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Prepared by: Dr Robert Barlow
CSIRO

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Meat and Livestock Australia Limited
Locked Bag 1961
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Real-time detection of faecal contamination of beef carcases

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ABSTRACT

There is a clear and well understood need to reduce the presence and concentration of pathogenic and food spoilage bacteria on red meat. Although the levels of pathogens and contaminating microflora are typically low in red meat products processed in Australian plants, there are no rapid and reliable methods of monitoring bacterial levels on meat during processing. The ability to detect faecal contamination online during processing would assist in reducing one of the causes of bacterial contamination of beef carcases.

The Veritide faecal detection system is able to detect non-visual contamination events to which an intervention can be applied thereby reducing the bacterial load entering the chiller following processing. The rate of faecal detection on carcases processed at ACC was 0.086% or approximately 1 in 1100 bodies. Notwithstanding that clustered contamination events can occur during processing and did occur during this study, the detection rate would equate to approximately 1.1 detections for each day of production at ACC. The detection of contamination events is likely to lead to improvements in food safety assurance and shelf-life for manufacturing beef and specific primal cuts that are sourced from Veritide positive carcases.

An ex-ante cost benefit analysis on real-time detection of faecal contamination on beef carcases was conducted by Greenleaf Enterprises. The analysis determined that the major influencing factor impacting the financial opportunity in each of the different process scenarios is the proportion of manufacturing beef (trim) contaminated with Shiga toxigenic *E. coli* (STEC). The net benefit was estimated at between $0.72 and $0.94 per head for plants with high contamination levels and minimal interventions compared with between -$0.35 and -$0.38 per head for plants with low contamination levels and multiple interventions.

The report recommends that due to the potential benefits and increased hygiene possible that the industry moves to invest in the commercialisation of the system. The Veritide system will provide an additional measure to reduce STEC contamination though it does not replace the need for detection and prevention of STEC contamination events. Ultimately, however, the need for Veritide and its place within the hygiene processing of carcases is plant-specific. This study was conducted at ACC, which is a plant that utilises pre-slaughter washing and spray chilling as part of its intervention strategy. Consequently it is predicted that installation of a Veritide system at ACC would result in a net loss of between $86,712 and $95,009 per annum.

It is recommended that due to the potential benefits and increased hygiene possible that the industry moves to invest in the commercialisation of the system, particularly in processing plants that do not use a combination of pre-slaughter washing and spray chilling. The Veritide system will provide an additional measure to reduce STEC contamination though it does not replace the need for detection and prevention of STEC contamination events. Ultimately, however, the need for Veritide and its place within the hygiene processing of carcases is plant-specific.

Executive summary

There is a clear and well understood need to reduce the presence and concentration of pathogenic and food spoilage bacteria on red meat. Although the levels of pathogens and contaminating microflora are typically low in red meat products processed in Australian plants, there are no rapid and reliable methods of monitoring bacterial levels on meat during processing. The ability to detect faecal contamination online during processing would assist in reducing one of the causes of bacterial contamination of beef carcases. Previously developed faecal detection systems did not gain widespread acceptance due to generation of false negatives and false positives. Advances in optical technology and microprocessor speeds since have enabled Veritide to develop an improved faecal detection system and algorithms that overcome the initial shortcomings of real-time faecal detection systems and the evaluation of the effectiveness of the Veritide system in a beef processing facility is therefore the next step in the commercial development of the Veritide system.

This study originally proposed to use Veritide's BluLine portable scanner system with ACC focussing systems setup (Milestone 1) and initial data collection (Milestone 2) efforts around the use of this system. Following the completion of Milestone 2, Veritide made the larger, more efficient Hot Spot camera scanner available for use in this study. Modifications were made to the gantry rail and enclosure in order to install the Hot Spot camera (Milestone 3) with Milestone 4 completed using the Veritide Hot Spot camera scanner and the BluLine portable scanner systems. A total of 33,842 bodies were tested for faecal contamination using the Veritide scanners. Faecal contamination was detected on 0.086% of carcases with rump (65.5%) and right side of the carcase (62.1%) representing the most commonly detected sites. Faecal contamination was detected on 29 occasions from 18 shifts with single and multiple detections occurring on 14 and 4 shifts, respectively. Multiple detections were typically clustered in time and likely caused by a single contamination event that effected nearby carcases. The mean TVC on excised meat samples from Veritide positive carcases was 3.46 $\log_{10}$ CFU/g and was significantly ($P<0.05$) higher than the mean TVC from Veritide negative samples. Trimming of the contaminated areas identified using the Veritide scanners reduced the bacterial load to a mean of 1.21 $\log_{10}$ CFU/cm^2 thereby confirming that the Veritide faecal detection system could impact positively on the shelf-life of final product. Detection of *E. coli* was not a common feature associated with Veritide positive samples, however the detection limit of the microbiological method used in this study is likely to be higher than what is generally observed in processing plants.

An ex-ante cost benefit analysis on real-time detection of faecal contamination on beef carcases was conducted by Greenleaf Enterprises. The analysis determined that the major influencing factor impacting the financial opportunity in each of the different process scenarios is the proportion of manufacturing beef (trim) contaminated with Shiga toxigenic *E. coli* (STEC). The net benefit was estimated at between $0.72 and $0.94 per head for plants with high contamination levels and minimal interventions compared with between -$0.35 and -$0.38 per head for plants with low contamination levels and multiple interventions. The report recommends that due to the potential benefits and increased hygiene possible that the industry moves to invest in the commercialisation of the system. The Veritide system will provide an additional measure to reduce STEC contamination though it does not replace the need for detection and prevention of STEC contamination events. Ultimately, however, the need for Veritide and its place within the hygiene processing of carcases is

plant-specific. This study was conducted at ACC, which is a plant that utilises pre-slaughter washing and spray chilling as part of its intervention strategy. Consequently it is predicted that installation of a Veritide system at ACC would result in a net loss of between $86,712 and $95,009 per annum. It should be noted however, that ACC do not currently export manufacturing beef to STEC regulated regions and consequently are unable to confirm that their current contamination frequencies align with the assumptions used in the cost benefit analysis. ACC is encouraged to assess their contamination frequency and likely export profile as a final step in determining the feasibility of a Veritide installation.

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1 Background

There is a clear and well understood need to reduce the presence and concentration of pathogenic and food spoilage bacteria on red meat. Although the levels of pathogens and contaminating microflora are typically low in red meat products processed in Australian plants, there are no rapid and reliable methods of monitoring bacterial levels on meat during processing. Red meat processors have a continual risk of recall and spoilage claims as well as regulatory consequences that may occur from the detection of organisms with 'zero tolerance' such as Shiga toxin-producing *E. coli* in North American markets. The ability to detect faecal contamination online during processing would assist in reducing one of the causes of bacterial contamination of beef carcases. However, the strength of correlation between the level of faecal contamination and shelf-life and the level of bacterial contamination on meat leaving the processing plant is not well understood.

Existing methods of bacterial contamination detection fall into two categories:

1. Visual inspection for faecal contamination is used to detect macro-contamination of beef carcases by faeces and other obvious contaminants after the slaughtering process. This is an expensive, inconsistent, subjective and unreliable process that routinely does not result in the removal of faecally-contaminated carcase material prior to chilling. Furthermore, it is unable to detect non-visible or micro-contamination events.
2. Microbiology testing is regularly carried out but is typically only performed on a very small amount of the overall product. While this is necessary and useful in many regards, it fails to be an effective method of detecting random and isolated faecal contamination events. It is also very slow, typically taking 2-7 days for results to become available thereby providing no opportunity for the processor to make an informed decision during slaughter or prior to boning and packaging of product.

Presently there are successful examples methods for direct and real-time detection of bacteria on meat. Whilst there are real-time and non-invasive systems for detecting non-bacterial contaminants (e.g. x-rays and metal detectors), bacterial detection in real-time remains problematic. Red meat processors implement and maintain good hygiene practices to help prevent bacterial contamination of red meat products, however they remain blind to frequency and concentration of bacterial contamination events that inevitably occur. Australian Country Choice would like to understand if faecal contamination detection provides a reliable quantitative method of predicting bacterial contamination and shelf-life.

In 2003, a faecal detection system was developed by eMerge Interactive and named 'VerifEYE'. This system failed to meet the requirements of several meat processors as it produced many false positives and false negatives. Advances in optical technology and microprocessor speeds since have enabled Veritide to develop an improved faecal detection system and algorithms that overcome the initial shortcomings of real-time faecal detection systems. Initial trials on lamb carcases were promising and the evaluation of the effectiveness of the Veritide system in a beef processing facility is the next step in the commercial development of the Veritide system. This report presents the findings of an evaluation of the Veritide faecal detection system at Australian Country Choice's (ACC) Cannon Hill processing facility.

2 Project objectives

The overall objective of the project is to evaluate the Veritide faecal detection system to provide an objective measure of the visual inspection process and visibility of the contamination level for the meat processor.

Specific objectives of the study include:

- To obtain a quantitative measure of the level of visible and non-visible faecal contamination that is present on beef carcases that have previously been visually inspected.
- To validate that the faecal detector may be used as a measuring (and monitoring) tool for process improvement by providing information on poor practices, show where process improvements need to be made and rapidly identify when processing errors are being made.
- To investigate how well the levels of faecal contamination on the meat, after intervention and improvement, correlate with the measured bacterial concentrations and shelf-life of the meat and bacterial concentrations within the processing facility.
- Reporting including in-house financial models to show the financial benefit before and after this faecal-detection-led intervention and improvement.

This final report is produced to satisfy the requirement of Milestone 5 of P.PIP.0552. Specifically, it summarises the findings of Milestones 1-4 which included:

- Milestone 1: System setup phase (data retrieval and ERP integration and training)
- Milestone 2: Data collection phase: technical support and analysis
- Milestone 3: Redesign and build gantry rail and enclosure
- Milestone 4: Independent testing and validation phase. Technology scanning, data gathering, financial models and swab tests

3 Milestone 1 & 2: System setup and data collection phase

3.1 Methodology

Stage 1: System setup phase: (Data retrieval and ERP integration and training)

Review history and load all current data including operational and QA non-compliance, ERP and training records. A milestone report provided on the data retrieval phase.

Stage 2: Data collection phase: Technical support and analysis

Start utilising the hand-held prototype devices with ongoing data capture and collection. Monitory and adjust the system based on results. The data set provided by this project will contain very crucial information such as the size, location, frequency and time of faecal contamination. From understanding the baseline faecal contamination and from the information gathered from the faecal detector, the second goal is to confirm that intervention of the slaughtering process can be made to reduce the levels of faecal contamination. A milestone report provided on the pilot phase. Report and recommendations for the pilot approved by project technical group.

