion.

Table 15: Outcomes of Wastewater Irrigation Modelling for Options

Parameter	Unit	Recommended	Blood Capture	Increased Irrigation Area	Nutrient Removal
Irrigation Area	ha		15	75 to 115	15
Wastewater Flow	kL/d		110	110	110
TN concentration	mg/L		420	790	105 to 157
TP concentration	mg/L		43	43	16 to 26
Irrigation Schedule			daily	daily	daily
TN Loading	kg/ha/yr	200 to 300	805	302	301
TP loading	kg/ha/yr	30 to 50	82	17	50

5.3.1 Capturing Beef and Swine Blood

This option did not consider further changes to the existing wastewater treatment.

Capturing blood during beef and swine processing aimed to significantly reduce nitrogen concentration in the wastewater with blood containing approximately 30 g/L of nitrogen[1]. The wastewater nitrogen concentration was calculated to be reduced to 420 mg/L by removing this blood from the wastewater. Calculations assumed that 80% of the 12 L blood per beef head and 4 L blood per swine head was captured and processed separately. Blood capture is more difficult in lamb processing and was not considered practicable.

Modeling found that despite blood capture the irrigation loading is not sustainable. Nitrogen and phosphorus loadings are 3 and 2 times the recommended values, respectively. However, the nitrogen loading is reduced by half compared to the case without blood capture. Further, there is the potential to gain some revenue from processing the blood.

Additional wastewater treatment for nutrient removal is required to achieve sustainable irrigation of the 15 hectares of the abattoir pasture.

5.3.2 Increased Irrigation Area

Irrigation modeling was employed to calculate the land area required to ensure an applied nitrogen loading of 200 to 300 kg/ha/yr. It was found that the sustainable irrigation of future nitrogen loads (without blood capture) would require a total land area of between 75 and 113 hectares. The land area would be approximately halved if blood processing was introduced. The land would need to be close to the abattoir, fitted with irrigation equipment and dedicated to cropping.

Given the not inconsiderable cost of installing biological treatment to achieve nitrogen reduction, the abattoir investigated the availability and cost of purchasing this additional land. They concluded that while it was generally available, the cost sought by sellers was more than that to install treatment.

5.3.3 Reduce nutrient concentration by upgraded wastewater treatment

Modeling of future wastewater irrigation volumes and composition found that increasing the irrigation area to 15 hectares and capturing blood was not sufficient to ensure sustainable irrigation. Consequently, the irrigation model was used to calculate effluent nutrient concentrations targets commensurate with sustainable irrigation of the full flow. These were nitrogen concentrations of 100 mg/L to 160 mg/L and phosphorus concentrations of 16 mg/L to 26 mg/L. The following section discusses the wastewater treatment upgrade required to achieve this degree of nutrient removal.

6.0 Proposed Wastewater Treatment

This section provides an overview of the proposed wastewater treatment plant upgrade at the abattoir. The upgrade seeks to provide consistent treatment of the wastewater generated from the future processing of 540 beef, 1950 sheep and 540 pigs per week. Final effluent will ensure non-odorous, sustainable irrigation on the 15 ha of the abattoir's land available for irrigation.

The proposed upgraded treatment is shown schematically in Figure 14. Proposed new equipment is indicated by coloured shading. This schematic is not intended for construction purposes.

