FINAL DRAFT

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Cost benefit analysis: Selected project investments by Australian Pork Limited

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1. BACKGROUND

1.1. CONTEXT OF THE ANALYSIS

In 2006 the Council of Rural Research and Development Corporations' Chairs (CRRDCC) outlined that "to help levy payers and the Australian Government better understand the value of the investment in rural R&D, the [Rural Research Corporations] RDCs have embarked on an ambitious plan to estimate aggregate RDC returns"[1]

To this end each RDC was asked to complete an independent cost benefit analysis of a number of major and completed investments that would demonstrate that a minimum positive return had been generated on their entire portfolio. These are the so called 'hero' projects. In addition the RDCs were asked to further undertake a program, over three years, of cost benefit assessments of randomly selected completed projects.

Evaluation guidelines were circulated by the Council in May 2007.

APL commissioned IDA Economics Pty Ltd to undertake these evaluations.

This report has been prepared by IDA Economics along the evaluation guidelines suggested by the CRRDCC.

Two completed 'projects' have been selected by APL for the 'hero stage' of the cost benefit analysis. These projects are:

- Five APL funded quantitative pig genetics projects which have been examined as a group given the linkages and overlaps between them.
- ICIP 04055: Development and implementation of an enhanced pig carcase grading system based on real time ultrasound.

In addition, the Council's Secretariat has selected three projects as a random sample of projects undertaken by APL since 2000. These projects are:

- 1763: Less expensive, more effective monitoring for land application of effluent
- 2015: A Measure to Manage toolkit for improving herd feed conversion efficiency
- 1711: Integration and further development of PIGBLUP and the national pig improvement program. This project is one of the projects in the quantitative pig genetics program reviewed in the 'hero' projects

1 CRRDCC, 2007, *The Benefits of Rural R&D*, September 5.

A key emphasis in the Council's Guidelines is the delineation of the range of benefits likely to have resulted from the projects. In particular:

- Overall returns from the RDCs collectively to industry.
- Public and spillover returns from the collective program.
- The public and spillover returns that are conditional on public contributions to the RDCs.

The Council's intention is to ensure that both public benefits (benefits to the community as a whole) as well as private benefits (to producers and others in the marketing chain) were examined given the concerns raised by the Productivity Commission in its assessment of future financing of research and, specifically, the taxpayer matching of rural industry levy contributions.[2]

1.2. MAJOR OR HERO PROJECT ANALYSIS

The Council outlined that the purpose of conducting a limited number of major successful projects (or programs) is to demonstrate at least a minimum positive return on investment on the total portfolio of projects has been achieved. It outlined that the following criteria should be applied to these projects:

- "Sufficient major projects should be analysed to demonstrate a positive return on the RDC investment over the specified period.
- The RDCs should collate a list of potential large scale successful projects and work down the list until a positive rate of return on the entire RDC investment is reached.
- Major projects should be selected based on the following criteria:
    - Projects or programs that demonstrate combinations of significance (good scientific results) and impact (high prospects for adoption).
    - A high level of information available on the project and likely impact and/or adoption rates
    - How suitable the benefits generated are for valuation.
    - Whether a boundary could easily be placed around the innovation in terms of inputs over time and across funding organizations.
    - The size of the RDC investment in the innovation.

[2] Productivity Commission 2007, *Public Support for Science and Innovation*, Research Report, Productivity Commission, Canberra.

- High levels of public benefits where possible."

APL considers that the major projects it has selected meet these criteria.

1.3. APPROACH

IDA has followed the guidelines outlined by the Council including as required reference to The Commonwealth Guidelines for benefit cost analysis (Department of Finance and Administration, *Handbook of Cost-Benefit Analysis,* 2006)

The Council outlined that there are three critical features of the CBAs to be prepared:

- 1. A clear identification of the net public and private benefits produced. Wherever possible the benefits should be quantified and attributed to those who produced them. Where quantification is not possible accurate descriptions of the benefits should be included.
- 2. All direct costs, including direct costs incurred by other organisations contributing to the funding of the research, incurred in producing the benefit need to be identified and reported. Direct costs are those that vary directly with the scale and scope of the project or program being analysed. Wherever possible, indirect costs (such as overheads) should be reported. Direct and indirect costs should be reported separately.
- 3. All CBAs will need to test the counterfactual. This requires the analysis of the benefits to recognise which if any benefits would be produced in the absence of RDC investment.

The Council noted that ultimately the CBAs will be used to better understand:

- The scale and scope of the returns to levy funds invested by the RDCs.
- Do the public funds committed to the RRDCs induce sufficient spillover benefits to make the funding worthwhile? *(the aggregate test).*
- Is it the case that changes in that funding – up or down – would increase or decrease the induced net private and spillover benefits? *(the marginal test).*

The following are general guidelines outlined by the Council for the conduct of the CBAs:

- CBAs should be on clusters of investments where outcomes can be reasonably estimated taking into account the likelihood of adoption or implementation.
- All projections and calculations should be in real terms (without escalating benefits and costs for inflation)
- All CBAs should report present values (NPVs) of net benefits (benefits minus costs); internal rates of return (IRRs); and benefit-to-cost ratios (BCRs) calculated using the present value of benefits and costs.

- Adoption rates should be estimated conservatively and be tested for their sensitivity: the RDCs should keep a database of adoption rates used in past CBAs, and over time use these to cross-check and revise adoption rates.
- CBAs should include sensitivity analysis on key variables or parameters once a benefit stream and costs have been calculated (e.g., if a project involves overseas markets, sensitivity analysis around exchange rate assumptions).
- A common discount rate of 5 per cent will be adopted for all CBAs:
- Common project horizons will be adopted: current year, 5, 10 and 20 year horizons (these are the minimum horizons and more can be added if required). It is noted that some R&D particularly natural resource management is often considered to have much larger time frames for the benefits to be generated and the appropriate time horizons should be included in the evaluation process
- Actual and anticipated benefit streams should also be included in the CBAs including the reference points listed in the previous dot point. The benefit streams should be charted out so that a clear picture of when they expected to increase, peak and decline is described.

2. PROJECT ANALYSIS: QUANTITATIVE GENETICS

2.1. RESEARCH UNDERTAKEN

2.1.1. Context

The Australian pig industry now relies exclusively on the domestic gene pool. The importation of pig genetics has been banned (except for one importation from Norway) since 1995 on quarantine grounds. In contrast, there is a significant trade in genetic material between Europe and North America which in effect creates very much larger gene pool.

Hence investment in the capacity to best utilize the available genetic pool is of particular importance to the Australian pig industry. The principal investment focus of APL has been in the field of quantitative genetics.

2.1.2. APL investment

Five APL projects are examined in this analysis. Given the overlaps between the projects and the outcomes, and thus benefits, both to the Australian pig industry and broader spillover benefits to other interests, the five projects have been grouped together. The analysis covers APL investment from 2000-2001 through to 2005-06.

The five projects are:

- Project 1335 - Genetic parameters for lean tissue deposition, birth weight, weaning weight and age at puberty. This project was completed in February 2002 and estimated heritabilities and correlations for use in the PIGBLUP program.
- Project 1637 – Characterisation and improvement of belly composition. The project studied genetic and management aspects of pork bellies which are one of the five major cuts from the pig and an important export commodity. Completion for this project was June 2004.
- Project 1711 - Integration and further development of PIGBLUP and the National Pig Improvement Program. This programme ran throughout the time period and included several new additions to the PIGBLUP program and to the NPIP as well as further extension and training.
- Project 1927 – Quantifying meat and eating quality differences between major Australian pig genotypes. There were two main components to the project – the comparison of traits in different genotypes and a study to investigate whether objective behavioural monitoring could be used to predict meat and eating quality in the live animal. Completion for this project was June 2005.
- Project 2023 – Comparison of Australian and Dutch pig genotypes. The idea behind this work was to use Australia semen in the Netherlands to allow some "benchmarking" of current Australian genotypes against genetically advanced European genotypes. Unfortunately, health protocols did not allow the project to go ahead.

The analysis draws on previous technical and economic analysis of these projects undertaken by R. Walters for AGBU (*Review of APL funded quantitative pig genetics in Australia*, 2006). The current analysis examines the costs and benefits in the framework outlined by the CRRDCC.

2.1.3. Project investment

Total expenditure on the research by APL project for the five projects is shown in Table 1.

In addition to the APL investment the projects were supported by substantial investment from breeders in the Australian industry and AGBU. These investments plus the APL investment are shown in Table 2.