3.2 Results and Discussion

The system setup and initial data collection phase were completed as planned and noted in the minutes of the project steering group meeting of May 23, 2017 (Appendix 1).

3.2.1 Proposed scanning locations

Locations for the use of the hand-held scanners were identified and are shown in Figure 1. Locations 1 and 2 would enable the scanning of carcases following evisceration and splitting and have proximity to the retain rail such that further trimming and swabbing can occur. Location 3 is immediately prior to chiller entry and allows for a final evaluation of the carcase to occur.

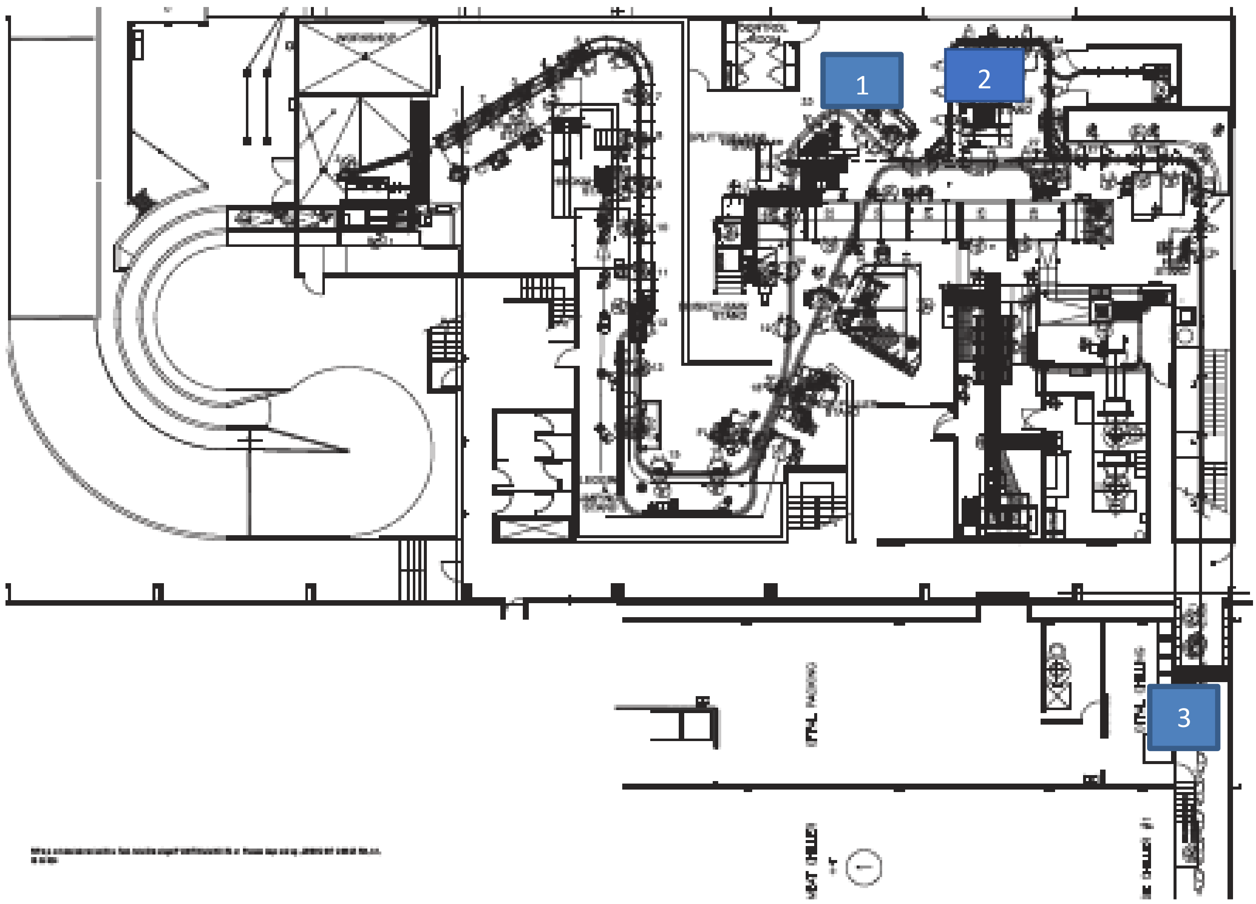


Figure 1. Proposed hand-held scanning locations.

3.2.2 Operating manual and protocol

Overview

This document provides the requirements, activities and protocol for the faecal detection research project to be carried out at ACC in Brisbane, using Veritide BluLine portable faecal scanners.

Trial Design

- 3 faecal scanners will be provided (two for the trial and one for backup)
- Batch/Sample size (x number of carcasses per day/week) TBA
- Where on line (e.g. before spray chilling or in a chiller)
- Action on detection (ACC to determine)
- At what level do ACC call and audit?
- Bacteria swabbing (where and when)

Technical

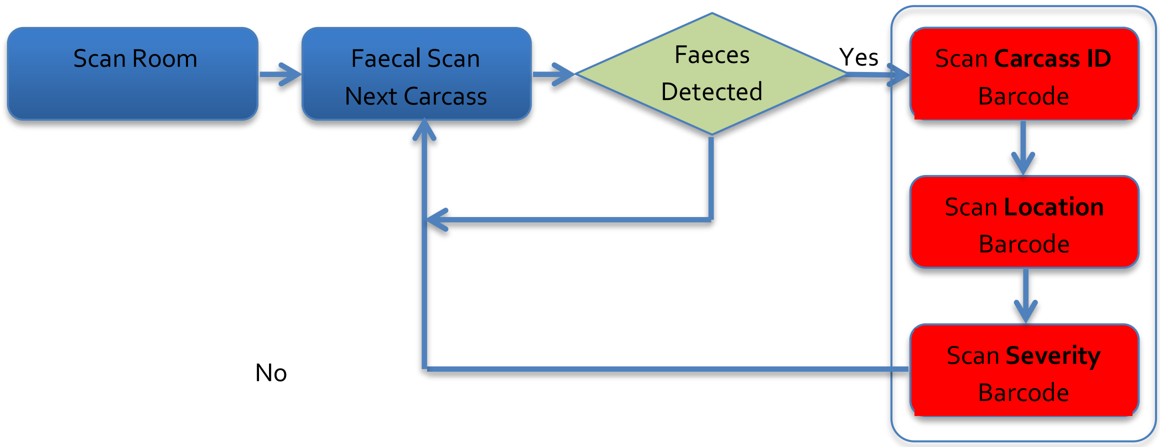
- Veritide will provide Wi-Fi connectivity within each faecal scanner to connect to the ACC network.

- Each faecal scanner will Auto-upload to the ACC database whenever it has a reliable Wi-Fi connection.
- Reporting from the ACC database will need to align the plant location, carcass ID and carcass position and contamination severity records chronologically, and allow for potentially missing barcode records.
- The faecal scanner barcode scan mode operates as follows:
    - Change to barcode scan mode by holding the trigger switch on the scanner for more than 1 second.
    - When in barcode scanning mode the display will flash alternate LEDs at a rate of 0.5s.
    - The scanner will exit barcode scanning mode immediately a barcode is detected or after 10 seconds.
    - When a barcode is detected the vibrator will activate for 0.5s.
    - The behaviour of the barcode reading process may need to be altered once it has been trialled.

Dataset

- A separate data record will be saved when faeces are detected or for each barcode that is scanned.
- All data records will have the following fields and datatypes:
    - **ScannerID** :String
    - **UTC Date & Time** :String
    - **Barcode** :String
- The **Barcode** field will contain one of the following items of information:
    - **Location** within the processing plant where the scanning will take place (barcode defined by ACC). Assume that all records AFTER a **Location** record and up to the following **Location** record are associated with this plant location.
    - The text string "**Faeces**", indicating that faeces have been detected. Assume that all records AFTER a "**Faeces**" record and are associated with this contamination. The "**Faeces**" records effectively provide a marker between the following three record types.
    - Unique **Carcase Identifier** as defined by ACC
    - **Position** of the contamination on the carcass as defined by ACC
    - **Severity** of the contamination as defined by ACC
- The scanner has no "knowledge" of the meaning of the ACC defined barcodes as these are simply forwarded through to the ACC database.

Protocol for Capture



Note: when a carcass ID tag is not present, the **Carcass ID** barcode cannot be entered. However, it is still possible to enter the **Location** and **Severity** barcodes while skipping the **Carcass ID** barcode.

Timeline

- Veritide will be ready for installation and commissioning after the 5th of April 2017.
- Allow 3 days for installation, commissioning
- and ensuring correct database connectivity.

Batteries

The BluLine portable scanner can operate with Li ion (14.8V) or NiMh (12V) batteries, but Li ion provides significantly longer operating time between charging. Unfortunately, it is no longer possible to transport small volumes of Li ion batteries cost effectively due to the dangerous goods transport requirements. Locally sourced Li ion batteries may be used. Their specifications are as follows:

- 14.8v Li ion (16.8v charge voltage)
- Must include a protection circuit module for over charge, over discharge and short circuit
- 6Ah or thereabouts (e.g. 8 cells) is a suitable capacity. It should be possible to fit two of these (i.e. one spare) in the scanner backpack battery pocket.

3.3 Conclusions/Recommendations

Milestones 1 and 2 were successfully completed with the design and commissioning of the hand held scanning units finalised. It was recommended that Milestone 3 proceed as scheduled.

4 Milestone 3: Redesign and build gantry rail and enclosure

Veritide produce two types of faecal detection systems: Veritide BluLine portable faecal scanner and Hot Spot Camera Scanner. Originally it was the intent of the project to conduct the evaluation using the BluLine portable scanners, however Veritide were also able to make the Hot Spot Camera Scanner available. The Hot Spot Camera Scanner is superior to the portable BluLine scanners as it is able to rapidly scan whole carcases for the presence of faecal detection.

4.1 Methodology

Identify an available area for the installation of the Veritide Hot Spot camera and design, draw and install gantry rail modifications.

4.2 Results

4.2.1 Gantry design and drawing

Location 3 (refer to Figure 1) was identified as a suitable space for the installation of the Hot Spot camera. The required gantry rail modifications were identified, designed and subsequently installed. The gantry rail installation drawing and the completed rail installation are shown in Figures 2 and 3.

