# final report

Project code: P.PIP.0538

Prepared by: Stephan Tait, Bernadette McCabe, Andrew Hill, Serhiy Marchuk
Centre for Agricultural Engineering, University of Southern Queensland
Aaditi Dang, Justin Caldwell, Andrew Triance
Oakey Beef Exports Pty Ltd

Date published: 17 May 2019

PUBLISHED BY
Meat and Livestock Australia Limited
Locked Bag 1961
NORTH SYDNEY NSW 2059

# Oakey Beef Exports Water Resource Sustainability

This is an MLA Donor Company funded project.

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

# Executive summary

This project assessed water efficiency, water supply risk, water savings initiatives and irrigation management tools/options for the Oakey Beef Exports (OBEX) meat processing facility at Oakey in the Darling Downs region of Queensland. The facility currently slaughters and bones up to 1,300 head per day and utilises approximately 2.8ML per day of water sourced from a combination of town water supply and a deep bore supply. The cost of town water supply to the OBEX facility is estimated to be in excess of $1m per year.

The project performed a detailed risk assessment regarding water availability and quality for the OBEX facility. This suggested that the ground water supply had higher affiliated risk than the town water supply. Key mitigation strategies included infrastructure maintenance and redundancy planning, development of response strategies if risk scenarios were to eventuate, and to implement water savings initiatives to improve water use efficiency and to reduce water constraints.

The project performed a detailed mapping of water uses at the OBEX facility and assessed the need for automated sub-metering, to make routine water use and water use efficiency more transparent within major processing areas. From this, OBEX secured capital funding and installed several sub-meters in important water use areas. An assessment of wastewater flows and composition showed that the wastewater at the OBEX facility was subject to the large spatial and temporal variability typical of meat processing facilities. The primary treatment systems at the OBEX facility appeared to have significant treatment redundancy to cater for this wastewater variability.

The project identified and defined several water savings initiatives for the OBEX facility, ranked these as “most desirable”, “moderately desirable”, “less desirable” and “least desirable”, and determined plausible timeframes for implementation. A high-level estimation of anticipated water savings and costs of implementation then enabled estimates of simple payback periods. The analysis suggested that several water savings initiatives had favourable payback periods and were worthy of further consideration. These included installation of flow restrictors on sterilisers in the boning room and automated clean in place belt wash units to ensure water efficient operation.

Salinity of irrigated effluent was an important consideration for the OBEX facility to develop sustainable irrigation management practices. The project developed a new irrigation/cropping management tool in a monitoring and compliance platform, Theta Technologies (Ileader), to allow OBEX to record and collate data relevant to irrigation and crop management at the facility. The aim was to enable OBEX to (a) determine functional relationships between predictors relating to wastewater and soil properties/characteristics and performance measures such as changes in soil properties associated with effluent irrigation and crop growth, and (b) to use the understanding gained of functional relationships to identify environmental indicators of soil and crop health conditions that can alert operators of potential problems and can inform decision-making regarding irrigation and cropping practices.

Overall, it was clear from project investigations that source water availability and quality can constrain meat processing from the “source” end, and that sustainable management of irrigated effluent can constrain meat processing from the “sink” end. Water savings initiatives (as outlined in this report) and improved water efficiency can address both these constraints to enable sustainable red meat processing.

# Table of contents

**Oakey Beef Exports Water Resource Sustainability** ........ **1**

**1 Background** ........ **4**

**2 Methods** ........ **4**

2.1 Risk assessment on potable water supply ........ 5

2.2 Assessment of existing primary and secondary wastewater treatment ........ 6

2.3 Water supply/usage mapping and identification of sub-metering ........ 8

2.4 Identification and evaluation of water savings initiatives ........ 10

2.5 Identification of sustainable re-use options for treated effluent and development of land application/cropping management tool ........ 11

**3 Results/Outcomes** ........ **12**

3.1 Risks associated with the OBEX potable water supply ........ 12

3.2 Existing primary and secondary wastewater treatment ........ 14

3.3 Identification of the need for additional sub-metering ........ 16

3.3.1 Identification of key water monitoring points ........ 16

3.3.2 Installation of water sub-meters ........ 17

3.4 Water savings initiatives ........ 22

3.4.1 Existing water savings initiatives implemented onsite by OBEX ........ 22

3.4.2 Prospective water savings initiatives for future consideration ........ 23

3.5 Sustainable effluent re-use and land application/cropping tool ........ 27

**4 Discussion** ........ **30**

4.1 Achievement of project objectives ........ 30

4.2 Implications/Recommendations ........ 31

**5 Conclusions/Key messages** ........ **33**

**6 Bibliography** ........ **34**

**Appendix A – Water map** ........ **37**

**Appendix B – Water savings initiative workshop memo** ........ **38**

**Appendix D - Composition of waste streams at Oakey Beef Exports during the intensive sampling campaign** ........ **39**

# 1 Background

Oakey Beef Exports (OBEX) operates a meat processing facility at Oakey in the Darling Downs region of Queensland, currently slaughtering and boning up to 1,000 head per day. The site operates on a one shift operation from 5:30am until approximately 4:00pm. The volume of water utilised on site is approximately 2.8ML per day, sourced from a combination of town water supply and a deep bore supply. The cost of town water supply is estimated to be in excess of $1M per year. Water supply, treatment and disposal have been identified as of strategic importance to the ongoing sustainability of the facility, because water supply is highly constrained and subject to significant risk as highlighted in this report.

NH Foods/OBEX collaborated in a team with the Centre for Agricultural Engineering at the University of Southern Queensland (USQ); to identify risks associated with the OBEX water supply and potential mitigation strategies; to identify, develop and evaluate water savings initiatives for the facility; and to clarify options for sustainable and beneficial reuse of final treated effluent via a new irrigation/cropping management tool. The long-term vision for the site is to be using wastewater for sustainable agricultural uses on either the OBEX site or on neighbouring cropped farming lands.

# 2 Methods

The following is a list of project milestone descriptions:

Milestone 1: a) Identification of and report on all risks associated with the plant's operation in relation to potable water supply under current conditions and future planning; b) Development of risk mitigation strategies for the sites potable water supply; c) Process water mapping of supply and usage; d) Identification and recommendation of key water monitoring points throughout the plant; e) Site effluent water mapping; and f) Cost benefit analysis (CBA) – installation of sub metering.

Milestone 2: Confirmation of water monitoring points throughout the plant, development of Theta Technologies Ileader data collation and reporting system for capturing and reporting of water usage across plant operations and costs involved with each process.

Milestone 3: Identification and installation of water meters and water saving technologies that can be implemented to site and estimated water savings for each identified opportunity. Ex ante CBA of water saving initiatives.

Milestone 4: Identify responsible / sustainable re-use options for treated effluent. Nutrient balance loads for application of effluent to land. Development of a land application / cropping management tool in ILeader, partnership with Theta technologies to be part of the NH Foods ILeader system.

These milestones were achieved as described in the sections that follow.

## 2.1 Risk assessment on potable water supply

The project team prepared a risk and issues management tool. This tool was then used in a project workshop to identify risks associated with the OBEX facility's potable water supply under current conditions and future planning, and to determine suitable mitigation strategies. For this, the plant's town water supply was considered separately to the plant's deep bore water supply. Identified risks were placed in one of a series of categories (Table 1).

**Table 1: Types of Issues/Risks**

| Type | Description |
|---|---|
| Natural disasters | such as floods, storms and drought |
| Legal | such as non-compliance with regulations, and liabilities |
| Technology | such as computer network failures and problems associated with using outdated equipment |
| Environmental | such as climate change, chemical spills and pollution |
| Property and equipment | such as damage from burst water pipes |
| Staffing | such as human error |
| Suppliers | such as issues within the supplier's business or industry resulting in failure or interruptions to the supply chain of products or raw materials (water related) |
| Market | such as changes in consumer preference and increased competition |
| Security | such as robbery and vandalism |
| Utilities and services | such as failures or interruptions to power |
| Anthropogenic | such as human activity and competitive uses |

A risk evaluation was performed during the workshop, considering the likelihood of a risk scenario occurring (Table 2) and a qualitative measure of impact if it was to occur (Table 3). The outcome was a ranking of risks as Low, Moderate, High or Extreme (Table 3). The project team then identified mitigation strategies for risks ranked as moderate, high or extreme. Risks that were ranked as low were not further considered, deemed to be appropriately mitigated by existing controls.

**Table 2: Qualitative Measure of Consequences of Risk Likelihood**

| Level | Descriptor | Description | |
|---|---|---|---|
| A | Almost certain | Is expected to occur in most circumstances. | More than once per month |
| B | Likely | Will probably occur in most circumstances. | 1 in 1 - 3 months |
| C | Possible | Might occur at some time. | 1 in 3 - 12 months |
| D | Unlikely | Could occur at some time. | 1 in 1 - 5 years |
| E | Rare | May occur in exceptional circumstances. | 1 in >5 years |

**Table 3: Qualitative Measure of Consequences of Impact**

| Level | Description | Example detail description |
|---|---|---|
| 1 | Insignificant | No low financial loss, no risk to reputation. |
| 2 | Minor | On-site impact immediately contained, medium financial loss, some customer dissatisfaction. |
| 3 | Moderate | On-site impact contained with outside assistance, high financial loss and public visibility. |
| 4 | Major | Loss of production capability, invocation of disaster recovery with no detrimental effects, major financial loss. |
| 5 | Catastrophic | Huge financial or reputational loss. |

**Table 4: Qualitative Risk Analysis Matrix**

| | Consequences | | | | |
|---|---|---|---|---|---|
| | **Insignificant** | **Minor** | **Moderate** | **Major** | **Catastrophic** |
| **Likelihood:** | 1 | 2 | 3 | 4 | 5 |
| **A (almost certain)** | H | H | E | E | E |
| **B (likely)** | M | H | H | E | E |
| **C (possible)** | L | M | H | E | E |
| **D (unlikely)** | L | L | M | H | E |
| **E (rare)** | L | L | M | H | H |

| Key | Description |
|---|---|
| **E** | Extreme Risk: Immediate action required to mitigate the risk. |
| **H** | High Risk: Action should be taken to compensate for the risk. |
| **M** | Moderate Risk: Action should be taken to monitor the risk. |
| **L** | Low Risk: Routine acceptance of the risk. |

The results from the risk assessment are presented in Section 3.1 below.