Table 1: APL investment by project: 2001 to 2006 ($m)

	Genetic parameters (1335)	PIGBLUP (1711)	Meat quality (1927)		Belly composition (1637)	International comparison (2023)		Total
	AGBU	AGBU	AGBU	QAF	QAF	AGBU	IPG	
2001	39,813	42,000			59,200			141,013
2002	10,000	190,000						200,000
2003		190,000						190,000
2004		190,000	2,000	65,000				257,000
2005		190,000	2,000	8,000				200,000
2006		160,450	1,415			9,471	10,968	182,304

Source: APL

Table 2: Total investment all sources: 2001 to 2006 ($m)

	APL	PIGBLUP fees paid by breeders	Genetic consultancy fees paid by breeders	Breeders Contributions	Breeder - in kind	AGBU cash	AGBU – in kind	Total
2001	141,013	68,514	98,583	11,600	59,240	15,129	235,846	629,926
2002	200,000	68,514	98,583	11,600	59,240	15,129	235,846	688,913
2003	190,000	68,514	98,583	11,600	59,240	15,129	235,846	678,913
2004	257,000	68,514	98,583	11,600	59,240	15,129	235,846	745,913
2005	200,000	68,514	98,583	11,600	59,240	15,129	235,846	688,913
2006	182,304	68,514	98,583	11,600	59,240	15,129	235,846	671,217

Notes. The PIGBLUP fees paid by breeders, genetic consulting fees paid by breeders can be either included as a cost to the industry or deducted from the gross economic benefit of PIGBLUP to arrive at the net returns from PIGBLUP. In this analysis they have been included as a component of the costs of delivering the gains from PIGBLUP.

Source: Walters

2.2. OUTPUTS OF THE RESEARCH

APL investment in pig genetic evaluation tools are PIGBLUP and the National Pig Improvement Program. The additional outputs in these two areas resulting from APL investment between 2001 and 2006 are as follows.

PIGBLUP

- Selection and Mate Allocation Module (PBSAMA)
- Provision of approximate accuracies of EBVs
- Alternative modelling for forming selection indexes
- Incorporation of marker information (PBMARKER)
- Introduction of pig profile graphic capability
- Implementation of a new program for improved data management (FileMerger)
- Introduction of an on-line PIGBLUP service for EBVs and trends for self-replacing herds (PBSELECT)

NPIP

- Implementation of automatic online across-herd genetic evaluations
- Introduction of automatic update of web pages
- Development of new procedures and guidelines
- Automatic display of genetic trends and EBVs of AI boars and top young animals on NPIP web page
- Setup of a terminal sire and maternal index to rank animals
- Breeders adopted automated system and submit data via e-mail
- Breeders adopted suggested naming of link sires to identify linkage between herds
- Breeders are responsible to ensure linkage between herds; no sire reference scheme is required
- Documentation of new procedures and guidelines for breeders
- Increase in NPIP members

Knowledge transfer:

- The development of Pig Genetics Information sheets
- Regular updating of AGBU web pages
- Biennial Pig Genetics Workshops
- Various training activities

- Liaison with extension services
- Presentations to producer groups
- General support of individual breeding programs

In summary there has been significant advancement in the PIGBLUP modules, the National Pig Improvement Program has been enhanced and transferred from the DPI in Queensland and there has been a considerable programme of industry education undertaken by AGBU staff.

Taken together these additions have delivered increases in litter size, growth rates and feed conversion resulting in lower costs of production (per kg) and thus improved industry competitiveness. There has also been a reduction of backfat and an increase in lean meat yield (again lowering the cost of production and improving carcass value).

2.3. Outcomes resulting: Benefits

The benefits that have come from PIGBLUP have been estimated by:

- Calculating the changes in on-farm performance (the phenotypic trends) in PIGBLUP impacted herds
- Estimating the combined economic value of these individual improvements in performance
- Applying this combined value to the relevant pig population.

2.3.1. Productivity trends

The change in key phenotypic trends litter size; lifetime growth rate; backfat and live weight are summarized in Table 3.

Table 3: Phenotypic trends for 9 Large White herds from 2000 until 2005

	2000	2001	2002	2003	2004	2005	Total change	Annual change
NBA	10.4	10.5	10.7	10.8	10.7	10.9	0.5	0.1
ADG	641	636	632	629	634	659	18	3.6
BF	11.34	10.9	11.03	10.61	10.69	10.65	-0.69	-0.14
Weight	96.7	98.1	97.1	96.7	96.7	97	0.3	0.06

Notes:

NBA = Litter size (piglets born alive/litter)

ADG = Lifetime growth rate (g/day)

BF = Backfat (mm)

Weight = Liveweight at test (kg)

Also, there were favourable phenotypic trends in all the key production traits, indicating that the herds were improving and capturing the benefit in quantifiable terms.

Data drawn from 9 herds with a Large White population. Only Large White populations were analysed because Large White is the largest purebred population within the AGBU database and phenotypic trends did not differ greatly between breeds within the same breeding company

Source: Walters, pg. 26

2.3.2. Value of gains per pig

Measured benefits from PIGBLUP

Walters estimated the *average* value of the annual genetic gain at $1.06 per pig slaughtered for the period 2001 to 2006. The methodology is shown in Box 1. This appears to be a systematic basis for analysis and is endorsed by APL and the industry as credible.

Box 1: Valuing the gains from genetic progress: The Walters analysis

Walters obtained genetic trends from 28 Australian pig populations through within-herd evaluations using PIGBLUP. These populations had at least 8 years of data available with the majority of populations having data from 1995 until 2005. Average genetic trends were obtained by regression using the mean trait EBVs for each year available from PIGBLUP on year.

The economic benefits of genetic gains were derived using economic weights presented by Cameron and Crump (2001). The economic weight for muscle depth was derived using the approach outlined by Hermesch (2005) assuming a reduction of the base price of $2.30 by $0.10 for every 5 mm decrease in muscle depth and an increase of $0.10 for every 5 mm increase in muscle depth below and above the mean of 60 mm.

The $Index was:

$Index = 0.049*EBVADG – 2.05*EBVBF – 21.1*EBVFCR + 1.0*EBVLMD + 3.56*EBVNBA

The average annual genetic gain of the 28 populations over the 5 years 2001 to 2006 is shown in below: This is converted to an annual average gain in value ($/pig).

The table also shows the expected gains by non users over the same period.

Trait		User average	Non-user	Difference
Growth rate (g/d)	(ADG)	5	5	0
Backfat (mm)	(BF)	-0.15	-0.05	-0.1
Feed conversion ratio (kg/kg)	(FCR)	-0.01	-0.005	-0.005
Live Muscle depth (mm)	(LMD)	0.05	0	0.05
Number born alive (piglets)	NBA	0.07	0	0.07
$Index ($/pig)		1.06	0.45	0.61

The above analysis does not include the costs incurred by breeders in participating in PIGBLUP. These costs are not insignificant and they include performance measurement of progeny, recording and data management. However, the key issue is whether these costs are significantly different to breeders using other approaches. It is probable that their costs are higher but it is likely that they are not substantially higher.

Source Walters, pg. 27

An important aspect of valuing genetic improvement over time is that it is cumulative. An average annual gain of $1.06/pig/annum implies that after five years the value of that gain in the fifth year is around $5.30 per pig.

The otherwise case

The benefits of PIGBLUP have to be considered compared to what might have happened otherwise.

Walters, using AGBU data, estimated the value of genetic gains in pigs using PIGBLUP compared to non-using herds (Box 1). This suggests an annual benefit to the use of PIFBLUP of $0.61/pig.

2.3.3. Applicable pig population

To estimate the potential population to which these benefits applied, Walters obtained data from all of the 15 herds using PIGBLUP to establish the size of their respective breeding pyramids in terms of the number of sows influenced by each breeder and the number of slaughter pigs produced by matings to their male lines by boars and semen.[3]

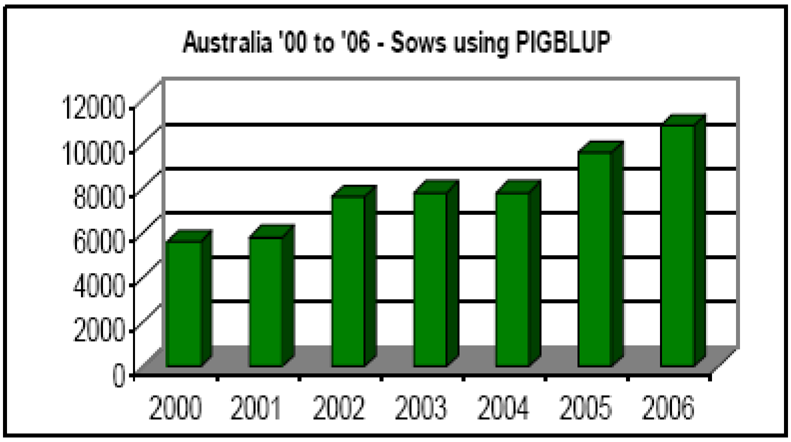
In 2001 there were eleven Australian herds using PIGBLUP representing approximately 5,600 sows. In 2006 sow numbers had grown to 10,800 (Figure 1). This expansion has been due to upgrades of six existing users to larger licence sizes plus four new users. The annual growth in sow numbers has been approximately 830 over the period, an annual increase of more than 11%. There are now (2006) 17 major breeding herds in Australia using BLUP technology, of which 15 use PIGBLUP. The other two companies have international linkages and therefore use proprietary BLUP programs to ensure integration with their international colleagues.