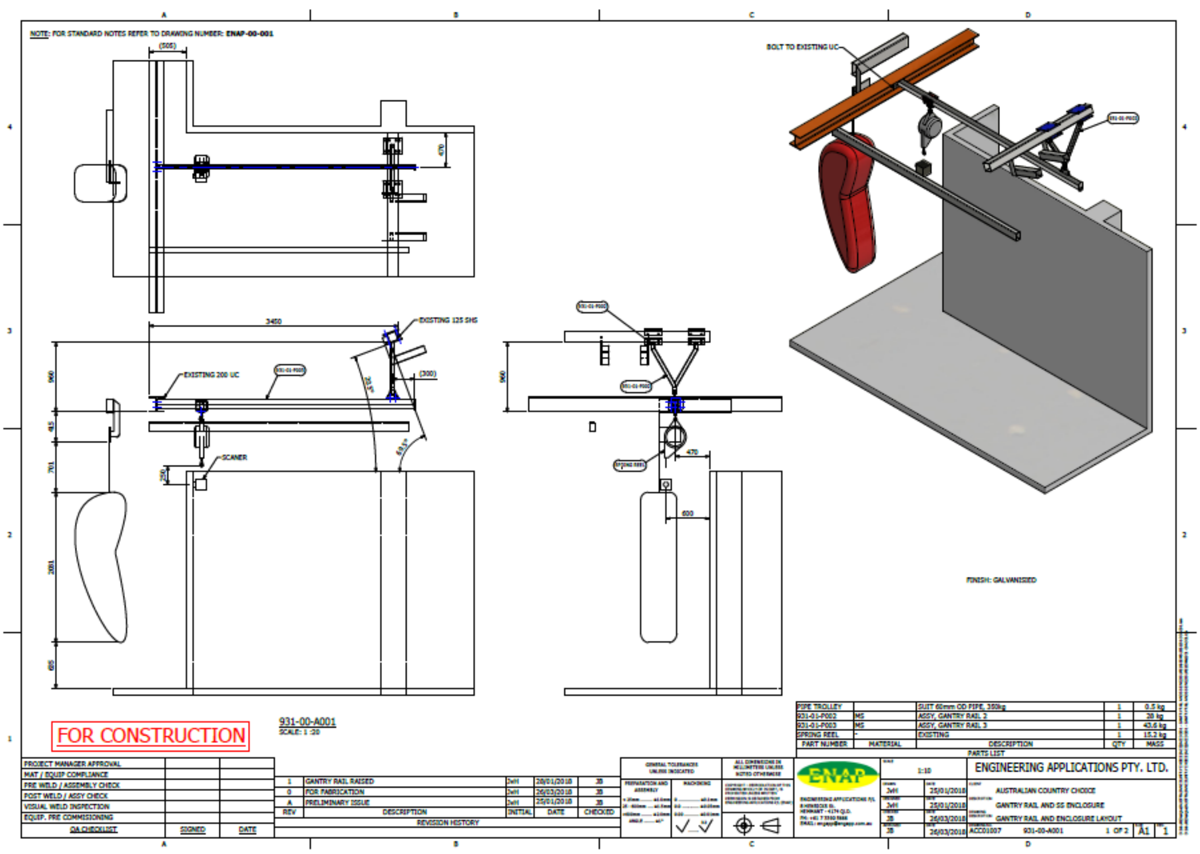


Figure 2. Gantry rail redesign drawings.

Figure 3. Photo of the installed gantry rail modifications.

4.3 Conclusions/Recommendations

The redesign and build of the gantry rail and enclosure were successfully completed and noted in the minutes of the project steering group meeting held June 26th, 2018 (Appendix 2). Installation of the data cable and data capture monitor was subsequently completed and the Hot Spot camera was commissioned in the week of July 9th, 2018. The project successfully completed Milestone 3 and it was recommended to progress to Milestone 4 as scheduled.

5 Milestone 4: Independent testing and validation phase

5.1 Methodology

5.1.1 Participating processing facility

Evaluation of Veritide's faecal detection system was conducted at the Australian Country Choice processing facility located at Cannon Hill, Brisbane, Queensland. The facility processes approximately 1200 grain-fed (feed-lotted) cattle per day across two shifts. The evaluation was conducted on all animals processed during the day shift between September 3rd, 2018 and November 20th, 2018.

5.1.2 Veritide faecal detection system

Veritide produce two types of faecal detection systems: Veritide BluLine portable faecal scanner and Hot Spot Camera Scanner. Originally it was the intent of the project to conduct the evaluation using the BluLine portable scanners, however Veritide were also able to make the Hot Spot Camera Scanner available. The Hot Spot Camera Scanner is superior to the portable BluLine scanners as it is able to rapidly scan whole carcases for the presence of faecal detection. The portable scanners require the user to scan the carcase is a pre-determined pattern and is typically used to focus on areas of the carcase that are most likely to be contaminated (e.g rump). In this study, the Hot Spot Scanner was used as the primary scanner, scanning all external surfaces of the carcase as well as all cut lines (see Figure 4). The BluLine scanners were subsequently used to confirm the finding of the Hot Spot Scanner and to identify the area of the carcase requiring additional trimming. Veritide provided initial training and supporting documentation to ACC in order for ACC staff to be deemed competent in the use of the Veritide scanners prior to the commencement of the trial.

Figure 4. Scanning of a beef carcase using the Hot Spot Camera Scanner.

5.1.3 Faecal detection frequency

Carcase scanning was performed on all carcases (left and right sides) during the day shift. Scanning was conducted immediately prior to chiller entry and involved the user making vertical passes of the carcase as it was held in set positions by a second user. Carcases that tested negative for faecal contamination using the Hot Spot scanner were released and immediately placed in the chiller. Conversely, carcases that tested positive using the Hot Spot Scanner were placed on a separate rail and the following actions performed:

- The body number and side were recorded.
- BluLine portable scanners were used to confirm the presence of faecal detection and the approximate area of contamination.
- The position of the contamination on the carcase was recorded (i.e rump, flank or brisket).
- As assessment of whether the contamination was visual or non-visual was made and recorded.
- The contaminated area was removed and sent for microbiological testing.
- A swab of the area from which the contaminated tissue was removed was swabbed and sent for microbiological testing.
- The carcase was then returned to the main processing line and placed into the chiller.

5.1.4 Determination of baseline carcase contamination concentrations

In order to determine the effectiveness of the Veritide detection system baseline data on the typical carcase contamination, concentrations present on cattle processed at ACC was required. Over a period of 15 days three Veritide negative carcases per day were removed from the main processing line for further testing. Attempts were made to sample across the day shift production with the three daily samples typically collected from the first third, second third and final third of production. In addition, the site for sampling was randomly assigned such that on each day a brisket, flank and rump sample were collected. For the purposes of analysis, a piece of tissue equivalent in size to what was typically removed from Veritide positive carcases was removed and sent for microbiological testing. Similarly, the excised area was then swabbed and also sent for microbiological testing.

5.1.5 Microbiological testing

Microbiological testing of all meat samples and carcase swabs was conducted by Merieux Nutrisciences Brisbane Laboratory. All samples were tested for the presence of total viable aerobic count (TVC) and *E. coli* and coliform counts using the method reference AOAC 990.12 and AOAC 991.14, respectively. Meat samples were analysed by weight and results recorded as CFU/g. Carcase swabs were analysed based on the area swabbed and results recorded at CFU/cm^2.

5.1.6 Statistical analysis

Statistical analysis was conducted using GraphPad Prism version 8.0.1 for Windows.

5.1.7 Cost benefit analysis

An independent ex-ante cost benefit analysis of real-time detection of faecal contamination on beef carcases was conducted by Greenleaf Enterprises. The methodology for the analysis is described within the Greenleaf Enterprises report (Appendix 3). The objectives of the ex-ante review were to:

1. Measure the expected value opportunity of real-time detection of faecal contamination of beef carcases.
2. Summarise the benefit and main drivers of value for the system.
3. Provide a framework which allows plants to identify the value of the system.
4. Deliver recommendations on opportunities offered through commercialisation.

5.2 Results and Discussion

5.2.1 Faecal detection frequency

The Veritide detection system was used to scan a total of 33,842 bodies that had been processed during day shifts at ACC. Scanning was conducted for a total of 56 days with a mean of 604 bodies scanned per shift. Faecal contamination was detected on 29 occasions from 18 shifts with single and multiple detections occurring on 14 and 4 shifts, respectively. A maximum of seven positives were recorded in any single shift. The overall frequency of detection of faecal contamination using the Veritide detection system was 0.086% or one detection every 1167 bodies. The BluLine portable scanners were able to confirm all of the Hot Spot Scanner detections. A summary of the Veritide positives are shown in Table 1.

Table 1. Details of Veritide positive carcases

DATE	BODY NUMBER	LEFT OR RIGHT	LOCATION	VISUAL
3/09/2018	300	L	Rump	No
3/09/2018	469	L	Rump	No
4/09/2018	525	L	Rump	Yes
4/09/2018	526	L	Rump	No
4/09/2018	526	R	Rump	No
4/09/2018	530	R	Rump	No
4/09/2018	540	R	Rump	No
4/09/2018	543	R	Rump	Yes
4/09/2018	546	L	Brisket	Yes
6/09/2018	510	R	Flank	No
6/09/2018	512	R	Rump	No
6/09/2018	524	R	Brisket	No
11/09/2018	573	R	Rump	No
13/09/2018	212	L	Rump	No
17/09/2018	424	L	Rump	Yes
18/09/2018	221	L	Flank	Yes

18/09/2018	521	L	Rump	Yes
18/09/2018	521	R	Rump	No
19/09/2018	173	L	Rump	No
21/09/2018	411	R	Flank	No
2/10/2018	425	R	Rump	No
3/10/2018	37	L	Flank	Yes
4/10/2018	355	R	Rump	No
8/10/2018	13	R	Brisket	No
9/10/2018	359	R	Brisket	No
11/10/2018	65	R	Flank	No
29/10/2018	119	R	Brisket	No
30/10/2018	431	R	Rump	No
13/11/2018	484	R	Rump	No

On the occasions where multiple detections were recorded in a shift there appears to be clustering of Veritide detections. For example, on 04/09/2018 there were seven detections recorded across a span of 22 bodies. From a spatial perspective, this represents approximately 15 minutes of production and is most likely the result of a single contamination event during processing that has impacted on the bodies present during the event. Similarly the three Veritide detections that occurred on 6/09/2018 also cluster within a 15 body span and are again likely due to a single contamination event.