6.1 Target Future Effluent Composition

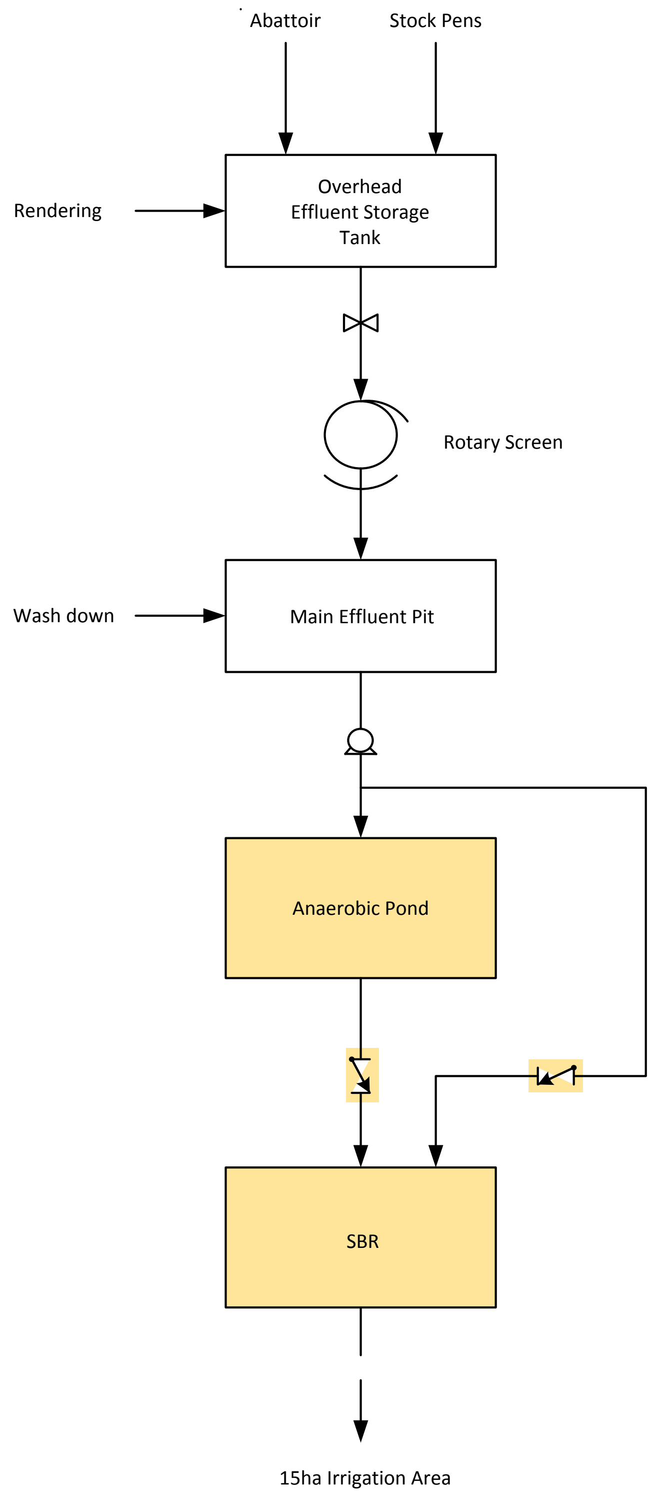
The future effluent composition target seeks to ensure sustainable irrigation and limit odour nuisance. Table 16 presents the current effluent and proposed future target effluent flow and composition.

The target future effluent composition is based on typical organic removals achieved by secondary treatment and the average nutrient concentrations required for sustainable irrigation on the abattoir irrigation land as determined through irrigation modelling (Table 15).

While phosphorus removal is recommended, it is not imperative and has not been considered in the overall wastewater treatment upgrade. This is because the soil has significant phosphorus sorption capacity remaining and its removal from the wastewater is expensive in terms of operating costs and would require alternate processing of waste activated sludge from the SBR system. It can be added at a future date as required.

Table 16: Comparison of Current and Proposed Wastewater Effluent parameters

Parameter	Unit	Current Value	Future Value
Flow	kL/d	82	110
COD	mg/L	8,150	150
BOD	mg/L	3,600	10
O&G	mg/L	450	10
TSS	mg/L	2,300	50
TN	mg/L	790	125
TP	mg/L	43	42



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Preliminary WW Design
Date: 12 May 2014
Dwg No: 65-01 Revision : A

Figure 14: Proposed Wastewater Treatment System (Not for construction)

6.2 Wastewater Treatment Description

There are four parts to the proposed upgrade of the existing wastewater treatment system.

1. Capture blood from beef and swine processing
2. Construct new anaerobic pond.
3. Construct new sequencing batch reactor.
4. Increase irrigation land area.

