

Milestones and outputs contracted with the Federal Government

Overview

A key challenge faced by the Australian pork industry is the need to maintain local production of high quality food for a reasonable price and return on production capital invested, without negatively impacting pig welfare, the environment or the health of the consumer. Through innovative, collaborative, whole value chain research, development and education programs within the CRC, the Australian pork industry will meet this challenge by facilitating production that:

- is efficient and ethical without the need for sow confinement in stalls or crates or widespread use of antibiotic medications
- delivers key nutrients, safely, enhancing the health and well-being of consumers
- utilises revolutionary feed sources and effluent management systems resulting in emissions of less than 1 kg of CO₂ per kg of pork produced
- contributes significantly to Australia's economic growth and food security without drawing on the ecological capital of other parts of the world.

Delivery of these outcomes will differentiate Australian pork as a “high integrity” meat that is welfare-optimal, premium quality, safe, nutritious and in high demand which can be produced while conserving energy and water resources, minimising greenhouse gas emissions and maintaining efficiency and cost of production at a level that promotes investment, growth and sustainability of the industry.

The research programs are:

Program 1 - *Reduced confinement of sows and piglets* - will optimise sow and piglet welfare in confinement-free systems while maintaining production efficiency.

Program 2 - *Herd Health Management* - will involve novel technologies for health diagnostics and management without antibiotics which will significantly reduce the reliance on antibiotic medications in production systems.

Program 3 - *Healthy Pork Consumption* - will complete research demonstrating that consumption of pork can improve the health status of target consumers through prevention or alleviation of Type-II diabetes, obesity, and colon cancer. It will also investigate paths to market for High Integrity Australian pork domestically and in Asia.

Program 4 - *Carbon Conscious Nutrient Inputs and Outputs* - will reduce effluent emissions through novel management, offsetting traditional nutrient inputs with alternate sources derived from algae, and restructuring grain breeding and ingredient evaluation programs to complement these new nutrient sources.

Program 5 - *Improving sow reproduction* - will enhance the reproductive efficiency of the Australian industry by providing better means of detecting pregnancy, increasing litter size and ultimately volume.

Program 6 - *Nutritional manipulations to enhance the performance and feed efficiency of growing pigs* - will enhance the performance and feed efficiency of growing pigs. The research, will establish the extent chemosensory factors or components of ingredients might be used in diet formulations to manipulate feed intake.

Program 1 - *Reduced confinement of sows and piglets*

The research will reduce and ultimately eliminate the need for sow confinement during farrowing, lactation and gestation through the development of innovative housing, mating and suckling systems. Research outputs will also enhance the welfare and future productivity of piglets through innovative weaning processes that stimulate immunity and gut development of the piglet whilst reducing stress.

Research will cover three core areas:

1A - *Mating and Lactation Innovations* will develop novel techniques and tools for mating during lactation which will reduce or eliminate the need for sow confinement during lactation and the subsequent gestation and reduce non-productive days to improve production efficiency - **R1.1, R1.2, R1.3.**

1B - *Innovative Weaning Systems* will use controlled separation of the sow and piglet during lactation without compromising welfare to reduce weaning stress and eliminate the post weaning growth check. Innovative weaning technologies including new housing systems, multi-suckling strategies and the development of nutritional supplements will ensure optimal gut integrity and high levels of piglet immunity that enhance piglet quality and optimise lifetime productivity - **R1.4.**

1C - *Management of Weaned Sows in Groups* investigates the complex and challenging interactions between sows housed in groups. Development of optimum management procedures for group housed sows while accommodating their individual requirements for nutrition, maintenance of health and well-being is required - **R1.5**

Output No.	Description	
R1.1	Develop management procedures that do not require sow confinement, other than the use of a farrowing crate for 7-14 days, for sows and piglets during farrowing, lactation and gestation. Test specialised procedures and accommodation for sows during the farrowing process.	
Output Milestones		Due date
1.1.1	Establish an international research program with University of Alberta. Recruit honours student	30 June 2012
1.1.2	Complete Honours program in reproductive physiology. Make first postgraduate award/internship in the subprogram.	30 June 2013
1.1.3	At least two producer workshops and two field days delivered on new management options. International exchange program established with University of Alberta. 5 papers published at APSA biennial conference.	30 June 2014
1.1.4	Recruit second postgraduate student in the subprogram. Critical research review completed and public recognition of progress provided from RSPCA and at least one of the major retailers.	30 June 2015
1.1.5	Publish developed management procedures and industry manual for confinement-free sows supplemented with farrowing crate use for the first 7-14 days. Complete first Postgraduate project in reproductive physiology. 5 papers published at APSA.	30 June 2016
1.1.6	Woolworths and RSPCA actively promote Australian confinement-free production systems to consumers and the general public. Provision of new information on oestrus induction and mating to industry through "manuals", workshops and industry publications.	30 June 2017
1.1.7	Complete second PhD program or Masters Internship in reproductive physiology. 5 papers published at APSA.	30 June 2018
1.1.8	Established confinement-free systems for sows supplemented with specialised accommodation for farrowing. Adoption by 50% of the Australian sow herd. Australian pork recognised internationally for production in confinement-free systems.	30 June 2019

Output No.	Description	
R1.2	Develop and test oestrus and mating management techniques for sows during lactation in groups to achieve pregnancies in 85% of sows by weaning. New housing systems for sows and piglets during lactation that accommodate controlled piglet separation and multi-suckling regimes with capacity for these new systems to be accommodated in existing facilities. Techniques and products for the measurement of feed intake of individual lactating sows housed in groups and assessment and maintenance of individual sow health.	
Output Milestones		Due date
1.2.1	Appoint a Postdoctoral Research Fellow. Recruitment of first postgraduate student in lactation/reproduction physiology.	30 June 2012
1.2.2	Demonstration sites for multi-suckling systems and piglet separation techniques established on key end-user farms. Recruit first honours student in the subprogram	30 June 2013
1.2.3	2 patents applied for on oestrus initiation and detection technologies. Prototypes for group gestation and farrowing housing systems. SME and end-user engagement over prototype testing and implementation. Complete honours project in lactational physiology	30 June 2014
1.2.4	Complete first PhD program or Masters Internship in reproductive or lactation physiology. Recruit second postgraduate student in the subprogram.	30 June 2015
1.2.5	Implement new oestrus and mating management techniques and new housing systems on 20% of commercial farms (minimum 85% viable pregnancies). 5 papers published at APSA.	30 June 2016
1.2.6	Refit of existing facilities in 30% of the Australian herd to accommodate multi-suckling and group gestation. SME delivery of new products for the measurement of feed intake of individual lactating sows housed in groups.	30 June 2017
1.2.7	Develop and deliver to industry information for the successful (based on reproduction and sow and piglet welfare) implementation of new oestrus induction and mating techniques. Provide the latest information to the relevant parts of industry. Complete second postgraduate project in lactational physiology. 5 papers published at APSA.	30 June 2018
1.2.8	SME and corporate delivery of health management products for sows in groups. Oestrus and mating management techniques implemented on 50% of commercial farms with minimum pregnancy rate of 85%.	30 June 2019