The timing at which Veritide detections occur can be deduced from the body number and therefore spatially assigned across the day's production. The mean body number for Veritide detections was 392.9 with a 95% confidence interval (CI) of 326.9 – 458.93. These results indicate that Veritide detections are more likely to occur towards the end of the shift and may be a function of a loss in concentration caused by fatigue. The number of detections occurring per 50 bodies is shown in Figure 5. Veritide positives were most likely to be detected within the rump area of the carcase (65.5%) and on the right side of the carcase (62.1%). Importantly, 22/29 (75.9%) occurred when there were no visible signs of faecal contaminations.

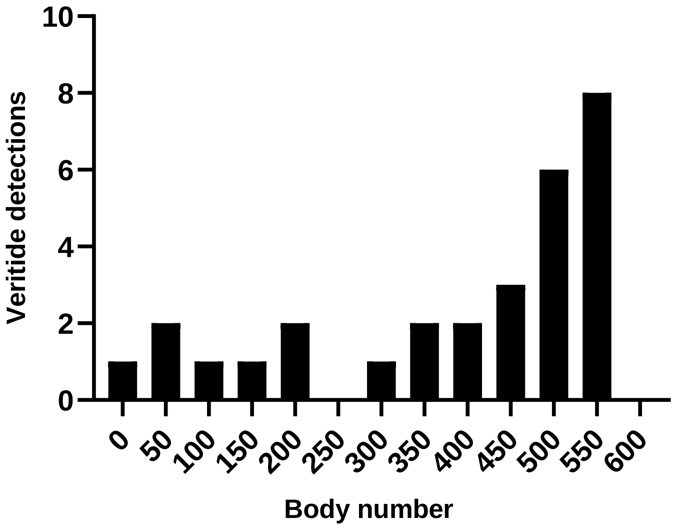


Figure 5. Histogram of Veritide detections per 50 bodies processed.

5.2.2 Microbiological evaluation of Veritide positive carcases

This study had aimed to microbiologically evaluate 100 Veritide positive carcases and the initial study design had scheduled this to occur across a two to three week period during the overall evaluation period. It became apparent after seven days of scanning that the Veritide detection rate would be insufficient to generate the number of samples required. The methodology was revised and attempts were made to collect and microbiologically assess all Veritide positive samples from September 13th, 2018 until the completion of the trial. The overall size of the trial was expanded in an attempt to capture additional Veritide positives. The final tally of 33,842 bodies represents a 69.2% increase in scanned bodies compared with the originally proposed 20,000. There were 16 Veritide positives recorded between 13/09/2018 and the completion of the trial and microbiological evaluation was performed on 13 of them. The TVC, *E. coli* and coliform counts of the excised meat sample and the swab of the excised area are shown in Table 2. In addition, the low frequency of faecal detection combined with its localised nature made it apparent that the overall change in carcase yield was negligible and collection of data for yield calculations was ceased.

Table 2. Microbiological evaluation of Veritide positive carcases.

DATE	CARCASE	LOCATION	EXCISED MEAT SAMPLE *			CARCASE SWAB#		
			TVC	COLIFORMS	*E. COLI*	TVC	COLIFORMS	*E. COLI*
13/09/2018	212L	Rump	3.00	1.00	1.00	1.44	<-1.10	<-1.10
18/09/2018	221L	Flank	2.34	<1.00	<1.00	0.62	-0.55	-0.55
18/09/2018	521R	Rump	3.41	1.95	<1.00	<-0.08	<-1.10	<-1.10
19/09/2018	173L	Rump	3.38	2.56	2.56	1.66	<-1.10	<-1.10
21/09/2018	411R	Flank	4.41	<1.00	<1.00	1.23	<-1.10	<-1.10
2/10/2018	425R	Rump	2.59	<1.00	<1.00	2.00	<-1.10	<-1.10
3/10/2018	37L	Flank	2.76	<1.00	<1.00	0.88	<-1.10	<-1.10
4/10/2018	355R	Rump	3.00	<1.00	<1.00	1.11	<-1.10	<-1.10
8/10/2018	13R	Brisket	5.00	3.61	1.95	1.72	0.15	<-1.10

DATE	CARCASE	LOCATION	EXCISED MEAT SAMPLE *			CARCASE SWAB#		
			TVC	COLIFORMS	*E. COLI*	TVC	COLIFORMS	*E. COLI*
9/10/2018	359R	Brisket	3.65	2.75	<1.00	0.82	<-1.10	<-1.10
11/10/2018	65R	Flank	4.49	2.15	1.70	3.88	-0.62	-0.62
30/10/2018	431R	Rump	3.91	2.32	<1.00	0.43	-0.32	<-1.10
13/11/2018	484R	Rump	3.00	<1.00	<1.00	<-0.08	<-1.10	<-1.10

* Counts are expressed as log_{10} CFU/g; # Counts are expressed as log_{10} CFU/cm^2

The mean TVC on excised meat samples from Veritide positive carcases was 3.46 log_{10} CFU/g. The detection of *E. coli* and coliforms occurred in 4/13 (30.8%) and 7/13 (53.8%), respectively. In samples that were positive for *E. coli* or coliforms, mean counts of 1.80 and 2.33 log_{10} CFU/g were observed. Swabbing of the excised area following removal of the contaminated area confirmed a reduction in bacterial concentration. The mean TVC on the excised area was 1.21 log_{10} CFU/cm^2 with *E. coli* and coliforms detected on two and four carcases, respectively. It must be noted that caution is required when attempting to compare the microbiological data from the excised meat sample and the carcase swabs as the meat sample is analysed based on weight whereas the swab sample is based on area. This results in the limit of detection being lower for the swab samples.

5.2.3 Determination of baseline carcase contamination concentrations

Baseline contamination data was generated by sampling three Veritide negative carcases each day for 15 days. The microbiological analysis of the excised meat samples is shown in Table 3. The mean TVC of the samples was 2.72 log_{10} CFU/g. *E. coli* and coliforms were detected in one and nine carcases, respectively. The mean TVC at each of the sampling sites was determined and found to be 2.93 log_{10} CFU/g for rump samples, 2.81 log_{10} CFU/g for flank samples, and 2.65 log_{10} CFU/g for brisket samples. The differences in mean TVC between sampling sites was not found to be significant ($p<0.05$). Carcase swabs of the excised area were analysed and found to have a mean TVC of 0.76 log_{10} CFU/cm^2 (data not shown).

Table 3. Microbiological analysis of excised meat samples from Veritide negative carcases.

DATE	SITE	TVC	COLIFORMS	*E. COLI*
31/10/2018	Brisket	2.77	<1.00	<1.00
31/10/2018	Brisket	2.52	<1.00	<1.00
1/11/2018	Brisket	3.48	1.00	<1.00
2/11/2018	Brisket	2.77	<1.00	<1.00
2/11/2018	Brisket	2.52	<1.00	<1.00
5/11/2018	Brisket	5.89	3.62	<1.00
6/11/2018	Brisket	1.70	<1.00	<1.00
7/11/2018	Brisket	2.20	<1.00	<1.00
8/11/2018	Brisket	2.04	<1.00	<1.00
9/11/2018	Brisket	1.00	<1.00	<1.00
12/11/2018	Brisket	2.60	<1.00	<1.00
14/11/2018	Brisket	3.08	<1.00	<1.00

15/11/2018	Brisket	3.62	<1.00	<1.00
16/11/2018	Brisket	1.60	<1.00	<1.00
19/11/2018	Brisket	1.60	<1.00	<1.00
20/11/2018	Brisket	3.00	<1.00	<1.00
31/10/2018	Flank	2.04	<1.00	<1.00
1/11/2018	Flank	3.58	<1.00	<1.00
2/11/2018	Flank	2.04	<1.00	<1.00
5/11/2018	Flank	4.08	1.85	<1.00
6/11/2018	Flank	3.30	1.60	1.00
7/11/2018	Flank	2.97	<1.00	<1.00
8/11/2018	Flank	3.48	1.30	<1.00
9/11/2018	Flank	2.34	<1.00	<1.00
12/11/2018	Flank	4.30	1.95	<1.00
14/11/2018	Flank	2.62	<1.00	<1.00
15/11/2018	Flank	3.38	<1.00	<1.00
16/11/2018	Flank	1.85	<1.00	<1.00
19/11/2018	Flank	1.85	<1.00	<1.00
20/11/2018	Flank	1.48	<1.00	<1.00
1/11/2018	Rump	4.70	1.00	<1.00
5/11/2018	Rump	3.00	1.85	<1.00
6/11/2018	Rump	4.75	3.40	<1.00
7/11/2018	Rump	2.32	<1.00	<1.00
8/11/2018	Rump	2.48	<1.00	<1.00
9/11/2018	Rump	1.60	<1.00	<1.00
12/11/2018	Rump	3.92	<1.00	<1.00
14/11/2018	Rump	2.99	<1.00	<1.00
15/11/2018	Rump	2.74	<1.00	<1.00
16/11/2018	Rump	2.40	<1.00	<1.00
19/11/2018	Rump	2.40	<1.00	<1.00
20/11/2018	Rump	1.90	<1.00	<1.00
13/11/2018	Unknown	2.32	<1.00	<1.00
13/11/2018	Unknown	1.30	<1.00	<1.00
13/11/2018	Unknown	1.85	<1.00	<1.00

5.2.4 Comparison of Veritide positive and negative carcases

The decision to implement a faecal detection system is likely to be based on the ability to reduce the overall level of contamination in finished product and the subsequent gains in shelf-life and reduced likelihood of pathogen detection in specific markets that are achieved. An unpaired two tail *t* test was used to compare the mean TVC from Veritide positive (3.46 $\log_{10}$ CFU/g) and Veritide negative (2.72 $\log_{10}$ CFU/g) samples. The difference in mean TVC between the two groups was 0.74 $\log_{10}$ CFU/g and the 95% CI of the difference was 0.13 to 1.35 $\log_{10}$ CFU/g. The difference between the mean TVC of Veritide positive carcases and Veritide negative carcases is considered to be significant ($p<0.05$) and therefore the use of the Veritide faecal detection system would reduce the overall concentration of bacteria in final product.

It is necessary, however, to consider the impact of faecal detection and TVC reduction from an overall production perspective. Whilst there are potential gains in the shelf-life of primal cuts from Veritide positive carcases, further investigations are required to understand the impact of elevated TVC prior to chiller entry. The chilling of the carcase along with any additional handling and trimming of the carcase will also contribute to the TVC of final product and therefore its shelf-life. For co-mingled products such as manufacturing beef there would appear to a low likelihood that the Veritide faecal detection system would significantly reduce the bacterial concentration or the risk of pathogen detection. This outcome is likely because of the low frequency of faecal detection combined with the observation that Veritide positive samples were most likely to not contain detectable levels of *E. coli*. It is noted that this study was conducted in a single plant and alternate conclusions may be drawn from assessments conducted in additional processing plants with different microbiological profiles. The microbiological findings of this study will be integrated into a cost benefit analysis and will be included in the final report (Milestone 5).