6.2.1 Capturing blood from beef and swine processing

While capturing blood is not within the realms of wastewater treatment, it is a process improvement that will significantly reduce wastewater treatment costs and merits the highest priority in the waste management hierarchy of eliminating waste. The method, equipment required or logistics of this process upgrade is not discussed further in this document. However, further wastewater treatment upgrades and effluent compositions assume the successful capture of 80% of the beef and swine blood from future processing.

Table 17 highlights typical blood composition and the wastewater composition before and after blood capture. Eighty percent of the blood from beef and swine processing will be a total of 6.9 tonnes of blood per week at future processing rates. Concentrations of COD, BOD and nitrogen decrease significantly with the blood capture.

Table 17: Results of Blood Collection

Parameter	Unit	Blood	Current wastewater with blood	Current wastewater without blood
BOD_5	mg/L	89,000	3,600	2,500
COD	mg/L	178,000	8,200	6,000
TN	mg/L	30,000	790	420
TP	mg/L	60	43	42

6.2.2 Construct new anaerobic pond

Installation of a new anaerobic pond is recommended to cost effectively reduce organic load at the higher wastewater flow generated by the future processing expansion. Anaerobic ponds are the first stage of biological treatment for meat processing effluent, especially for subsequent biological nitrogen removal (BNR) which is hindered at high organic loads.

In the anaerobic pond, anaerobic bacteria break down the complex organic compounds in the wastewater in the absence of oxygen to release carbon dioxide and methane as the main products of decomposition in addition to a small increase in bacterial numbers. These products are gaseous and are released to atmosphere. Sludge production is 10 – 20% that of equivalent aerobic treatment and tends to escape as elevated suspended solids in the anaerobic pond discharge.

Key design parameters and dimensions of the proposed 1 ML anaerobic pond are given in Table 18. These parameters are subject to geotechnical survey and are not for construction. The pond is suitable for handling the design abattoir flow and remains at the lower end of usual industry design values for these types of ponds. These values are calculated on a 7-day basis which allows for the fact that there is negligible weekend load since the abattoir only operates week days. These design values are based on the pond working year-round at water temperatures between 20 – 30°C (see Table 8).

Table 18. Design parameters for the CAL (not for construction)

Parameter	Units	Design
Design Flow	kL/day	110
Design BOD load	kg/d	275
Design COD load	kg/d	660
Pond depth (TWL)	m	4.0
Pond area TWL	m^2	570
Pond Volume (TWL)	m^3	1,000
Design HRT	d	13
Volumetric loading rate	$kgBOD/m^3.d$	0.19
Design BOD removal	%	70
BOD exit load	kg/d	83
Freeboard (above TWL)	m	0.5

Notes: HRT & loading rates are given on a 7-day basis (e.g. allowing for negligible weekend load). TWL – top water level; HRT – hydraulic retention time.

Simple inlet and outlet structures are sufficient. A pond floor and wall liner are strongly recommended to ensure that the permeability meets modern regulatory requirements, especially since there is usable bore water at the site.

The proposal is for a naturally crusted anaerobic pond. This reduces the cost of installing expensive pre-treatment technologies required to protect a synthetic pond cover. The payback for a cover is poor in the absence of carbon tax liability.

6.2.3 Construct new sequencing batch reactor

Installation of the sequencing batch reactor is recommended to reduce the irrigation area nitrogen load to sustainable levels. Through a cycle of aeration, suspension, settling and discharge the soluble nitrogen in the wastewater is converted to nitrogen gas and released to the atmosphere.

The proposed SBR cycle is as follows:

a. Gravity feed from the anaerobic pond via a time controlled valve;
b. Aeration by 22 kW surface aerator for at least 50% of cycle time;
c. Suspension of sludge by slow operation of surface aeration;
d. Settling within basin;
e. Wastewater discharge to irrigation area via submersible pump. Excess sludge will also be discharged directly to the irrigation area to remove need for solids dewatering and disposal, which are very expensive and require supervision.