Output No.	Description	
R1.3	New dam lines selected using Australian and international assessments of key heritable traits that reflect robust performance in confinement-free systems. Enhanced longevity of sows and reduction in culling rates as a result of lameness or poor reproductive performance in Australian herds using confinement-free systems. Commercial breeding programs incorporating new selection traits and delivering new genotypes.	
Output Milestones		Due date
1.3.1	National and international genetic selection process and genomics programs underway. Engagement with Smithfield Premium Genetics and/or the Hanor Group over genetic assessment program.	30 June 2012
1.3.2	Commence commercial breeding programs based on genomics and heritable trait research. 5 papers published at APSA.	30 June 2014
1.3.3	30% reduction in culling rates in Australian herds as a result of new genotypes. 5 papers published at APSA.	30 June 2016
1.3.4	First new dam lines introduced into 30% of Australian herds.	30 June 2017
1.3.5	Enhanced longevity of sows and reduction in culling rates as a result of lameness or poor reproductive performance in Australian herds using confinement-free systems. 5 papers published at APSA.	30 June 2018
1.3.6	New dam lines in confinement-free systems in 50% of Australian herds.	30 June 2019

Output No.	Description	
R1.4	Higher health-status piglets with enhanced gut development through alternative farrowing/lactation systems based on new piglet diets that support growth and gut development of pre-weaned piglets during controlled separation from the sow during lactation, minimal pre-weaning mortality of piglets (<3%) with limited reliance on chemo-medications, and post-weaning growth rates exceeding 250 g/d (industry standard currently between 0 and 100 g/d) in the week immediately after weaning.	
Output Milestones		Due date
1.4.1	First honours student recruited and first postgraduate project or internship in the subprogram awarded.	30 June 2012
1.4.2	Demonstration sites for multi-suckling systems and piglet separation techniques established on key end-user farms. Post-doctoral research fellow appointed. Optimal piglet/sow separation times defined. Complete first Honours project in neonatal nutrition or weaning management.	30 June 2013
1.4.3	5 papers published at APSA.	30 June 2014
1.4.4	New creep diets developed and delivered by SME's and corporate mills. Patents applied for creep production processes. Complete first postgraduate project in neonatal nutrition. Second postgraduate student recruited.	30 June 2015
1.4.5	Implement alternative farrowing/lactation systems in 20% of the Australian sow herd. Growth rates in the first two weeks post weaning growth rates to be at least 150 g/d and pre-weaning mortality beyond the first 7 days after farrowing to be less than 4%. 5 papers published at APSA. Second honours award granted in the subprogram.	30 June 2016
1.4.6	Complete second Honours project in neonatal nutrition or weaning management.	30 June 2017
1.4.7	Implement alternative farrowing/lactation systems in 20% of the Australian sow herd. Growth rates in the first two weeks post weaning growth rates to be at least 200 g/d and pre-weaning mortality beyond the first 7 days after farrowing to be less than 3%. Complete second postgraduate project in neonatal nutrition. 5 papers published at APSA.	30 June 2018
1.4.8	Implement alternative farrowing/lactation systems in 20% of the Australian sow herd. Growth rates in the first two weeks post weaning to be at least 250 g/d and pre-weaning mortality beyond the first 7 days after farrowing to be less than 3%.	30 June 2019

Output No.	Description	
R1.5	Procedures for the successful grouping of sows immediately post-weaning and during gestation that minimise negative interactions, reduce variation between sows and optimise body condition and health. Techniques and products for the measurement and control of individual gestating sow feed intake while they are housed in groups.	
Output Milestones		Due date
1.5.1	Engagement with Ohio State University and Monash University in the research program through the University of Melbourne Animal Welfare Science Centre. Recruitment of first Honours student in the subprogram and first postgraduate scholarship awarded in the group housing/management of sows.	30 June 2012
1.5.2	Complete first Honours project on sow behaviour. Implementation of successful group housing and management systems for pregnant sows across 60% of Australian sow herd. Demonstration on end-user participant farms of housing and management techniques which enhance sow welfare and have no adverse effects on reproduction. 5 papers published at APSA.	30 June 2014
1.5.3	Implementation of successful group housing of gestating sows across 70% of Australian sow herd. Publication of manual on factors/strategies for the successful introduction of group housing gestating sows based on welfare and reproduction. Complete first postgraduate project on group management of sows. Second postgraduate scholarship awarded.	30 June 2015
1.5.4	Implementation of successful group housing of gestating sows across 80% of Australian sow herd. Reduced culling of sows by 25% as a result of aggression and interactions alleviated through new grouping/management techniques. 5 papers published at APSA. Recruitment of second honours student in the subprogram. Provision of new information and informal and formal training of production staff in management of animals in confinement free housing systems.	30 June 2016
1.5.5	Complete second Honours project on sow behaviour.	30 June 2017
1.5.6	Complete second postgraduate project on sow behaviour/management. SME delivery of products to assist with measurement and control of feed intake of gestating sows in groups. 5 papers published at APSA.	30 June 2018
1.5.7	Measured reduction in variation in body condition between grouped sows during gestation by 20%, based on new grouping procedures.	30 June 2019