## 2.2 Assessment of existing primary and secondary wastewater treatment

To assess wastewater composition and thereby explore the impact of wastewater treatment onsite at the OBEX facility on subsequent nutrient loads to irrigated effluent, wastewater flows were metered over an intensive 5-week period (4 Feb-9 Mar 2017) for 6 waste streams (Table 5) using calibrated strap-on TDS-100F Ultrasonic flow meters, and fixed on-site electromagnetic flowmeters (Proline Promag L 400) for cross comparison (Figure 1). During this same period, an intensive wastewater sampling campaign (Figure 2) was conducted to determine typical wastewater composition and load. For most of the wastewater samples, flow-proportional or time-proportional composite samples were collected using three ISCO portable autosamplers (Figure 3), operated in parallel over the 5-week period. This is typically preferred over collection of grab samples, because of the large observed variability in the wastewater composition onsite.

A total of 12 wastewater streams were sampled and analysed for 9 physical and chemical parameters, namely:

- Total Chemical Oxygen Demand (TCOD);
- Total Solids (TS);
- Volatile Solids (VS);
- Fat, Oil and Grease (FOG);
- Total Nitrogen (TN);
- Total Phosphorous (TP);
- Total ammoniacal nitrogen ($NH_4$-N);
- Volatile Fatty Acids (VFA); and
- pH.

**Table 5: Wastewater flow metering and sampling locations. See figure 2 for further details.**

| **Code** | | **Location Description** |
|---|---|---|
| **Metered flow** | **Sample** | |
| | S1 | Tripe wash pre-screen |
| | S2 | Tripe wash post-screen |
| | S3 | Stick water |
| F3 | S4 | Boning room (Total flow) |
| F5 | S6 | Saveall South Combined sample |
| ~F5 | S8 | Saveall South effluent post-screen |
| ~F5 | S9 | Saveall South effluent post-DAF |
| | S10 | Combined cattle wash |
| | S11 | Paunch/green wash combined |
| F7 | S12 | Decontamination |
| F9 | S14 | Saveall North Combined sample |
| F10 | S15 | Combined Saveall North and South |
| ~F12 | S16 | Kill floor red stream |
| F12 | S17 | Kill floor post-DAF |

**Figure 1: Ultrasonic flowmeters placed on saveall south waste stream (F5) (left) and saveall north waste stream (F9) (right) (yellow circles). Fixed on-site electromagnetic flowmeter on F5 (red circle). See figure 2 for flow metering locations.**

## 2.3 Water supply/usage mapping and identification of sub-metering

The project team traced water flows throughout the abattoir and prepared a water usage map presented in Appendix A. To conduct a mass balance across the entire abattoir, water usage was also measured and recorded during the same period as the intensive wastewater metering and sampling campaign and was compared with the measured combined wastewater flow (Section 2.2). The flow metering also allowed identification of important water uses throughout the abattoir and to identify which water flows should ideally be routinely sub-metered during normal operation. Additional sub-metering identified for installation was then prioritised to provide reliable estimates of water savings opportunities within specific process areas where water use was high or where the submetering could quantify benefits of future water savings initiatives once implemented in onsite process areas.

The identification of sub-metering requirements did consider that bulk metering and monitoring via a manual check and recording system was already used in many cases onsite for key process areas, and therefore that the purpose of the sub-metering would rather be to provide time-based resolution of water uses within major process areas and to prevent human error that may influence results with the routine use of manual data collection.

**Figure 2: Process flow schematic of onsite wastewater treatment systems at the Oakey abattoir, also showing sampling and flow metering locations during the intensive sampling and analysis period**

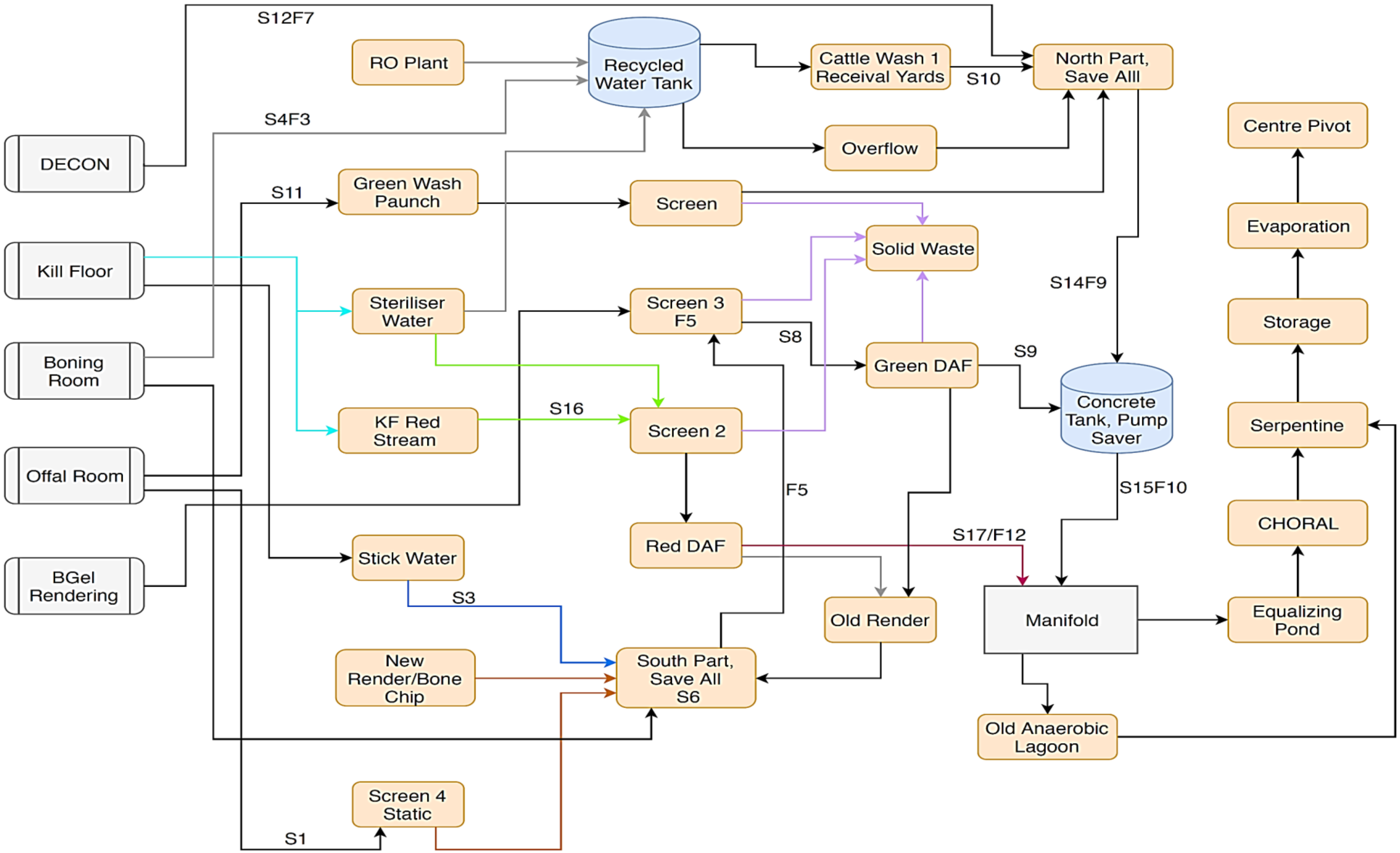


**Figure 3: ISCO autosampler on saveall south waste stream (S6) (left) and saveall south post-screen waste stream (S8) (right).**

## 2.4 Identification and evaluation of water savings initiatives

To identify potential water savings options for the OBEX facility, relevant past literature published by the Australian Meat Processor Corporation (AMPC) and Meat and Livestock Australia (MLA) were reviewed. This literature included (McNeil and Husband 1995, Pagan, Renouf et al. 2002, FSA Consulting 2004, Northern Co-Operative Meat Company Ltd 2004, Australia Meat Holdings – Dinmore QLD 2006, Leslie and Cox 2006, Oakey Abattoir Pty Ltd 2006, Spence 2006, Cobbold 2008, JJC Engineering Pty Ltd and Kurrajong Meat Technology Pty Ltd 2008, Nicol 2008, Warnecke, Farrugia et al. 2008, Australian Meat Processor Corporation 2011, Colley 2011, Colley 2011, Johns 2011, Johns and Nicol 2011, Sentance 2011, Teys Bros Pty Ltd 2011, Wade Phillips and Tatiara Meat Company 2011, Jensen and Batstone 2012, Andrew-Kabilafkas 2013, Collen 2013, Ford 2013, Ford 2013, JBS Australia Pty Ltd 2014, Ridoutt, Sanguansri et al. 2015, Pype, Doederer et al. 2017, Pype, Walduck et al. 2017).

The findings from this review were written up in the memorandum in Appendix B. Informed by the available literature, the project team held a workshop to identify and evaluate potential water savings initiatives. During the workshop, OBEX operations personnel assisted with brainstorming of water savings initiatives that could be plausible for the facility. The workshop identified separate water savings initiatives for each of the main processing areas (i.e. cattle yards, kill floor, boning room, chiller room, offal room, decontamination unit, rendering, cleaning and services). Amenities and outside general plant water uses were considered out of scope, because these required relatively little water compared to the major processing areas and typically used high quality potable water not feasible to attain via reuse or recycling.

Evaluation of the various water savings initiatives considered the following feasibility factors:

- amount of potential water saved by the option/technology;
- practicality of implementation;
- level of cost for implementation;
- robustness and track-record of solution; and
- other notable benefits/costs/risks (e.g. reduced/increased labour demand).

The workshop performed a preliminary ranking of various water savings options in terms of whether they were deemed “most desirable”, “moderately desirable”, “less desirable” or “least desirable”, based on the above feasibility factors, and in terms of whether they could be implemented in the short (1-3 years), medium (3-5 years) or long term (+ 5 years).

The project team then prepared a cost estimate of the “most desirable” and some of the “moderately desirable” water savings initiatives and performed a simple cost benefit analysis to identify which options would be most attractive for further consideration and development.

## 2.5 Identification of sustainable re-use options for treated effluent and development of land application/cropping management tool

The major determining factors for sustainable re-use of treated effluent include:

1. Salinity, sodicity and chloride levels and their impacts on soil structure and function and crop growth performance with feedback impacts on nutrient accumulation/uptake; and
2. Nutrients and their impact on crop growth performance and ancillary environmental risks presented by excessive levels of nutrients in soil and water.

OBEX irrigation effluent has both a significant nutrient and salt content. Bore water at the site is expected to be moderately saline (FSA Consulting, 2014) and may be contributing the majority of the salt content in the irrigated effluent. For this reason, irrigated effluent quality may be relatively insensitive to typical salt reduction strategies at meat processing facilities (e.g. reduced chemical use in a processing plant).