The main reason for the expansion of PIGBLUP usage in the Australian industry has been the increasing nucleus herd size. Breeders note that there has been a significant increase in demand for their breeding stock both at home and overseas over the past five years deriving from a substantial increase in the use of AI in Australia. Many commercial producers now require trait EBVs to help them chose boars for their individual situation. In turn, this means that PIGBLUP is having an increasing influence on the commercial slaughter pig in the industry. Another reason is that new breeders appear convinced that using PIGBLUP will be of benefit to them through making better use of genetics.

As well as the expansion in PIGBLUP usage there has also been a significant increase in the number of herds and sows in the NPIP

3 Walters considered the data to be reliable. Breeders provided extensive information about semen sales and sales of live animals and cross-referencing between breeders suggesting that the individually claimed figures were close to most competitor estimates. This suggests that the data are as accurate as is possible to access without having some independent means to check the individual breeder data

Figure 1: Australian sows using PIGBLUP: 2000 to 2006



Source: Walters

The numbers of sows on PIGBLUP appears very small when compared with the total Australian sow herd. However, pig breeding is based on a pyramid system where a relatively small number of nucleus, or Great Grand Parent (GGP), animals are responsible for genetic improvement through selection. The dam line genes are then multiplied through the pyramid to produce commercial replacements while terminal sire genes pass directly to the commercial level through Artificial Insemination or by natural service.

- Each GGP sow can support some 160 or more commercial sows
- Each boar produced supports either about 100 litters per year (@ 2 matings/week) if used for natural mating or about 1820 matings per year (@35 double doses per week) if used for artificial insemination.

Walters estimated total pyramid of sows influenced by PIGBLUP was 157,945. Based on an average national sow herd size of 333,333 sows (2001-2006) these data suggest that PIGBLUP has had an influence on 47% of Australian genetics.

There is typically a lag between undertaking the research, its adoption by breeders and its subsequent influence on the sow herd. PIGBLUP benefited from significant research prior to 2001 and certainly it was then well placed to capitalise upon the subsequent APL and other investment that took place between 2001 and 2006. If the economic benefits are to be based on the realised average benefits between 2001 and 2006, this has to take account of the prior investment. Alternatively a lag between the 2001-06 investment and realisation of industry benefits is needed. The latter approach has been adopted here since it is important to disentangle the earlier and subsequent benefits..

Given the lag between incorporating information into PIGBLUP, its use by breeders, the time for it to be realised in improved genetics in the progeny sold by breeders and in the subsequent returns by pig producers generally, it has been assumed that the industry did not start to benefit from the 2001-2006 investment until around 2004. It has further been assumed and that the proportion of slaughterings impacted was 25% at that time, with the proportion increasing by 25% per annum after that.

The economic benefits of PIGBLUP could be expected to continue past 2006 even without additional APL or other investment in PIGBLUP. Some of the genetic improvement is embodied in the existing sow population and even with no additional investment the stock of knowledge within PIGBLUP, use of PIGBLUP would still enable breeders to make improvements in performance. However, these residual gains could be expected to diminish over time. Forecasting the magnitude of these continuing gains is difficult. For the purposes of this analysis it has been assumed that the economic gains decline by 20% per annum post 2006. This implies that the average annual gain from PIGBLUP, in the absence of any additional investment post 2006, would be around $0.16 by 2015. This is a relatively high rate of decline and ensures a degree of conservatism in the analysis.

2.3.4. Benefits to Australian pig producers

Taking the estimated benefits of PIGBLUP per pig slaughtered and the number of pigs slaughtered gives an estimated annual economic impact for the industry (

Table 4).

To complete the analysis of readily measurable economic benefits, several adjustments were considered.

- Potential supply response by producers. In the short run the capacity of producers to increase production in response to higher net returns is limited by availability of infrastructure, breeding animal numbers and perhaps skills. A supply elasticity of unity (a 1% increase in price would induce an increase in supply of 1%) is likely to be reasonable. Even so a $1.06/per pig increase equals around a 0.6% increase in supply and, even in aggregate, a negligible increase in total supply.

- Impacts on prices received by producers as result of the supply response. This impact is likely to be very marginal since the supply increase is small and Australian pork prices appear to be essentially determined by import prices. Any increase in Australian production is unlikely to push prices down.[4]

- Receipts by ABGU from overseas licencing have to be included. Walters estimated these to be $170,000 over the five year period, around $34,000 per annum. Again this is quite small.

2.3.5. Other benefits of the investment in quantitative genetics

Benefits to breeders not using PIGBLUP

There are two breeders which do not use PIGBLUP but more generally utilise the capability of AGBU. The resource at AGBU is based on credible R&D and that the benefits are available to everyone regardless of whether they are, or are not, PIGBLUP users. The AGBU resource is available to the whole industry and is the only group in Australia that offers independent genetic advice.

4 Previous analysis using the respective demand and supply elasticities suggests that producers would retain about 75% of the estimated benefits. Historically, the domestic fresh market has been viewed as relatively price inelastic (around -0.8) while the price elasticity of export demand for fresh product is more elastic (-1.2) and the price elasticity of domestic demand for processed product is much more elastic (-5), the latter reflecting the importance of import prices in setting domestic processing prices. The producer share of the benefits is determined by the relative elasticities of supply and demand (producer share =ed/(ed+es). In more recent years it has become evident that domestic processing prices are much more influenced by import prices, suggesting that a greater share of any cost reductions from R&D will be retained by Australian pig producers/processors Thus the share retained by pig producers/pig processors is likely to be much greater and closer to 85%.

With very few exceptions the results of R&D and across-herd evaluations are available to the breeding industry through publications. In turn, many of the results of R&D have then been incorporated into the sophistication of the PIGBLUP programs. These breeders have been able to attend the AGBU Pig Genetics Workshops and view the results from the R&D projects in a variety of formats.

- One of the companies directly receives genetics from one of the PIGBLUP users who, in turn, samples genes from NPIP users.
- The other company receives consultancy services from AGBU as required.

Table 4: Estimated annual benefits to Australian pig producers from PIGBLUP: 2001 to 2006

	Total slaughterings	Potential slaughterings influenced by PIGBLUP	Pig slaughtering influenced by PIGBLUP	Additional economic gain/pig slaughtered
	no	no	no	$/pig
2001	5,016,000	2,357,520	-	-
2002	5,402,000	2,538,940	-	-
2003	5,742,000	2,698,740	-	-
2004	5,591,000	2,627,770	656,943	0.61
2005	5,342,000	2,510,740	821,178	0.61
2006	5,370,000	2,523,900	1,026,473	0.61
2007	5,322,000	2,501,340	1,283,091	0.61
2008	5,450,000	2,561,500	1,603,864	0.61
2009	5,250,000	2,467,500	2,004,829	0.61
2010	5,250,000	2,467,500	2,506,037	0.49
2011	5,250,000	2,467,500	2,506,037	0.39
2012	5,250,000	2,467,500	2,506,037	0.31
2013	5,250,000	2,467,500	2,506,037	0.25
2014	5,250,000	2,467,500	2,506,037	0.20
2015	5,250,000	2,467,500	2,506,037	0.16
2016	5,250,000	2,467,500	2,506,037	0.13
2017	5,250,000	2,467,500	2,506,037	0.10
2018	5,250,000	2,467,500	2,506,037	0.08
2019	5,250,000	2,467,500	2,506,037	0.07
2020	5,250,000	2,467,500	2,506,037	0.05
2021	5,250,000	2,467,500	2,506,037	0.04
2022	5,250,000	2,467,500	2,506,037	0.03
2023	5,250,000	2,467,500	2,506,037	0.03
2024	5,250,000	2,467,500	2,506,037	0.02
2025	5,250,000	2,467,500	2,506,037	0.02

Slaughterings ABARE historical data and forecasts to 2009; Slaughterings assumed to remain unchanged past 2009; Pig slaughterings influenced by PIGBLUP increase by 25% per annum from 2004

Net economic value of PIGBLUP equals $0.61, in 2008 prices, until 2009; Net economic value of PIGBLUP declines by 20% per annum after 2010, assuming no additional APL investment post 2006

Training

A recognized outcome of R&D is the training of postgraduate students. Between 2001 and 2006 AGBU had two students awarded a higher degree while one other student has submitted their thesis for external examination. In addition, one postgraduate student from Wageningen University in the Netherlands visited AGBU and two chapters of his Ph.D thesis were based on Australian data.