Utilisation No.	Description	
U1.1	Utilise use of new production systems by more than 50% of the Australian herd (by sow numbers). Outputs 1.1, 1.2, 1.3, 1.4 and 1.5 will contribute to unique pig production systems based on confinement-free sow and piglet management to be used by pig producers in Australia and New Zealand. Retailers such as Woolworths and welfare advocates such as the RSPCA will develop marketing strategies based on the outputs. Exporters will use outputs as a basis for securing markets for High Integrity Australian pork, particularly in Asia. State and Federal Governments will use outputs when reviewing the Model Code of Practice for pig production from 2017. Consumers will use outputs when making meal choices. We assume a national herd of 260,000 sows with 50% implementation completed by 2019 and 90% by 2023.	
Utilisation Milestones		Due date
U1.1.1	Outputs used to convert 25% of Australian production to new systems based on confinement-free sow and piglet management.	30 June 2015
U1.1.2	Retailers and welfare advocates use data to endorse Australian pork production methods and increase consumer food choices. Two PhD graduates employed by end-users to implement technologies.	30 June 2016
U1.1.3	State and Federal government and stakeholder use outputs to develop initial revised Model Codes of Practice for pork production.	30 June 2017
U1.1.4	Consumer use of outcomes and resulting food choices increase proportion of Australian pork in processed products.	30 June 2018
U1.1.5	Outputs used to convert 50% of Australian sow herd to new systems based on confinement-free sow and piglet management. Two PhD graduates employed by industry to implement technologies.	30 June 2019

Utilisation No.	Description	
U1.2	Outputs 1.2, 1.3, 1.4 and 1.5 will contribute products including oestrus initiation and detection technologies, feed intake measurement and control tools for lactating and gestating sows, respectively, health assessment tools for sows in groups, new, robust dam lines suited to group lactation and gestation, and novel creep diets. Users will include SME's specialising in feed additives and diagnostics, veterinarians, nutritionists, feed millers, genetics companies, and pork producers.	
Utilisation Milestones		Due date
U1.2.1	Feed millers use outputs to introduce new creep diets to confinement-free systems in Australia.	30 June 2016
U1.2.2	Outputs used for oestrus detection/induction in group housed sows during lactation by veterinarians and commercial herds. First usage of new dam lines in confinement-free systems	30 June 2017
U1.2.3	New dam lines used in 40% of Australian herds.	30 June 2018
U1.2.4	Outputs used to measure feed intake of individual lactating sows in groups in 50% of Australian production systems.	30 June 2019

Research Program 2 - Herd health management

The research will involve new and novel diagnostic tools to monitor enteric and respiratory pathogen loads in production units and better characterisation and understanding of the virulence genes which cause disease. These technologies and information will enable the development of new strategies which will include new quantitative genetic methodology and the strategic use of genomics to identify and develop robust genetic lines more resilient to environmental constraints, including disease. The aim of the program is to enhance animal health, while reducing routine antibiotic use in commercial pork production.

Research will cover three core areas:

2A - Novel Disease Diagnostics will involve the refinement of quantitative PCR and other diagnostic tools developed for enteric pathogens in the current Pork CRC and investment with the University of Melbourne on the development of PCR analysis of respiratory pathogen loads. Non-specific measures can be used to identify acute changes in herd health in real time and in combination with these, new cost-effective diagnostics will be developed for diseases such as Rotavirus and Corona virus. Conventional diagnostics which fail to separate causal and non-causal subtypes in enteric organisms such as *E.coli* and Salmonella also require improvement - **R2.1**.

2B - Healthy, Robust Pig Genotypes will arise from selection strategies that focus on welfare and health status of highly productive pigs across multiple commercial grow-out systems with varying environmental stressors, with the development of new selection criteria, statistical methodology and molecular, genetic strategies to improve disease resilience and robustness in current Australian genotypes. Collaborative research programs with Iowa State University and INRA (through AGBU) both of whom have unique selection lines (for immune responsiveness and disease tolerance) and expertise in strategic genomics will be integral in this program - **R2.2**.

2C - Replacement of Antibiotics with Effective Integrated Health Strategies will allow reduction in expenditure on therapeutics while maintaining or enhancing production efficiency. This approach also reduces concerns for human health associated with antibiotic use in livestock production. Research results from Program 2.1 will be utilised to produce eco-suppressive agents, which may include nutrients (nutriceuticals) such as organic acids, beneficial bacteria such as *Lactobacilli*, and gene based vaccines, probiotics, and bacteriophages, all of which are designed to alter the ecology of the gut or respiratory microbial populations, thus suppressing pathogens. New vaccine technology and integrated management systems will be developed - **R2.3**.

Output No.	Description	
R2.1	Identification of virulence gene patterns for major disease pathogens to enable the development of novel eco-suppressive agents. Health monitoring systems incorporating real-time feed and water intake and quantitative PCR analysis for direct measurement of environmental pathogen loads in commercial units. IgA ELISA systems for <i>Actinobacillus pleuropneumonia</i> (APP) to allow more precise diagnosis and enhanced treatment strategies.	
Output Milestones		Due date
2.1.1	Recruitment of postgraduate into gene virulence studies.	30 June 2012
2.1.2	IgA ELISA systems developed for <i>Actinobacillus pleuropneumonia</i> (APP) to allow more precise diagnosis and enhance treatment systems developed in current Pork CRC. Recruitment of Honours student into gene virulence studies.	30 June 2013
2.1.3	Health monitoring system incorporating real time feed and water intake commercialised. First round virulence genes identified. Complete honours project. 2 papers published at APSA.	30 June 2014
2.1.4	At least 2 patents relating to new diagnostics technologies applied for. Postgraduate project completed.	30 June 2015
2.1.5	Second round of virulence genes identified. Quantitative PCR technologies for direct measurement of pathogen loads available. 4 papers published at APSA.	30 June 2016
2.1.6	Industry internship awarded. 5 papers published at APSA.	30 June 2018