5.2.5 Ex-ante cost benefit analysis

An ex-ante cost benefit analysis was conducted by Greenleaf Enterprises. The full cost-benefit report is attached in Appendix (Section 7.1). The analysis evaluated the value gain that may eventuate following the installation of a Veritide system in plants with three different process scenarios:

- Pre-slaughter wash with spray chilling
- Pre-slaughter wash without spray chilling, and
- Spray chilling only

The analysis determined that the major influencing factor impacting the financial opportunity in each of the different process scenarios is the proportion of manufacturing beef (trim) contaminated with Shiga toxigenic *E. coli* (STEC). Not surprisingly, the net benefit of the Veritide system was inversely correlated to the number and efficacy of existing interventions within each of the process scenarios evaluated. Consequently, plants that only conducted spray chilling had the greatest net benefit resulting the installation of a Veritide system with gains of between $0.72 and $0.94 per head and a payback timeframe on the capital investment of between 0.50 and 0.65 years. Plants using a pre-slaughter wash without spray chilling had net gains of between $0.02 and $0.11 per head with payback timeframes of 3.07 to 7.57 years. There is no payback timeframe for the process scenario of pre-slaughter wash with spray chilling. In this scenario the net benefit ranges from -$0.35 to -$0.38 per head with an annual net cost to the plant of between $86,712 and $95,009.

The report recommends that due to the potential benefits and increased hygiene possible that the industry moves to invest in the commercialisation of the system. The Veritide system will provide an additional measure to reduce STEC contamination though it does not replace the need for detection and prevention of STEC contamination events. Ultimately, however, the need for Veritide and its place within the hygiene processing of carcases is plant-specific. Different climates, throughput and current hygiene processing are all factors influencing the viability of the Veritide system.

The study reported here detailed the application of the Veritide system at the ACC processing plant. ACC utilise both pre-slaughter washing and spray chilling within their existing process and therefore it is predicted that a net loss may result from the installation of a Veritide system at ACC in the absence of any additional changes. It should be noted that ACC do not currently export manufacturing beef to STEC regulated regions and consequently are unable to confirm that their current contamination frequencies align with the assumptions used in the cost benefit analysis. ACC is encouraged to assess their contamination frequency and likely export profile as a final step in determining the feasibility of a Veritide installation.

5.3 Conclusions

The Veritide faecal detection system is able to detect non-visual contamination events to which an intervention can be applied thereby reducing the bacterial load entering the chiller following processing.

The rate of faecal detection on carcases processed at ACC was 0.086% or approximately 1 in 1100 bodies. Notwithstanding that clustered contamination events can occur during processing and did occur during this study, the detection rate would equate to approximately 1.1 detections for each day of production at ACC.

The detection of contamination events is likely to lead to improvements in food safety assurance and shelf-life for manufacturing beef and specific primal cuts that are sourced from Veritide positive carcases.

6 Conclusions/Recommendations

6.1.1 Conclusions

This study originally proposed to use Veritide's BluLine portable scanner system with ACC focussing systems setup (Milestone 1) and initial data collection (Milestone 2) efforts around the use of this system. Following the completion of Milestone 2, Veritide made the larger, more efficient Hot Spot camera scanner available for use in this study. Modifications were made to the gantry rail and enclosure in order to install the Hot Spot camera (Milestone 3) with Milestone 4 completed using the Veritide Hot Spot camera scanner and the BluLine portable scanner systems. A total of 33,842 bodies were tested for faecal contamination using the Veritide scanners. Faecal contamination was detected on 0.086% of carcases with rump (65.5%) and right side of the carcase (62.1%) representing the most commonly detected sites. Faecal contamination was detected on 29 occasions from 18 shifts with single and multiple detections occurring on 14 and 4 shifts, respectively. Multiple detections were typically clustered in time and likely caused by a single contamination event that effected nearby carcases. The mean TVC on excised meat samples from Veritide positive carcases was 3.46 log_{10} CFU/g and was significantly ($P<0.05$) higher than the mean TVC from Veritide negative samples. Trimming of the contaminated areas identified using the Veritide scanners reduced the bacterial load to a mean of 1.21 log_{10} CFU/cm^2 thereby confirming that the Veritide faecal detection system could impact positively on the shelf-life of final product. Detection of *E. coli* was not a common feature associated with Veritide positive samples, however the detection limit of the microbiological method used in this study is likely to be higher than what is generally observed in processing plants.

The Veritide faecal detection system is able to detect non-visual contamination events to which an intervention can be applied thereby reducing the bacterial load entering the chiller following processing. The rate of faecal detection on carcases processed at ACC was 0.086% or approximately

1 in 1100 bodies. Notwithstanding that clustered contamination events can occur during processing and did occur during this study, the detection rate would equate to approximately 1.1 detections for each day of production at ACC. The detection of contamination events is likely to lead to improvements in food safety assurance and shelf-life for manufacturing beef and specific primal cuts that are sourced from Veritide positive carcases.

An ex-ante cost benefit analysis on real-time detection of faecal contamination on beef carcases was conducted by Greenleaf Enterprises. The analysis determined that the major influencing factor impacting the financial opportunity in each of the different process scenarios is the proportion of manufacturing beef (trim) contaminated with Shiga toxigenic *E. coli* (STEC). The net benefit was estimated at between $0.72 and $0.94 per head for plants with high contamination levels and minimal interventions compared with between -$0.35 and -$0.38 per head for plants with low contamination levels and multiple interventions. The report recommends that due to the potential benefits and increased hygiene possible that the industry moves to invest in the commercialisation of the system. The Veritide system will provide an additional measure to reduce STEC contamination though it does not replace the need for detection and prevention of STEC contamination events. Ultimately, however, the need for Veritide and its place within the hygiene processing of carcases is plant-specific. This study was conducted at ACC, which is a plant that utilises pre-slaughter washing and spray chilling as part of its intervention strategy. Consequently it is predicted that installation of a Veritide system at ACC would result in a net loss of between $86,712 and $95,009 per annum.

6.1.2 Recommendations

It is recommended that:

- Due to the potential benefits and increased hygiene possible that the industry moves to invest in the commercialisation of the system, particularly in processing plants that do not use a combination of pre-slaughter washing and spray chilling. The Veritide system will provide an additional measure to reduce STEC contamination though it does not replace the need for detection and prevention of STEC contamination events. Ultimately, however, the need for Veritide and its place within the hygiene processing of carcases is plant-specific.
- ACC currently use a combination of pre-slaughter washing and spray chilling and therefore the installation of a Veritide system is predicted to result in a net loss. However, ACC is encouraged to determine their STEC contamination frequency and likely export profile as final steps in assessing the feasibility of a Veritide installation.

7 Appendix

7.1 Cost-benefit analysis report

Ex-ante cost benefit analysis of real-time detection of faecal contamination on beef carcases

Prepared By:	K. Bryan, J. Green Greenleaf Enterprises
Date Published:	14th March, 2019

Executive Summary

The Veritide system increases the levels of faecal contamination on carcases, allowing plants to reduce *E. coli* contamination. Methods of pre-slaughter washing and spray chilling have been used to prevent or lessen the frequency of *E. coli* contamination. Contaminated product sold through STEC markets are tested and if found to be positive must be heat-treated, which lessens the value of the product by 50%. Additionally, batches of trim product that test positive for *E. coli* can cause reputation damage, forcing processors to accept lower prices for trim.

However, Veritide will allow processors to reduce the cost of faecal contamination. It is estimated that the devaluation of trim due to heat-treating will decrease by 75% and that 75% of tests showing presumptive positives (false positives) will return negative results through the implementation of the Veritide system. Accordingly, the significantly higher effectiveness of faecal matter detection is expected to reduce reputation damage by 100%. Plants would no longer need to offer customers discounts resulting from reputation damage.

Table A3.1, demonstrates the three methods (process scenarios) currently used to reduce *E. coli* contamination on carcases. The major influencing factor which impacts of the financial opportunity in each scenario (listed below) is the levels of *E. coli* contamination identified in trim when exported to STEC countries.

1. Pre-slaughter wash with spray chilling, net benefit between -$0.35 and -$0.38/hd
2. Pre-slaughter wash without spray chilling, net benefit $0.02 to $0.11/hd
3. Spray chilling only, net benefit between $0.72 and $0.94/hd

Table A3.1: Summary of Performance and Net Benefit the Veritide system provides the plant based on process scenario

SUMMARY PERFORMANCE MEASURES						
	Pre-slaughter wash with spray chilling		Pre-slaughter wash without spray chilling		Spray chilling only	
Hd / annum	288,000		288,000		288,000	
Production increase with equipment	-1.1%		-1.1%		-1.1%	
	From	To	From	To	From	To
Capital cost (pmt option, upfront)	$144,400		$144,400		$144,400	
Gross return Per head	($0.19)	($0.16)	$0.20	$0.30	$0.91	$1.13
Total costs Per head	$0.19		$0.19		$0.19	
Net Benefit Per head	($0.38)	($0.35)	$0.02	$0.11	$0.72	$0.94
Annual Net Benefit for the plant	-$ 109,449	-$ 101,152	$ 4,638	$ 32,567	$ 208,053	$ 271,795
Annual Net Benefit for the ex cap	-$ 95,009	-$ 86,712	$ 19,078	$ 47,007	$ 222,493	$ 286,235
Pay back (years)	-1.52	-1.67	7.57	3.07	0.65	0.50
Net Present Value of investment	($531,655)	($473,385)	$269,641	$465,803	$1,698,342	$2,146,045

It is recommended that due to the potential benefits and increased hygiene possible that the industry moves to invest in the commercialisation of the system. The Veritide system will provide an additional measure to reduce *E. coli* contamination. It does not replace the need for detection and prevention of *E. coli*. Having higher standards through both pre-wash and spray-chilling could also reap benefits not accounted for in this cost-benefit analysis.

The benefit presented in this Ex-ante report should be reviewed once the system has been commercialised to update assumptions with the actual figures.