Research dissemination

Since most of the work undertaken by AGBU is not affected by confidentiality clauses (as it is in many parts of the world) refereed scientific journal papers and refereed papers at conferences are a vital part of the dissemination of information. Over the reporting period, 4 journal papers were published, 9 papers were presented at international conferences and 27 papers were presented at either the Association for the Advancement of Animal Breeding and Genetics (AAABG) or the Australian Pig Science Association (APSA). This information potentially benefits others outside of the Australian pig industry, including other animal breeding industries in Australia as well as pig producers and others overseas. These benefits are broadly of a public nature and potentially genuine spillover benefits resulting from APL investment.

Benefits to overseas breeders and industry

There are slightly more sows on PIGBLUP overseas than in Australia. Current overseas sow numbers are 12,200. The use of PIGBLUP overseas is a major benefit because of the increased flow of ideas from foreign breeding companies and the valuable source of income for AGBU and the PIGBLUP programme. The benefits of having an international component to the AGBU programme include networking with other leaders in genetic technology, attracting international scientists to collaborate, visit and work at AGBU, awareness of the global situation in pig breeding and improved funding through PIGBLUP licences. Overseas licensing generated more than half the fees received over the period 2001-2006, contributing $170,000 to total cash revenues for the program.

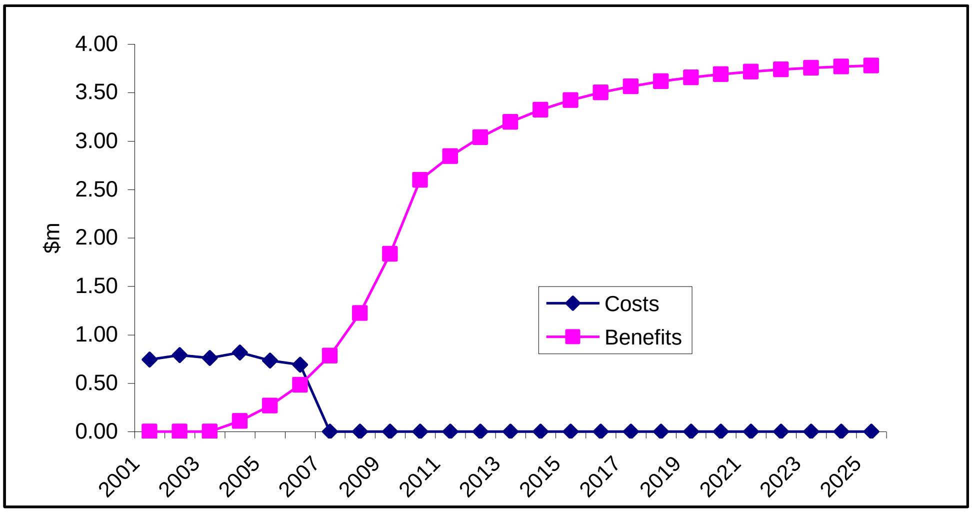
2.4. BENEFIT COST ANALYSIS

2.4.1. Overview

Benefits and costs

The timeframe of benefits and costs, give the above data and assumptions, is shown in Figure 2.

Figure 2: APL quantitative genetics projects: Total costs and benefits (undiscounted): Time profile 2001-2025



Investment performance

Using a 5% interest rate (to compound past costs and benefits to a 2008 present value and and discount future costs and benefits to 2008), the APL and partner investment shows a significant return (

Table 5).

- The present value of benefits totals around $41.8 and costs $7.7m
- The Benefit cost ratio is 5.4, suggesting that for each dollar of investment the return has been $5.4
- The Internal rate of return is around 27%[5]

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5 The principal reasons why this analysis differs to the Walters analysis are that the above analysis assesses the impact on the total population of pigs influenced by PIGBLUP, (in contrast to Walters which estimated the gains from additional users of PIGBLUP); total investment includes other partners as well as APL; ad a lag between the realization of benefits after the R&D investment takes place (of around 3 years) has been introduced.

Table 5: Economic performance of APL and partner investment in quantitative genetics 2001-06

	APL and partners	APL
Present value of real costs ($m)	7.7	2.2
Present value of real benefits ($m)	41.8	11.9
Net present value ($m)	34.1	9.7
Benefit cost ratio	5.4	5.4
Internal rate of return (%)	27%	27%

Notes

Costs and benefits 2001 to 2025
Benefits equal cumulative value of average annual genetic gains
Historical (pre 2008) costs and benefits converted (inflated) to real (2008) costs and benefits using the CPI (all capital cities average)
Present value of costs and benefits calculated using a 5% interest rate/discount rate
APL share of the total investment (and implied for benefits) is calculated to be 29% (Table 2)

When the analysis is undertaken from the perspective of APL, with the benefits allocated on the basis of the share of the total investment contributed by APL (around 29%) the present value of the benefits totals $11.9m and the cost $2.4. The benefit cost ratio is 5.4 and the IRR remains the same at 27%.

3. APL PROJECT ICI 04055: DEVELOPMENT AND IMPLEMENTATION OF AN ENHANCED PIG CARCASE GRADING SYSTEM BASED ON REAL TIME ULTRASOUND

3.1. BACKGROUND

3.1.1. Context

Accurate carcase measurement to determine the commercial value is of major importance to the Australian pork processing sector. Currently, carcase fatness at the P2 site is measured manually using either the Hennessy Grading Probe (HGP) or intrascope, however the ability of a single fat measurement to predict carcase leanness is poor. As the Victorian Farmers Federation said in their 2004 Submission to the Productivity Commission:

> *The (then) current method for predicting carcase value (P2 fat depth) no longer predicts lean meat yield with sufficient accuracy to support payment systems, is inherently prone to unacceptable operator error and does not have the confidence of producers. A new measurement and payments system is needed that better reflects one of the two components of true commercial value of carcases (ie lean meat yield)*[6]

The suppliers of the HGP are discontinuing the current model, requiring users to lease a newer model with an additional fee for carcasses scanned and expensive yearly service fee. Therefore, increased costs and little, to no, improvement in carcase information received by producers and lean meat yield prediction following the implementation of the new HGP model and high capital costs of adopting technology in use overseas led to Australian pig processors' significant interest in developing a cost effective measurement system to accurately predict lean meat yield.

Against this background and the long held industry objective of improving carcass measurement, given the limitations of the current system, led a consortium of industry interests, including APL to develop Project ICIP 04055.

3.1.2. Previous research in the area and current situation

The P2 measurement of subcutaneous fat depth over the loin muscle has been shown to be the best single point measurement to predict whole carcase fatness and inversely to predict the yield of carcase lean meat (LMY), the main component of saleable pork cuts.

6 http://www.pc.gov.au/__data/assets/file/0007/42793/sub030.rtf

When measured accurately on each carcase, P2 fat depth alone can explain about 65% of the variation observed in lean meat yield (LMY) (adjusted Ṙ squared value), the minimum accuracy standard set in the EU for commercial carcase measurement devices. However, most hand-held commercial P2 measurement devices (Hennessy Grading Probe; UltraFom) are prone to substantial operator error, so that under commercial conditions the Ṙ value often falls to about 30%. Further, producers have little confidence in the accuracy of these devices.

In 1999, APL identified the Animal Ultrasound Services Inc (AUS) system, developed and patented by Dr Jim Stouffer of Cornell University and based on real time ultrasound, as the best available technology for Australian abattoirs at an affordable price. This decision was subsequently arrived at independently by QAF Meat Industries staff, and verified by several independent comparative trials in Canada. This system measures average fat and loin muscle depths over a 5 rib section of the loin, and in 1999 was reportedly purchased by IBP (now Tyson) to estimate LMY on over 20m carcases per year. All major pig abattoirs in Australia were shown the AUS system and a number were interested in moving quickly to replace their current HGP probes, which are becoming obsolete.

The supplier is refusing to replace or service the current HGP model, and is insisting that customers lease a newer model with a new 15-20c per carcase fee, plus an expensive mandatory yearly service fee.

The following concerns and deficiencies with the AUS system were identified and reported to the parent company in response to the proposed change in arrangements for use of the HGP model.

- not designed as a commercial system and is a piece of R&D software that is now being adapted for different commercial environments. It was estimated that the base software has not changed substantially since 1992;
- not designed with a commercial operation in mind and no consideration was given for the system to be calibrated, audited or monitored by independent third parties;
- no thought given to exception handling and what happens if a carcase was not imaged and how it was to be paid for;
- the AUS-supplied handpiece used by the abattoir operator is bulky, cumbersome and not ergonomically designed.
- the carcase alignment device needed to be redesigned so the operator can position the probe on the carcase with high repeatability.

- the AUS software was not designed with a view to be used in commercial abattoirs where the output from the system forms the basis of payment. The software is DOS - based with a Windows operating system “bolted on” rather than being purpose built in Windows. This results in potential for instability and continual “crashes” with the software, with resulting loss of data (no automatic save function). This was supported by comments received from AUS that there were changes that the software programmer did not want to make since he was concerned that it would become “unstable”.

