AUSTRALIAN EGG CORPORATION LIMITED

AECL R&D PROGRAM EVALUATION

Stage 1 and 2 Analysis

Draft Report

A report for the Australian Egg Corporation Limited

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Contents

Abbreviations

ABS	Australian Bureau of Statistics
AI	Avian Influenza
AECL	Australian Egg Corporation Limited
BCR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
CPI	Consumer Price Index (measure of inflation)
CRC	Cooperative Research Centre
CRRDCC	Council for Rural Research and Development Corporation Chairs
DOHA	Department of Health and Aging
DAFF	Australian Government Department of Agriculture Forestry and Fisheries
DoF	Australian Government Department of Finance
FSANZ	Food Standards Australia and New Zealand
ICC	Industry Consultative Committee
IRR	Internal Rate of Return
LWA	Land and Water Australia
MLA	Meat and Livestock Australia
NPV	Net Present Value
NSP	Non Starch Polysaccharides
PC	Productivity Commission
QRA	Quantitative Risk Assessment
RCM	Retail Category Management
RDC	Research and Development Corporation or Company
RIRDC	Rural Industries Research and Development Corporation
RSPCA	Royal Society for the Prevention of Cruelty to Animals
SE	Salmonella Enteriditis
SI	Salmonella Infantis

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Executive Summary

This document is a review of the impact of Australian Egg Corporation Limited (AECL) research and development (R&D) investments. It was prepared to inform both levy paying producers and the Australian Government of the returns each achieves from their investments.

The review was completed in two parts: stage 1 is an overview of all R&D projects and stage 2 is a cost benefit analysis of four 'hero' research clusters.

The stage 1 overview of all R&D projects reveals:

- Since 2000 the egg industry R&D program has supported 130 projects across eight major objectives with investment totalling $21 million.
- For an outlay of approximately $4.4 million (since the year 2000), levy paying producers have been able to direct a $21 million egg research portfolio.
- Most research has been directed toward flock health, disease management, feed, nutrition, husbandry and hen welfare.
- The AECL R&D portfolio addresses all Australian Government Rural Research Priorities with the exception of climate change (which was added in 2007).
- Most research effort has been directed toward outcome-oriented activities that can be used in production in some way. Projects have also been completed in both basic research and extension.
- Initial portfolio analysis reveals that the majority of investments are assessed as having either a medium or high impact on the Australian egg industry.
- Initial portfolio assessment also reveals that there has been a very high orientation of projects towards those that deliver both producer and community benefits. In only 5% of cases would these projects have been funded in the absence of current levy arrangements.

Stage 2 detailed cost benefit analyses was completed on four project clusters, they were:

- The control of *Salmonella* in eggs for the purposes of creating beneficial public health outcomes;
- Cannibalism control in layers using diet to enhance industry productivity and improve hen welfare;
- Consumer sensory research to ensure customers receive the quality of eggs they require and producers are rewarded for these attributes; and
- An audit of supply chain ullage to reduce wastage, lower producer costs and ensure consumer safety.

The cost benefit analyses have not been able to quantify all R&D benefits to levy paying producers or the public (spillover) benefits. Where this has not been possible a detailed description of the benefit (or cost) item has been provided. However, in all instances benefits to the main beneficiary have been quantified with a measure of accuracy. Cost benefit analysis results for the four clusters are summarised in Table E.1 with the main beneficiary of the research noted and the quantum of benefit shown.

Table E.1 Cluster Evaluation Results – AECL R&D Program

Cluster	BCR (1:x)	Levy Payer NPV ($'million)	Public Spillover NPV ($'million)	Total NPV ($'million)
Salmonella	1.4	0	15	15
Cannibalism	117.0	43	0	43
Sensory	23.6	42	0	42
Ullage	1.6	8	0	8

Source: AgEconPlus analysis

Total producer levy payer investment in R&D since AECL inception in 2003 has been approximately $3.5 million. Any one of these research clusters (up to five projects in a portfolio of approximately eighty) has been sufficient to justify this investment. Total Australian Government investment in egg R&D channelled through AECL has been of a similar magnitude to levy payers (funds are matched dollar for dollar). Benefits received by the Australian community through improved health outcomes associated with the Salmonella control cluster, on its own, has been sufficient to justify public investment.

Projects, such as the Salmonella control cluster, with a primary focus on spillover benefits would not be funded outside current levy arrangements.

1. Introduction

Evaluation Purpose

This document was prepared for the Australian Egg Corporation Limited (AECL or the Corporation). It is an evaluation of the impact of the Corporation's research and development (R&D) investments.

The evaluation was completed to present to egg industry levy payers the benefits they have received from investing in the Corporation and to provide the Australian Government with an assessment of the returns being generated on the matching public contributions. In addition, the evaluation addresses the central question of the recent Productivity Commission (PC) report, *Public Support for Science and Innovation*: 'are the public benefits (spillovers) that would not be delivered in the absence of public contributions sufficient to justify the amount of public funds contributed to the Corporation?'

The evaluation provides an analysis of the following key issues:

1. The scale and scope of the returns levy payers receive on the funds they contribute to the AECL;
2. The scale and scope of the returns to the public funds invested in the AECL beyond that which would deliver if public contributions were scaled back; and
3. The capacity and incentive industry has to invest in egg related R&D in the absence of the levy and the current level of public contributions.

Evaluation Approach

The program evaluation was approached in two parts using the methodology preferred by the Rural Industries Research and Development Corporation (RIRDC) for evaluation of their R&D programs including the Egg Industry Program in 1999 (CIE 1999a and 1999b). The two-stage approach is:

- *Stage 1: An overview of all projects*. Stage 1 reviewed all projects completed since 2000. Stage 1 included analysis of projects by classification (i.e. by Australian Rural Research and Development Priorities 2007), analysis by R&D stage (fundamental research, development, extension) and initial portfolio assessment. Stage 1 results provide stakeholders with an overview of the program including total investment, information on what project investments have been made, the number of successful projects in the portfolio, and the likelihood that the project would have been completed without levy funding.
- *Stage 2: An assessment of investment returns*. Stage 2 focuses on four 'hero' project clusters. It employs Cost Benefit Analysis (CBA) as described by the Council for Rural Research and Development Corporation Chairs (CRRDCC) in their Guidelines for Evaluation (May 2007). Stage 2 delivers analysis on the scale and scope of the returns realised from clusters of projects by levy payers and returns realised from the public funds invested beyond that which would be delivered if public contributions were scaled back.

In addition to the stage 1 and 2 analyses the evaluation included:

- Analysis of the capacity and incentive industry has to invest in egg related research and development in the absence of the levy and the current level of public contributions.
- Presentation of draft results to an AECL Industry Forum Launceston 23 November 2007.

Cost Benefit Analysis Methodology

Stage 2 Cost Benefit Analysis was completed using the Guidelines for Evaluation (May 2007) prepared by the CRRDCC. The specific method used was:

1. Selection of project clusters with AECL.
2. Description of the project and the problem(s) being addressed through AECL investment.
3. Quantification of all direct costs, including direct costs contributed by other organisations. Inclusion of indirect costs (such as overheads) as a separate reporting item wherever possible. Also included were:
    - Costs associated with development and extension
    - Marketing costs associated with increasing demand for a product
    - All cost contributions from all contributors
    - Any industry costs of adoption eg training, new machinery, etc
4. A clear identification of the private levy payer benefits and net public benefits (spillovers) produced – with quantification. Inclusion of economic, social and environmental benefits. Classification of benefits by:
    - Industry benefits – to levy payers
    - Industry benefits – that spillover into other industries in the supply chain
    - Industry benefits – that result in improved research capability
    - Environmental benefits – public good or spillover benefits
    - Environmental benefits – also relevant for levy payers
    - Social benefits – OH&S, public health, animal welfare, biosecurity, consumer, etc
    - Social benefits – eg benefits of vaccine to unvaccinated people
    - Social benefits – delivering on changed community expectations
5. Testing of the counterfactual including:
    - Would the project benefits have been produced in the absence of AECL investment?
    - Has AECL investment brought forward a benefit for industry and the community?
    - Would the outcome have been produced eventually by foreign research?
    - Have other groups been working on substitute technologies?
    - Without AECL would other groups have got together and addressed the problem?
    - Is AECL's involvement likely to have increased adoption rates?
6. Additionality – the amount of spillovers that are conditional on public support for AECL
7. Completion of the analyses in real terms and reporting NPVs of net benefits (benefits minus costs), IRRs and BCRs calculated as the present value of benefits and costs.
8. Conservative estimation of adoption rates with testing for their sensitivity.
9. Sensitivity testing of key parameters once benefit and cost streams have been established.
10. Use of a common discount rate – 5% real with sensitivities at 0% and 10%.
11. Common project horizons – current year, 5, 10 and 20-year horizons/benefit reference points.
12. Actual and anticipated benefit streams included and clearly identified.
13. Appropriate treatment of risk and uncertainty – including obsolescence, non-performance of the technology and lower than expected adoption rates (to be addressed through sensitivity testing).

2. Overview of all Projects

The Stage 1 initial assessment covers R&D investments for the period 2000 to 2007 – the period since the last Stage 1 review of the egg industry R&D program (CIE 1999). Results from the Stage 1 assessment are provided below.

Resource Allocation by AECL Priority

AECL has allocated R&D investments for the period 2000 to 2007 under nine major headings – Table 2.1.