Glossary

Term	Description
CBA	Cost-Benefit Analysis
CL	Chemical Lean
MLA	Meat and Livestock Australia
OH & S	Occupational Health and Safety
STEC	Shiga toxin-producing *E. coli* (STEC – O26, O45, O103, O111, O121 and O145)

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1 Introduction

There is a clear and well understood need to reduce the presence and concentration of pathogenic and food spoilage bacteria on red meat. Although the levels of pathogens and contaminating microflora are typically low in red meat products processed in Australian plants, there are no rapid and reliable methods of monitoring bacterial levels on meat during processing. Red meat processors have a continual risk of recall and spoilage claims as well as regulatory consequences that may occur from the detection of organisms with 'zero tolerance' such as Shiga toxin-producing E. coli in North American markets. The ability to detect faecal contamination online during processing would assist in reducing one of the causes of bacterial contamination of beef carcases. However, the strength of correlation between the level of faecal contamination and shelf-life and the level of bacterial contamination on meat leaving the processing plant is not well understood.

Existing methods of bacterial contamination detection fall into two categories:

3. Visual inspection for faecal contamination is used to detect macro-contamination of beef carcases by faeces and other obvious contaminants after the slaughtering process. This is an expensive, inconsistent, subjective and unreliable process that routinely does not result in the removal of faecally-contaminated carcase material prior to chilling. Furthermore, it is unable to detect non-visible or micro-contamination events.
4. Microbiology testing is regularly carried out but is typically only performed on a very small amount of the overall product. While this is necessary and useful in many regards, it fails to be an effective method of detecting random and isolated faecal contamination events. It is also very slow, typically taking 2-7 days for results to become available thereby providing no opportunity for the processor to make an informed decision during slaughter or prior to boning and packaging of product.

Presently there are successful examples methods for direct and real-time detection of bacteria on meat. Whilst there are real-time and non-invasive systems for detecting non-bacterial contaminants (e.g. x-rays and metal detectors), bacterial detection in real-time remains problematic. Red meat processors implement and maintain good hygiene practices to help prevent bacterial contamination of red meat products; however, they remain blind to the frequency and concentration of bacterial contamination events that inevitably occur. The focus of this report is to provide an ex-ante cost benefit analysis for real-time detection of faecal contamination of beef carcases.

2 Objectives

The objectives of this ex-ante review were to:

1. Measure the expected value opportunity of real-time detection of faecal contamination of beef carcases.
2. Summarise the benefit and main drivers of value for the system.
3. Provide a framework which allows plants to identify the value of the system.
4. Deliver recommendations on opportunities offered through commercialisation.

3 Methodology

The focus for the methodology was to present an ex-ante value proposition for the development of the Veritide system to detect faecal contamination on beef carcases. In order to calculate the benefits data from publicly available sources (MLA Statistics) and personal communications with interested parties, were used to collect data required to complete the evaluation. This data was used to identify current processing requirements and values, particularly with regards to detecting and preventing *E. coli* contamination. Some assumptions were also used to estimate the benefit the Veritide system would offer processing plants these may vary based on the success of the system specific to each plant. Expectations of labour requirements and OH & S results may also differ in practice, based on plant requirements.

Table A3.2 contains the volume of trim exported to STEC (Shiga toxin-producing *E. coli*) regulated countries.

Table A3.2: Batches of trim exported assumptions

Trim Sales to USA ($/hd)	$ 119.01
Assumption	**Value**
Average Carton Weight	27.40
Aver number of cartons per batch	350
Kg per batch	9,590
Batches of trim per year	2,430

In evaluating benefits delivered by the Veritide system, some assumptions have been made to help quantify the benefit. The following are the expected impact of the Veritide system to current costs associated with *E. coli* contamination (Table A3.3):

- The reduction in heat-treating contaminated trim to kill off bacteria will result in a 75% decrease in devalued trim
- It has been assumed that 75% of tests that currently show presumptive positives will return negative results after the installation of the Veritide system
- Due to such a higher effectiveness of faecal matter detection, thus preventing *E. coli* contamination by 75%, plants will no longer need to offer a discount because of reputation damage (100% reduction).

Table A3.3: Reduction compared to the current processors

Devalued trim due to contamination	75%
Reduced cost of testing	75%
Reputation damage	100%

3.1 Devalued trim due to contamination

E. coli contamination of products varies based on processing method; three different processing methods were illustrated as three different scenarios, each of which had a different contamination rate which would reflect a different marginal benefit for each variable the Veritide system would influence.

Trim prices and volumes were obtained from MLA statistics, which can be seen in Table A3.3. The high trim price and low trim price reflect the highest and lowest monthly trim prices from 2017. These were used to calculate the high and low cost and benefits shown in tables throughout the report.

Table A3.4: Trim Exports from Australia during 2017 and the import price to USA

Assuptions	Value
USA Trim Exports (Tonnes)	55,735
Total Exports (Tonnes)	208,903
Percentage of trim exported to USA	27%
Lost value due to positive test	50%
High trim price (2017, AUD/kg)	$ 5.51
Low trim price (2017, AUD/kg)	$ 4.67
Average Trim per Body	80.92

3.2 *E. coli* testing costs

Table A3.5 shows the estimated cost per batch for *E. coli* screening tests, and the cost for a confirmation test completed on trim with a presumptive positive *E. coli* test. These values reflect the cost of batches that have been contaminated by *E. coli*. The batch of product (trim) heat-treated to decontaminate the trim, which results in a 50% reduction in the selling price of the trim (refer to Table A3.5). Additionally, the cost of confirming the contamination of the product from *E. coli* is $1,900 per batch.

Table A3.5: Estimated *E. coli* testing costs

E.Coli Tests	Cost per Batch
Screening Tests	$ 130
Confirmation Tests	$ 1,900

3.3 Reputation Damage

Reputation damage relates to the discount imposed by buyers based on the level of *E. coli* contamination. In section 4.3, the trim discount is lower processors with lower levels of contamination (0.25% for pre-wash with spray chilling), and progressively higher as the level of contamination increases: 0.5% for only pre-wash and 0.75% for only spray chilling. This results from lower contamination levels providing a quality of product.

However, it's assumed that through implementation of the Veritide system, buyer perceptions will be raised sufficiently for all three processes so that there are no longer any reputation damage costs incurred (discount is 0% for all three processes).

3.4 Operating and OH & S Costs

The operational and OH & S data collected includes:

- Staffing levels per shift;
- Cost per hour for staff;
- OH & S claim costs over the last 10 years;
- Power costs;
- Maintenance costs.

These figures were used to calculate an average operating cost to facilitate comparison between the manual and automated systems. Obviously, variations in the system will occur between plants. Higher throughput will results in variations in equipment depreciation, servicing costs, and vary labour requirements.

The system will have a minimal impact on OH & S costs, particularly if plants can completely automate the system. These are not extensively discussed, but plants should consider how their use of the Veritide system may affect their OH&S requirements.

3.5 Fixed Model Drivers

The benefits for plants are highly impacted by throughput, the production numbers shown in Table A3.6 were used for all calculations. The three scenarios for the Ex-ante are based on different levels of *E. coli* contamination detection in trim. The following are the main implications for each Scenario:

1. Manual is the baseline which the comparisons are all based on.
2. Pre-slaughter wash with spray chilling, 0.09% *E. coli* detection rate.
3. Pre-slaughter wash without spray chilling, 0.51% *E. coli* detection rate.
4. Only spray chilling, 1.14% *E. coli* detection rate.

These levels of detection rates were all obtained from the MLA report CBA on the detection methods of STEC (Fanning, 2017).

Table A3.6: Production figures used for determining production volume base line

	Operation speeds			
	Manual	Pre-slaughter wash with spray chilling	Pre-slaughter wash without spray chilling	Spray chilling only
Carcases / min	1.32	1.32	1.32	1.32
Carcases / Statn./hr	79	79	79	79
Carcases / day	1200	1200	1200	1200
Annual days	240	240	240	240
Annual # of hd	288,000	288,000	288,000	288,000

4 Cost Benefit Analysis

Trim typically accounts for approximately 28% of each carcass. Increasing value gained from trim is highly beneficial for the industry. Variables can decrease the value gained from trim are taken very seriously. The contamination of *E. coli* can cause product wastage, damage to buyer perception of quality and increase costs associated with testing.

However, when resources are invested in technology or processes that create tangible improvements to increase safety of meat processing, the bottom line of a processing plant can improve.

4.1 Devalued trim due to contamination

The following tables show the benefit from installing the Veritide system. These benefits are all associated with the ability to detect and remove the faecal contamination. The cost certain elements in the process have and the benefit Veritide provides is expressed with a high value and a low value; these reflect the variation in trim pricing during 2017. The following is important to consider:

- Positive *E. coli* tests have been identified from the V.MFS.0424 project report in the client materials folder.
- Estimated that the Veritide system will reduce costs by about 75% (Table A3.3).

Table A3.7: Benefits per head for each process used in Australian abattoirs with cost per head slaughtered for each system

Assumptions	Pre-slaughter wash with spray chilling	Pre-slaughter wash without spray chilling	Spray chilling only
Positive E- Coli tests	0.09%	0.51%	1.14%
Batches rejected per year	1.00	4.00	8.00
Volume of trim rejected per year	9,590	38,360	76,720
Volume per hd per year	0.03	0.13	0.27
Trim rejection costs per head	**Pre-slaughter wash with spray chilling**	**Pre-slaughter wash without spray chilling**	**Spray chilling only**
High	$ 0.09	$ 0.37	$ 0.73
Low	$ 0.08	$ 0.31	$ 0.62

The positive *E. coli* tests in Table A3.7 reflect the percentage of tests confirming the trim is contaminated with any of the STEC strains of *E. coli*. When positive test results are returned the contaminated batch must be heat-treated, which reduces the sales price by 50%.

The percentages in this table are the results of tests using the current systems. The use of Veritide will further reduce trim rejection by 75%. Therefore, the trim rejection costs per head will be decrease by 75% when using the Veritide system, generating an average benefit of approximately $0.06, $0.26 and $0.51 per head for Scenario 1, Scenario 2 and Scenario 3 respectively.

4.2 Reduced cost of testing

Table A3.8 shows the results of the screening tests for general *E. coli* contamination (shown to have a cost per batch of $130 in Table A3.5). If the presumptive test comes back negative, processors don't have to test any further. If it comes back positive, they must do the additional confirmation test. The values of 1.3%, 1.95% and 2.6% for the respective process scenarios are the *E. coli* tests that come back with a presumptive positive. These batches are presumed positive and are then tested further, using the $1900 confirmation test discussed in Section 4.1.

By implementing Veritide, the level of the presumptive positives is reduced by 75%. This means that the number of batches required to undergo the $1900 confirmation test will reduce by 75%. This reduces the presumptive positive tests to 0.33%, 0.49% and 0.65% for Scenario 1, 2 and 3 respectively.