OBEX conducts semi-regular studies on the irrigated areas to determine soil condition, nutrient inventories, and salinity levels. This information is then used to inform amelioration practices (e.g. application of gypsum or organic amendments) and to inform irrigation scheduling. However, irrigation at the OBEX site is constrained, and as such requires close monitoring and control to achieve sustainable practices. Complete seizing of irrigation is simply not an option for OBEX, albeit that movement of irrigation equipment around the site may be feasible to spread the irrigation load across a larger area.

OBEX has proactively sought better decision tools to allow irrigation scheduling and identification of the need for amelioration and to evaluate crop options. MEDLI and SALF were considered by the project team for this purpose, as these are typically used by consultants and industry specialists to assess irrigation impacts. However, the project team decided that these commercial tools would not be suitable for OBEX’s internal use, because they require on-going specialist skills to run and maintain, and without such skills would risk incorrect or poor diagnoses leading to ill-informed irrigation management onsite. Instead, the project team decided to develop a customised data collation tool in the NHF OBEX platform ILeader, that OBEX staff could then use on an on-going basis to assess nutrient and salt balances, and to evaluate the retrospective impacts of irrigation practices and amelioration activities on soil and important performance measures (e.g. cut-and-cart yields, soil moisture holding capacity and hydraulic conductivity). In the long-term, this tool would provide record of experience onsite, frequently calibrated with new data, and could inform decisions about land application/cropping management.

The project team decided that the tool should mimic a successful nutrient tracking tool previously developed for the NHF Wingham facility, which had been in use to track nutrient exports with cut-and-cart removal of crops offsite. This nutrient tracking tool was transferred onto the OBEX Environmental Compliance Monitoring system and augmented for the purposes of the current project. This included the following alterations:

1. add potassium, zinc and total dissolved solids (TDS) as tracked quantities in irrigated effluent and cut-and-cart tonnages;
2. add other salt-tolerant crop options not available in the Wingham tool (e.g. Rhodes grass) with multiplying factors that relate crop amounts with nutrient amounts (to be updated as actual measurement data became available on crop compositions);
3. add a data-entry to record tonnages of amelioration agents applied to irrigated soils;
4. add meteorological records such as rainfall, temperature and pan evaporation;
5. add a data-entry for irrigation amounts (in a dedicated water irrigation section);
6. add a data-entry for measured irrigated effluent characteristics (e.g. TDS, nutrients, pH, sodium absorption ratio); and
7. add a reporting section that provides time trends of the above measures and calculated nutrient balances (irrigated minus exported by cut-and-cart), which in the future can be correlated to historic values of predictor variables.

# 3 Results/Outcomes

The following section reports on outcomes and results from the project activities.

## 3.1 Risks associated with the OBEX potable water supply

The OBEX meat processing plant uses on average 2.8 $ML.day^{-1}$ of source water, which equates to around 8.25 $kL.tonne^{-1}$ HSCW (2.97 $kL.head^{-1}$). This is near to the most recently published industry benchmark water usage performance (Ridoutt et al., 2015). The OBEX facility sources approximately 50% of its supply from the town water and the other 50% is extracted from a deep bore onsite. Future growth in processing is constrained by water availability.

A risk identification and evaluation spreadsheet was prepared and used during a project risk workshop. Risks were identified separately for the town water supply and for the deep bore supply.

The workshop highlighted the "deep bore" supply to be at greater risk than the town water supply, with several risk scenarios for the deep bore supply ranking as "high" and even "extreme". Risks with an "extreme" rating included potential for the supply to no longer meet potable water standards and use onsite. This was rated as extreme because the town water supply could not realistically meet additional onsite demand for water if bore water use was discontinued, making the site reliant on advanced treatment of bore water to provide potable water. This advanced treatment to a potable standard would be costly and filtrate removed would require careful disposal at additional cost. In addition, any substantial change in source water may be subject to export and meat product quality requirements. OBEX could explore alternate bore aquifers, but whether such supplies exist is uncertain. The project team noted a recent reverse osmosis (RO) study that may provide further information on treatment requirements and costs. It was noted that extensive risk management studies may form part of a significant change involving potable source water from advanced treatment.

Another "extreme" risk scenario for the deep bore supply was onsite soil quality potentially preventing irrigation of effluent. As the site is likely unable to operate without irrigation (minimal interim storage capacity for treated effluent), this could severely limit processing throughput. Potential mitigation strategies were; to employ a suitably qualified soil/environmental scientist to proactively address water quality concerns (this has been done as part of this project); to use gypsum or other suitable soil amelioration agents to boost soil health and/or crop performance; to spread irrigation over a larger area to reduce impacts; or to finely control irrigation requiring knowledge of irrigation water-soil-ground water-crop interactions and potential risks of environmental impact.

Risks for the bore water that ranked "high" included bore collapse or electrical and/or mechanical faults in the bore pump, if these faults were to occur below ground, because such would require major intervention, resulting in the bore water being unavailable for up to 1 month. In this case, processing would need to reduce to 1 in every 2 days, because of the complete reliance on town water as sole water supply. In the case of bore collapse, a new bore would need to be instated. Risks affiliated with drought and potential over-extraction were also ranked "high", as there may be limited opportunities to purchase additional water rights and a third-party impact study may be required to first determine sustainable extraction rates or access to an alternate (potentially deeper) aquifer. The workshop team noted that OBEX does not currently hold a spare bore pump and should therefore conduct redundancy planning for bore water extraction infrastructure.

Only one risk for the town water supply ranked "high" (no extreme risks), namely potential for the supply to no longer meet potable water standards and use onsite, which may be caused by inappropriate upstream water treatment or may result from a deterioration in the source water quality of the water treatment plant. Mitigation strategies for OBEX could include; stop using town water and rely completely on bore water as sole water source. This would likely require advanced treatment at additional cost to achieve a potable water standard. The project team again recalled the bore water impact study and RO study noted above, as potential sources of relevant information.

Other risks for town water that ranked as "moderate" included mechanical faults or failures in water piping and infrastructure or a change in town water pricing caused by competitive uses or a change in government water policies or imposing of water restrictions. The project team could not identify any major emerging competitive uses for the town water supply, but it was noted that the availability of the town water supply would likely be limiting to planned future increases in processing capacity.

Key action items recommended from the risk analysis are listed in Section 5 below.

## 3.2 Existing primary and secondary wastewater treatment

Wastewater generated onsite is treated by a series of solids removal steps, including phase separation, screens and dissolved air floatation (Appendix A). This removes a large proportion of suspended solids, and produces solids sent to onsite composting. Table 6 provides a summary of wastewater and source water flows measured or estimated during the intensive sampling campaign (Section 2.2). The data in this table show that there was reasonable closure in the overall water mass balance across the meat processing facility, indicating that source water metering was reasonably reliable during the monitoring period, and also that water usage by the facility was approximately 2.8 ML/d. The difference between in and out flows shown in Table 6 was deemed plausible considering evaporative losses typical of meat processing facilities. Figure 4 shows samples of wastewater collected at a Saveall over a 24-hour period, and the colour differences and differences in the amount of solid float clearly show variability of wastewater composition produced over time.

**Table 6: Water supplied to the facility during the intensive sampling campaign**

| Water stream | Volumetric flow (kL.day$^{-1}$) |
|---|---|
| **Water in** | |
| Town water | 1294 |
| Bore water | 1560 |
| **Total in** | **2854** |
| **Total effluent (F10+F12)** | **2638 (see Figure 2)** |

**Figure 4: Autosampler collection at combined saveall waste flow showing clear variability amongst samples collected over a 24 hour period.**

Appendix C presents stream composition and flow measurement data for the wastewater streams sampled during the intensive sampling campaign. In general, the wastewater streams could be grouped into the following categories based on strength:

1. **Very strong waste streams** (very high COD between >40,000 mg/L; high FOG (>6,000mg/L). These include:
    - Saveall south combined sample (S6)
    - Tripe wash pre-screen (S1)
2. **Strong waste streams** (high COD between >30,000 mg/L; high FOG (>5,000mg/L). This includes:
    - Saveall south effluent post screen (S8)
3. **Medium - strong waste streams** (high COD between >20,000 mg/L; high FOG (>1,000mg/L). These include:
    - Stick water (S3)
    - Saveall south effluent post DAF (S9)
    - Kill floor (S16)
4. **Medium waste streams** (COD between 5,000-10,000 mg/L; FOG up to 1,000mg/L). These include:
    - Paunch/green wash combined (S11)
    - Combined saveall north and south (S15)
    - Kill floor post-DAF (S17)

5. **Weak/dilute waste streams** (COD between 1,000-5,000 mg/L; FOG up to 1,000mg/L). These include:
    - Decontamination (S11)
    - Saveall north combined (S14)
    - Combined cattle wash (S10)
6. **Very weak/dilute waste streams** (COD 500 mg/L; FOG < 50mg/L). This includes:
    - Boning room (S4)

The wastewater mapping (Appendix A) indicated that there was significant onsite treatment redundancy, with additional systems likely progressively added over time onto the onsite treatment train. The analysis indicated that the current primary treatment performance was not atypical of treatment systems at other meat processing facilities, removing solids and organic matter from the wastewater, despite a notable variability in wastewater composition and strength over time.

## 3.3 Identification of the need for additional sub-metering

### 3.3.1 Identification of key water monitoring points

Many of the water flows throughout the OBEX facility had bulk metering and monitoring via a manual check and recording system, but the addition of sub-metering was considered important to provide measurement resolution within major processing areas. This would assist in identifying large water uses that could be targeted by potential water saving initiatives. Also, sub-metering would enable OBEX to quantify water reduction benefits of future water savings initiatives once implemented. Areas identified as significant water users requiring additional sub-metering were:

1. Boning room
2. the Offal/tripe room
3. the DECON room
4. Rendering/bone gel

In addition, warm water mixtures at the facility is prepared using hot water mixed with cold water, so individual sub-metering of kill floor water streams was deemed important to resolve differences in the water use at the various temperatures.

The selection of suitable flow meters (and thus their cost) in general depends on:

- Required accuracy
- Pipe diameter and thus meter size
- Type and conditions of fluid to be measured
- Standards to comply with (e.g. working in specialised zonings)

A preliminary estimate found that each sub-meter could cost an approximate mid-range value of \$2,500. As an example, if this meter was installed to quantify a nominal 10% saving in boning room water use (estimated saving of $50kL.day^{-1}$), which at a typical total water cost of $\$3.5.kL^{-1}$ (nominal) could amount to a \$65,000 pa saving. This simple cost benefit analysis suggests that there was a reasonably strong business case for installation of sub-metering.