Table 2.1: Expenditure by AECL Priority Area 2000 to 2007

Priority	Number of Projects	Total ($'million)	AECL /RIRDC	Other	Percentage of Total
Implications economic environment	1	133,557	121,377	12,180	1%
New and existing markets	30	1,869,788	1,869,788	0	9%
Public health	9	1,688,640	890,417	798,223	8%
Flock health and disease management	33	7,708,456	2,610,067	5,098,389	37%
Feed availability and nutrition	10	5,199,605	765,982	4,433,623	25%
Husbandry and welfare	13	3,354,132	2,195,605	1,158,527	16%
Environmentally sustainable management	5	223,322	113,864	109,458	1%
Training, info and technology transfer	21	716,420	503,729	212,691	3%
Miscellaneous	8	96,500	96,500	0	0%
Total	**130**	**20,990,419**	**9,167,329**	**11,823,091**	**100%**

Source: AgEconPlus analysis of AECL database

Since 2000 the egg industry R&D program has supported 130 projects with a total expenditure of $21 million. AECL, and RIRDC before them, have contributed 44% of the funds for these projects (including the levy) and others, including research organisations, have made up the balance. For every one-dollar AECL has invested others have invested a further one-dollar-thirty.

On average AECL has invested $1.1 million pa in industry R&D of which egg producers have contributed approximately $550,000 and the Australian Government, through matching levy payments, has contributed the balance. For an outlay of approximately $4.4 million, the industry has been able to direct a $21 million egg research portfolio.

A diverse portfolio of investments has been achieved for the Australian egg industry over this time. The most significant areas of investment have been:

- Flock health and disease management (37%);
- Feed availability and nutrition (25%); and
- Hen husbandry and welfare (16%).

Miscellaneous projects include Industry Consultative Committee (ICC) costs – advisory committees set up to identify industry issues and support R&D project delivery. Extension is a key component of the program.

A random sample of 79 R&D projects, 61% of the total portfolio, for which complete data sets were available have been selected for further analysis. The analysis is reported over page.

Analysis by Australian Government Research Priority

The Australian Government sets both National Research Priorities and Rural Research Priorities. Australian Government Rural Research Priorities were updated in 2007 and now include climate variability and climate change. AECL R&D investment against Australian Government Rural Research Priorities is shown in Table 2.2.

Table 2.2: AECL Investment by Australian Government Rural Research Priority

Priority	Number of Projects (No.)	Total AECL Investment ($'million)	Percentage of Total AECL Investment (%)
Productivity and adding value	38	4,052,995	60%
Supply chains and markets	2	57,900	1%
Natural resource management	6	176,864	3%
Climate variability, climate change	0	0	0%
Biosecurity	33	2,502,378	37%
Total	**79**	**6,790,137**	**100%**

Source: AgEconPlus analysis of AECL database

The AECL R&D portfolio is spread across all Rural Research Priorities, with the exception of climate change (a 2007 addition), with most investment in productivity, adding value and biosecurity. These priorities are consistent with AECL producer (levy payer) requirements.

Analysis by Stage of R&D

Stage of R&D undertaken in the project also sheds light on portfolio balance and resource allocation. R&D can be thought of as a three-stage process (CIE 1999):

- Stage 1 represents fundamental or basic research. It may be scientific in nature, for example exploring molecular composition, or it can be economic, for example looking at the potential returns on an activity before it is pursued. The distinguishing characteristic of this research stage is that its outputs are usually inputs into further research or a decision process, rather than leading to a final outcome.
- Stage 2 R&D usually aims to deliver a specific output that can be used in production in some way, including the production of further research. While often applied, strategic R&D can also be in stage 2.
- Stage 3 categorises projects at the other end of the research cycle, and are largely focussed on promoting adoption of R&D and development of the industry.

Table 2.3 summarises the allocation of portfolio funds across these stages.

Table 2.3: Stage of R&D

Classification	Number of Projects (No.)	Total AECL Investment ($'million)	Percentage of Total AECL Investment (%)
Stage 1	18	1,704,243	25%
Stage 2	39	4,647,174	68%
Stage 3	22	438,720	6%
Total	**79**	**6,790,137**	**100%**

Source: AgEconPlus analysis of AECL database

The table shows a reasonably typical allocation for an established industry like egg production. Most research effort is allocated to practical, outcome-oriented activities that can be used in production in

some way. Stage 1, fundamental or basis research has received a higher allocation of funds in the past and other AECL communication tools augment stage 3 investments.

Initial Portfolio Assessment

As part of the evaluation the program manager was asked to provide an initial assessment of the impacts of the projects undertaken in the program. The results are summarised in Table 2.4.

Table 2.4: Initial Assessment

Project Impact Rating	Number of Projects (No.)	Total AECL Investment ($'million)	Percentage of Total AECL Investment (%)
High	16	1,175,815	17%
Medium-high	6	252,652	4%
Medium	31	1,656,712	24%
Low-medium	4	1,324,249	20%
Low	2	20,005	0%
Too early	20	2,360,704	35%
Total	**79**	**6,790,137**	**100%**

Source: AgEconPlus analysis of AECL database

The majority of the investment is assessed as having either a medium or high impact on the industry and this is confirmed in the cost benefit (Stage 2) analysis.

Producer and Community Benefits

The program manager was also asked to assess the number of projects that will deliver producer economic benefits and those that will deliver community social and environmental benefits – Table 2.5.

Table 2.5: Benefits by Stakeholder and Investment without Levy

Indicator	Number of Projects		Percentage of Total - Yes
	Yes	No	
Levy payer economic benefits	57	22	72%
Community social benefits eg human health or animal welfare outcomes	51	28	65%
Community environmental benefits eg waste management or EMS	41	38	52%
Project Funded without the R&D levy	4	75	5%

Source: AgEconPlus analysis of AECL database

The analysis shows a very high orientation toward projects that deliver both producer and community benefits. In only 5% of cases would these projects be funded in the absence of current levy arrangements.

Lessons Learned Stage 1 Analysis

The following 'take home' messages are noted from the Stage 1 review:

- Since 2000 the egg industry R&D program has supported 130 projects across eight major objectives with investment totalling $21 million.
- For an outlay of approximately $4.4 million, levy payers has been able to direct a $21 million egg research portfolio.
- Most research has been directed toward flock health, disease management, feed, nutrition, husbandry and hen welfare.
- The AECL R&D portfolio addresses all Australian Government Rural Research Priorities with the exception of climate change (which was added in 2007).
- Most research effort has been directed toward outcome-oriented activities that can be used in production in some way.
- Initial portfolio assessment reveals that the majority of investments are assessed as having either a medium or high impact on the industry.
- Initial portfolio assessment also reveals that there has been a very high orientation of projects towards those that deliver both producer and community benefits. In only 5% of cases would these projects have been funded in the absence of current levy arrangements.

Stage 2 is a detailed analysis of four project clusters.

3. Cluster 1: Salmonella Control in Eggs for Public Health Benefits

Cluster Identification

This cluster analysis addresses five egg research and development projects funded through the egg producer levy, they are – UQ-19E, DAV-146A, CIF-1A, SAR-42A and SAR-47.

Table 3.1 R&D Projects included in the Salmonella Public Health Cluster

ID	Project Title	Project Period
UQ-19E	The significance of *Salmonella*, particularly *Salmonella* Infantis (SI), to the Australian egg industry.	1994-1996
DAV-146A	International review of *Salmonella* Enteritidis (SE) epidemiology and control policies.	1999-2000
CIF-1A	Rapid detection of virulent *Salmonella* in egg and poultry products.	2000-2003
SAR-42A	A *Salmonella* quantitative risk assessment model for the egg industry.	2002-2003
SAR-47	National food safety risk profile of eggs and egg products.	2004

Source: AECL Project Database

The cluster has a contiguous and consistent research theme built around understanding *Salmonella* in the Australian egg industry, developing detection and risk management tools and applying these tools to minimise the risk to public health from egg consumption.

It is noted upfront that a clean fresh egg without a cracked shell is naturally a safe food (NSW Food Authority 2005) and that there are 67.543 million dozen shell eggs sold at retail each year (AC Nielsen research). Project descriptions need to be considered in light of this information.

Cluster Description and the Problem Being Addressed

Project objectives, outputs and outcomes are described for each of the five projects in the *Salmonella* public health cluster.

UQ-19E *The significance of Salmonella, particularly Salmonella* Infantis*, to the Australian egg industry (2002).*

Survey based research completed between 1991 and 1993 established the freedom of Australian poultry flocks from virulent *Salmonella* Enteriditis of the type causing significant public health problems in Europe and the USA. Nevertheless this survey work revealed a variable but overall significant carriage rate in Australian layers of a range of salmonellae with potential to cause human disease. Thus this project (UQ-19E) was initiated to investigate the significance of one particular problematic salmonellae, *Salmonella* Infantis (SI), to the Australian egg industry.

Salmonella Infantis, associated with the egg and especially the chicken meat industry, has been of significant public health concern in many countries, and remains so in some regions. Due to its previously observed dominance in layer flocks and in raw egg products in south-east Queensland, it

was considered to be of potential significance to the Australian egg industry, with regard to egg-borne transmission to humans and the likely public health consequences.

By conducting appropriate surveys to monitor *Salmonella* Infantis prevalence, vital information was acquired through this project to help assess the status of Australian layer flocks. Application of molecular techniques enabled good discrimination between *Salmonella* Infantis isolates for epidemiological purposes, providing information on the existing relationships between isolates of this serovar from similar and different environments.