Table A3.8: Percentage of *E. coli* screening tests that are returned positive for each process

Assumptions	Pre-slaughter wash with spray chilling	Pre-slaughter wash without spray chilling	Spray chilling only
Presumptive positives E- Coli tests	1.30%	1.95%	2.60%
Batchers tested per year	9.00	13.00	17.00
Testing Costs	$ 17,100	$ 24,700	$ 32,300
Cost per head	0.06	0.09	0.11

Trim rejection costs per head	Pre-slaughter wash with spray chilling	Pre-slaughter wash without spray chilling	Spray chilling only
High	$ 0.06	$ 0.09	$ 0.11
Low	$ 0.06	$ 0.09	$ 0.11

4.3 Reputation damage

Table A3.9 shows the estimated reputation damage per head, which is based on a reduced trim value, resulting from previous *E. coli* contamination levels. The reduction in trim value through reputation damage is directly linked to the level of contamination recorded in carcases. Thus, the lower the level of contamination, the lower the current cost to the processor is. This reflects the fact that using fewer comprehensive methods for *E. coli* prevention can decrease the expectations of buyers of the quality and safety of the trim. Therefore, Scenario 1 has a lower trim discount of 0.1%, Scenario 2 has 0.3% discount, and Scenario 3 has the highest discount of 0.75%, reflecting the comparative effectiveness of each method of contamination prevention (pre-slaughter wash and spray chilling).

Table A3.9: Trim Discount % offered by buyers based on process method

Trim rejection costs per head	Pre-slaughter wash with spray chilling	Pre-slaughter wash without spray chilling	Spray chilling only
Trim value per head exported to USA			
High	$ 119.01	$ 119.01	$ 119.01
Low	$ 100.76	$ 100.76	$ 100.76
Cost per head			
Trim Discount %	0.10%	0.30%	0.75%
High	$ 0.12	$ 0.36	$ 0.89
Low	$ 0.10	$ 0.30	$ 0.76

4.4 Labour Savings

Table A3.10 shows the number of staff required in each position of the slaughter floor per shift for each process. The use of the Veritide system is expected to resulted in an increase in labour for the slaughter floor. The number of staff required to manage the system may change throughout the development phase of the system, which could vary based on plant throughput.

The pilot system that was utilised during the project required 5 FTE's to operate the system, which would noticeably increase the cost of operation. The developers of the technology are looking to refine the system require 1 to 2 FTE's. As can be seen from Table A3.10, we have only included 1 FTE to operate the system additional FTE's would naturally reduce the saving per head further in proportion to the number of FTE's and their wage costs. Based on one additional FTE as in Table A3.10, there is an additional cost per head due to labour of $0.40.

Table A3.10: Labour savings achieved with the systems per shift.

Labour Savings per day				
	Number labour units required per day			
Task	Manual	Pre-slaughter wash with spray chilling	Pre-slaughter wash without spray chilling	Spray chilling only
Slaughter floor staff	92	92	92	92
Veritide Operator	0	1	1	1
Total FTE's required	92	93	93	93
Total FTE's saved	-	- 1	- 1	- 1
Saving per head	$0.00	-$0.40	-$0.40	-$0.40

4.5 Equipment Costs

4.5.1 Capital Costs

Equipment purchase price is based on prices supplied by the manufacturer but is only an estimate as the system design is still being refined. Installation costs will be site specific and will depend largely on the footprint available within the existing plant. Infrastructure upgrades may be required at some plants and allowance has been provided in the model for site specific numbers to be included. The capital cost per head will reduce as the total plant production increases, gradually increasing the overall net benefit the Veritide system provides.

4.5.2 Maintenance and Service Costs

Maintenance and service costs were also supplied by the equipment manufacturer. Maintenance costs are additional running costs that the plant will incur because of the installation of the equipment and it includes components such as parts and labour. The service contract covers ongoing servicing and maintenance of the system. The assumption is that these costs are a “per head cost” and therefore do not reduce with increasing production. Thus, maintenance costs are likely to be consistent from one plant to another, provided the system implemented has the same structure in both plants. Any variations can be updated in the model.

4.5.3 Risk of Down Time

The ability of the automated system to calibrate whilst still monitoring product has been factored in to down time cost calculations. Calibration of other systems requires an average of 5 minutes of stoppage time per day.

The same labour cost figures used for calculating increases in labour efficiency (Table A3.10) are used to calculate the cost of down time. The amount of weekly down time is an adjustable figure found on the “Costs” sheet of the model.

4.5.4 Summary of Equipment Costs

Table A3.11 below shows the total cost of the equipment including capital and operational costs. The data is based off a single installation but is considered typical (judging by the cost breakdown of the site’s installation). Real costs will be site-specific and will depend on the installation costs of a particular site.

The advanced carton manager system needs to be calibrated whist in use. Therefore, it is expected that the time spent calibrating the machine will reduce the down-time of the boning room as a result.

Table A3.11: Estimated capital and operating costs of the beef trim management system

Capital Cost	Manual		Pre-slaughter wash with		Pre-slaughter wash without		Spray chilling only	
	Cost	Life span	Cost	Life span	Cost	Life span	Cost	Life span
Automation Costs			$140,000	10	$140,000	10	$140,000	10
Data - terminal and licence			$4,400	10	$4,400	10	$4,400	10
Other Capital install				10		10		10
Total			**$144,400**		**$144,400**		**$144,400**	
Service maintenance	Manual		Pre-slaughter wash with		Pre-slaughter wash without		Spray chilling only	
	Units	Cost	Units	Cost	Units	Cost	Units	Cost
Estimated - COSTS								
Electricity	6.00 KW	$0.22 /KWH	6.00 KW	$0.22 /KWH	6.00 KW	$0.22 /KWH	6.00 KW	$0.22 /KWH
Maintenance labour (Daily)		0.00 /Yr		14000.00 /Yr		14000.00 /Yr		14000.00 /Yr
Maintenance labour (Preventative)		0.00 /Yr		400.00 /Yr		400.00 /Yr		400.00 /Yr
Maintenance labour (Breakdown)		0.00 /Yr		0.00 /Yr		0.00 /Yr		0.00 /Yr
Maintenance labour (Training)		0.00 /Yr		0.00 /Yr		0.00 /Yr		0.00 /Yr
Operational		**$4,815**		**$19,215**		**$19,215**		**$19,215**
Maintenance		**$0**		**$0**		**$0**		**$0**
Annual Sub Total (excluding major overhaul		**$4,815**		**$19,215**		**$19,215**		**$19,215**

5 Cost Benefit Analysis Summary

Benefits came from increased trim accuracy, and labour savings. The summary results in Table A3.12 demonstrate the performance of the machine when installed at a typical beef processor, based on the current throughput with efficiency decreasing by 1.1% based on the assumptions made throughout the report (production decreases due to the system adding another step in the processing practices).

The net benefit is estimated at between -**$0.35/hd** and -**$0.38/hd** for plants with low levels of contamination and between **$0.72/hd** and **$0.94/hd** for plants with a relatively high level of contamination. The payback period estimations range from **0.50 years to 7.57 years** for Process scenario 2 and 3. There is no payback period for Process scenario 1; annual net benefit for the plant is predicted to be between -$86,712 and -$95,009.

Table A3.12: Summary of benefits for the return using no throughput benefit.

SUMMARY PERFORMANCE MEASURES						
	Pre-slaughter wash with spray chilling		Pre-slaughter wash without spray chilling		Spray chilling only	
Hd / annum	288,000		288,000		288,000	
Production increase with equipment	-1.1%		-1.1%		-1.1%	
	From	To	From	To	From	To
Capital cost (pmt option, upfront)	$144,400		$144,400		$144,400	
Gross return Per head	($0.19)	($0.16)	$0.20	$0.30	$0.91	$1.13
Total costs Per head	$0.19		$0.19		$0.19	
Net Benefit Per head	($0.38)	($0.35)	$0.02	$0.11	$0.72	$0.94
Annual Net Benefit for the plant	-$ 109,449	-$ 101,152	$ 4,638	$ 32,567	$ 208,053	$ 271,795
Annual Net Benefit for the ex cap	-$ 95,009	-$ 86,712	$ 19,078	$ 47,007	$ 222,493	$ 286,235
Pay back (years)	-1.52	-1.67	7.57	3.07	0.65	0.50
Net Present Value of investment	($531,655)	($473,385)	$269,641	$465,803	$1,698,342	$2,146,045

The benefits identified can be broadly summarised as driven by increases in product value; Figure A3.1 shows all the benefits yielded are related to product value. There are no benefits yielded due to processing efficiency, processing efficiency decreases, with a slightly slower process (1.1% slower) and higher labour costs due to the need for FTEs to operate the system.

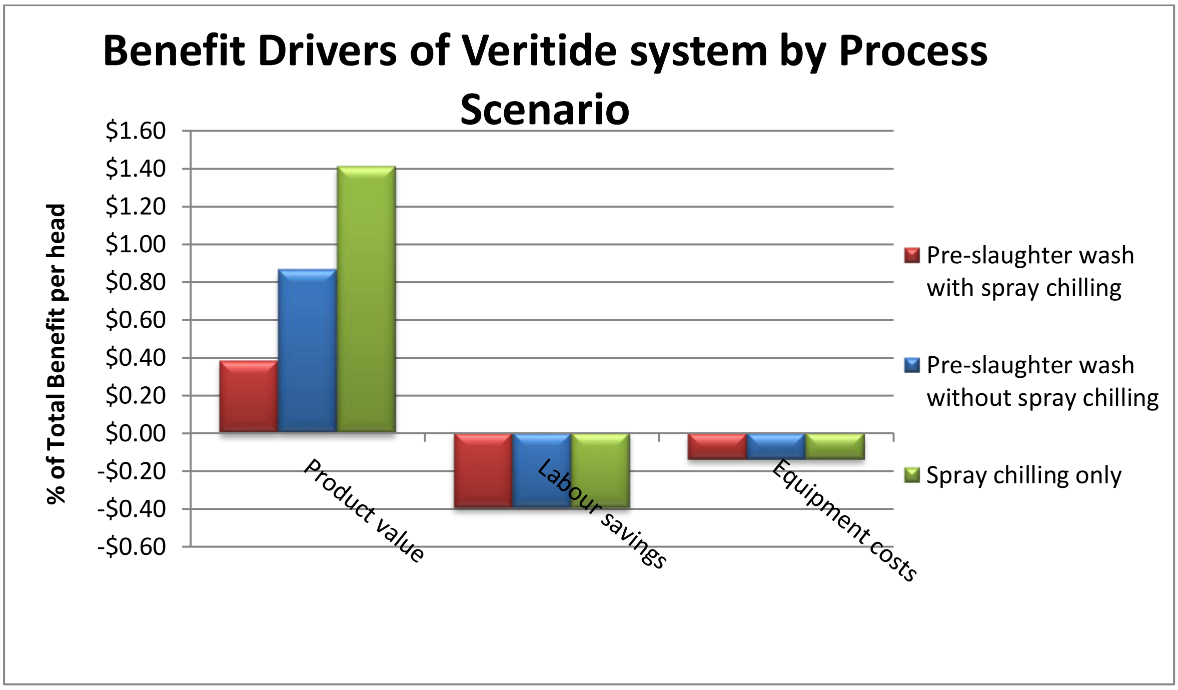

Figure A3.1: Broad grouping of benefits delivered by the advanced carton inspection system.