Output No.	Description	
R2.2	Identification and development of new selection criteria, statistical methodology and molecular genetics strategies to improve disease resilience and robustness in current Australian genotypes.	
Output Milestones		Due date
2.2.1	Establish international research projects/partnerships with Iowa State University (ISU) and INRA (through AGBU). Recruit a postgraduate and an Honours student into research projects.	30 June 2012
2.2.2	Identification of potential immune competence traits for disease resilience using existing overseas lines. Complete honours project.	30 June 2013
2.2.3	Determine genetic parameters for immune competence traits in Australian genotypes. Establishment of genomic and phenotypic relationships for robustness traits using overseas and Australian genetics. 2 papers published at APSA.	30 June 2014
2.2.4	Statistical methodology developed for incorporating environmental pathogen challenge data in current BLUP programs. Complete postgraduate project /internship.	30 June 2015
2.2.5	Genomic technologies incorporated into Australian genetics. First new genetics with increased disease resilience and robustness, commercially available. 4 papers published at APSA.	30 June 2016
2.2.6	Development of molecular genetics strategy for improved disease resilience.	30 June 2017
2.2.7	Second release of new genetics with increased disease resilience and robustness to industry. At least 4 papers published at APSA.	30 June 2018

Output No.	Description	
R2.3	Antibiotic-free integrated health management strategies based on eco-suppressive agents capable of targeting pathogenic subtypes of disease causing organisms, new vaccines composed entirely of virulence gene antigens and Implement integrated health programs on commercial farms resulting in a 50% reduction in the use of antibiotics.	
Output Milestones		Due date
2.3.1	Postdoctoral position in new generation health management awarded. Recruitment of first postgraduate and first Honours students into the project.	30 June 2012
2.3.2	Gene based probiotics and bacteriophages developed and tested. Complete first honours program in alternative health management. Madec-like health scoring systems and auditing manuals developed for Australian conditions.	30 June 2013
2.3.3	First suite of Eco-suppressive agents developed and tested. Certificate III and IV training programs commence. Second Honours student recruited into subprogram. 5 research papers published at APSA.	30 June 2014
2.3.4	Misting technologies for disinfectants based on real time monitoring of pathogen challenge commercialised. 2 patents applied for on new health therapies. First postgraduate project and second Honours project completed. Second postgraduate recruited into subprogram.	30 June 2015
2.3.5	New vaccines composed entirely of virulence gene antigens developed. 5 research papers published at APSA.	30 June 2016
2.3.6	Two patents applied for on new vaccines and alternative health strategies.	30 June 2017
2.3.7	Second postgraduate project in integrated health management completed. 5 research papers published at APSA.	30 June 2018
2.3.8	Implement integrated health programs on commercial farms resulting in a 50% reduction in the use of antibiotics	30 June 2019

Utilisation No.	Description	
U2.1	The program will deliver diagnostic tools to veterinarians, producers and laboratories to accurately assess/monitor pathogen challenge loads in commercial production environments and alternative health strategies which will enable the use of antibiotics, which are becoming increasingly ineffective, to be reduced and animal health to be improved. The outputs will be combined into new diagnostic and health monitoring systems and antibiotic-free integrated health management tools and strategies.	
Utilisation Milestones		Due date
U2.1.1	Implement diagnostic tests for enteric pathogens. Utilisation of new diagnostic tools for <i>E coli</i> , ileitis and swine dysentery	30 June 2013
U2.1.2	Commercialisation of first probiotics.	30 June 2014
U2.1.3	Implement environmental monitoring systems of virulence genes in major disease causing pathogens. Deliver a first stage integrated health package. Commercialisation and utilisation of health packages commences.	30 June 2015
U2.1.4	Availability of novel bacteriophages. Commercialisation of novel bacteriophage technology.	30 June 2017
U2.1.5	New vaccines commercially available. Commercialisation of new vaccines.	30 June 2018
U2.1.6	Implement integrated health programs on commercial farms resulting in a 50% reduction in the use of antibiotics. All technologies available commercially.	30 June 2019

Utilisation No.	Description	
U2.2	New genotypes based on disease resilience and robustness made available to Australian producers. The new lines will be the first to be selected for their "tolerance" of environmental stressors and under known disease challenges. Improvements in performance and efficiency will be on a group basis, and additional to those associated with muscle growth potential, and those inherent within the animal. The new selection technologies should enable the animal's potential to be more fully and more consistently expressed. New genomic tools available to Australian and International genetic supply companies.	
Utilisation Milestones		Due date
U2.2.1	Results from overseas selection lines are used to determine new selection criteria for disease resilience and robustness.	30 June 2013
U2.2.2	New selection indices for disease resilience and robustness available to Australian genetic supply companies.	30 June 2015
U2.2.3	Genetic supply companies incorporate first stage genomic selection tools.	30 June 2017
U2.2.4	New genotypes for disease resilience and robustness available to Australian producers. Utilisation of new genes and genotypes by industry.	30 June 2018
U2.2.5	Genetic supply companies include second stage genomic selection tools to complement existing selection strategies.	30 June 2019

Research Program 3 - *Healthy pork consumption*

The research will develop quality assessment and assurance tools for pork for domestic and overseas markets and an understanding of key Asian markets and how the *High Integrity Australian Pork* concept fits within these markets. Preliminary research initiated within the current Pork CRC will be expanded to demonstrate the inherent properties of pork that contribute to improved consumer health when pork is consumed as part of a total diet.

Research will cover three core areas:

3A - *Optimal Pork Quality for Multiple Markets* will develop pork quality predictive models for a range of supply chains, on-line screening tests for taint markers and other quality parameters, carcass assessment technologies to define carcass and primal cuts for different markets, and trace element traceability technologies to underpin integrity of Australian pork - **R3.1, R3.2.**

3B - *Inherent Properties of Australian Pork to Enhance Consumer Health* will research the inherent health properties of pork to address key issues such as obesity, cardiovascular disease and diabetes. Human health models will be developed to validate the effects of pork consumption and new value added products benefiting consumer health - **R3.3.**

3C - *Market Demand for High Integrity Australian Pork* will undertake research to define and validate the market traction of High Integrity Australian pork attributes, consumer quality and product requirements (carcass and primal cut) specifications for the different Asian markets. The forecast growth in imported pork from 2009 to 2019 for the two major Asian importing countries has been estimated to be 35% for China and 49% for South Korea giving Australia tremendous opportunity to expand exports to these countries if the markets are understood - **R3.4.**