The research showed that *Salmonella* Infantis was able to penetrate the eggshell and grow in some cases within the contents of the egg, thereby stressing the importance of removing faecal material from the surface of the egg to maintain safe and good food handling practices along the egg production environment. Experimental infection of layer hens completed as part of the project demonstrated that trans-ovarian transmission is less likely to occur than eggshell penetration.

Implementation of the study's findings through channels such as the industry's QA program Egg Corp Assured has resulted in a decreased risk of consumers contracting salmonella from Australian eggs. The study has also resulted in recognition of the need for additional knowledge on risk pathways for *Salmonella* infection between bird and egg destined for human consumption.

DAV-146A: International review of Salmonella Enteritidis *(SE) epidemiology and control policies (2000).*

In Europe and the USA, *Salmonella* Enteriditis (SE) is a major threat to public health and is responsible for a lack of consumer confidence in the quality and safety of egg production. The absence of *Salmonella* Enteriditis from Australian poultry provides significant commercial opportunities for the Australian industry. In 2000 when this research was completed, *Salmonella* Enteriditis has been detected only once in an Australian backyard poultry flock and was transmitted, in this instance, through overseas human- acquired infection. Subsequently there have been reports of SE detection in South East Queensland but SE has not been responsible for any reported cases of Salmonellosis in Australia.

The ever-increasing rate of overseas travel along with *Salmonella* Enteriditis' prevalence in many overseas countries means that Australian layer flocks are increasingly susceptible to SE infection and subsequent establishment.

The best approach to ensuring that an incursion of *Salmonella* Enteriditis in Australian layers is controllable and, ideally, eradicable, is by establishing monitoring programs that ensure early detection of infection and implementation of effective control strategies. Consistent and systematic monitoring of layer breeding flocks and product is essential.

The objectives of the project were to:

- Review the international situation with respect to *Salmonella* Enteriditis infestation, elimination and control.
- Raise awareness of the potential threat that *Salmonella* Enteriditis poses to Australian poultry production through organisations such as the Australian Veterinary Poultry Association.
- Recommend monitoring systems to keep Australian flocks *Salmonella* Enteriditis free and maintain Australia's current commercial and trade advantages.
- Develop eradication and control strategies for Australia in the event of a *Salmonella* Enteriditis outbreak.

Each of these objectives was successfully completed.

As a consequence of this project SE awareness was raised and monitoring and control strategies developed. The study also resulted in recognition of the need to develop rapid detection tests for virulent and non-virulent salmonella strains.

CIF-1A: Rapid detection of virulent Salmonella in egg and poultry products

Salmonella Enteriditis is the most significant cause of human illness from eggs internationally, yet it is not present in Australian commercial layer flocks. Therefore continuous surveillance of Australian layer flocks for this *Salmonella* serovar is vitally important for maintaining the high degree of public acceptance in eggs as a safe and healthy food product in Australia.

The most common *Salmonella* serovar isolated from Australian chickens is *Salmonella* subsp. II Sofia (approximately 50% of isolation). As this serovar is considered to be essentially avirulent, a rapid test that would allow differentiation of *Salmonella* subsp. II Sofia from other more virulent *Salmonella* serovars would be of value to the industry.

Molecular methods have allowed for the rapid and specific identification of organisms based on the differences in genetic sequence of the organisms and these techniques were applied to the research.

The research objective was to develop rapid and specific molecular detection methods for the differentiation of *Salmonella* Enteritidis and *Salmonella* subsp. II Sofia from other *Salmonella* serovars in egg and poultry products.

More specifically the projects objectives were:

- To develop a system based on gene sequences for the rapid characterisation and differentiation of *Salmonella* spp. of economic and public health significance in egg and poultry products and in environmental samples.
- To develop simple sample preparation techniques for the isolation and concentration of *Salmonella* spp. from egg products for use in combination with identification systems.
- To apply the developed detection and identification systems for differentiation of non-pathogenic *S. sofia* and pathogenic non-*S. sofia* isolates and *S. Enteriditis* (SE) PT4 (a major poultry pathogen in Europe and USA) and other *Salmonella* spp. of industry importance.
- To develop user-friendly systems such as ‘BioChips’ (DNA micro-array systems) and colorimetric detection systems for the identification of multiple products.

The research outcome was a series of rapid tests that allow for the specific detection of *Salmonella* Enteritidis and *Salmonella* subsp.II Sofia in egg products. In addition, the approaches developed in this project can be used for specific detection of other major egg and poultry serovars of Salmonella. Once validated, the diagnostic tools developed will be available for use in conjunction with salmonella food risk assessment.

SAR-42A: A Salmonella quantitative risk assessment model for the egg industry

Egg products contaminated with *Salmonella* are a recognised cause of food borne illness. The Australian egg industry is untroubled by strains of *Salmonella* Enteriditis that have caused human illness abroad, however unwanted introduction of specific *Salmonella* into populations of humans and poultry has significant implications for public health and national and international trade through introduction of technical barriers in the international trade of egg products.
The projects objectives were:

- To develop a Quantitative Risk Assessment (QRA) model for *Salmonella* in eggs that will allow assessment of the impact of industry practices on the occurrence of Salmonellosis in humans.

- To evaluate the food safety risk of alternative control measures and production systems.

A comprehensive review of Australian egg related food-borne outbreaks was completed as part of the project. Data collected from the FAO Risk Assessment of *Salmonella* in eggs and broilers was re-evaluated and used to develop a dose response model. Modular exposure assessment models for shell eggs that describe production from point of lay to the end of retail storage were developed using data from surveys of Australian egg production and processing practices. The impact of production, processing, wholesale and retail practices on potential for growth of *Salmonella* in retail eggs has also been evaluated. Risks to consumers were estimated for different food types containing eggs contaminated with *Salmonella*. The exposure assessment and inactivation kinetics of *Salmonella* were also used for analysis of risk associated with current practices used for processing of liquid egg products and review of current Australian standards.

As a result of this research project a quantitative methodology is now available for the Australian egg industry that allows assessment of the *Salmonella* risk to consumers from various industry practices.

SAR-47: National food safety risk profile of eggs and egg products

Risk profiling is now recognised as an important first step that is essential for effective food safety risk management. It has recently been defined as "a description of a food safety problem and its context developed for the purpose of identifying those elements of a hazard or risk that are relevant to risk management decisions" (Codex Alimentarius Commission). This project aimed to conduct a through chain food safety risk profile for the Australian egg industry.

Specifically the projects objectives were to:

- Identify public health hazards that enter any point of the food chain for eggs and egg products produced in Australia and rank them in terms of health risk to the consumer.
- Identify hazards of potentially high risk where too little information exists for a confident ranking of risk and provide 'what if' scenarios raised by risk managers during expert consultations.
- Identify potential management strategies for the identified hazards.
- Identify product/pathogen combinations in which, further risk analysis might be required by risk managers.

Expert consultations between risk managers and assessors were held to thoroughly assess the feasibility of risk profile work, ensure risk management questions were clearly articulated, provide ongoing review of technical outputs for relevance against these objectives and modify/expand expected outputs in terms of opportunities created by early findings. Risks associated with existing and potential biological, chemical and physical hazards were examined. Risk ranking of hazard/product combinations was achieved using both an established semi-quantitative and a qualitative methodology, that embodied established principles of food safety risk assessment from farm-to-fork. Scenarios of egg-use and consumption pathways were modelled to establish risk rankings of hazard/egg and egg product combinations.

Non-SE Salmonella was identified as the principal egg-associated hazard. Highest risk arises from foods prepared using non-commercial cracked eggs or un-pasteurised egg pulp in uncooked or lightly cooked meals. The relative risk of eggs from non-cage systems for *Salmonella* is unknown and warrants further consideration. Other contributory factors to risk for which data is lacking include efficacy of egg washing conditions and time/temperature of egg handling storage between egg grading floors and retail in Australia.
The report provides a technical resource for industry and regulatory agencies to address food safety issues associated with eggs and egg products. The project provided a through chain food safety risk profile for the Australian egg industry.

Research results from this project were incorporated into Food Standards Australia New Zealand (FSANZ) food safety requirements and the report has been downloaded more than 2,000 times since posting on the AECL website.

The *Salmonella* research cluster has clearly met an Australian public health need.

Funding for the Project Cluster

Egg producer levy funding for the cluster contributed through RIRDC and AECL managed research portfolios along with research organisation and other contributions are shown in the table.

Table 3.2 Project Cluster Funding by Year and Source ($)

	AECL/RIRDC	Research Organisation	Other	Total
UQ-19E				
1993-94	28,541	0	0	28,541
1995-96	28,541	0	0	28,541
DAV-146A				
1998-99	20,000	25,569	0	45,569
1999-00	20,000	25,569	0	45,569
CIF-1A				
2000-01	62,250	46,079	18,750	127,079
2001-02	62,250	46,079	18,750	127,079
2002-03	62,250	46,079	18,750	127,079
2003-04	62,250	46,079	18,750	127,079
SAR-42A				
2002-03	11,310	0	0	11,310
2003-04	11,310	0	0	11,310
SAR-47				
2003-04	38,000	0	0	38,000
2004-05	38,000	0	0	38,000

Source: AECL Project Database

The grand total of direct project costs was $755,156

In addition to the direct project costs associated with this *Salmonella* public health cluster, costs were incurred to realise human health and other cluster related benefits in the Australian community. These costs included:

- The development and implementation of FSANZ food guidelines to realise the public health benefits identified in the RIRDC/AECL research; and
- Costs to egg producers and the food chain from adoption of resultant FSANZ food safety programs and other measures (eg NSW Food Act Egg Food Safety Scheme, The Egg Industry Act (Tas), Food Safety Scheme for Eggs and Egg Products (Qld), etc).