### 3.3.2 Installation of water sub-meters

OBEX subsequently applied for and secured capital funding to install 8 new electromagnetic water meters with PTFE lining from Endress and Hauser (E&H) for this project. Meters from E&H had been previously used throughout the plant, so OBEX had significant experience, including with connecting of such meters into the wider existing plant systems.

The selection of specific electromagnetic meters considered (a) the required measurement reproducibility/resolution and range; (b) installation pipe diameter; (c) type of fluid being measured; (d) standards alignment; and (e) temperature range and composition of the fluid being measured.

Electromagnetic flow meters measures a voltage signal produced when a conductive fluid flows through a magnetic field generated by the meter, and the voltage is related to the flow rate of the fluid. Electromagnetic flow meters are well-known and robust in many applications. They are insensitive to temperature, pressure, density, and viscosity of the flowing fluid, and are reasonably robust to entrained solids and bubbles in the fluid being measured. Electromagnetic flow meters also have the advantage of not presenting obstructive parts to the path of fluid flow, thereby preventing blockages. It was decided to install new meters on flows to the boning room, bone gel and kill floor, for the reasons given above (Figure 5), given here with meter models in brackets;

1. the kill floor recycled water line (Promag 10E50, DN50 2 inch);
2. the kill floor chilled water line (Promag 10E50, DN50 2 inch);
3. the condenser town water supply line (Promag 10E50, DN50 2 inch);
4. the bone gel return water line (Promag 10E1H, DN100 4 inch);
5. the bone gel makeup water line (Promag 10E1H, DN100 4 inch);
6. three additional meters in the boning room, to resolve supply water supplied to distinct functions. In the boning room, one meter was for cold process water, one for the 65°C water and finally a meter for potable town water supply. Promag 10E1H, DN100 4 inch; Promag 10E1H, DN100 4 inch and Promag 10E50, DN50 2 inch

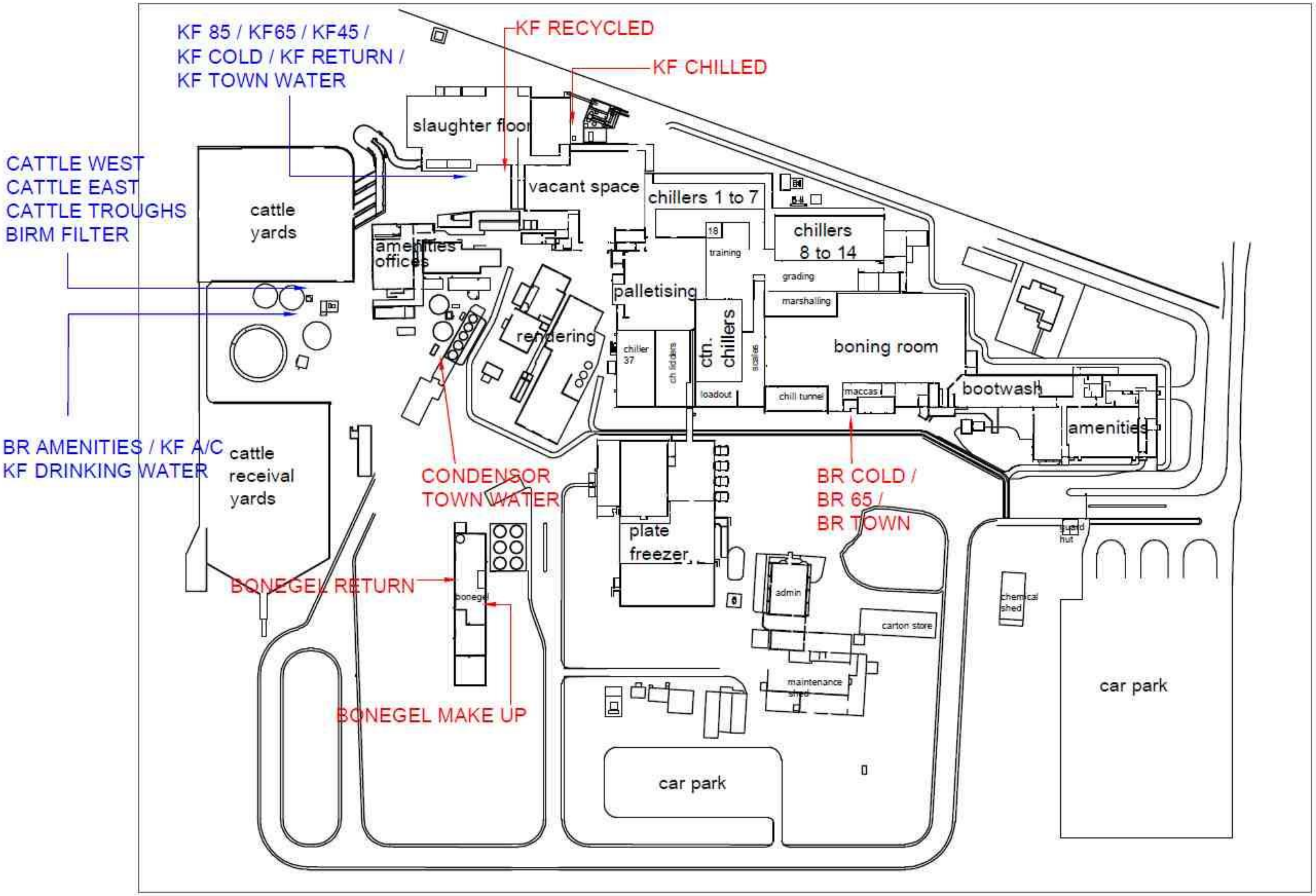



**Figure 5: Areas where new water sub-meters were planned for installation are depicted in red and the blue shows existing meters which were flagged for augmentation. Source OBEX**

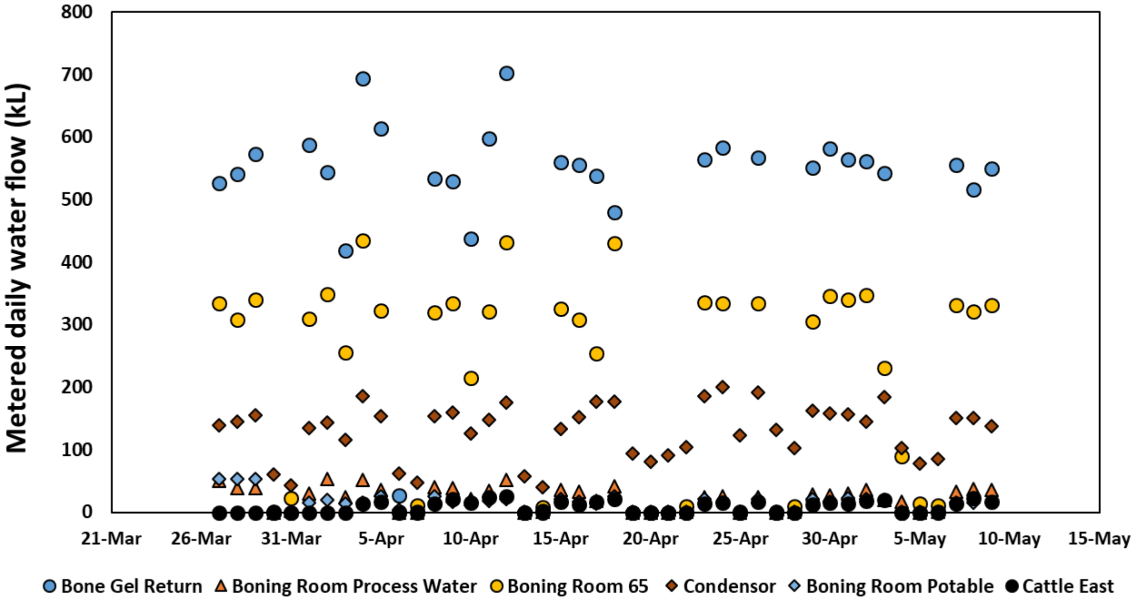
Figure 6 shows photographs of the various sub-meters installed around the facility.


**Figure 6: New Water meters installed around the OBEX facility; including A: Bone Gel Makeup; B: Condenser town water; C: Boning Room hot water; D: Boning Room cold water; E: KF Chilled water; and F: KF Recycled water. Source OBEX**

Along with the installation of the water sub-meters, an overlay monitoring system was installed to allow automatic monitoring of the sub-meter readings. This system was a Spider AMR (Figure 7) with a 3G base station (wireless) installed by Halytech. This system can receive large numbers of utility metering data and is an integrated monitoring, control and alarm system suitable for remote, low power, battery powered applications, minimising the requirements for remote power supply. The Spider system offers remote communications via a mobile phone module and can be accessed either locally via a direct cable connection or remotely via a modem or by sending and receiving SMS messages. The full development of this happened once the meters had been installed. The meters provided a digital read-out on each meter, and once the monitoring system had been installed, validation studies were carried out to ensure that the meters were correctly communicating with the Spider system and that the readings from the meters were being correctly relayed.

**Figure 7: Spider AMR system to transmit water meter data. Source OBEX**

Figure 8 shows a recent sample of data set collected from the various installed and augmented sub-meters at the OBEX facility. From these measurements, the week-day production is clearly distinguishable from the weekend down-time. The resolution provided by this new and augmented sub-metering will greatly facilitate performance tracking of various existing and future water savings initiatives around the OBEX facility.