Due to the small size of the Australian industry, relative to North America and European competitors, the processing sector relies on equipment and technology imported from overseas.

The major abattoir companies all recognised deficiencies in the three imported carcase measurement devices currently used in Australia and consequently, five of these processors invested in this project. All consortium members have contributed to the project direction and have trialled and provide feedback on prototypes as they are developed.

APL has previously invested over $200,000 in producer levies and matching government funds to reach the current state of knowledge of the potential and weaknesses in the AUS ultrasound system.

3.1.3. Project objective

The objective of this project is to develop and implement, within 15 months, an improved manual carcase grading system for Australian pig abattoirs based on real time ultrasound that predicts P2 and lean meat yield in key primals with significantly greater accuracy than the current system.

This project has three major stages:

- the development of software, accessory hardware and release of a basic manual system accredited by AUSMEAT based on accurate P2 fat depth measurement

- the development of software, additional hardware and image capture systems for linear light striping of carcases to predict lean meat yield and individual primal yield.

- The development of a belly fat measurement system to predict belly lean meat yield.

3.1.4. Approach and technology

This system uses medical grade ultrasound hardware and other components readily available in Australia, which can be serviced by established suppliers.

The Stage 1 version is based on results of preliminary APL research, with software designed and written for carcase image capture and analysis based on the longitudinal loin scan using a modern and efficient software language and incorporating commercially-available advanced image analysis and enhancement software. The ultrasound hardware has a greater image definition and detail than that used in the past. The current project is utilising a CT scanning facility and personnel experienced with analysis of pig carcases to enable accurate assessment of actual carcase lean meat yield and tissue distribution to enable relationships between linear measurements and yield prediction to be quantified.

The Stage 2 system is using external measurements of overall carcase shape and loin fat depth to increase the precision of carcase lean meat yield prediction. It is anticipated that this level of precision will allow sorting of carcases based on predicted yield of individual primals to improve boning room yield efficiency for processors.

The Stage 3 system is addressing the industry's needs of more accurately describing carcases in terms of lean and fat composition in the belly, the most variable primal in the carcase. Ultrasound is allowing visualisation of the underlying anatomical structures. Prototype systems have been developed to measure the belly and the system is currently being reviewed by patent attorneys to determine if the intellectual property associated with its design and application can be protected.

3.2. INVESTMENT

3.2.1. Investors

The consortium comprises APL and the five largest pork processors, Big River Pork, QAF Meat Industries, Swickers Bacon Co-operative, Primo Smallgoods and Linley Valley Pork. These five companies slaughter about 60% of Australia's pigs.

The consortium members have invested capital and operating support in the project and the project has been further supported by AusIndustry funding.

The project commenced on 18 December 2006 upon signing of the Consortium Agreement and Grant Agreement by AusIndustry and Australian Pork Limited.

Recent trials involving 1000 carcasses comparing the carcass testing (P2 fat depth measurement) showed the two systems to be highly comparable a correlation of .94 between the two systems. About 45% of measurements were no different and 88%% of measurements were within 1mm of each other. The differences between operators were within the exacted range.

It is anticipated that the project will be completed by end June 2008.

3.2.2. Level of investment

Direct investment by the consortium partners and APL is summarized in Table 6

Table 6: APL Project ICI ICI 04055: Direct investment

	2006-07	2007-08	Total
Australian Pork Limited	$ 230,512	$112,711	$ 343,223
Consortium Investment	$ 265,000	$135,000	$ 400,000
AusIndustry	$ 266,666	$133,334	$ 400,000
Total	$ 762,178	$381,045	$ 1,143,223

Source: APL

In addition there are commercial R&D costs outside the scope of the project which have been incurred by individual partners. These are expected to total an estimated $120,000.

The capital costs of installing the technology, per 520,000 pigs slaughtered annually, are estimated to comprise:

- Equipment cost: $55,000 (replaced every 5 years)
- Hand piece cost (probe and handle): $10,000 (replaced every 5 years)
- Software fee: $20,000 (per year)

There are no additional labour costs, nor saving in labour costs in using PorkScan.

3.3. RESEARCH OUTPUTS

3.3.1. Research

This PorkScan system being developed uses medical grade ultrasound hardware and other components readily available in Australia, which can be serviced by established suppliers. The processor members have now all seen and trialled the Stage 1 system for measuring P2 fat depth.

The Stage 1 version was based on results of preliminary APL research already completed, with software designed and written for carcase image capture and analysis based on the longitudinal loin scan, as used in the AUS ultrasound system, but in a modern and efficient software language and incorporating commercially-available advanced image analysis and enhancement software. Commercially available ultrasound hardware was purchased and assembled, using harsh environment computers and cabinets, to ensure that it can fit all components of the final system, and an ergonomic handpiece has been built and supplied to processors. The ultrasound hardware has a greater image definition and detail than that used in the past.

Specialist skills (including ultrasound usage, image analysis, software programming, industrial design for handpieces) and equipment (CT-scan, tissue analysis) have been provided by external APL consultants. The current project is utilising a CT scanning facility and personnel experienced with analysis of pig carcases to enable accurate assessment of actual carcase lean meat yield and tissue distribution to enable relationships between linear measurements and yield prediction to be quantified.

The Stage 2 system is taking the proof of concept published research by Fortin et al. (2003), in which transverse real time ultrasound scanning to visualise the loin muscle area and manual drawing of the recorded images, are being combined with manual linear length and width, external measurements of overall carcase shape and loin fat depth to increase the precision of carcase lean meat yield prediction to R^2 ~0.8.[7] This level of precision should allow sorting of carcases based on predicted yield of individual primals to improve boning room yield efficiency for processors.

The Stage 3 system is addressing the industry's needs of more accurately describing carcases in terms of lean and fat composition in the belly, the most variable primal in the carcase. Ultrasound is allowing visualisation of the underlying anatomical structures. Prototype systems have been developed to measure the belly and are currently being reviewed by patent attorneys to determine if the intellectual property associated with its design and application can be protected.

3.3.2. Adoption pathway

The APL Board indicated that as product development and supply is not the core business of the Company, and as processors do not contribute R&D levies to APL, the financial and commercial risks associated with any venture into commercial development, production, distribution and maintenance must be shared with the processors.

Similarly, product development and supply is not the core business of the processors in the consortium. The strength and success of the joint project is that the system developed will have national application. A key role for APL is to ensure that the national, industry wide application, is achieved.

Patent applications are being drafted to protect the intellectual property arising from research undertaken in this project. Licence agreements will also be developed and a new shelf company will be established to administer PorkScan with all licensees paying installation, system support and per carcass fees for each component of the system. Expenditure on legal fees will be covered by Australian Pork Limited in accordance with the AusIndustry Consortium Agreement signed by all parties on 15 December 2006.

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7 Fortin, A., Tong, A. K. W., Robertson, W. M., Zawadski, S. M., Landry, S. J., Robinson, D. J., Liu, T., Mockford, R. J.(2003). A novel approach to grading pork carcases: computer vision and ultrasound. Meat Science 63, 451-462

3.4. Outcomes and benefits

3.4.1. Intended industry and other applications

It is an industry objective that the PorkScan system is positioned to apply to over 90% of Australia's pig slaughter.

- Plants owned by consortium members have been the first to adopt the technology and full adoption across these plants will be achieved within two years.
- Other plants will be targeted for adoption of this system on the basis that the new system has substantial advantages (including cost savings) over continued use of the Hennessy Grading Probe or intrascope. The additional benefits arising from adoption of the belly and light striping components and communication of outputs to producers will also be promoted.

The benefits of the project are being disseminated to the broader industry through demonstrations and sale/licensing of the developed technology to processors outside of the consortium. Smaller processors will therefore also benefit from this project, as the grading system will be licensed to them and all pig producers will have a more transparent and accurate grading and payment system.

Additional markets, including the Australian lamb industry for measurement of fat and muscle depth at the GR site and New Zealand pork industry, are also being investigated.

Licence agreements for all components of the PorkScan system are proposed to commence on 1st July 2008. Additionally, the shelf company is also proposed to begin operations on this date.

3.4.2. Benefits of Porkscan

There are three broad groups of potential benefits to the Australian pig industry:

- Cost savings, since the new technology is expected to offer Australia pork processors a lower cost alternative to the new generation HGP and the associated new user pricing structure. However, given the limited accuracy of the new generation HGP technology, processors had made the decision not to utilize that option. Hence, there are no measurable cost savings relative to the HGP option
- Superior productivity through better assessment of carcass quality and lean meat yield
- More economically efficient pig and pork production since future production is targeted toward higher performing carcasses.

In addition there are potential spillover benefits to other industries within Australia (such as lamb) as well as overseas industries, such as the New Zealand pork industry. Some of these potential benefits to these industries maybe able to be captured by the consortium as technology licence fees.