Output No.	Description	
R3.1	On-line screening test for the second dose of the boar taint vaccine, Improvac. Commercial Implement ultrasound technology for on-line measurement of belly lean meat yield on the slaughter floor to allow Australian processors to correctly grade belly primals for specific target markets in Asia. New applications for the Physi-Trace™ technology for emulsified, ground and diced processed meat products to guarantee the country of origin status for further manufactured products made with high integrity Australian pork.	
Output Milestones		Due date
3.1.1	Generic pork quality predictive model developed. National pork quality survey completed. Post-doctoral research fellow appointed.	30 June 2013
3.1.2	PorkScan carcass and primal classification technologies on-line Physi-Trace™ technology to guarantee integrity for further manufactured products made with High Integrity Australian pork. First honours student recruited. 2 papers published at APSA.	30 December 2013
3.1.3	Pork quality predictive model for established supply chains validated. First Honours project completed. First postgraduate student/intern recruited. Patent applied for on-line screening test for assessing the success of Improvac vaccination.	30 June 2015
3.1.4	An on-line screening test for markers to determine whether male pigs have received a second dose of the boar taint vaccine, Improvac. 3 papers published at APSA. Second Honours student recruited.	30 June 2016
3.1.5	Postgraduate project and second Honours project completed.	30 June 2017
3.1.6	2 papers published at APSA.	30 June 2018

Output No.	Description	
R3.2	Fresh Australian pork with improved display life and colour stability. Improved water holding capacity of pork by developing cost-effective processing solutions, including modified chilling procedures and pre-slaughter interventions.	
Output Milestones		Due date
3.2.1	Improved water holding capacity of pork by developing cost-effective processing technologies, including modified chilling procedures and pre-slaughter interventions. 2 papers published at APSA. First Honours student in subprogram recruited.	30 June 2014
3.2.2	Fresh Australian pork with improved display life and colour stability achieved by supplementing pigs with natural products. First honours project completed.	30 June 2015
3.2.3	2 papers published at APSA. Second Honours student recruited.	30 June 2016
3.2.4	Second Honours project completed.	30 June 2017
3.2.5	2 papers published at APSA.	30 June 2018

Output No.	Description	
R3.3	Demonstrated health benefits of pork consumption including the effect on adult and child satiation, identified level and duration of Selenium-enriched pork consumption for the prevention of early stage colonic and prostate cancer , defined longer term benefits of high pork diets on cardio-metabolic health and weight maintenance, defined role of high pork meals in the nutrition of Type 2 diabetics, contribution of pork to the iron status of consumers and the capacity of pork to lower circulating cholesterol. New value-added pork products that benefit the health of consumers.	
Output Milestones		Due date
3.3.1	Demonstrate the effects of the nutrients in pork on human cognition in particular children and the elderly. New value added pork products that benefit the health of target domestic & export consumers. 2 papers published at APSA and at least 1 at Nutrition Society meeting. First postgraduate student recruited.	30 June 2015
3.3.2	Demonstrate inherent properties of pork can lower low-density lipoprotein, triglyceride levels and total cholesterol of humans. Pork Nutritional and Health information packages developed for health professionals. Demonstrate the effects of the nutrients in pork on the rate of digestion and absorption on satiation of people. Define the longer term benefits of high protein, high pork diets on cardio-metabolic health and weight maintenance. 2 papers published at APSA	30 June 2016
3.3.3	Postgraduate project completed At least 2 papers published at Nutrition Society meeting. Define the role of high protein, high pork meals in the control of postprandial glucose responses and body composition of people with Type 2 diabetes. 2 papers published at APSA.	30 June 2018
3.3.4	Demonstrate the role of pork in children's diets. Understand the mechanisms and synthesis of haemoglobin. Updated Pork Nutritional and Health information packages for health professionals developed and distributed.	30 June 2019

Output No.	Description	
R3.4	Quantitative data that defines the relative importance of consumer drivers in different markets and how the perception of High Integrity Australian pork products differs between and within domestic and export markets. Definition of how High Integrity Australian pork's quality attributes compare against major competitors. New tools for the mapping and assessment of behaviour of the public and consumers towards High Integrity pig production systems. Models that define domestic and export opportunities for Australian pork and pork products.	
Output Milestones		Due date
3.4.1	Define High Integrity Australian pork's quality attributes. Define the relative importance of consumer drivers and how the perception of Australian pork products differs in different markets.	30 June 2014
3.4.2	New tools developed for the mapping and assessment of behaviour of the general public and consumers towards "High" Integrity pork production systems. First honours student recruited.	30 June 2015
3.4.3	Models developed that define domestic and export opportunities, in food service and/or retail segments, for Australian pork and pork products. First Honours project in the subprogram completed. At least 1 paper published at APSA	30 June 2016
3.4.4	Re-mapping and assessment of behaviour of the general public and consumers towards "High Integrity" pig production systems.	30 June 2017
3.4.5	At least 2 papers published at APSA.	30 June 2018

Utilisation No.	Description	
U3.1	Recognition of the inherent health benefits of pork and new enhanced pork products for frequent and infrequent domestic consumers, as well as for key markets within Asia such as international hotel chains and supermarkets. This collectively will lead to increased value of pork and ultimately increase the consumer demand for pork products. The users of this information include domestic and international retailers and food service sectors, as well as human health professionals and dieticians.	
Utilisation Milestones		Due date
U3.1.1	Human health animal models to test benefits of Australian Pork consumption established.	30 June 2015
U3.1.2	Key inherent health attributes of Australian pork established. Development of strategies to enhance the nutritional component of pork. Release of Nutritional and Health information packages. Increase in annual pork consumption by frequent and infrequent pork consumers by 3%.	30 June 2016
U3.1.3	Launch of High-Integrity Australian Pork. Increase in annual pork consumption by frequent and infrequent pork consumers by 4%.	30 June 2017
U3.1.4	Nutritional survey of Australian Pork. Identify additional health benefits of Australian Pork consumption. Increase in annual pork consumption by frequent and infrequent pork consumers by 4%.	30 June 2018
U3.1.5	Update of Nutritional and Health information packages. Revise marketing plan and relaunch. Increase in annual pork consumption by frequent and infrequent pork consumers by 4%.	30 June 2019