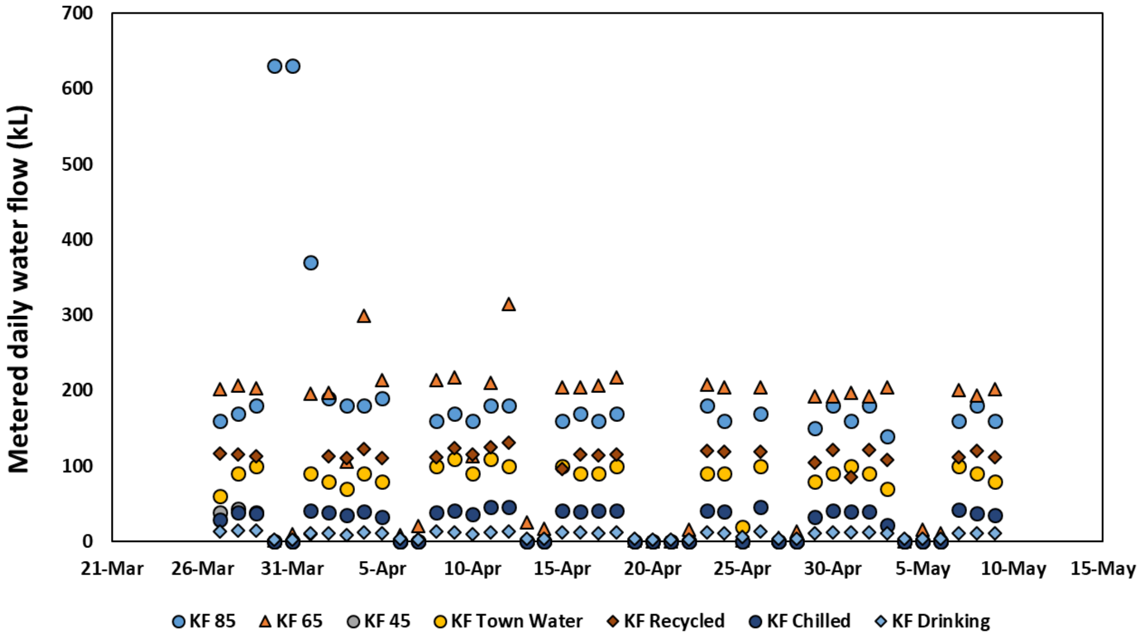




**Figure 8: Sample sub-metered water flow data from newly installed and augmented water flow meters over the period 27 March 2019 – 9 May 2019**

## 3.4 Water savings initiatives

Potential water savings initiatives reported and discussed in the available literature published by AMPC and MLA were found to belong to one of the following general categories:

a) *Reduction in water use*, e.g. installing flow restrictors or timed/controlled/automated supply of water; or
b) *Water repurposing requiring minimal or no prior pre-treatment*, e.g. steriliser water from clean end of viscera table being used for initial viscera table wash or for paunch initial emptying, maintaining high temperature lethal to pathogens; or
c) *Water repurposing requiring significant treatment prior to use*, e.g. carcase decontamination wash water collected, coarsely filtered and reused immediately for the same purpose, whilst maintaining temperature lethal to pathogens.

The extent of cost of treatment of the water prior to reuse was observed to have a significant impact on the feasibility of various water repurposing options. Because of this, relative efforts of past projects to date have typically emphasized water use efficiency improvements over water repurposing with and without prior treatment, because improved water use efficiency can offer substantially shorter payback periods.

### 3.4.1 Existing water savings initiatives implemented onsite by OBEX

Whilst a project workshop was held to identify and evaluate future water savings initiatives for OBEX, the workshop discussions highlighted that OBEX had already implemented significant water savings initiatives onsite before and during the project period. These included:

**Cattle Yards**

1. *Dedagging of cattle at the supply feedlot* already written into supply contracts, so that penalties apply if cattle received at the processing facility are too dirty. This *reduces water requirements for cattle washing*. This strategy was implemented prior to the project period.
2. A *portion of sterilizer water is captured* and sent to the cattle yards for initial cattle wash, cleaning of cattle yards, and cooling of cattle (Oakey Abattoir Pty Ltd 2006). This amounts to an estimated 200-400 $kL.day^{-1}$, with injection of a disinfection chemical in line. This reduces water use at the cattle yards by at least 50%. During the workshop, it was noted that not all the steriliser water that is available via this initiative can be used effectively at the cattle yards, and appropriate additional uses may be of interest. This strategy was implemented prior to the project period.

**Kill Floor**

3. *Alternate flooring for reduced cleaning water use* – OBEX has begun to change non-slip flooring within the kill floor from fiberglass grating to full stainless-steel flooring with welded dimples. This alternate flooring is much easier to clean and therefore uses less labour and less water. The replaced floor area represents a small proportion of total cleaned area but does include all new platforms within the boning room. Labour savings have been substantial (estimate 3 labour units across boning room and kill floor) and water savings would also have been significant. The workshop noted further education was needed in the use of alternate flooring systems.

4. *High pressure low flow cleaning systems* had been installed *on viscera tables* approximately 2 years ago, providing reduction in cleaning time and water savings. This strategy was largely implemented within the project period.
5. *Steriliser water flowrate* - Preliminary trials were conducted on the impact of steriliser water flowrate on measured temperature above 82°C and the ability to continuously remove debris. These trials identified a significant opportunity to operate sterilisers effectively well below the current typical operating water flowrate. The workshop noted that further education was needed in operating of sterilisers at lower flowrates to boost operator confidence in the operational efficacy at such lower flowrates. Any reduction in steriliser water flowrate should also consider local effects from the extent and nature of meat products debris to be continuously flushed away.
6. The *Decontamination Unit* currently reuses its water to an extent, maintaining temperature and clarity of water via a sand filter removing turbidity. This has resulted in water use reduction from about 65 $kL.day^{-1}$ to about 30 $kL.day^{-1}$. This system has been operational for approximately 2 years, and hence was largely implemented within the project period.

### 3.4.2 Prospective water savings initiatives for future consideration

The workshop identified prospective water savings initiatives for future consideration by OBEX. These were separately explored and identified for each of the main production areas (i.e. cattle yards, kill floor, boning room, chiller room, offal room, decontamination unit, rendering, cleaning and services). The workshop team performed a preliminary ranking of various options as outlined in Section 2.4 and determined how soon the options could feasibly be implemented (short, medium or long term).

Prospective water savings initiatives identified and ranked as **most desirable** included:

1. Replacing the current Reverse Osmosis (RO) unit with a new system. The current system is aged and inefficient, requiring approximately double as much feed water as state-of-the-art RO units, because of relatively poor water recovery. RO water is utilised in boilers onsite. The workshop team thought this option could be implemented in the short term.
2. OBEX expressed an interest in conducting a future trial of UV and spray-based sterilisation, to reduce water use. Trials of these technology options will likely proceed in the short term.
3. Consider installation of *flow restrictors on sterilisers in boning room*, because currently many sterilisers are operating well above necessary water flow rate for efficient operation. A trial at OBEX is likely to proceed in the short term.
4. An opportunity for improved *education*, potentially using regular online training options, to *increase awareness of water use efficiency*. An example from the workshop was operators running sterilisers at water flowrates well above necessary for effective sterilisation, because of habit and a reluctance to change. There may be potential for inclusion of performance targets around water use efficiency. This strategy could also explore types of training that have already been provided/are available to the industry via committees such as MINTRAC. The workshop team thought that this option could only be implemented in the long term.

Prospective water savings initiatives identified and ranked as **moderately desirable** included:

5. *Automate Clean in Place (CIP) belt wash in boning room*. Currently, this system performs more wash cycles than necessary for effective cleaning. The workshop team estimated a potential saving of at least 1 labour unit as an added benefit. The workshop team thought this option could be implemented in the short term.
6. *Replacing additional processing floor area with non-slip alternative flooring* for ease and efficiency of cleaning (See Existing Initiative 3 above). The workshop team thought that this option could be implemented in the short term.
7. *Automate main supply of steriliser water to turn-off supply during intermittent worker breaks*. This would be expected to save both water and energy. The extent of water savings needs to be estimated, but are expected to be substantial. The return water lines would need to be considered in future planning of this initiative. The workshop team thought this option could be implemented in the medium term.
8. Explore the *repurposing options for stick water from rendering* in other plant areas. The workshop team thought this option could be implemented in the medium term.
9. Installation and use of *additional automated water efficient CIP units* for cutting board washes, tub washes, etc. The workshop team thought this option could be implemented in the medium term.

Prospective water savings initiatives identified and ranked as **less desirable** included:

10. Explore the option of repurposing final tripe rinse for initial tripe rinse. The workshop team thought this option could be implemented in the medium term.
11. Consider automating the hot water refresh rate in the decontamination unit (Hot water above 82°C provided for a period of time on carcasses), to be controlled based on measured turbidity. At the moment, the unit operates continuously, with or without product going through. Improvements could also include a sensor to switch water supply on when product is going through the system. The workshop team thought this option could be implemented in the medium term.
12. Explore the option of steam cleaning of belts in the boning room. Trials have been conducted in the past, but have observed issues with protein count, possibly due to high temperature adhesion. Future work could explore timing and temperatures. This option was noted to be beneficial with zero tolerances and cleaning of the entire belt, with potential for significant savings of 90% water use for cleaning tasks and at least 1 labour unit. The workshop team thought this option could be implemented in the medium term.
13. Explore additional *opportunities for high-pressure low-volume cleaning* processes, noting the OH&S and training needs implications. The workshop team thought this option could be implemented in the long term.
14. Consider the option of redesigning the product conveying system in the kill floor to reduce the amount of build-up and overflow of residues, to reduce cleaning requirements and thus water use. The workshop team thought this option could be implemented in the long term.

Prospective water savings initiatives identified and ranked as **least desirable** included:

15. Using steriliser water for paunch washing.
16. Dry cleaning and electrical mechanical floor scrubbers for use in carcase chillers.
17. Using steam and/or $CO_2$ for cleaning

The less desirable and least desirable water savings options were not further considered in this project, but may be of future interest.

Table 7 presents a simple cost benefit analysis performed for several moderately desirable and most desirable initiatives above. Based on estimates of potential water savings (based on a percentage of current sub-meter flow data) and a nominal water cost of $\$3.5.kL^{-1}$ (which could include extraction pumping costs/town water supply costs and treatment/irrigation costs), simple payback periods were also estimated and are summarised in Table 7. Note that the estimates of potential water savings may differ substantially from actual achievable water savings and should be confirmed by detailed future analysis. However, the results in Table 7 do indicate attractive simple payback periods.