These costs are more fully developed in the cluster evaluation and are included in the cost benefit analysis.

Project Outcomes and Research Benefits

Project Outcomes

Outcomes from the five projects that make up the *Salmonella* public health cluster are shown in the table.

Table 3.3 Outcomes from Salmonella Public Health Cluster

R&D

UQ-19E 'The significance of salmonella, particularly *S. Infantis*, to the Aust egg industry'.	DAV-146A 'International review of *Salmonella Enteritidis* (SE) epidemiology and control policies'.	CIF-1A 'Rapid detection of virulent Salmonella in egg and poultry products'.	SAR-42A 'A Salmonella quantitative risk assessment model for the egg industry'.	SAR-47 'National food safety risk profile of eggs and egg products'.

Outputs

Baseline survey of salmonella prevalence in Aust layer flocks.	An international review of virulent *Salmonella Enteritidis* and its control.	Development of tests to separate virulent and non-virulent salmonella strains in poultry.	A 'dose response' model for assessing the impact of food industry practices on occurrence of salmonella.	An audit of the human health risk from salmonella in Australian eggs.

Outcomes

Limited *Salmonella. Enteriditis* in Aust (a virulent and human life threatening form).	Awareness raising with Aust poultry vets – economic importance of ongoing freedom from SE.	Tests developed with commercial application.	A review of salmonella outbreaks in Australia and overseas.	Identification of public health hazards.
However *Salmonella Infantis* is a significant public health issue and is present in Aust layer flocks.	Monitoring systems developed for early detection of SE and to keep Australian flocks Salmonella Enteritidis free.	Capacity to diagnose salmonella strain and respond quickly to strains with human health implications.	Ability to test alternative egg production, food preparation and disease control measures.	Management strategies for the risks identified.
S Infantis is able to penetrate the eggshell if in contact with infected faecal matter.	Control and eradication strategies put in place for the Aust situation.	Diagnostic tools available for use in conjunction with salmonella food risk assessment.	Ability to measure salmonella risk from 'point of lay' to alternative retail practices and food types.	Non SE salmonella identified as the principal egg-associated human health hazard.
Recommendations on faecal material on eggshells subsequently incorporated into Egg Corp Assured.	Recognition of the need to develop rapid detection tests for virulent and non-virulent salmonella strains.		Tools for the completion of a national salmonella food risk assessment.	Study recommendations immediately incorporated into new Aust NZ Food Standards Code.
Recognition of the need for additional knowledge on risk pathways for salmonella infection between bird and egg for human consumption.				

Source: AgEconPlus analysis

AECL's investment of grower levies in the salmonella public health cluster has resulted in:

- Knowledge from a baseline survey of the prevalence of salmonella in Australian layer flocks and the infection pathways between bird and egg;
- Assurance that the virulent salmonella form, *S. Enteriditis*, which is highly problematic in Europe and the USA, has limited prevalence in Australia;
- Improved awareness, monitoring and control strategies for *S. Enteriditis;*
- A new diagnostic test that is able to distinguish non-virulent from virulent salmonella strains;
- A dose response model that is able to assess the impact of food industry practices on the occurrence of salmonella in eggs and egg products; and
- A national risk assessment for eggs and egg products the recommendations from which have been incorporated into new National Food Standards, subsequent state legislation and egg industry food safety programs.

In short, all these outcomes have contributed to a reduction in food borne illness due to egg consumption.

How these project outcomes translate into economic benefits for the Australian community and levy paying egg producers is developed in the section below.

Identification of Research Benefits

A schematic of benefit flow resulting from levy payer funded research is shown in Figure 1 over page.

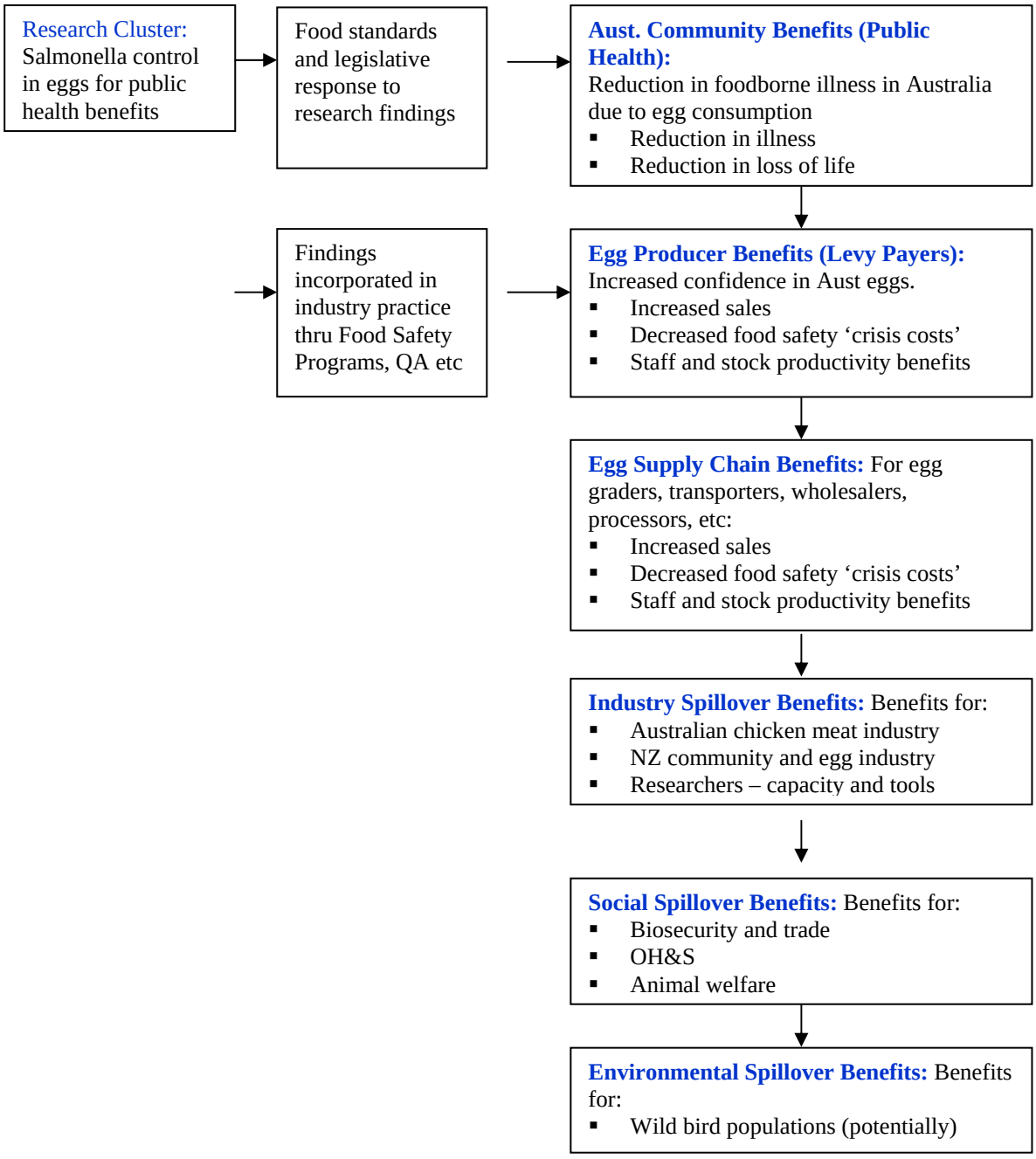
Australian Community Benefits (Public Health)

Outcomes from this cluster of levy payer research have been taken up by FSANZ and incorporated into Australia New Zealand Food Standard 2.2.2 and are likely to shape the National Food Safety Standard for Eggs and Egg Products due for completion in 2008. Subsequently state based food authorities have implemented Australia New Zealand Food Standard 2.2.2 through state based legislative responses and overseen the implementation of food safety programs in egg businesses and the supply chain where this has been warranted (for example Food Safety Scheme for Eggs and Egg Products in Qld and the Egg Food Safety Scheme under development in NSW).

Research implementation will result in a reduction in foodborne illness in Australia due to egg consumption.

The cost benefit analysis places most emphasis on the evaluation of this benefit (and its associated costs) given its primacy to the objectives of the research cluster.

Figure 3.1: Potential Benefits to the Aust Community and Levy Paying Egg Producers



Egg Producer Benefits (Levy Payers)

Implementation of findings from the research cluster will result in safer food and increased confidence in Australian eggs. The NSW Food Authority (2005) identified the benefits to egg producers of implementing Food Standard 2.2.2 through a food safety program as being:

- Decreased risk of damage to the egg industry from salmonella outbreaks.
- Better satisfaction of customers and insurance companies.
- Increased understanding and commitment to food safety.
- Management improvement through clear delineation of staff responsibilities (a requirement of an effective, audited food safety program).
- Better stock management leading to less wastage (spoilage).

In short research implementation will translate into additional sales and fewer food safety 'crisis' costs for egg producers. Crisis costs might include temporary closure of the industry through a salmonella outbreak and resultant reestablishment costs.

Egg Supply Chain Benefits

In addition to egg producer benefits, those in the egg supply chain (egg graders, processors, transporters, wholesalers, storage operators, retailers, etc) will benefit from a safer product through additional sales and fewer 'crisis' costs for the supply chain.