Utilisation No.	Description	
U3.2	Quality pathways commercially established - commercial supply chain participants. The users will be the whole supply chain from producers (on-farm and animal factors) and processors (slaughter and post-slaughter factors) to retailers (packaging and shelf-life factors). The key usage will be the development of on-line processing diagnostic tools for key quality attributes such as boar taint, and carcass attributes. New on-line ultrasound technologies to provide pork processors with real-time assessment of sensory quality will also be investigated.	
Utilisation Milestones		Due date
U3.2.1	Various PorkScan carcass classification technologies amalgamated on-line. National Pork quality study completed.	30 June 2013
U3.2.2	New production systems quality determined.	30 June 2014
U3.2.3	Eating Quality Pathway validated and released	30 June 2015
U3.2.4	Utilization of Pathways. On-line diagnostic systems for pork quality established. Marketing of High Integrity Pork into select Asian markets.	30 June 2016
U3.2.5	Next Generation (PorkScan) carcass classification system implemented. Marketing of High Integrity Pork into select Asian markets commences.	30 June 2017
U3.2.6	29% increase in Australian pork production being exported into high-end Asian markets over 8 years.	30 June 2019

Research Program 4 - *Carbon-conscious nutrient inputs and outputs*

The research will develop commercially viable feeding and effluent management systems for pig production that significantly reduce the net carbon footprint whilst maintaining production efficiency. In particular, the research program will establish pork production systems that are carbon neutral through novel use of nutrient sources such as algae. The research program will transform the Australian pig industry to specifically address critical environmental and economic issues that confront its sustainability.

Research will cover three core areas:

4A - *Future Feeds for Future Needs* will reduce competing demand on feed grains by establishing commercial quantities of algae products that meet the nutrient requirements of pigs. This program will also facilitate replacement of 10% of existing feed with ingredients that have been derived from waste streams. Two sources of algal products will be investigated - algae specifically grown using nutrients from piggery waste streams and processed on farm and algae or co-products that are derived from large scale production involved with industrial CO2 mitigation or biodiesel production - **R4.1**.

4B - *Enhanced Use of Traditional Protein and Energy Sources* will build on specific outcomes from the current Pork CRC including development of real-time near infra-red analysis of feed ingredients and better use of this information in new plant breeding programs. Further development of innovative processing methods will improve the nutritional yield from ingredients - **R4.2, R4.3, R4.4**.

4C - *Carbon-Neutral Pork Production* will involve highly novel research to maximise methane production from effluent ponds so that collection and use of gas is economically viable. Alternative approaches to waste management will also be studied to develop solid-waste pork production systems that mitigate carbon outputs - **R4.5**.

Output No.	Description	
R4.1	Evaluation of the available algae and their ability to match and meet the nutrient requirements of pigs in balanced diets. Defined feasibility and economics of various algae production systems suitable for utilisation by the pork industry. Selected algae species suitable for growth on piggery effluent and that have superior nutritional qualities for pigs. Nutritional characterisation of algae and algae products that are produced from CO ₂ sequestration and other waste effluent systems. Establishment of growing, harvesting and processing systems for algae and algae products.	
Output Milestones		Due date
4.1.1	Desk top studies and reviews conducted to determine the feasibility and economics of various algae production systems. Recruit first postgraduate student.	30 June 2012
4.1.2	Identification and selection of algae species that most closely match the nutrient requirements of pigs.	30 June 2013
4.1.3	Collaboration with commercial partners to identify and examine suitability for pigs of algae produced from industrial systems relying upon waste water and CO ₂ capture.	30 June 2014
4.1.4	Pilot algae production systems established on piggeries. Complete first postgraduate project. Recruitment of second postgraduate student.	30 June 2015
4.1.5	5 papers published at APSA.	30 June 2016
4.1.6	Established systems for growing, harvesting and processing algae for inclusion in pig diets.	30 June 2017
4.1.7	Commercial "non-piggery" algae production systems that produce algae suitable for inclusion in pig diets. Complete second postgraduate project. 5 papers published at APSA.	30 June 2018
4.1.8	Commercial algae production systems established on several piggeries that produce algae for pig diets and/or successfully treat piggery effluent.	30 June 2019

Output No.	Description	
R4.2	New and adapted cereal and pulse grain varieties with superior yield, wide adaptation and improved feed quality characteristics together with sowing program options, guidelines and timelines for growers of feed grains in pork producing regions.	
Output Milestones		Due date
4.2.1	New cereal grain variety commercially released.	30 June 2013

Output No.	Description	
R4.3	Real-time application of robust commercially self-sustaining NIRS calibrations that accurately predict the nutrient content of cereal grains (available energy content) and major protein sources (available amino acid content) will enable more efficient purchase of grains based upon quality. The Implement controlled supply chain systems for grains and pulses will ensure that both grain growers and pork producers will share in these benefits.	
Output Milestones		Due date
4.3.1	Establish the key drivers for grain growers to grow feed grains for the pork industry.	30 June 2012
4.3.2	Real-time NIR technology used on-line in commercial situation. Enhanced NIRS calibrations for cereal grains, including corn.	30 June 2013
4.3.3	Robust NIRS calibrations for nutritional quality accepted by the feed milling industry.	30 June 2014
4.3.4	Effective and efficient supply chain system established for triticale in particular regions in southern Australia. Feed grain beginning to be traded on nutritional quality aspects.	30 June 2015
4.3.5	Effective supply chain system operational in NSW/Qld for field peas. 3 papers published at APSA.	30 June 2016
4.3.6	The purchase of at least 50% of the feed grains by the feed and pork industries will be on nutritional quality basis.	30 June 2017
4.3.7	Several effective supply chain systems established for the efficient purchase of feed grains. 3 papers published at APSA.	30 June 2018