**Table 7: Most desirable and moderately desirable water savings initiatives, with simple cost benefit analysis at nominal water cost of $\$3.5.kL^{-1}$**

| Water savings initiative | Description | Estimated Cost of implementation | Estimated water savings based on metering data, estimate of simple payback period |
|---|---|---|---|
| Bore Water RO treatment | Replacing the current Reverse Osmosis (RO) unit with a new system. The current system is aged and inefficient, requiring approximately double as much feed water as state-of-the-art RO units, because of relatively poor water recovery. RO water is utilised in condensors onsite.<br><br>Purchase, install and commission new RO unit and associated fittings. | >$400k | 500 $kL.day^{-1}$ minus 200 $kL.day^{-1}$ estimate of current RO production<br>= 250 $kL.day^{-1}$ saving<br>> 1.5 years |
| UV sterilizers | UV and spray-based sterilisation, to reduce water use.<br><br>Purchase, install, commission and maintain new UV sterilizers (150 units). | >$80k | 20% of kill floor 65°C flow metered<br>=200 $kL.week^{-1}$<br>> 2 years |
| Flow restriction | Installation of *flow restrictors on sterilisers in boning room*, because currently many sterilisers are operating well above necessary water flow rate for efficient operation.<br><br>Install flow restriction valves on all sterilizer lines (approx. 150 lines). | >$15k | 10% of metered boning room 65°C flow<br>=160 $kL.week^{-1}$<br>> 0.5 year |
| CIP belt wash | *Automate Clean in Place (CIP) belt wash in boning room*. Currently, this system performs more wash cycles than necessary for effective cleaning.<br><br>Design, fabricate, install and commission CIP facilities for Bone Room. | >$30k | As directly above<br>> 1 year |
| External Area | Explore the *repurposing options for stick water from rendering* in other plant areas. The workshop team thought this option could be implemented in the medium term.<br><br>Re-use wastewater in external areas around the site i.e. hardstand washdown, lairage, truck washing, wastewater screen washing. This would involve extensive treatment system infrastructure, including glass media filtration bank with coagulant dosing and UV disinfection and finally chlorine dosing. | >$180k | 150 $kL.d^{-1}$ (uncertain of available demand and suitability of quality)<br>> 1 year |
| CIP for board washes and tubs etc | Installation and use of *additional automated water efficient CIP units* for cutting board washes, tub washes, etc.<br><br>Install CIP facilities in all wash areas. | >$30k | 20% of kill floor 65°C flow<br>= 200 $kL.week^{-1}$ metering<br>> 1 year |

## 3.5 Sustainable effluent re-use and land application/cropping tool

The purpose of this component of the project was to identify sustainable options for irrigation of treated effluent and to develop a land application/cropping management tool in the ILeader interface.

In order to apply irrigated effluent sustainably to land, it is necessary to know what impact the irrigated water will have on the soil and crop being grown on nutrients present in the irrigated effluent. As highlighted above, salinity is generally moderate to high in the OBEX treated effluent, expected to be largely contributed by the extracted bore water. Assessing the suitability of soil under moderate-high salinity irrigation is critical to develop sustainable irrigation practices.

Soil salinity and sodicity are well-known soil-degrading processes (Rengasamy, 2008). A threshold salinity level exists above which deleterious effects occur in soil, but this threshold can vary depending on several factors including plant type, soil-water regime and climatic conditions (Rengasamy, 2006; Maas, 1986). Hence, the project team considered it important to capture these predictors in a new land application/cropping management tool in ILeader. This would then allow OBEX to:

(a) determine functional relationships between predictors (wastewater and soil) and performance measures (changes in soil properties associated with application of wastewater); and

(b) determine environmental indicators of soil health conditions and alert operators to potential problems.

While salinity can improve soil structure, it can also negatively affect plant growth and crop yields and directly affects the physiological functions of the plant (through osmotic and toxicity effects). Sodicity also causes well-known deterioration of the soil's physical properties, which indirectly impacts on plant growth and survival. Sodicity reduces hydraulic conductivity and infiltration rates due to dispersion and swelling of clay particles in soils. While swelling is a reversible process (after drying), dispersion is not. Higher salinity also makes it harder for plants to extract water (water becomes denser and harder for plants to take up). Hence, salt tolerant crops are essential for irrigated saline effluent, and the project team thought it would be important for the new land application/cropping management tool to have additional salt tolerant crops in-built in the model database e.g. Rhodes grass.

The effects of salinity on soil can to some extent be reversible with rainfall, potentially allowing irrigation on certain areas to be seized to allow the area to recover. This occurs when rainwater causes leaching of salts down the soil profile, and decreasing the salt concentration in the top soil. However, at the same time the water can induce dispersion of the soil's clay and potentially also blockages of water-supplying pores. This is because in pure water, soils disperse, in saline water much less. With wetting-drying cycles, drying induces cracking and redistribution of pores. So, soil might recover to some extent by this mechanical disturbance with wetting-drying, but also through active mechanical disturbance such as via tillage. It may be possible to ameliorate sodic and saline–sodic soils to some extent through a plant-assisted approach, generically termed "phytoremediation" (Qadir et al, 2005).

Phytoremediation (or vegetative bioremediation or biological reclamation) of sodic and saline–sodic soils is said to not be primarily achieved by removal of Na+ in plants, but by the ability of plant roots to increase the dissolution rate of calcite. The salinity-sodicity combination present in the soil solution during the phytoremediation process maintains adequate soil structure and aggregate stability that enhances the amelioration process (Oster et al. 1999).

For the development of an Oakey land application/cropping management tool in ILeader, an existing nutrient tracking tool used at the NHF Wingham facility was brought across into Oakey ILeader and expanded as described in Section 2.5. The tool was set up to allow tracking of various environmental and irrigation related predictors (e.g. salt load and amount of irrigated effluent) and then separately track performance measures relevant to irrigated plant growth (e.g. hydraulic conductivity, plant yield recorded for cut-and-cart events). This would allow an analysis of historic records to determine functional relationships between predictors and performance measures, and these in turn will inform future decisions about irrigation and crop management. Figure 9 below presents a screenshot of one of the main data entry pages of the new Oakey land application/cropping management tool, in this case showing irrigated volume records and meteorological records.

The tool also has a reporting section that provides time trends of the above measures and calculated nutrient balances (=irrigated minus exported by cut-and-cart), which in the future can be correlated to historic predictor variables available in the tool database. Figure 10 presents an example of a report provided by the tool.

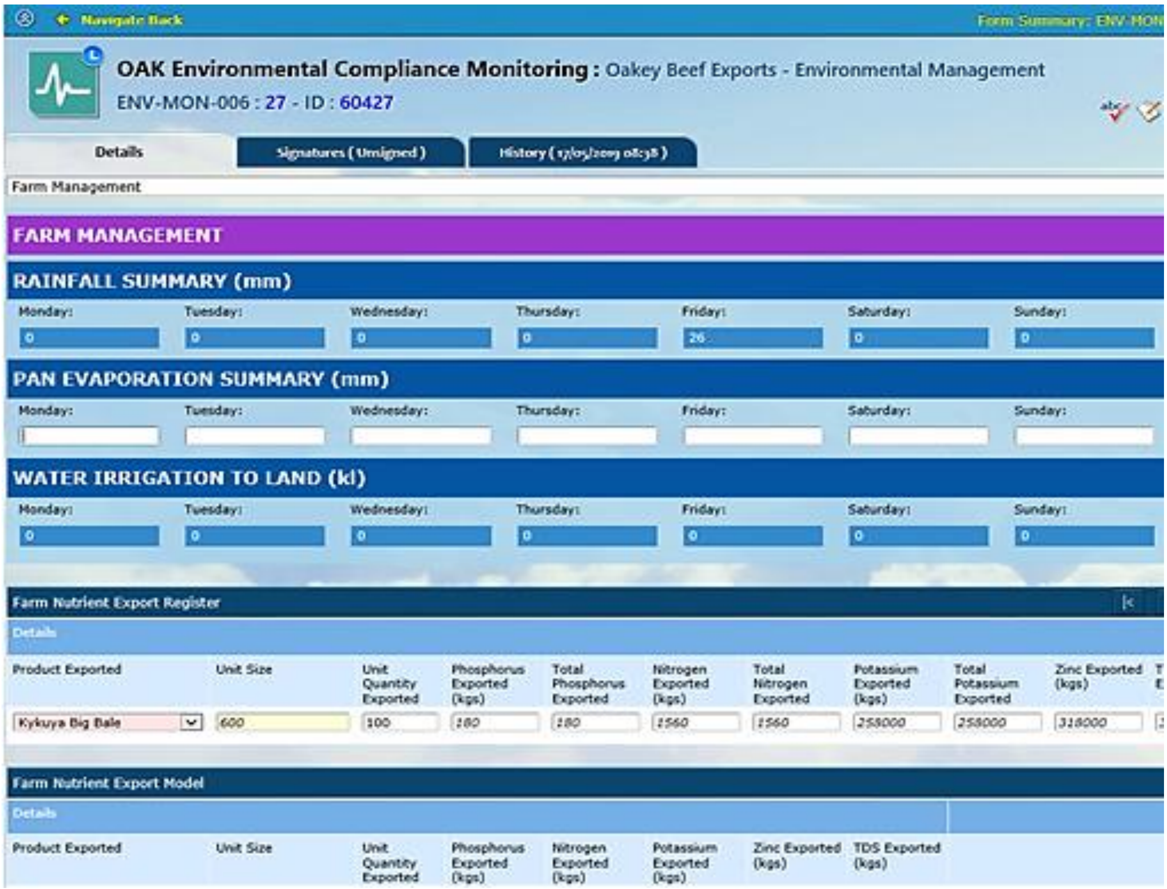
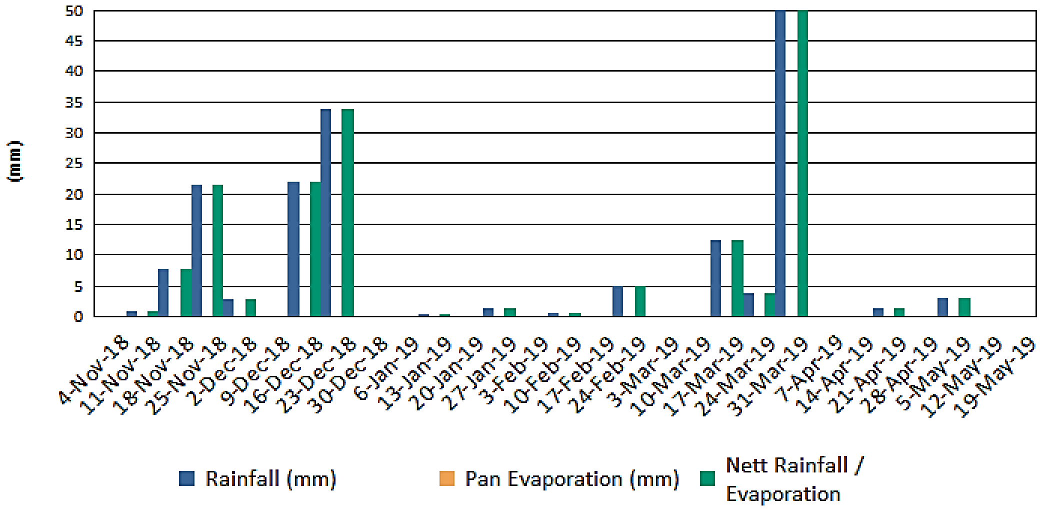



**Figure 9: New Oakey land application/cropping management tool in ILeader, data entry page.**

NH Foods
Oakey Beef Exports

*Land Application & Cropping Management Tool*

**FARM - RAINFALL & EVAPORATION EVALULATION**




| *Period Totals* | *Rainfall (mm)* | *Pan Evaporation (mm)* | *Nett Moisture (mm)* |
|---|---|---|---|
| | **169** | **0** | **169** |

| *Period Start* | *Period Finish* | *Rainfall (mm)* | *Pan Evaporation (mm)* | *Nett Moisture (mm)* |
|---|---|---|---|---|
| 29-Oct-18 | 4-Nov-18 | 0.0 | 0.0 | **0.0** |
| 5-Nov-18 | 11-Nov-18 | 0.8 | 0.0 | **0.8** |
| 12-Nov-18 | 18-Nov-18 | 7.6 | 0.0 | **7.6** |
| 19-Nov-18 | 25-Nov-18 | 21.4 | 0.0 | **21.4** |
| 26-Nov-18 | 2-Dec-18 | 2.8 | 0.0 | **2.8** |
| 3-Dec-18 | 9-Dec-18 | 0.0 | 0.0 | **0.0** |
| 10-Dec-18 | 16-Dec-18 | 21.8 | 0.0 | **21.8** |
| 17-Dec-18 | 23-Dec-18 | 33.8 | 0.0 | **33.8** |
| 24-Dec-18 | 30-Dec-18 | 0.0 | 0.0 | **0.0** |
| 31-Dec-18 | 6-Jan-19 | 0.0 | 0.0 | **0.0** |

**Figure 10: New Oakey land application/cropping management tool in ILeader, a report page generated, also showing calculated net water balance (difference between rainfall and evaporation)**

Potential use of the new tool and recommended future activities are described in Section 4.2 below.