The SBR will be a HDPE lined pond with an aerator and decanter pump. Proposed dimensions are a 600 m^3 square pond with a liquid depth of 2.5m and a freeboard of 1.0m. Aeration will be provided by a 22kW surface aerator fitted with VSD. Decant will be achieved by a submersible pump suspended just below water surface. This SBR is designed to the specific site conditions at the abattoir.

An automatic control system will be necessary to enable stable, reliable SBR operation. Feedback from a dissolved oxygen and level sensor, along with cycle times, will automatically determine operation of the inlet valve, aerator and decanter pump. This system should run 24 hours per day, 7 days per week with limited manual intervention.

6.2.4 Increase irrigation land area

The increase of irrigation land area to the 15 hectares available on the abattoir existing site is the final step in the overall wastewater treatment upgrade. Simply extending the length of the run of the travelling irrigator should facilitate the extra land area required as the new irrigation land is immediately adjacent to the existing irrigation land. The cost of the irrigation land extension is not included in the Equipment Cost Estimates in Section 6.3.

6.3 Equipment Cost Estimates

Order of magnitude capital costs of the wastewater treatment upgrade are summarised in Table 19. This price includes piping and civils but excludes costs to implement blood capture and expansion of irrigation area. It has a typical accuracy of ±25%.

Table 19: CAPEX for proposed WWTP upgrade

Item	% major CAPEX)	Cost
1 x Anaerobic Pond (with inlet/outlet pit)		$58,500
1 x SBR		$166,500
1 x irrigation pump		$12,000
Sub total major CAPEX		**$237,000**
Contingency	15%	$35,500
Engineering & Admin	15%	$35,500
Commissioning	5%	$11,500
Total CAPEX		**$319,500**

Operating expenses are estimated and summarised in Table 20.

Table 20: OPEX for proposed WWTP upgrade

Item	OPEX ($/yr)
Electricity	$9,650
Chemical	$0
Operating labour	$18,750
Maintenance	$6,200
Analytical	$10,000
Total	$44,600

7.0 Conclusions

The abattoir requires an upgraded wastewater treatment plant to achieve environmental sustainability of future processing effluent. Wastewater volumes will increase significantly and its disposal using current methods will only further exacerbate current environmental challenges.

The proposed wastewater treatment upgrade system is well suited to the small scale operation at the abattoir. Blood capture, anaerobic ponds and sequencing batch reactors are well established and proven technologies in the meat industry. The selected treatment options are economically feasible and configured for operational simplicity for example by co irrigation of waste sludge rather than dewatering and disposal. While the sequencing batch reactor involves mechanical aeration on a timed cycle and a number of control parameters, it is still a relatively simple and cost effective means of nitrogen removal from a high strength effluent stream.

The resultant wastewater treatment system will complement the process expansion planned for the abattoir.

Abbreviations

BOD_5	=	Biochemical Oxygen Demand (measured in 5 days at 20°C) (mg/ℓ).
CAPEX	=	capital expenditure
COD	=	Chemical Oxygen Demand (mg/ℓ)
DAF	=	Dissolved Air Flotation
EC	=	Electrical conductivity
HDPE	=	High Density PolyEthylene
HRT	=	Hydraulic Retention Time (days)
NH_3-N	=	ammonia-nitrogen concentration (mg/ℓ)
NO_2-N	=	nitrite-nitrogen concentration (mg/ℓ)
NO_3-N	=	nitrate-nitrogen concentration (mg/ℓ)
O&G	=	Oil and Grease
SBR	=	Sequencing Batch Reactor
SS	=	suspended solids concentration (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)
TWL	=	Top Water Level
VFA	=	Volatile Fatty Acids (mg/ℓ)
VSD	=	Variable Speed (Frequency) Drive

List of Units

kL/d	=	kilolitres (cubic metres) per day
L	=	litre
m	=	metre
mg/L	=	milligrams per litre = ppm.
ML	=	Megalitres (1,000 kL)

Appendix A : MEDLI Irrigation Modelling

Document Management

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