Output No.	Description	
R4.4	Novel and/or improved methods of processing of feed ingredients and complete feeds to increase the nutritional yield in pig diets plus novel processing methods to develop new feed ingredients based upon existing cereal and pulse grains. Processing technologies will be developed to improve homogeneity of particle size and moisture integrity of milled grains to improve milling efficiency. Fractionation of grains and pulses by sieving, and new technologies such as air separation will provide new more flexible feed ingredients from these tradition feed grain.	
Output Milestones		Due date
4.4.1	Fractionation studies of grains and pulses established. First postgraduate student in the subprogram recruited.	30 June 2013
4.4.2	Influence of particle size homogeneity and moisture integrity of grains on milling efficiency and pig performance established.	30 June 2014
4.4.3	Novel feed processing methods to improve nutritional value by up to 10%. Recruitment of second postgraduate student in the subprogram	30 June 2015
4.4.4	At least 1 new feed ingredient established by innovative processing technology. First postgraduate project in feed processing completed. 5 papers published at APSA.	30 June 2016
4.4.5	Novel feed processing methods established in commercial feed mills.	30 June 2017
4.4.6	Second postgraduate project completed. 5 papers published at APSA.	30 June 2018

Output No.	Description	
R4.5	Management procedures and technologies that will maximise methane production from anaerobic effluent ponds. Innovative systems developed for efficient capture of this increased production of methane from new and existing effluent systems. Subsequent development of innovative systems to efficiently store and utilise the captured methane. Strategies and products that minimise greenhouse gas emissions from anaerobic, aerobic and deep-litter solid waste systems without subsequent methane capture.	
Output Milestones		Due date
4.5.1	Appoint post doctoral fellow in methane production in anaerobic ponds.	30 June 2012
4.5.2	Establish pilot/demonstration sites for carbon reduction and greenhouse gas mitigation studies. Recruitment of first postgraduate student in the subprogram	30 June 2013
4.5.3	Strategies to maximise methane production from anaerobic ponds.	30 June 2014
4.5.4	On-farming training begins in revised effluent management systems. Run LCA to confirm expected reductions in greenhouse gas emissions. Recruitment of second postgraduate student in the subprogram	30 June 2015
4.5.5	Viable system established for production, capture and utilisation of methane from anaerobic ponds. First postgraduate project completed. 5 papers published at APSA.	30 June 2016
4.5.6	Strategies established in solid waste and aerobic systems to minimise greenhouse gas emissions.	30 June 2017
4.5.7	Second postgraduate project completed. 5 papers published at APSA.	30 June 2018
4.5.8	Run LCA to confirm expected reductions in greenhouse gas emissions.	30 June 2019

Utilisation No.	Description	
U4.1	<p>High yielding pig specific grains and pulses which grain growers will preferentially produce for the pork industry. These grains are likely to cost more to grow and produce, but yields, and nutrient yields, will be at least 10% greater, thereby allowing the opportunity for cheaper grains to the pork industry and greater returns per hectare for the grain grower. Feed manufacturing and processing techniques will be used by feed manufacturers to improve the nutritional quality of ingredients and diets. These modifications are likely to increase milling costs by up to \$10/tonne, but we would expect considerable improvement in efficiencies and animal performance. Annual grain usage is approx 1.1 million tonnes. Use of novel nutrients by pork producers and the feed industry will reduce the reliance on ingredients that are under increasing pressure for human food.</p>	
Utilisation Milestones		Due date
U4.1.1	New varieties of grains available. Selection of key algae species.	30 June 2013
U4.1.2	Feed processing changes. Robust NIRS calibrations for nutritional quality enhanced and accepted by 80% of the feed milling industry.	30 June 2014
U4.1.3	10% pork production will save 5% of feed costs by better feed efficiency and/or lower ingredient costs.	30 June 2015
U4.1.4	Commercially viable algae systems available. Novel feed processing methods established in commercial feed mills supplying 50% of the market. 20% pork production will save 5% of feed costs by better feed efficiency and/or lower ingredient costs.	30 June 2017
U4.1.5	Several effective supply chain systems established for the efficient purchase of feed grains. 25% grain is traded through effective supply chain marketing systems based upon nutrient basis.	30 June 2018
U4.1.6	Commercial algae production systems established on several piggeries, accounting for up to 25% of the industry. 35% pork production will save 5% of feed costs by better feed efficiency and/or lower ingredient costs.	30 June 2019

Utilisation No.	Description	
U4.2	<p>The users will be pork producers, regulatory authorities, local governments and consultants. It is expected that some of the tools for reducing carbon emissions will be available within a couple of years, but technologies that can be commercially implemented for reducing greenhouse gas emissions from the present 3-6 kg CO₂ equivalents/kg pork produced to 1 kg CO₂ equivalents/kg pork will take longer to apply if successfully developed. There may be spinoffs to other industries, such as dairy, food processing and rendering industries that may adapt the technology that will be developed to treat their effluent in a similar way. It is quite difficult to estimate the usage costs, however the costs of implementing effective strategies to reduce greenhouse gas emissions to the above level are likely to be in the order of \$30/sow, or \$7.2m across the industry. Annual operating costs are anticipated as 10% of capital investment or \$3/sow.</p>	
Utilisation Milestones		Due date
U4.2.1	Regulators will be engaged with the program.	30 June 2012
U4.2.2	On farm demonstration sites established	30 June 2013
U4.2.3	5% pork production will have reduced greenhouse gas emissions to about 1 kg CO ₂ equivalent/kg pork produced.	30 June 2015
U4.2.4	On farm demonstration sites will be operating efficiently. 10% pork production will have reduced greenhouse gas emissions to about 1 kg CO ₂ equivalent/kg pork produced	30 June 2016
U4.2.5	Range of commercially available systems available to industry. Consultants have the tools to implement new effluent strategies to economically minimise greenhouse gas emissions. 20% pork production will have reduced greenhouse gas emissions to about 1 kg CO ₂ equivalent/kg pork produced.	30 June 2017
U4.2.6	Effluent systems capable of significantly reducing greenhouse gas emissions implemented in 40% of pork production. 40% pork production will have reduced greenhouse gas emissions to about 1 kg CO ₂ equivalent/kg pork produced	30 June 2018
U4.2.7	60% pork production will have reduced greenhouse gas emissions to about 1 kg CO ₂ equivalent/kg pork produced.	30 June 2019

Research Program 5 - Improving sow reproduction

The research will complete work commenced as part of the Pork CRC for enhancing global competitiveness of the Australian pork industry. The research will enhance the reproductive efficiency of the Australian industry by providing better means of detecting pregnancy, increasing litter size and ultimately volume.