# 4 Discussion

## 4.1 Achievement of project objectives

The following lists the original objectives for this project:

1. Map water usage and supply at Oakey Beef Exports (OBEX)
2. Identify areas within the plant that require continuous monitoring using sub-meters (installation of a monitoring system supplier Halytech)
3. Identify water savings initiatives – such as evisceration table, Halal slaughter table, Tripe processing, Steriliser water re-use
4. Investigate new primary and tertiary treatment options for abattoir effluent

These objectives were achieved as follows:

**Water mapping:** A revised water map was drawn up by the project team based on available information, showing significant water uses at the OBEX facility. This map is given in the Drawing in Appendix A. Important water uses (as metered) are outlined in Section 3.3.

**Water sub-meter identification:** The analysis performed for the water mapping (Section 2.3), indicated that metered source water volumes (bore and town water) were consistent with metered wastewater volumes produced/treated onsite by the treatment plant. This also suggested that there was a reasonable closure in the water balance across the OBEX facility. The water map was used to identify important water uses yet to be routinely sub-metered. Capital funding was secured, and sub-meters were installed or augmented as required to routinely meter these important water uses. Section 3.3.2 lists the newly installed or augmented water meters, and these new routine water meters were indicated on the water map (Appendix A).

**Identify water savings initiatives:** A literature review was conducted to identify water savings initiatives generally promoted across the meat processing sector, and to identify opportunities, barriers and important considerations relevant to water savings initiatives at a meat processing facility. This review formed the basis for a project workshop, where the project team brainstormed and evaluated, at a high level, potential water savings initiatives for the OBEX facility. These initiatives were ranked as “most desirable”, “moderately desirable”, “less desirable” and “least desirable”. The project team performed a cost estimation and simple payback period calculations on several “most desirable” and “moderately desirable” initiatives, as presented in Table 7. Options that involved a change in people processes or people behavior were identified during the workshop, but not costed up for the cost benefit analysis (CBA). The CBA analysis indicated that several water savings initiatives would have attractive payback periods and would be worthy of further consideration.

**Investigate new primary and tertiary treatment options for abattoir effluent:** A review of current treatment systems onsite showed that treatment performance was not atypical of systems at other meat processing facilities, removing solids and organic matter from the wastewater produced despite notable variability in wastewater composition/strength. This would at least be partially due to significant onsite treatment redundancy, as it seems that additional treatment systems have been progressively added onto the onsite treatment train over time to provide additional or targeted treatment. The analysis of the wastewater and treatment systems is provided in Section 3.2 above.

Consolidation and/or replacement of the existing onsite primary treatment systems would unlikely add substantial value, unless a higher value end-use could be found for separated products (e.g. paunch, DAF sludge). With respect to effluent irrigation, an important issue appeared to be salinity, originating largely from salt content of the extracted bore water. Tertiary treatment of effluent prior to irrigation could remove salt but would produce a concentrated brine stream containing a similar salt load to the original irrigation effluent and still requiring disposal. For these reasons, the project team instead explored tertiary treatment options for extracted bore water prior to use, as a potential water savings initiative. Source water onsite is already treated using RO, to prepare desalinated boiler feed water. However, this RO system was said to be aged and ineffective, with a much high reject fraction than typical of similar new RO systems. Whilst RO reject was able to be recycled onsite for use in non-contact cattle yard wash, this wash water was often in excess of useful demand. Tertiary treatment of extracted bore source water could increase the *proportion* of product water, thereby reducing the volume of raw water that would need to be extracted from the bore, thereby reducing amount of entrained salt that is extracted with bore water, and thereby reducing the salt load ultimately ending up in irrigated effluent. Proposed water savings initiatives, including expanded RO treatment, were outlined in Section 3.4.2.

## 4.2 Implications/Recommendations

In general, the analysis of this project indicated that water availability would be constraining future growth in processing at the OBEX facility and that water supply to the facility is subject to significant risk. It is expected that similar constraints would apply to other Australian red meat processing facilities. To mitigate water-related risk at the OBEX facility, the following key actions were identified during the project risk assessment:

1. Explore bore water impact studies, to clarify draw-down capability of the deep bore supply and potential impacts on water quality.
2. Consider redundancy planning for water extraction and supply infrastructure.
3. Consider a further impact scenario analysis on potential for town or bore water supply to no longer meet potable water standards and use onsite, to develop clear response strategies. This should include a review of the impact of tertiary treated potable water on export and meat product requirements and should examine a bore water impact study as noted in (1.) to determine feasibility of processing solely on treated bore water, if the town water supply was to become unsuitable for use.
4. Further plan and develop the water savings initiatives identified in the project, to increase water use efficiency at the facility, and thereby reduce water constraints.

In this project, the cost benefit of new sub-metering at the OBEX facility appeared to be good, based on the anticipated water savings becoming clearly identifiable using this new sub-metering. As a result, OBEX successfully secured capital funding and installed sub-metering on major water use areas. The aims were (a) to provide greater water use resolution for specific plant areas, and thereby allow close tracking of water efficiency within these areas, and (b) to quantify the benefits of future water savings initiatives.

With water sub-metering at the OBEX facility, it is recommended that:

1. the streaming and access of sub-metering data be further integrated into the plant operating systems, to make the data and reports of data more accessible for performance tracking and benchmarking purposes; and
2. that additional trials of water savings initiatives be planned and implemented at the OBEX site (e.g. trialling automation of supply and flow restriction to sterilisers) using the routine sub-metering to quantify water savings that are achieved.

The project identified several potential water savings initiatives for the OBEX facility. It is expected that similar water savings initiatives would exist at other Australian red meat processing facilities. Prior to and during the project, OBEX had already implemented several water savings initiatives, which greatly reduced water use onsite.

The following “most desirable” and “moderately desirable” future savings initiatives appeared to show a strong business case for implementation at the OBEX facility, and is therefore recommended for further development:

1. Installation of flow restrictors on sterilisers in boning room;
2. Installation and use of additional automated water efficient CIP units for cutting board washes, tub washes; and
3. to Automate Clean in Place (CIP) belt wash in the boning room, to operate with the number of wash cycles necessary for effective cleaning.

Salinity of irrigated effluent at the OBEX facility was generally moderate to high and thus requires careful management to ensure that irrigation is sustainable. This salinity was expected to be largely contributed by the extracted bore water, therefore salt content in the irrigated effluent may be less sensitive to salt reduction strategies than at other meat processing facilities. A new RO treatment system for bore water was explored as a water savings initiative in the project, because this may reduce the amount of bore water and entrained salt being extracted at the OBEX facility, by improving the RO product water recovery.

The project developed a new land application/cropping management tool for the OBEX facility to assist in future decision-making about irrigation and cropping. The tool was set up to track various environmental and irrigation related predictors (e.g. salt load and amount of irrigated effluent) and then separately track performance measures relevant to soil health and irrigated plant growth (e.g. hydraulic conductivity, plant yield recorded for cut-and-cart events). It is recommended that data be routinely fed into the tool and that the reporting component of the tool be used to prepare time-trend data for comparison and identification of relationships between predictors (many of which can be altered by intervention strategies) and the performance measures. In this way, OBEX can build an understanding of the impact of site management practices relating to irrigation and cropping and a record of experience that can inform future decision making. It is also expected that the repository of data in the new tool, will become a valuable resource for future third-party cropping, irrigation and soil studies to be commissioned by OBEX.

Whilst the land application/cropping management tool will provide actual in-field performance tracking and recording, it is also important that the suitability of soils at the OBEX facility be assessed for moderate-high salinity irrigation, in order to develop sustainable irrigation practices. For this, it is possible to experimentally determine the impact of sodicity on loss of soil hydraulic conductivity and infiltration rates in a soil, using a set of simple soil-column experiments under controlled laboratory conditions. Such experiments could also include an amelioration, to determine its impact in terms of improving resilience to salinity or remediation potential. In such experiments, a set of soil properties is measured to adequately reflect the loss of soil infiltration rates, hydraulic conductivity and increase in sodicity and salinity levels up to a critical level. The results from such a laboratory study only provide an indication of what might be observed when full validation tests are carried out on an irrigated area during and after irrigation events, but can be much simpler and more cost-effective and well-controlled to perform than in-field testing. It is recommended that OBEX commission and conduct such soil-column experimental studies on soils planned for irrigation.

# 5 Conclusions/Key messages

Risk assessment methods can be effectively applied (as described in this report) to better understand the risk profile of a meat processing facility regarding water availability and water quality, and can also be used to identify and develop appropriate risk mitigation strategies.

Source water availability and quality can constrain meat processing from the “source” end, and sustainable management of irrigated effluent can constrain meat processing from the “sink” end. Water savings initiatives (as outlined in this report) can address both these constraints and enable sustainable meat processing.

Wastewater treatment systems onsite at a meat processing facility provide treatment of wastewaters with significant spatial and temporal variability, and therefore must be flexible and robust enough to handle this variability. This may require significant treatment redundancy onsite at the facility, with multiple treatment steps to remove solids, FOG, organic matter and nutrients.

If a higher-value use can be identified for separated products (e.g. paunch, DAF sludge) from primary treatment at a meat processing facility, this may justify implementing step-change improvements in treatment performance.