Industry Spillover Benefits

Spillover benefits will be generated through the application of research findings to the chicken meat industry in Australia where salmonella is also a problem of economic significance.

Benefits will also be realised in the New Zealand community and New Zealand egg industry when FSANZ food standards, which cover Australasia and include AECL research outcomes, are implemented in that country.

Furthermore research community knowledge and tools were produced as a result of investment in this research cluster. This intellectual capital has potential for further application to the egg and other Australian industries. Detection test products from research project CIF-1A, for example, are currently embargoed while the intellectual property owners explore additional commercialisation opportunities. Revenue streams from salmonella detection test commercialisation opportunities have not been quantified in the cost benefit analysis.

Social Spillover Benefits

Animal welfare gains through healthier flocks with less salmonella and OH&S gains for those working on egg farms are also possible from the completion of this research. Healthier flocks and improved working conditions result from salmonella management through food safety programs informed by this research cluster.

A social spillover benefit of more significance resulting from this research is the capacity of the Australian egg industry to both detect the presence of the deadly SE salmonella serovar in Australia and prevent its establishment. This capacity also enhances Australia's ability to negotiate trade access for Australian egg and egg products on the basis of the ability to prove ongoing SE freedom.

Environmental Spillover Benefits

Spillover benefits into wild bird populations/environmental health associated with a reduction in salmonella in human population may be possible. This benefit is relatively minor but given the capacity of diseases such as Avian Influenza to move between wild bird populations and humans should not be underestimated.

These benefit items are considered in the cluster evaluation.

Approach to the Cluster Evaluation

The Economic Base Case

Salmonella is the principle cause of egg related food poisoning events in Australia (Daughtry *et al* 2002 and NSW Food Authority 2005).

Illness Caused by Egg Consumption

In Australia an estimated 5.4 million people experience foodborne illness each year. This rate of infection (one out of approximately every four persons) is similar to that found in other developed countries (Commonwealth Department of Health and Aging (DOHA) OzFood Net Working Group 2005). Surveillance and monitoring also indicates that incidences of foodborne illness are increasing.

DoHA's OzFoodNet foodborne illness database recorded 375 reported outbreaks of foodborne or suspected foodborne disease over 42 months between January 2001 and June 2004 - pre incorporation of AECL's salmonella public health research into FSANZ Food Standard 2.2.2. i.e. they occurred under the base case.

Of these outbreaks, 31 or 8.3% (31/375) were potentially associated with egg consumption. Eggs or food which contains eggs as a key ingredient were closely associated with 19 (59%) of these outbreaks and food made with raw eggs was involved in 15 outbreaks. These 31 outbreaks affected 733 people, with 125 people hospitalised and 3 people not surviving (NSW Food Authority 2005).

Investigators reported that five (16%) outbreaks were due to mixed meals, of which one component was an egg dish. In eight outbreaks (25%) a food vehicle was unable to be implicated as the cause of illness. However, eggs had been eaten in some of the cases and in five of the eight outbreaks food made with raw eggs had been consumed (NSW Food Authority 2005).

In a 1996 outbreak of Salmonella, egg product in a dessert sauce supplied to an Australian airline was implicated in 488 reported cases of gastro-associated illnesses among airline passengers, 56 of which required hospital treatment (NSW Food Authority 2005).

OzFoodNet data also showed that of the agents responsible for the 23,250 cases of foodborne diseases notified in Australia in 2003, 31% were due to salmonella (NSW Food Authority 2005).

It is important to note that the OzFoodNet data represents only those cases that are the most clearly attributable to eggs. The data is only a small proportion of the actual cases of foodborne illness associated with eggs, given that most illnesses go unreported (NSW Food Authority 2005).

Queensland for the past eight years recorded at least twelve outbreaks of egg related foodborne illness, resulting in 796 cases of illness, 81 hospitalisations and 2 deaths. Poor food safety and quality control at the primary end of the food chain was found to be a contributing factor in a high profile egg related foodborne illness incident in 2003 at an aged care facility in Queensland, which resulted in 47 cases of illness and 2 deaths.

Less than 5% of foodborne illness cases are actually reported in formal notifications because the overwhelming proportion of outbreaks goes unrecognised. It is often very difficult to identify a key ingredient or critical factor contributing to the occurrence of the illness.

Loss of Life Caused by Foodborne Illness Due to Eggs

DoHA generally does not identify the outbreaks where death due to illness associated with the consumption of eggs has occurred because they can be subject to coronial findings.

DoHA estimates that the multiplier for Salmonella infections in eggs and egg products is approximately 1 notified infection to every 15 infections occurring in the community, with a credible interval of 5 to 25.

In 2003 the following deaths involving eggs or egg products were recorded:

- Two deaths in a Queensland outbreak of salmonella in a nursing home where raw egg drinks (suspected cause) were given to residents.
- One death in a Victorian outbreak of salmonella associated with Vietnamese pork rolls.

Base Case Economic Implications

Illness and loss of life caused by eggs under the base case will be averted following implementation of AECL funded public heath cluster findings. Base case illness/loss of life rates due to egg consumption are summarised in the table below. Base case illness rates/loss of life rates and their economic consequences were sourced from a NSW Food Authority Regulatory Impact Statement (NSW Food Authority 2005), which was prepared to support implementation of the AECL research through FSANZ national food standards. Base case data used by the NSW Food Authority included:

Illness caused by egg consumption:

- Australia wide there are an average of 8.8 cases pa of salmonella linked foodborne illness associated with egg consumption.
- For each case reported there are 15 cases that go unreported i.e. 132 cases per annum.
- Each case results in the hospitalisation of 6 people i.e. 792 are made sick to the point of requiring hospitalisation with salmonella from consuming eggs each year.
- The cost per illness reflected in lost wages, carer costs and medical expenses is $2,470 per person. Hospitalisation and other costs sourced from Food Science Australia and Minter Ellison Consulting (2002).

Loss of life caused by foodborne illness due to egg consumption:

- Australia wide there is one death per annum attributable to salmonella linked foodborne illness associated with egg consumption.
- Human life has equal value regardless of age, sex, race, job, vocation or education and a value per human life of $5 million is ascribed. Human life value was sourced from Food Science Australia and Minter Ellison Consulting (2002).

Table 3.4 Base Case Foodborne Illness Rates, Loss of Life and Economic Cost Due to Salmonellosis Resulting from Egg Consumption (cost per annum)

	Number of Cases (i.e. people impacted under the base case)	Cost Per Person ($/person)	Annual Cost ($)
Illness Caused by Egg Consumption	792	$2,470	$1,956,240
Loss of Life Caused by Foodborne Illness Due to Egg Consumption	1	$5,000,000	$5,000,000

Source: AgEconPlus analysis of NSW Food Authority data

The economic cost to the Australian community of illness/loss of life associated with egg consumption and salmonella under the base case is almost $7 million per annum.

Estimation of Cluster Benefits

Australian Community Benefits (Public Health)

As a consequence of the implementation of the findings of this research cluster through FSANZ and the state food safety agencies there will be a reduction in base case foodborne illness rates and loss of human life. This public health benefit was quantified by the NSW Food Authority in their Regulatory Impact Statement using the following data:

- Public health benefits from improved salmonella risk management in eggs and egg products will be realised through the implementation and auditing of Food Safety Programs consistent with FSANZ Food Standard 2.2.2.
- Food safety program implementation on-farm and through the egg supply chain will not be 100% effective in eliminating salmonella from shell eggs and egg based products.
- Best available evidence is that Food Safety Schemes reduce the risk of foodborne illness by 70% over base case levels (Food Science Australia and Minter Ellison Consulting (2002).
- On this basis implementation of research cluster findings through FSANZ and state based food safety programs will result in 554 fewer illnesses caused by egg consumption (792 illnesses by a 70% annual reduction) and 0.7 of a life saved (1 life lost under the base case by a 70% annual reduction).

It is noted that there are 67.543 million dozen shell eggs sold at retail each year (AC Nielsen research).

The economic implications of these data are shown in the table below.

Table 3.5 Public Health Benefits from Salmonella Research Cluster Implementation

	Number of Cases Avoided (i.e. people no longer impacted)	Cost Avoided Per Person ($/person)	Annual Benefit ($)
Reduction in Illness Caused by Egg Consumption	554	$2,470	$1,368,380
Reduction in Loss of Life Caused by Foodborne Illness Due to Egg Consumption	0.7	$5,000,000	$3,500,000

Source: AgEconPlus analysis of NSW Food Authority data

The annual public health benefit from salmonella research cluster implementation is almost $5 million. This benefit is realised through the imposition of industry and other costs. These costs are estimated in the valuation of cluster costs section below.

Spillover Benefits – Egg Producers, Supply Chain, Social and Environmental

The NSW Food Authority was able to quantify a series of spillover benefits for egg producers and the supply chain from research implementation through a food safety program. The NSW Food Authority drew on the following data:

- Nationally there are 775 businesses in the egg production and supply chain including 423 egg producers.
- Quantifiable benefits are realised for each of these businesses as a result of decreased risk of damage to the reputation of the egg industry, better satisfaction of customers and insurance companies, better management practices and record keeping, increased staff understanding of and commitment to food safety, management improvement through clear delineation of staff responsibilities and better stock management leading to less wastage (spoilage).
- In aggregate the value of these benefits to egg producers and the supply chain was estimated at $5,500 per business per annum.

A research cluster spillover benefit of $4,262,500 per annum was realised ($5,500 per business by 775 egg businesses).