As already discussed, product value is higher for Scenario 3 and lowest for Scenario 1 due to the marginal benefit the Veritide system provides each scenario. Table A3.13 shows how product value drives benefit for each scenario. Because processing costs are assumed to be fixed (labour and equipment are shown to be standard across each scenario), product value determines whether the system is profitable or not. And, due to a higher marginal benefit per head which is represented by a higher product value for plants that spray chill only, Scenario 3 provides a positive $/hd benefit ($0.88/hd), whereas Scenario 1 has a negative $/head value (-$0.15/hd) due to a lower marginal benefit.

Table A3.13: Breakdown of benefits and costs by area expected as a result of the installation of the system

Benefit Drivers for System						
	Pre-slaughter wash with		**Pre-slaughter wash**		**Spray chilling only**	
	$/ hd	$/ annum	$/ hd	$/ annum	$/ hd	$/ annum
Processing	-$0.53	-$153,635	-$0.53	-$153,635	-$0.53	-$153,635
Product value	$0.22	$62,775	$0.65	$186,678	$1.42	$407,999
	-$0.32	**-$90,861**	**$0.11**	**$33,042**	**$0.88**	**$254,364**
Product value	$0.22	$62,775	$0.65	$186,678	$1.42	$407,999
Labour savings	-$0.40	-$113,763	-$0.40	-$113,763	-$0.40	-$113,763
Equipment costs	-$0.14	-$39,872	-$0.14	-$39,872	-$0.14	-$39,872
	-$0.32	**-$90,861**	**$0.11**	**$33,042**	**$0.88**	**$254,364**

A summary of the range in costs and benefits for each scenario are included in Table A3.14 below.

Table A3.14: Ex-post costs and benefits breakdown for the current throughput.

COST - BENEFIT ANALYSIS OF SYSTEM						
	Pre-slaughter wash with spray chilling		Pre-slaughter wash without spray chilling		Spray chilling only	
Benefit summary	$/hd		$/hd		$/hd	
	From	To	From	To	From	To
$ Accuracy Benefit per head	$0.20	$0.23	$0.60	$0.70	$1.31	$1.53
$ Technique Benefit per head	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
$ Labour Benefit per head	($0.40)	($0.40)	($0.40)	($0.40)	($0.40)	($0.40)
$ Overall Benefit per head	**-$0.19**	**-$0.16**	**$0.20**	**$0.30**	**$0.91**	**$1.13**
** Cost is reported as the inaccuracy from target specification OR as the difference between Manual vs. Auto costs*						
COST ASSOCIATED WITH OPERATING SYSTEM						
	$/hd		$/hd		$/hd	
Capital cost	$0.05		$0.05		$0.05	
Maintenance	$0.00		$0.00		$0.00	
Operation	$0.07		$0.07		$0.07	
Risk of mechanical failure	$0.07		$0.07		$0.07	
Total cost per head	$0.19		$0.19		$0.19	
Total cost per head (EX CAP)	$0.14		$0.14		$0.14	

Table A3.15 shows the system's expected annual value for one processing plant, based on the assumptions used throughout the report. The cost is calculated as any loss from the maximum possible benefit. Presenting the figures this way in the detailed section of the model demonstrates the total costs involved and highlights areas in which future savings could be generated. Should there be variation in the costs for individual plants, the model can be updated to reflect values consistent with their particular operating costs.

Table A3.15: Summary results of individual savings associated with advanced carton inspections system

TOTAL BENEFIT							
		Pre-slaughter wash with spray chilling		Pre-slaughter wash without spray chilling		Spray chilling only	
Benefit summary		$/hd From	$/hd To	$/hd From	$/hd To	$/hd From	$/hd To
1.1 Product Value	Devalued trim due to contamination	$0.06	$0.07	$0.23	$0.28	$0.47	$0.55
	Reduced cost of testing	$0.04	$0.04	$0.06	$0.06	$0.08	$0.08
	Reputation damage	$0.10	$0.12	$0.30	$0.36	$0.76	$0.89
2. Throughput benefit		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
3. OH&S benefit		$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
4. Labour benefit		-$0.40	-$0.40	-$0.40	-$0.40	-$0.40	-$0.40
Equipment costs	**Maintenance**	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Operation	-$0.07	-$0.07	-$0.07	-$0.07	-$0.07	-$0.07
	Risk of failure	-$0.07	-$0.07	-$0.07	-$0.07	-$0.07	-$0.07
	$ Benefit per head	**-$0.33**	**-$0.30**	**$0.07**	**$0.16**	**$0.77**	**$0.99**
$ Annual Benefit overall plant		**-$95,009**	**-$86,712**	**$19,078**	**$47,007**	**$222,493**	**$286,235**

Figure A3.2 shows the differences in benefit based on the method of contamination prevention plants use prior to processing livestock.

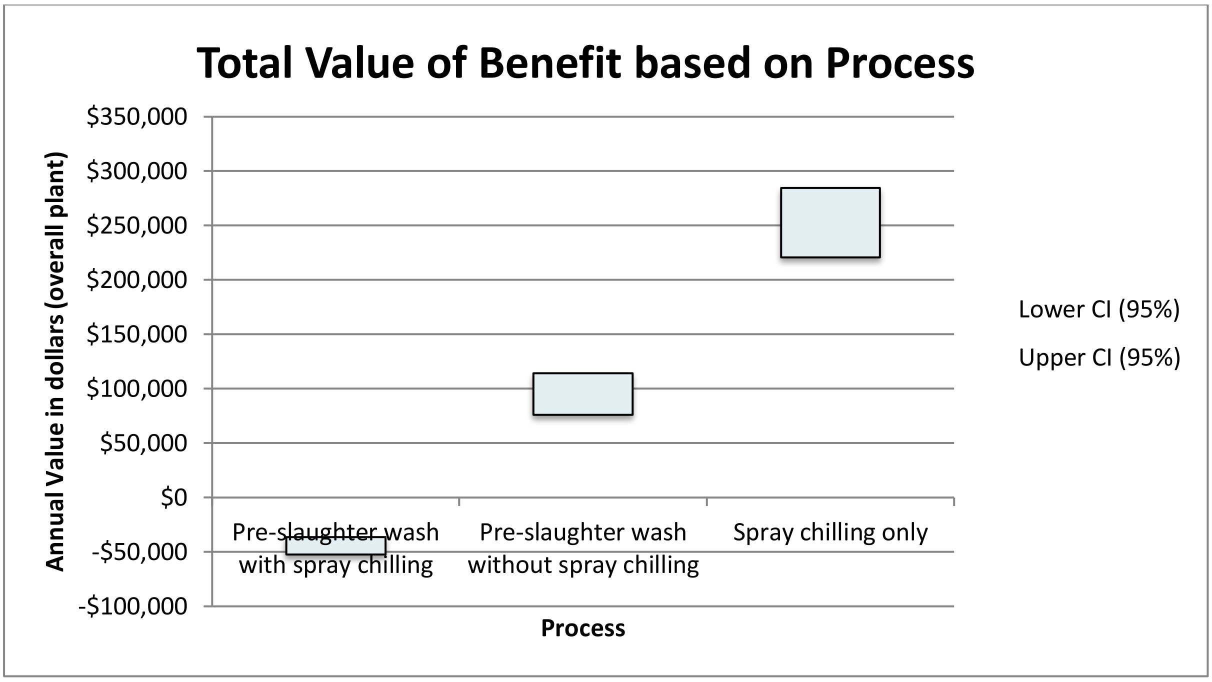

Figure A3.2: Graphical representation of Benefits captured in Table 16

Table A3.15 and Figure A3.2 show the annual benefit in dollars that the Veritide system yields in dollars to processing plants using one of the three different processes. The highest benefit is yielded to plants currently processing using spray chilling only. This is because of the higher levels of *E. coli* contamination, thus increasing their capability of detecting and preventing contamination to the same level as the other methods means the marginal benefit they receive is much higher. Pre-slaughter wash without spray chilling also yields increased value when using the Veritide system.

However, the marginal benefit is much smaller for Method 1 (pre-slaughter wash with spray chilling). This is because this method is much more effective for preventing *E. coli,* reducing the contamination *E. coli*. The annual value the Veritide system creates is negative; the cost of the system (capital, labour etc.) is greater than the benefit. This will be further discussed in the recommendations.

6 Recommendations

Impact on Industry

It is recommended that due to the potential benefits and increased hygiene possible that the industry moves to invest in the commercialisation of the system. The Veritide system will provide an additional measure to reduce *E. coli* contamination. It does not replace the need for detection and prevention of *E. coli*. Having higher standards through both pre-wash and spray-chilling could also reap benefits not accounted for in this cost-benefit analysis.

Ultimately, the need for Veritide and its place within the hygiene processing of carcases is plant-specific. Different climates, throughput and current hygiene processing are all factors influencing the viability of the Veritide system. Plants can look at their current contamination frequencies and processing requirements to identify whether Veritide is a worthwhile investment for their plant.

Opportunity and Feasibility of Veritide System

Veritide also provides an opportunity for plants to decrease their level of contamination without capital investment into cattle washes or spray chilling, although these systems do have other benefits not considered in the current project.

Plants considering implementing this technology will need to assess their processing capabilities and systems in evaluating the feasibility of integrating Veritide into their operation.

Potential for Automation of the System

The benefit to processing technology advancements through the introduction of automating processes has grown significantly in recent years. Automation reduces the need for labour operators and increases the throughput of carcasses, improving efficiency and driving revenue.

The implementation of automated processes or technology into the Veritide system would likely present itself as a viable option in the future. It would reduce the number of FTEs required to operate the Veritide system while maintaining and possibly increasing the product value benefits the system provides.

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