3.4.3. Quantification of benefits

Two broad areas of benefit have been identified as resulting from the PorkScan technology.

- An increase in LMY yield in the future as the technology impacts on the price grid and price signals are relayed back to producers

- Cost savings to processors in being able to more accurately identify, prior to entering the boning room, carcasses of appropriate LMY for specific product. This potential cost saving, through not having to re-direct carcasses to the relevant boning out area or subsequent boning out/product packing, While important is more difficult to quantify, and has not been examined here.

The potential benefits of the Porkscan technology have been estimated on the basis of the increase in LMY yield as a result of applying the technology, development of pricing grids which reflect more accurate LMY and subsequent breeding and production industry responses to the price grids.

In developing the project it was anticipated that the industry benefit would be of the order of $180m, in present value terms (0.28% increase in LMY; 6% discount rate; 2006 production and price levels).

The present analysis is based on:

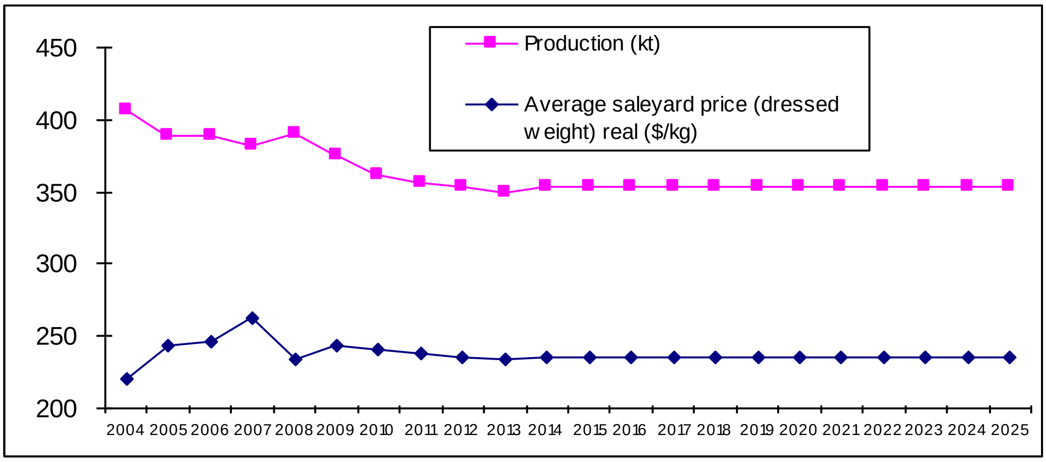
- A potential improvement in LMY as a result of more precise LMY measurement technology (that is, in comparison with the alternative, existing, technology option). Based on Danish experience (over the past decade) this gain might be of the order of 0.28% per annum (cumulative).[8]

- Since the technology is virtually fully developed, there is a very high likelihood (95%) that the technology will be successful in achieving this increase in LMY

8 The lean meat percentage in Danish pigs has now reached a level of around 60%, which the industry considers ideal and lean meat is now a less significant breeding goal than previously. However, it is still necessary to include lean meat percentage in the breeding goal in order to maintain it at its present level. This is partly due to increasing slaughter weights as well as other breeding objectives, which may have a negative influence of lean meat percentage. Source: http://www.danskeslagterier.dk/smcms/Danish_English/Danish_Quality/1_Primary/1_2_breeding_prog/1_2_5_quality/Index.htm?ID=4228

- An increase in LMY 2 years after the technology is adopted (reflecting the time to incorporate better measurement/price grid information into the breeding herd and subsequently production
- The technology being available and applied in the processing sector in 2009
- It is apparent that some processing plants will chose to adopt only the P2 measurement technology arising from Stage 1 and not all three components (P2 measurement, external measurements to increase the precision of estimating LMY and more accurately describing lean and fat composition in the belly, the most valuable carcase primals) — at least in the near term.
    - On this basis it has been assumed that the full potential gains will be realised across 75% of production from 2011 with the other 25% of production realising half of the potential gains for the first 5 years and then realising the full potential gains 2016 onwards.
- The increase in LMY does not require additional feed: in other words the feed conversion ratio for LMY increases since animals are being bred on the basis of the lean meat, not just weight.
- Pork production based on historical data and projected unchanged production post 2013 (Figure 3).
- Unchanged real pork prices post 2013 (Figure 3).
- 5% discount rate

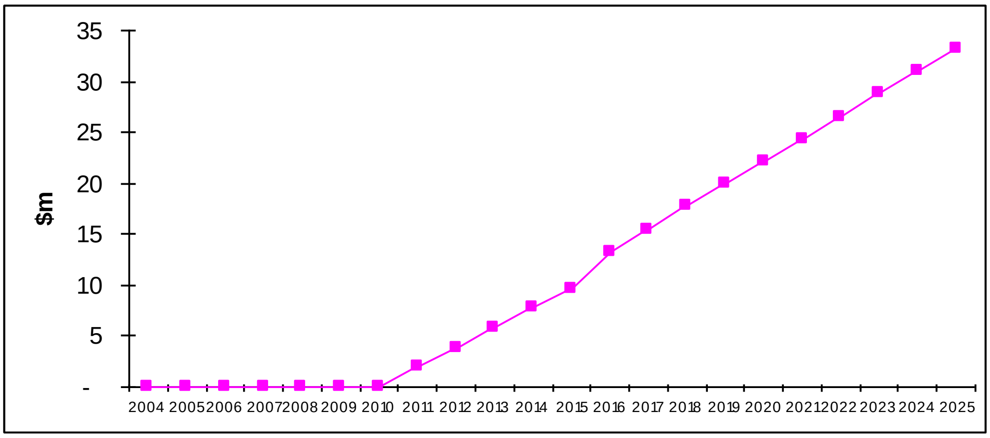
Figure 3: Australian pork production and prices: 2004 to 2025 (projected)



Notes:

Actual 2004-2007 (ABARE); ABARE forecast 2008-2013; Forecast 2014-2025 (average 2011-2013), Thus the annual estimated benefits amount to around $2m in 2011 and increase to around $33m by 2025 (Figure 4).

Figure 4: PorkScan: Annual benefits, undiscounted, 2008 real values



3.5. INVESTMENT PERFORMANCE

The assessed investment performance of the PorkScan project is presented in Table 7.

The project is estimated to deliver around $139m in future benefits (in present value terms), implying a benefit cost ratio of 25:1 and an Internal Rate of Return of 65%.

An issue is the extent to which APL can be credited with the benefits of the project. APL's investment, relative to the investment by other parties and the associated capital and software fee costs for processors is quite small — around 6%. On this basis APL's share of the net benefits is small. However, the relative levels of investment likely does not reflect the key role of APL in brokering the consortium arrangement; in securing AusIndustry support. Further, the relative small investment contribution from APL in the total investment reflects the significant capital and annual fees associated with implementing the technology. In terms of the R&D investment, APL has contributed around 30% of the total.

Table 7: APL Project ICIP 04055: Economic performance

	All investment	APL investment*
Present value of real costs ($m)	5.7	0.4
Present value of real benefits ($m)	145	9
Net present value ($m)	139	9
Benefit cost ratio	25	25
Internal rate of return (%)	65%	65%

* APL's financial contribution estimated at 6.2% of the total investment, (R&D plus capital and annual software fee costs) and 30% of the total R&D investment.

4. APL PROJECT: 1763 - LESS EXPENSIVE, MORE EFFECTIVE MONITORING FOR LAND APPLICATION OF EFFLUENT

4.1. BACKGROUND

Disposal of effluent from piggeries is a major issue for the Australian pig industry and one that it has addressed at the individual piggery level and more broadly at the industry level. The key issues are cost effective disposal with the objectives of minimising health risks and off site impacts.

The industry has developed effluent disposal guidelines in association with the respective state and local government agencies responsible regulating environmental impacts of activities. A key aspect of these regulations and guidelines is environmental monitoring of pig effluent disposal.

The pork industry guidelines state that:

> *"Environmental monitoring, including using sustainability indicators to interpret results, is critical to the overall environmental management of a piggery. It provides a mechanism to assess the effectiveness of strategies chosen to minimise environmental harm." (Tucker et al. 2004)*

Further, the guiding principles for environmental monitoring of piggeries (and beef lot-feeding) emphasize the importance of site specific management and monitoring:

> *"… environmental monitoring requirements for piggery or feedlot reuse areas should be tailored to match the potential risk to the environment… The level of risk is a function of the environmental vulnerability of the site, the quantity of water, nutrients and salt for reuse and the design and management of the reuse areas. .(McGahan & Tucker 2003)"*

Monitoring is the process of gaining feedback on the performance of a system, allowing improvements to its operation and management. In general terms, the reasons for environmental monitoring include:

- 1. To assess pollution effects on man and his environment.
- 2. To study and evaluate pollutant interactions and patterns, to apportion sources, and to study pollutant pathways.
- 3. To assess the need for legislative controls, to assess the effectiveness of legislation, and to ensure compliance with emission standards.
- 4. To activate emergency procedures where the consequences of pollution may be acute.
- 5. To obtain a historical record of environmental quality.