Additional social and environmental benefits are flagged but not quantified in this analysis.

Estimating Cluster Costs

Research Costs

Research costs total $755,156 (see Table 2) and were incurred by levy payers, research organisations and others between 1993 and 2005. All research costs are included in the cost benefit analysis.

Implementation and Other Costs

Implementation of research findings through FSANZ Food Standards, state based food agency regulations and industry food safety programs will result in industry and agency costs. The NSW Food Authority quantified these costs for the NSW situation on the following basis and the same logic is applied to this cost benefit analysis for the national situation:

- Costs will be incurred by egg producers and other egg businesses for egg food safety program implementation. The NSW Food Authority, working with industry, established that costs will be incurred for licensing, food safety program establishment and management, auditing, food sampling and any one off capital improvements.

- Annualised these egg producer and egg supply chain business costs are estimated at $4,400 per egg business.

Research implementation costs, borne by the egg industry are estimated at $3,410,000 per annum ($4,400 per business by 775 egg businesses).

There are no Australian community, researcher, environmental or social costs associated with this research or its implementation. The additional cost to the egg industry of food safety programs will be borne by egg producers and the supply chain. Market forces are such that consumers will resist opportunities to pass on costs in the form of higher prices.

Testing the Cluster Counterfactual

Testing the counterfactual is the process used to determine the additional value created by AECL from investment in the research cluster. The counterfactual analyses the benefits (public and private) that would have been produced if the investment had not been made (CRRDCC 2007).

The counterfactual is addressed by posing a series of questions directed at what would have occurred in the absence of AECL investment (CRRDCC 2007).

Would the research have occurred without AECL investment (i.e. does the research address a market failure)?

The research would not have occurred without AECL investment. The benefits delivered by this research are for the Australian community. They are additional public health benefits. Spillover or incidental benefits i.e. increased confidence in Australian eggs are captured as an aside by Australian egg producers.

Were the benefits simply brought forward as a result of AECL investment?

No there is insufficient incentive for the research to be completed outside the current funding model.

Has an efficient use of funds occurred because of the funding model/public private partnership?

Yes an efficient use of funds has occurred. The presence of funding from the Australian government to match producer levy contributions has allowed investment in a public good outcome that would not have occurred if only private levy payer funds were available.

Is AECL an efficient model for research delivery?

AECL is an efficient model for research delivery. The RDC is able to pool levy payers' funds, leverage them through matching Australian Government payments and channel them into public benefit research projects that are beyond the scope of individual egg producers. Individual egg producers do not have the capacity to address projects with public health benefits even if spillovers from this research increase confidence in Australian eggs. Other more immediate research priorities with greater emphasis on the producer 'bottom line' would capture egg producer funds.

Does the Presence of AECL increase the resultant adoption rate?

Yes the presence of AECL increases resultant food safety program adoption rates. Recommendations are incorporated in tools such as the egg industry's quality assurance program Egg Corp Assured and through AECL endorsement of statutory food safety programs.

Would the research have been completed overseas and been available to Australia anyway?

No in fact there is a risk that overseas salmonella research incorporating findings from countries with more virulent salmonella strains largely absent from Australia (eg *Salmonella Enteriditis*) would have driven regulatory food safety programs here in Australia. In this situation the Australian industry may have found itself with a more punitive food safety program with consequential losses in efficiency for both egg producers and the Australian community. For example SE control overseas has resulted in a regulatory requirement for the whole supply chain to be refrigerated. Food Science Australia estimate that this would add $180 million in egg industry costs.

Would substitute technologies have been developed?

CIF-1A produced diagnostic technologies. The remaining projects in the cluster were concerned with the generation of knowledge of a disease in the food chain in the Australian situation. Substitute technologies for this knowledge are not available.

Are there sufficient incentives for voluntary groups to get together and complete the research?

No research outcomes are public benefit in nature and are therefore realised by the whole community rather than individuals for private gain. Groups of producers or more likely substantial egg producing individuals might put individual food safety programs in place uninformed by their own research but they would still be subject to the negative outcomes for their businesses associated with disease outbreak caused by other individual producers or links in the food chain.

Additionality

Refers to the amount of spillovers that are conditional on public support for AECL (CRRDCC 2007). In this instance all project benefits are reliant on public support for the salmonella research cluster.

Capacity/Incentive to Invest in Absence of Levy and Public Contribution

This research cluster would not be funded in the absence of public funding under the RDC model for AECL. In the absence of a compulsory levy there is insufficient capacity and incentive for the egg industry to complete this research cluster.

Informed by the counterfactual, additionality and the need for a public contribution to fund this research cluster the evaluation was completed.

Results and Sensitivity Testing

Project cost benefit analysis was completed using the Guidelines for Evaluation (May 2007) prepared by the CRRDCC. Data driving the analysis is summarised in Table 3.6 and results are presented in Table 3.7.

Table 3.6 Key Parameters Underlying the Analysis

- The discount rate for future costs and benefits and the compound rate for historical research costs is 5% real.
- Nationally there are 775 businesses in egg production.
- Implementation of research findings through food safety programs will cost each egg business $4,400 pa.
- National implementation of egg food safety programs occurs in 2008.
- The research has a useful economic life of 15 years before the industry situation in relation to salmonella changes and the FSANZ food standards are re-written.
- The Australian Community Benefits (public health) are available from 2008
- Egg producer benefits, egg supply chain benefits, industry spillover benefits, social spillover benefits and environmental spillover benefits have not been quantified.

Table 3.7 Cost Benefit Analysis, Salmonella Control in Eggs for Public Health Benefits

Key Parameter	Net Present Value (5% discount rate)	Benefit Cost Ratio	Internal Rate of Return
Food Safety Program 'life' of 5 years	$6 million	1.37	154%
Food Safety Program 'life' of 15 years	$15 million	1.43	156%
Food Safety Program 'life' of 20 years	$18 million	1.43	156%

Source: AgEconPlus analysis

The project returns a strong result for the Australian community, which realises significant human health benefits funded by Australian egg producers. The Net Present Value (NPV) of the project cluster is $15 million using the 'core' data set and a real discount rate of 5%.

The sensitivity of this result to changes in the 'life' of the current generation of national and state food safety programs that build on this research cluster is also shown in Table 7. Reducing the 'life' of food safety programs that incorporate research cluster results from 15 to 5 years still delivers a positive outcome for the Australian community – a NPV of $6 million.

Conclusion

Cluster 1 Salmonella control in eggs for public health benefits is an R&D 'hero' project that delivers substantial benefits for the Australian community and in so doing protects the integrity of the Australian egg industry.

4. Cluster 2: Cannibalism Control in Layers – Diet, Microbes and Fibre

Cluster Identification

This cluster analysis addresses a single egg producer levy funded project – UNE-72A which commenced 1 July 1999 and was completed 1 November 2002.

Table 4.1 R&D Projects included in the Cannibalism Control Cluster

ID	Project Title	Project Period
UNE-72A	Effect of diet composition, gut microbial status and fibre forms on cannibalism in layers.	1999-2002

Source: AECL Project Database

Cluster Description and the Problem Being Addressed

Cannibalism, the behaviour where birds start pecking or eating flesh of other birds, was a major problem for the Australian layer industry. Prior to the commencement of this study in 1999 mortality from cannibalism in some strains ranged from 10% to 20%, depending on the production system and management strategies employed (Cumming *et al*., 1998). Cannibalism appeared to be highest in imported bird strains. The Australian egg industry had a flock size of approximately 10 million layers in 1999 and a 10% across the industry mortality during lay meant a potential loss to the industry of $10 million per annum.

The objectives of this project were to:

- Examine the interaction between diet composition and the incidence of cannibalism.
- Investigate the effect of gut microbial status on cannibalism in layers.
- Develop dietary strategies to minimise cannibalism in laying hens.

Dietary strategies that reduce cannibalism in layers reduce flock morbidity and mortality and enhance the economic position of egg farmers.

Funding for the Project Cluster

Egg producer levy funding for the cluster contributed through RIRDC and AECL managed research portfolios along with research organisation and other contributions are shown in the table.

Table 4.2 Project Cluster Funding by Year and Source ($)

	AECL/RIRDC	Research Organisation	Other	Total
UNE-72A				
1999-00	56,316	14,173	0	70,489
2000-01	56,316	14,173	0	70,489
2001-02	56,316	14,173	0	70,489
2002-03	56,316	14,173	0	70,489

Source: AECL Project Database

The grand total of direct project costs was $282,000.

Project Outcomes and Research Benefits

Project Outcomes

Outputs from the project include four publications in the Australian Poultry Science Symposium and one publication in the Journal of Applied Poultry Research.