The research will cover two areas:

- **Early pregnancy detection and predicting litter size** will develop technologies for rapidly determining whether sows are pregnant within days of mating, and for predicting litter size prior to farrowing. The technologies will use urine and/or blood to detect pregnancy, and foetal hormones for pregnancy and litter size respectively. The technologies will enable producers and veterinarians to detect pregnant and non-pregnant sows within days of mating, and to estimate litter size during gestation. The pregnancy information will be used to manage mating regimes and reduce the number of failed matings and non-productive days. The information on litter size will enable producers and nutritionists to modify the nutrition and management of sows having different litter sizes.
- **Increasing litter size and reproductive efficiency** will investigate the use of progesterone implants to maintain pregnancy and increase litter size in sows. Nutrition studies will examine ways to increase pregnancy rates and litter size in sows. The research will enable producers and managers to improve pregnancy rates and litter sizes, particularly during summer and in older sows. Poor reproduction in summer and in aging sows, remain major constraints on the efficiency of the Australian industry and the research addresses both constraints.

Output No.	Description	
R5.1	Develop technologies/techniques for rapidly determining pregnancy in sows shortly after mating and for predicting the litter size of pregnant sows.	
Output Milestones		Due date
5.1.1	Complete investigations of rapidly determining pregnancy in sows within days of mating and patent the resulting technology.	30 June 2012
5.1.2	Complete investigations of predicting the litter size of pregnant sows. Test the outcome on commercial units.	30 June 2012

Output No.	Description	
R5.2	Investigate nutritional and other means of maintaining higher rates of pregnancy in sows and for increasing litter size.	
Output Milestones		Due date
5.2.1	Complete investigations on the potential of progesterone implants to enhance pregnancy and litter size in sows and patent the resultant technology.	30 June 2012
5.2.2	Complete investigations on the effects of nutrition, season, and parity and management strategies on luteal function and embryo quality in sows. Increase pregnancy rates and litter size in the Australian sow population.	30 June 2012

Utilisation No.	Description	
U5.1	Provide industry with technologies for rapidly determining pregnancy in sows after mating and for predicting litter size in pregnant sows.	
Utilisation Milestones		Due date
U5.1.1	A simple and rapid pregnancy test commercialised and made available to the Australian pork industry. Commercialisation of pregnancy test.	30 December 2012
U5.1.2	A test/assay for predicting the litter size of pregnant gilts and sows made available to the Australian pork industry. Commercialisation of test for litter size.	30 December 2012

Utilisation No.	Description	
U5.2	Availability of new information and nutritional technologies for producers and consultants to enhance the reproductive performance of sows.	
Utilisation Milestones		Due date
U5.2.1	Commercialise progesterone implants for increasing pregnancy rates and litter size in sows.	30 December 2012
U5.2.2	Publish and distribute information on the effects of temperature on the timing of ovulation and luteal function in sows, and mating and management techniques to maximise reproductive performance during different seasons.	30 December 2012

Research Program 6 - Nutritional manipulations to enhance the performance and feed efficiency of growing pigs

Feed intake and feed efficiency are the two factors most affecting the performance of growing pigs. The research will complete work commenced as part of nutritional innovations in the Pork CRC. The work will establish the extent chemosensory factors, or components of ingredients, might be used in diet formulations to manipulate feed intake, and to establish the extent nutrient asynchrony may play in preventing pigs exhibiting their genetic potential under commercial situations. The research will establish the extent nutrient availability is affected by ingredients and grain processing, and the extent nutrient asynchrony may play in determining animal performance.

The research will cover two areas:

- **Peripheral chemosensing and feed intake** will screen 'tastants' for their impacts on the feed intake of growing pigs. Tastants and ingredients will be ranked on their preferences by pigs and tested alone and/or in combinations to establish how ingredients might be selected to manipulate the feed intake of pigs.
- **Influence of nutrient asynchrony on pig growth performance and feed efficiency** will investigate the extent the combination of different ingredients and how grains are processed influences the synchrony with which nutrients are made available in the small intestine and the consequent effects on animal performance but particularly feed efficiency. The outcomes will help establish the extent nutrient asynchrony might influence commercial feed efficiency. The extent the selection of ingredients and processing conditions might affect the synchrony of nutrient availability is not currently taken into account in diet formulations.

Output No.	Description	
R6.1	Establish the chemosensory components of ingredients and the extent these affect the feed intake of growing pigs and how they can be used to manipulate the feed intake of growing pigs.	
Output Milestones		Due date
6.1.1	Complete investigations on the extent different tastants influence the feed intake of growing pigs. Rank ingredients on their preference by pigs and investigate how combinations of ingredients ranked on the basis of their "preference" by pigs can be used to manipulate (increase or reduce) feed intake.	30 June 2012

Output No.	Description	
R6.2	Investigate and establish the extent nutrient asynchrony affects the growth performance of pigs under commercial situations. The research will establish how different ingredients and processing technologies affect the rate and site of nutrient availability in the small intestine and the extent nutrient asynchrony might affect the performance of pigs under commercial situations.	
Output Milestones		Due date
6.2.1	Complete investigations on the effects of ingredients and grain processing technologies on nutrient asynchrony in growing pigs.	30 June 2012

Utilisation No.	Description	
U6.1	Provide industry, feed mills and nutritionists with information on the preference rankings of ingredients and additives used in pig diets.	
Utilisation Milestones		Due date
U6.1.1	Publish and distribute the preference rankings of ingredients used in pig diets, and develop diets/products for SMEs, that promote higher feed intake in younger pigs and could reduce feed intake in older pigs.	30 December 2012
Utilisation No.	Description	
U6.2	New information on the effects of ingredients and how grains are processed on the timing and extent of nutrient availability in the small intestine and the consequent effects on animal performance.	
Utilisation Milestones		Due date
U6.2.1	Publish and distribute information on the effects of different ingredients and grain processing technologies on nutrient asynchrony and the impact on animal performance. Distribute new information for nutritionists and consultants to improve feed efficiency under commercial situations.	30 December 2012