- 6. To ensure the suitability of a natural resource for a proposed use.

Redding has outlined that while these reasons touch on some of the motivations for environmental monitoring within industries, they do not adequately recognise the value of monitoring within a production system, or the role of environmental monitoring in enabling sustainable natural resource management.

For pig production in Australia, environmental monitoring has come to be regarded as the means to provide feedback on the environmental performance of the production system; assisting optimisation of the management system for the twin goals of profit and sustainability; and demonstrating performance to any relevant regulatory authority. Specifically monitoring, or nutrient management is needed to

- Maximise production on areas irrigated
- Manage the water resource contamination potential, through runoff and leaching
- Recognise Greenhouse gas emissions, noting that nitrous oxide is 300 times as potent as CO2 and driven by excess nitrogen one study suggesting that this could total 6 kg of N2O-N/ha/year

The range of monitoring requirements (and techniques) varies between regulatory agencies. Further, the monitoring requirements are in various levels of development, although generally they have increased in recent years. The potential for these requirements to become more detailed and more demanding was an underlying stimulus for this project and APL investment in effluent disposal more generally.

In addition, and specific to the origins of the project, soil sampling is the currently required monitoring protocol. However it is expensive and for that reason the level of sampling is reduced. Redding suggests that the protocol requires around 20 samples per hectare but in practice around 12 samples are usually taken. Certainly this reduces the cost but it also limited the usefulness of the results, to the point where the results are of very limited usefulness.

4.2. Research costs

The project was undertaken by the Queensland Department of Primary Industries and Fisheries between 2003 and 2006. Project costs by APL and QDPI are shown in

Table 8: APL Project 1763: APL project and agency costs

	APL	QDPI
2002	$119,595	$72,067
2003	$102,934	$64,892
2004	$48,353	$87,045

4.3. RESEARCH OUTPUTS

The key output is the monitoring protocol document "Environmental monitoring for effluent application areas by piggery managers: A draft for discussion and demonstration". It is a simplified, step by step guide to using the alternative monitoring protocol. This new protocol combines soil sampling with soil water monitoring, and has substantial cost and accuracy advantages.

The researchers report that The proposed protocol can improve monitoring accuracy and reduce costs by using soil water collection techniques in conjunction with surface soil sampling (0-0.1 m) to replace the current soil sampling based monitoring protocols.[9] Studies indicated that current protocols are likely to return inaccurate monitoring results that differ by much more than 20 % from the real paddock values. The proposed protocol is designed to meet this modest level of accuracy, and is capable of doing so with an estimated on-going monitoring cost that is about 60% of some current sampling recommendations. This allows the initial installation cost for the system to be recovered within 4 to 5 years of operation (depending on the selected installation configuration).

4.4. RESEARCH OUTCOMES

The proposed protocol remains a proposal at this stage. Since the compilation of the final report there has been limited activity in promoting the protocol to respective regulatory agencies or the pig industry at large. This situation is now changing with the principal investigator of the project now resuming work in Australia.

A recent workshop focussed on the issue of environmental monitoring showed great interest in the proposed protocol, suggesting that with an investment in promoting eh protocol the cost savings and greater accuracy of monitoring could now be achieved. Equally it has to be recognised that amending the current regulatory requirements will take time and possibly considerable time recognising that there are implications from a change in the protocols. In particular, some effluent disposal systems may be assessed as operating under the current protocols but may have difficulty gaining acceptance under the proposed protocol, thus suggesting some resistance by producers to adopting the proposed protocol.

9 Dr. M Redding and J Devereux, *Less expensive, more effective monitoring for land application of effluent*, Final report to APL, 20 July 2005.

The estimated cost savings from the proposed protocol comprise initial higher capital costs but annual cost savings thereafter. The cost savings (recognising the time profile of costs) suggests cost savings of around $2200 per operating unit (typically 200 sows) (Table 9). A 200 farrowing sow unit requires 20 ha for disposing of treated effluent and 76 ha of pond sludge, total 96 ha.[10] Assuming that the costs savings are the same for all piggeries on a 200 sow basis the cost savings across the industry (333,000 sows or 1665 piggeries equivalent to 200 sows in 2007), suggesting a cost saving across the industry of $3.7m, if regulatory approval is obtained.

Table 9: Environmental monitoring: Costs savings proposed protocol compared with current protocol: 20 year time frame

Proposed protocol	Cost for first 4 years	Annual continuing cost	
Components	$756	$0	
Maintenance	$160	$100	
Installation labour (incluidng on costs)	$438	$0	
Water and surface soil sample collections (labour including on-costs)	$510	$128	
Water sample analysis (EC, NH4-N, Nox-N, MRP)	$159	$40	
Soil analysis	$537	$134	
Total	$2,560	$402	
NPV cost (over 12 years, 5% discount rate)			$6,229
Old protocol			
Collection of soil samples from 3 depths (labour plus on-costs)	$978	$244	
Analysis	$1,610	$403	
Total	$2,588	$647	
NPV cost (over 12 years, 5% discount rate)			$8,466
Cost saving			$2,237

Source: Dr M Redding, How much monitoring is required to support NMP? Conference paper Brisbane, April, 2008.

10 QDPI, *Piggery assessment spreadsheet* To assist in the preparation of applications for new and expanding piggery developments,

This comparison between the proposed and current assumes that the current protocol is being applied and therefore that they level and accuracy of monitoring is the same. In practice, as noted above current practice does not accord with the current protocol.

4.5. INVESTMENT ANALYSIS

The investment analysis incorporates the above estimates of costs and benefits and also recognises that it will take time for regulatory approval (assumed 5 years from 2007) and that there is only a modest likelihood that approval will be achieved (assumed 50% likelihood).

The summary investment analysis for the cost savings from the proposed protocol shows that the investment will have been worthwhile returning a return of 29% . Two key factors determine this lower than might otherwise be expected outcome, apart from the assessed cost savings. First, the benefits (cost savings) do not accrue for another 5 years — regulatory approval will take time. Second, there is only an assumed 50% likelihood of achieving the cost savings (ie regulatory approval for the proposed protocol).

Table 10: APL project 1763: Investment analysis

PV benefits ($m)	$1.44
PV costs (&m)	$0.89
NPV ($m)	$0.55
Benefit cost ratio	1.6
IRR	29%

In practice the more likely outcome is that it will take, say, a decade to achieve regulatory approval. Again however, the delay in gaining approval diminishes the present day value of the benefits and does little to improve the investment return.

4.6. OTHER INDUSTRY BENEFITS

A lower cost environmental monitoring system can be expected to have benefits to other industries besides pigs. In particular, the cattle industries (dairy and beef feedlot) can be expected to also benefit, as well as other non farming industries (such as starch manufacture) and indeed any industry having to address environmental monitoring from effluent disposal. It is further possible that the same protocol principles could be used in monitoring sewage disposal.

These gains are within Australia. It is probable that similar gains can be achieved in overseas countries and the QDPI could be a relevant aspect of future Australian aid investments.

5. APL PROJECT 2015 - A MEASURE TO MANAGE TOOLKIT FOR IMPROVING HERD FEED CONVERSION EFFICIENCY

5.1. PROJECT ORIGINS

The current and expected challenges facing Australian pig producers prompted a greater focus on farm level performance including feed conversion. Analysis for the industry as whole (ie herds participating in the 2000-2004 APL sample) showed a feed conversion ratio of 4.2:1. However, such a average has limited application at the individual producer level is assessing their respective levels of performance since various factors (such as herd composition, expansion, production system) differ between farms. Similarly comparisons with the industry average provide limited guidance, and possibly false conclusions as to individual farm performance or opportunities for improvement.

Against this background Innovative Agribusiness Solutions and the Queensland Department of Primary Industries and Fisheries commenced an APL funded project to easily identify easily recorded Key Performance Indicators (KPIs) to

- establish benchmarks for a range of production systems
- prioritise the strengths and weaknesses of a business
- provide guidelines on opportunities to improve performance.

At the project start (2004) it was noted that a 10% improvement in the Australian Pig Herd Feed Conversion Ratio (FCR) would save the industry approximately $50 million per year. The project was completed in late 2006.

5.2. PROJECT COSTS

APL project costs around $87,000 (actual costs adjusted fro inflation, excluding GST). In addition QDPI staff time was involved, and this is estimated to total around $20,000 per year for the three years of the project. These costs total around $158,000 in real, 2007 present value terms. While there will be some continuing future costs (in extension) these are part of the total extension cost and as it turns out will likely substitute for other extension costs that would be required to assist producers in improving FCRs.