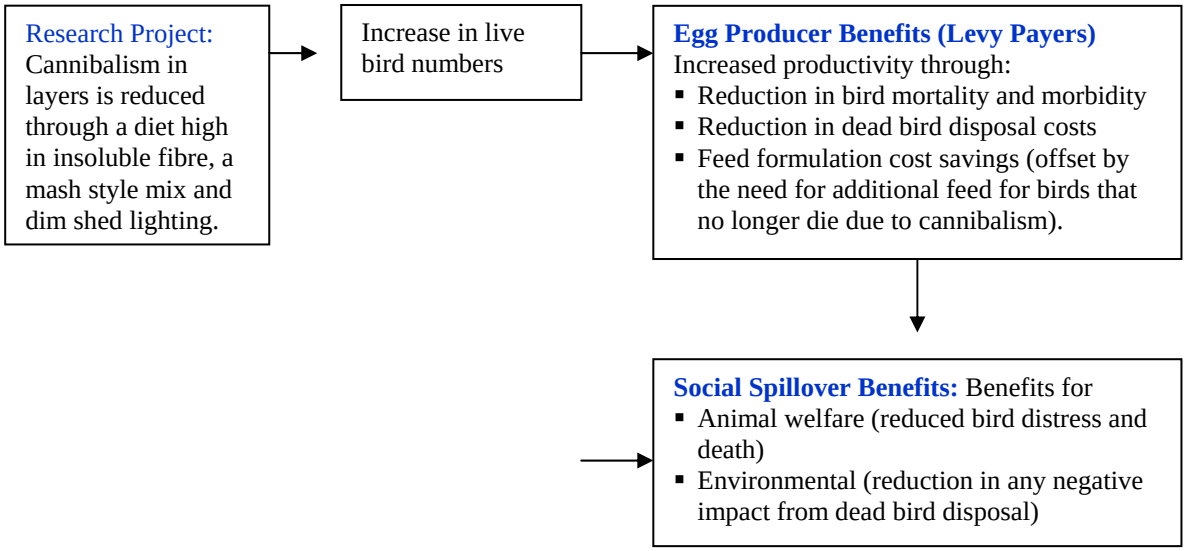
The research has shown that layers reared under dim light and supplied with a diet containing high-insoluble dietary fibre, such as low cost rice hulls, decreased the incidence of cannibalism mortality, whereas brightly lit sheds and a diet containing high soluble dietary fibre increased the incidence of pecking leading to cannibalism. Increased digesta passage rate seems to result in birds feeling hungry quicker and as a consequence birds spend more time feeding and less time pecking. A mash diet form was more effective in reducing cannibalism than the pelleted form.

The project has shown that a high-insoluble fibre diet, a mash style mix and dim shed lighting reduces cannibalism in layers.

Identification of Research Benefits

A schematic of benefit flow resulting from levy payer funded research is shown in Figure 4.1 below.

Figure 4.1: Potential Benefits to the Aust Community and Levy Paying Egg Producers



Egg Producer Benefits

Egg producer implementation of findings from the cannibalism control in layers project resulted in a reduction in lost production from dead and injured birds, cost savings in dead bird disposal and a reduction in feed cost associated with a change to a lower cost, high fibre feed.

The principal egg producer benefit from this research will be a reduction in lost production from dead and injured birds caused by cannibalism. Dead bird disposal cost will be a minor positive benefit for egg producers and feed cost savings from a low cost high fibre diet together with cost savings from converting to a mash style mix (where a mash style mix isn't already standard farm practice) will be offset by the additional cost of feed for birds that no longer die due to cannibalism.

Social Spillover Benefits

Implementation of findings from the cannibalism control in layers project will improve the welfare of layers. There will be less pecking in layer flocks leading to less death and injury requiring subsequent

euthanasia. Cannibalism affects hens in cage, barn and free-range production systems but is more prevalent in barn and free-range systems. As a result of implementing findings from this project, birds will lead longer, less stressful and more productive lives.

In addition research implementation will result in environmental benefits from not having to dispose of as many dead or dying birds in a premature and high cost way. Birds who are the victim of cannibalism can be disposed to farm pits or at rendering plants but most are disposed to local council owned landfill. Costs are incurred for freezing dead birds before collection, transportation and the cost of landfill. In contrast birds that are disposed of at the end of their productive lives either earn a small positive return for farmers or are removed at no cost.

Approach to the Cluster Evaluation

The Economic Base Case

In the absence of research outputs from this project there would still have been positive reductions in layer mortality rates during the current century. This is because reductions in layer mortality since the early 2000s have been due to a combination of factors including:

- Genetic improvement in day old chicks supplied to egg producers. Chicks are now more robust with lower 'background' level mortality rates than they were in 1999.
- Vaccination for disease control such as Marek's disease, which previously had a significant impact on layer mortality. Individual shed mortality rates of 20% were not uncommon prior to the widespread adoption of Rispen's vaccine.
- Adoption of effective animal husbandry techniques including the newly developed laser beak trimming of day old chicks. Beak trimming has reduced the incidence of pecking in Australian flocks.
- Movement to controlled environment sheds with control of light below 5 lux. Previously layer sheds were constructed to make use of natural light and ventilation. Reliance on natural light and ventilation resulted in uneven temperatures with less productivity from the birds.
- Uniform artificial lighting achieved through the use of improved controlled environment shedding. Recommendations on lighting were made as a result of investment in this and other Australian and international egg industry research projects.
- General advances in layer nutrition and feed formulation. Again improvements in feed formulation are linked to this project as well as other research outcomes.

This project is part of a research continuum stretching back to the 1970s showing that dietary fibre reduces cannibalism in poultry. Certainly in the period since the release of this report (2003) high fibre diets have become increasingly popular for cost, nutrition and cannibalism prevention reasons. Pre 2000 Australian industry nutritionalists were recommending a maximum of 5% dietary fibre in layer diets. In 2007 they are recommending diets with 6% fibre. Furthermore, and drought permitting, fibre (eg lucerne meal, rice hulls, etc) is a relatively low cost feed and a plentiful feed source.

Consequently this project is only able to claim a proportion of the improvement in mortality rates experienced in Australian layer sheds since 1999.

Mortality rates in the Australian egg industry vary between sheds, farm production system and the strain of bird used. Popular layer strains such as ISA, Hyline and Inghams Hisex all have different 'background' mortality rates. Furthermore mortality information tends to be confidential to individual farm operations and is not collated across the industry.

Best estimate mortality rates pre project implementation, post project implementation and what is attributable to this project (i.e. reduction in cannibalism rates due to UNE-72A) are shown in Table 4.3. These 'best estimates' are reviewed in the cost benefit analysis using sensitivity testing.

Table 4.3 Across the Board Industry Mortality Rates for Hens in Lay

Production System	Industry Mortality Rate (Flock %)		
	Pre-Project Implementation (2000 to 2003)	Post Project Implementation (2004 to 2024)	Attributable to this Project
Cage Laid	10	7	1.5
Barn Laid	12	8	2
Free Range	16	10	3

Source: AgEconPlus consultation with industry consultants and nutritionists

Estimation of Cluster Benefits

Reduction in lost production as a result of cannibalism control is the principal benefit originating from this project. This benefit is quantified using the following data:

- The Australian layer flock is currently 13.175 million hens (ABS Catalogue No 7121 reported in AECL Annual Report 2006). The flock is stable at this level over the 30-year life of the cost benefit analysis.
- Cage eggs account for 75% of Australian production by volume, barn laid 5% and free range 20% (ACNielsen reported in AECL Annual Report 2006).
- The reduction in mortality attributable to this project is 1.5% for cage laid, 2% for barn laid and 3% for free-range (estimates shown in Table 3).
- The benefit of the research is death avoided in these birds between 16 and 35 weeks i.e. through the peak of their productive lives (AgEconPlus assumption).
- Lost production is 160 eggs per bird at an average farm gate value for eggs of $1.62 dozen (ABS Catalogue No 7503 reported in AECL Annual Report 2006 with no allowance for variation in price for production system or the current drought).
- The additional production from hens no longer lost to cannibalism as a result of this research project has no impact on the price of eggs received by egg producers.
- By 2007, five years after the research reports release 80% of Australian layer flocks have adopted low cost high fibre diets. This adoption rate remains constant throughout the analysis period. This data is tested using sensitivity analysis.

The value of the reduction in lost production is shown in Table 4.4.

Table 4.4 Egg Producer Benefits, Additional Production Due to Cannibalism Control

Production System	Industry Mortality Rate (Flock %)		
	Hens Protected from Cannibalism (No.)	Eggs from Protected Hens (Dozen)	Annual Producer Benefit ($ farm gate)
Cage Laid	118,000	1,600,000	$2.6 million
Barn Laid	10,000	133,000	$215,000
Free Range	63,000	840,000	$1.4 million

Source: AgEconPlus analysis
NB: There were 13.175 million hens in the Australian industry at 30 June 2005.

The annual producer benefit from cannibalism control as a result of this research project is $4.2 million.

Estimating Cluster Costs

Research Costs

Research costs total $282,000 (see Table 2) and were incurred by levy payers and research organisations between 1999 and 2003. All research costs are included in the cost benefit analysis.

Implementation Costs

Implementation of the findings from this project results in no additional cost to egg producers. Fibre is added to layer feed rations reducing the calorie level and the need for other higher cost ingredients. The cost of feeding additional birds that no longer die resulting in improved production, as a result of reduced cannibalism, together with the savings in costs of converting to a mash based feed mix, offsets increased feed consumption as a result of a slight increase in feed consumption due to feeding a lower density feed.

There are no costs to other parts of the supply chain or the Australian community from implementing the cannibalism research findings.

Testing the Cluster Counterfactual

The counterfactual, the benefit that would have been produced if investment in the project had not been made, is tested through the following questions.

Would the research have occurred without AECL investment (i.e. does the research address a market failure)?

The research is of direct benefit to Australian egg producers who were having difficulty with overseas-developed layer lines under Australian production conditions. The research benefits Australian egg producers and spillover animal welfare and environmental benefits are incidental.

Given that the research addressed a significant industry problem, it is possible that one of the larger industry producers may have undertaken this research for themselves. However, under these conditions resulting outcomes would have been 'commercial-in-confidence' and would not have been available to all producers in the industry. Completing the research through the AECL structure has resulted in a superior outcome for industry with spillover benefits (animal welfare and environmental) for the Australian community.