Sub-metering of water flows at a meat processing facility provides transparency and helps to track water efficiency changes and actual benefits of water savings initiatives. In this project, the cost benefit of sub-metering appeared to be good based on anticipated water savings.

There are likely to be several potential water savings initiatives available to a meat processing facility (as was identified for a meat processing facility in this report) and these initiatives may exhibit favourable payback periods of <2 years.

Water savings initiatives will typically fall in the general categories of a) reduction in water use; (b) water repurposing requiring minimal or no prior pre-treatment; and c) water repurposing requiring significant treatment. An increase in the required extent of treatment will likely increase treatment costs and impact on cost feasibility. Maintaining a suitable water quality is a key requirement to ensure product quality is maintained.

Monitoring and evaluation tools are used at meat processing facilities to track of soil and crop health subjected to irrigated effluent. This can build a record of historical performance in terms of intervention strategies and irrigation practices, and how they impact on nutrient management and soil health. The experience can inform future decision making to effect sustainable irrigation practices.

# 6 Bibliography

Andrew-Kabilafkas, C. (2013). Water Saving in the Routine Cleaning of Carcase Chillers. A report prepared for Meat & Livestock Australia Limited. Project Code A.ENV.0139.

Australia Meat Holdings – Dinmore QLD (2006). “Every drop counts” – The Australia Meat Holdings Pty Ltd water efficiency campaign. A report prepared for MLA.

Australian Meat Processor Corporation (2011). Water Efficiency Projects. AMPC RD&E Case Study 8.

Cobbold, R. (2008). Innovative stock washing system to control cattle cleanliness A report prepared for Meat & Livestock Australia Limited. Project Code P.PIP.0143.

Collen, M. (2013). Bore Water Purification for Abattoir Use. A report prepared for Meat & Livestock Australia Limited. Project Code P.PIP.0355.

Colley, T. (2011). Energy efficiency opportunities program report (Federal Government). A report prepared for Meat & Livestock Australia Limited. Project Code A.ENV.0103 Part 1.

Colley, T. (2011). State Government energy and greenhouse programs; NSW – Energy savings actions plans (ESAP); VIC – Environment and resource efficiency plans program (EREP). A report prepared for Meat & Livestock Australia Limited. Project Code A.ENV.0103 Part 2.

Ford, R. (2013). Facilitation of Water Reuse Projects. A report prepared for Meat & Livestock Australia Limited. Project Code A.ENV.0159.

Ford, R. (2013). Water Saving in the Routine Cleaning of Carcase Chillers. A report prepared for Meat & Livestock Australia Limited. Project Code A.ENV.0138.

FSA Consulting (2004). Water Reuse Project Priority Setting Through Assessment of Industry Impact. A report prepared for AMPC/MLA Project PRENV.030.

FSA Consulting (2014). Irrigation management plan - Oakey Abattoir, Report prepared for Project 8225/1, Toowoomba, QLD, 4350.

JBS Australia Pty Ltd (2014). Tripe wash water reuse in beef processing. A report prepared for Meat & Livestock Australia Limited. Project Code A.ENV.0137.

Jensen, P. and D. Batstone (2012). Energy and Nutrient analysis on Individual Waste Streams. A report prepared for Meat and Livestock Australia. Project A.ENV.0131.

JJC Engineering Pty Ltd and Kurrajong Meat Technology Pty Ltd (2008). Process integration study investigations into water use, salt discharge and energy reductions in the meat processing and rendering sector. Report prepared for MLA donor company. Project P.PSH.0201.

Johns, M. (2011). Water collection and data analysis. A report prepared for Meat & Livestock Australia Limited. Project Code P.PIP.0172.

Johns, M. and R. Nicol (2011). First waterless cleaning workshop. A report prepared for Meat & Livestock Australia Limited. Project Code A.ENV.0108.

Leslie, G. and S. Cox (2006). Feasibility Study of the Microfiltration of Steriliser Water for Reuse. A report prepared for Meat & Livestock Australia Limited. Project Code PRENV.040.

Maas E.V., 1986. Salt tolerance of plants. Applied Agricultural Research 1, 12–25.

McNeil, I. and P. Husband (1995). Water and Waste Minimisation. A report prepared for Meat and Livestock Australia Limited. Project A.MT. 002.

Nicol, R. (2008). Waterless Cleaning of Meat Processing Plants. A report prepared for Meat & Livestock Australia Limited. Project Code A.ENV.0066.

Northern Co-Operative Meat Company Ltd (2004). Potential for Reuse of Low Contamination Abattoir Effluent. A report prepared for Meat and Livestock Australia. Project PIP.010.

Oakey Abattoir Pty Ltd (2006). The environmental, social and economic benefits of water use, reuse and effluent management projects. A report prepared for MLA.

Oster J D, Shainberg I and Abrol I P 1999 Reclamation of salt affected soils. In Agricultural Drainage. Eds. R W Skaggs and J Van Schilfgaarde. pp. 659–691. ASA-CSSA-SSSA, Madison, WI.

Pagan, R., M. Renouf and P. Prasad (2002). Eco-Efficiency Manual for Meat Processing, Prepared for Meat and Livestock Australia Ltd on behalf of the Department of State Development, Qld, Food and Meat Industries Taskforce.

Pype, M.-L., K. Doederer, P. Jensen, J. Keller and R. Ford (2017). Strategic evaluation of RD&E opportunities for water reuse and recycling at Australian abattoirs. A report prepared for AMPC Project 2016.1021.

Pype, M.-L., K. Walduck, B. Goebel and P. Jensen (2017). Investigating water and wastewater reuse and recycling opportunities: identification and segregation of various waste streams. A report prepared for AMPC Project 2017.1042.

Qadir, M., Noble, A., Oster, J., Schubert, S. & Ghafoor, A., 2005, Driving forces for sodium removal during phytoremediation of calcareous sodic and saline-sodic soils: a review, Soil Use and Management, 21, 173-180.

Rengasamy, P., Sumner, M.E., 1998. Processes Involved in Sodic Behaviour. In: Sumner, M.E., Naidu, R. (Eds.), Sodic Soils. Distribution, Properties, Management, and Environmental Consequences. New York Press., New York, pp. 35-50.

Rengasamy, P., 2008. Salinity in the landscape: A growing problem in Australia. Geotimes 53, 34-39.

Rengasamy P (2006) World salinization with emphasis on Australia. Journal of Experimental Botany 57:1017-1023.

Ridoutt, B., P. Sanguansri and D. Alexander (2015). Environmental performance review: Red meat processing sector 2015. Prepared for the Australian Meat Processor Corporation., Australian Meat Processor Corporation.

Sentance, C. (2011). Optimising integrated water reuse and waste heat recovery in rendering plants and abattoirs. A report prepared for Meat & Livestock Australia Limited. Project Code P.PIP.0058.

Spence, M. (2006). Churchill Abattoir (CA) large scale demonstration wastewater recycling plant. A report prepared for Meat & Livestock Australia Limited. Project Code P.PIP.0141.

Teys Bros Pty Ltd (2011). Visceration table water reuse. A report prepared for Meat & Livestock Australia Limited. Project Code A.ENV.0081.

US Salinity Laboratory Staff (1954) Diagnosis and improvement of saline and alkali soils. United States Salinity Laboratory Handbook No.60.

Wade Phillips and Tatiara Meat Company (2011). Re-use of steriliser water for contra-shear and hose down outside rendering. Report prepared for AMPC/MLA. Project A.ENV.0078.

Warnecke, M., T. Farrugia and C. Ferguson (2008). Review of abattoir water usage reduction, recycling and reuse. A report prepared for Meat & Livestock Australia Limited. Project Code A.PIA.0086.

# Appendix A – Water map

# Appendix B – Water savings initiative workshop memo

# Appendix D - Composition of waste streams at Oakey Beef Exports during the intensive sampling campaign

| Source | Code | Sampling method * | Flow (kL.d$^{-1}$) | TS (% FM) | VS (% TS) | pH | Total COD (mg.L$^{-1}$) | VFA (mg.L$^{-1}$) | FOG (mg.L$^{-1}$) | $NH_4$ (mg.L$^{-1}$) | Total N (mg.L$^{-1}$) | Total P (mg.L$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Saveall South Combined sample | S6 F5 | flow prop n=5 | 331 | 2.1 | 92.5 | 5.8 | 52656 | 1080 | 6100 | 84 | 366 | 66 |
| Saveall South effluent post-screen | S8 F5 | flow prop n=4 | 331 | 1.4 | 89.6 | 6.2 | 37063 | 1003 | 5525 | 116 | 316 | 56 |
| Saveall South effluent post-DAF | S9 F5 | flow prop n=4 | 331 | 0.8 | 85.0 | 6.7 | 21600 | 831 | 3000 | 130 | 339 | 48 |
| Boning room | S4 F3 | flow prop n=3 | 491 | 0.1 | 45.2 | 7.2 | 542 | 38 | 96 | 0 | 8 | 4 |
| Decontamination | S12 F7 | flow prop n=1 | 155 | 0.2 | 62.1 | 7.8 | 2005 | 121 | 1910 | 3 | 31 | 12 |
| Saveall North Combined sample | S14 F9 | flow prop n=4 | 552 | 0.4 | 60.2 | 8.1 | 4340 | 314 | 297 | 162 | 216 | 61 |
| Combined Saveall North and South | S15 F10 | flow prop n=2 | 1325 | 0.5 | 74.8 | 6.9 | 11925 | 553 | 1060 | 79 | 235 | 43 |
| Combined cattle wash | S10 | time prop n=2 | | 0.2 | 48.6 | 8.7 | 2530 | 196 | 129 | 300 | 310 | 30 |
| Paunch/green wash combined | S11 | time prop n=2 | | 0.6 | 69.8 | 7.1 | 10160 | 411 | 1013 | 28 | 125 | 152 |
| Tripe wash pre-screen | S1 | time prop n=2 | | 2.4 | 94.1 | 5.6 | 40385 | 642 | 6700 | 27 | 95 | 113 |
| Kill floor post-DAF | S17 F12 | grab n=2 | 986 | 0.3 | 70.3 | 7.1 | 5715 | 321 | 470 | 35 | 150 | 44 |
| Kill floor | S16 F12 | grab n=3 | 986 | 0.7 | 84.8 | 6.7 | 18190 | 603 | 1300 | 34 | 333 | 62 |
| Stick water | S3 | grab n=4 | | 1.8 | 78.0 | 4.7 | 30060 | 723 | 1080 | 62 | 1330 | 140 |

*n = number of sampling periods