5.3. PROJECT OUTPUTS

Basic data were collected from a number of Queensland and NSW farms on the efficiency of feed use. The KPIs for a typical farrow to finish unit were

- Breeder herd: 55 kgs per weaner produced
- Weaner herd: FCR 1.6:1 from weaning at 6kg to 30kg LW
- Grower/finisher herd: FCR 2.6:1 from 30kg to 105kg LW

- Milling and mixing plant: $200 per sow per annum milling and mixing cost

Significantly these KPIs suggested an FCR for aherd producing pigs for slaughter of 3.7:1. Producers able to perform at this KPI (compared to the ‘industry average of 4.2:1’) were saving 650 kgs of feed per sow per year, which equated (in 2005) to $81,000 per annum in a 500 sow herd.

Against these findings and analysis, the project developed a “Measure to Manage” toolkit for improving herd feed conversion efficiency. Excel programs, with associated manuals and distributed as CDs, were developed for four profit centres:

- breeding herd
- weaner herd
- grower/finisher herd
- milling and mixing plant.

5.4. Adoption and project outcomes

Press articles in regional newspapers and the Pork Producer have been written by Queensland DPI Pig Extension staff since 2005. This has had two effects.

- First, a number of producer volunteered to participate in the testing the toolkit programs. Cooperating producers in the development and testing of the programs were responsible for managing around 15,000 sows and their progeny.
- Second, in informing and encouraging producers to seek out the toolkits and apply them ion their own situation. Both the researchers and QDPI extension staff have been involved in training producers in the use of the toolkit.

At project completion, manuals and CDs for the toolkit have been made available to producers (and others such as education institutions, advisors, feed suppliers) requesting copies. The manuals provide a source of information based on best practice — more or less a checklist of relevant actions for possible causes of low productivity for each of the four profit centres. The spreadsheets enable a comparison of the farms’ own data for a range of production variables against best practice benchmark and provides guidance on when action is required to address poor performance.

Since project completion the toolkit has been promoted by QDPI within Queensland. It has not been promoted outside of Queensland at this stage, according to the researchers.

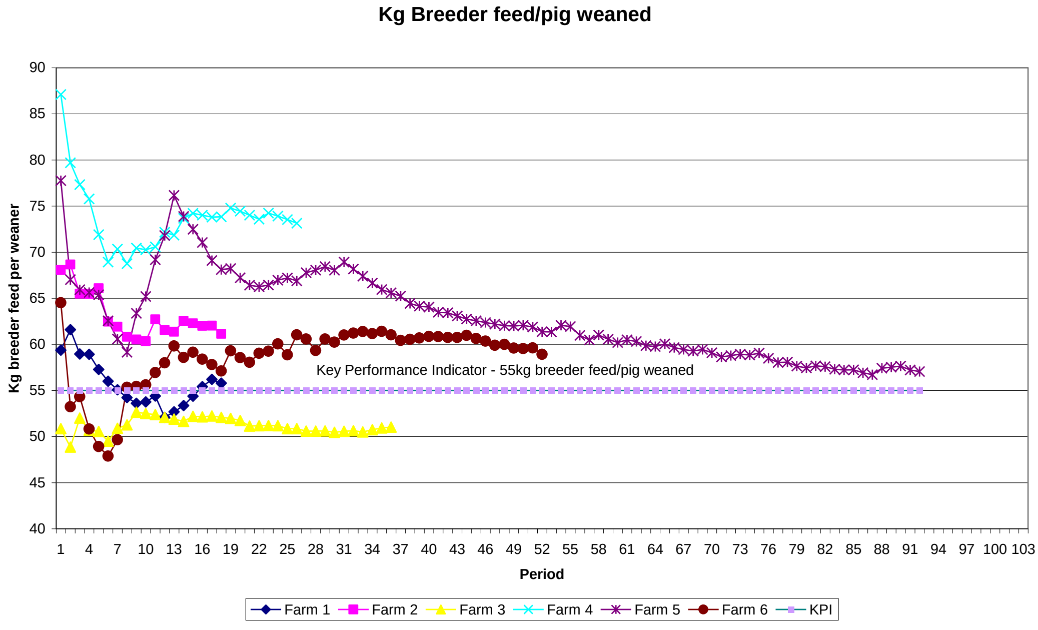
IAS and QDPI both acknowledge that it is difficult to asses the extent to which the tool kit as whole or components of it have been adopted across the industry. Although the QDPI extension officers use and promote the kits as a matter of course and there have been continuing requests for the kit since it was released in 2007, there has not been either specific promotion of the toolkit nor an assessment of its application.

That said, it is reasonable to assume that it has been used and is delivering benefits to producers.

- The toolkit is easy to use and is based on accessible data: it does not require producers to develop totally new skills or recoding systems. A key value of the toolkit is that it poses possible reasons for under performance, thus enabling producers to examine potential issues and actions for their individual situation.

- The gains from adopting best practice are significant. The potential for improvement is illustrated from the research results for 6 participating producers (Figure 5). For most of the year, half of the producers were well above the KPI for feed use, resulting in much higher production costs. . As noted above, a gain in feed use efficiency (an FCR of 3.7 compared with 4.2) offers a potential net gain of $81,000 in a 500 sow herd, that is, around $160/sow. All of this gain accrues to the producer since there is no additional production or marketing costs. On a conservative basis, even if a gain of a quarter of this improvement could be achieved from adopting some component of the toolkit it would represent a significant improvement in profitability. Anecdotal comment from the researchers concerning particular producers endorses the view that such gains are being achieved by producers who are using the toolkit.

Figure 5: Feed for breeders per pig weaned



- Pig producers are under intense financial pressure given feed prices increases and static product prices. However, some producers are achieving best practice, thus the toolkit will not benefit all producers, and more than likely not even the majority of pigs since larger producers are more likely to be achieving best practice, given that they can justify the investment in specialist advice on ways to improve performance.

Pig producers potentially benefit from advice from a wide range of sources. The toolkit is another source. It will not displace other advice; indeed it may lead to increased demand for other advice and subsequent productivity improvement as it helps narrow the range of issues which are affecting production performance. For some producers it will be a source of advice which is simpler to apply and therefore have an impact where previous other advisory alternatives have not worked (as indicated by the range in performance in breeder feeding).

The toolkit is not a unique product that could not be developed by other interests, commercial or otherwise. Indeed advisors in the industry currently employ benchmarking analysis to help clients improve performance. Typically the KPIs are drawn from the client group. However, there are some producers who are not part of an advisory group. The Measure to manage" toolkit has particular application to this group as it provides them with relevant KPIs and a process for establishing the reasons for possible under performance. Discussions with the researchers/extension people involved suggest that it is highly likely that at least 4 per cent of pigs (sows) would, by 2009, be more productive as a result of the producers using the tool kit. On an average herd sow herd size of 500, this implies adoption by only half a dozen or so producers. To introduce a further element of conservatism it is assumed that the toolkit would have been developed by another party or that it would be superseded by other techniques/sources of advice after 2010.

Given these assumptions, current and forecast sow numbers and a constant Queensland share of the national sow herd (23%), the benefits of the project have been estimated at $0.4m.

Table 11: Measure to manage toolkit: Estimated benefits

	Sow numbers		Proportion actual adopters	Benefits: applicable sow population	Benefits per sow	Qld benefits	Discounted benefits
	Aust (ABARE)	Est Qld sow numbers					5%
	'000	'000	'000	'000	$/sow	$m	$m
		23%	1.0%		$162		
			0.01		25%		
2004		-				$0	
2005		-		-		$0	
2006	352	81	1.00%	0.8	$41	$0.03	
2007	333	77	2.00%	1.5	$41	$0.06	$0.40
2008	310	71	3.00%	2.1	$41	$0.09	
2009	297	68	4.00%	2.7	$41	$0.11	
2010	292	67	5.00%	3.4	$41	$0.14	

5.5. INVESTMENT RETURNS

Summary investment returns on the project are shown in Table 12. The project is expected to deliver a high investment return since the costs are quite small and the potential benefits per sow significant even though the benefits are expected to apply to only a small proportion of the Queensland sow herd. The assumptions used in the analysis are quite conservative: it is assumed that only a half dozen or so producers (with sow herds of 500) would benefit from the toolkit.

Table 12: Project 2015: Investment returns

PV benefits $m)	$0.40
PV costs ($m)	$0.15
PV net benefits ($m)	$0.25
Benefit cost ratio	2.7
IRR	51%

The benefits of the project may turn out to be much higher if the toolkit is adopted by other producers in Queensland, producers in other states (noting that there has not been an extension effort applied in the other states) and more components of the toolkit are used by producers leading to higher gains per sow.

A doubling of the number of average producers benefiting from the tool kit would increase the estimated benefits to $0.8m and the investment return to over 100% — further emphasising the importance of adoption in securing high returns in R&D investment.

5.6. OTHER BENEFITS OUTSIDE OF THE PIG INDUSTRY

There are no readily identifiable benefits outside of the pig industry.