Were the benefits simply brought forward as a result of AECL investment?

No there is insufficient incentive for the research to be completed, and available for the whole industry, outside the current funding model.

Has an efficient use of funds occurred because of the funding model/public private partnership?

An efficient use of funds has occurred because of the public private partnership funding model. The presence of matching public monies has provided incentive for an industry levy and investment in projects of this nature. In the absence of the current model, it is likely that the research findings would only be available to the industry's larger players.

Is AECL an efficient model for research delivery?

AECL is an efficient model for research delivery. In this instance AECL was able to work with the researcher to scope an appropriate project that delivered outcomes of benefit to industry. Research cost was a relatively modest $282,000.

Does the presence of AECL increase the resultant adoption rate?

Yes the presence of AECL increases resultant adoption rates. Research outcomes are communicated through AECL channels that include newsletters and bulletins, research update reports, industry extension officers and on farm demonstrations of research outcomes. The fact that it is an AECL research outcome also assures egg producers that the research is not promoting a vested interest eg a feed supply company marketing high fibre additives.

Would the research have been completed overseas and been available to Australia anyway?

The project addressed an 'Australia specific' research issue i.e. the performance of overseas developed layer lines under Australian conditions. It could not have been completed overseas.

Would substitute technologies have been developed?

Possibly substitute technologies would have been developed in this instance eg proprietary feed additives to mitigate cannibalism. However, it is unlikely that an 'elegant' solution such as substituting a high cost ingredient for a lower cost fibre would have been produced.

Are there sufficient incentives for voluntary groups to get together and complete the research?

While it is possible that voluntary groups may have got together and completed the research it is more likely that smaller producers would have missed out on research findings and larger producers would have completed the investigation and kept 'commercial-in-confidence' resultant research implications.

Additionality

Additionality refers to the spillovers that are conditional on public support for AECL. In this instance it is unlikely that the spillover benefits realised would be available in the absence of a levy, smaller producers would simply have 'missed out' and resultant animal welfare and environmental gains would not have been realised. However, a levy without matching government funds may still have been sufficient to ensure the project was completed.

Capacity/Incentive to Invest in Absence of Levy and Public Contribution

Given the commercial nature of outcomes from this research, i.e. additional production at a lower cost, this research might well have been completed in the absence of a public contribution.

Results and Sensitivity Testing

Project cost benefit analysis was completed using the Guidelines for Evaluation (May 2007) prepared by the CRRDCC. Results are summarised in Table 4.5.

Table 4.5 Cost Benefit Analysis, Cannibalism Control in Layers

Key Parameter	Net Present Value (5% discount rate)	Benefit Cost Ratio	Internal Rate of Return
Low lift in mortality rate of 0.5%, 60% research adoption	$8 million	24	220%
Mean lift in mortality rate of 1.5%, 80% research adoption	$43 million	117	1083%
High lift in mortality rate of 2.0%, 100% research adoption	$58 million	159	1468%

Source: AgEconPlus analysis

The project yields a very strong result for industry. A Net Present Value (NPV) for industry of $43 million is realised using the 'core' data set and a real discount rate of 5%.

The sensitivity of this result to changes in 'core' data is also shown in Table 5. A halving of the improvement in mortality rates attributable to this project (i.e. improvement in cage layer mortality of 0.5% rather than the core analysis value of 1.5%) together with a 20% reduction in the uptake of research results (i.e. 60% of the industry adopt rather than the 80% assumed) still delivers a very healthy outcome for industry – a NPV of $8 million.

Conclusion

UNE-72A research on the effect of diet composition, gut microbial status and fibre forms on cannibalism in layers is an R&D 'hero' project with returns for industry of present value $43 million for a present value outlay of $370,000.

5. Cluster 3: Project Egg - Consumer Sensory Research

Cluster Identification

This cluster analysis addresses a single egg producer levy funded project delivered by Colmar Brunton, David McKinna *et al* and the University of Sydney between February and October 2006 – Project Egg: Consumer Sensory Research. The project was to identify the sensory parameters of egg quality as determined by consumers.

Table 5.1 R&D Projects included in the Sensory Research Cluster

ID	Project Title	Project Period
1ECSR	Project Egg: Consumer Sensory Research.	2006

Source: AECL Project Database

Cluster Description and the Problem Being Addressed

The project's aim was to improve consumer perceived egg quality and consistency as a means of increasing consumer satisfaction and thus provide a framework for differentiating eggs, attracting a price premium for superior eggs and in so doing enable the facilitation of the growth and development of the Australian egg industry.

The objectives of this project were to:

- Identify the key drivers that determine consumers' perception of egg quality.
- Quantify the relative importance of each driver.
- Determine for each attribute the threshold at which consumer perception moves from unacceptable to acceptable to superior.
- Examine the importance of branding, packaging and endorsements in the overall egg offering.
- Quantify the impact of egg quality on the price consumers are willing to pay for eggs.
- Assess the correlation between consumer visual rating of broken eggs in situ versus a digital image.

Funding for the Project Cluster

Egg producer levy funding for the cluster contributed through the AECL managed research portfolio, along with research organisation and other contributions are shown in the table.

Table 5.2 Project Cluster Funding by Year and Source ($)

	AECL	Research Organisation	Other	Total
1ECSR				
2006-07	$286,310	0	0	$286,310

Source: AECL Project Database

The grand total of direct project costs was $286,310.

Project Outcomes and Research Benefits

Project Outcomes

Outputs were delivered for all six project objectives. The key drivers that determine consumers' perception of egg quality, and their relative importance, were found to be as per Table 5.3.

Table 5.3 Consumer Perception of Egg Quality

Variable	Importance (%)
Yolk colour	47
Albumen quality (measured in Haugh units)	17
Blood/meat spots	15
Shell colour	14
Weight	7

Source: Colmar Brunton 2006

Yolk colour is the most important driver, followed by albumen quality, blood/meat spots, shell colour and total egg weight. The study reports the threshold at which consumer perception of each of these drivers moves from unacceptable to acceptable to superior. Consumer requirements for yolk colour are easily met through the addition of a low cost natural colouring to layer feed.

Branding, packaging and endorsements in the overall egg offering are also reported. The study found that the most compelling components of packaging appeared to be:

- Production system used – free-range, organic, barn laid.
- Endorsements – RSPCA, Heart Foundation tick.
- Functional benefits/claims – Omega 3, antibiotic, hormone free.
- Carton – strong, recyclable, clear, colourful, informative labels.
- Egg size – extra large, large.

In 2006, the branding of eggs was largely seen as insignificant in the eyes of the Australian consumer. The pack size and configuration also appeared to be relatively unimportant.

Consumer willingness to pay for superior quality eggs was also tested and assuming the average retail price for a dozen eggs was $3.00, the majority of consumers indicated that they would be willing to pay up to $3.50 for eggs of their 'ideal' quality. This indicates that consumers, on the whole, would be willing to pay around 15% more for eggs that are of a superior quality to the eggs they currently buy.

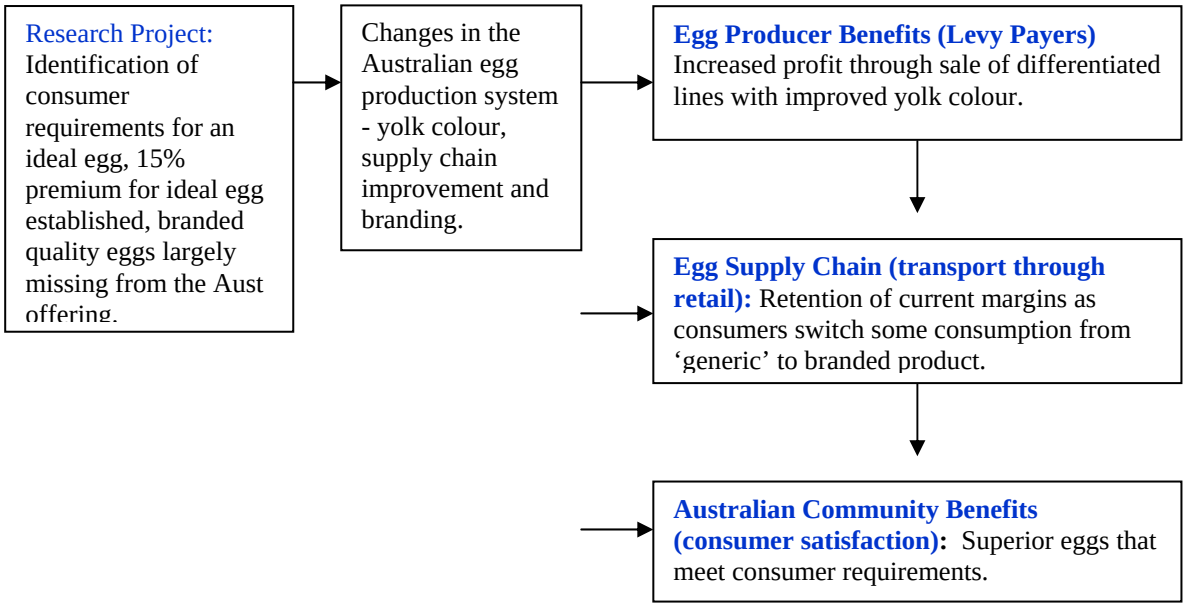
The implications of the research are that in order to produce superior eggs, egg producers should focus on producing large, pink brown shelled eggs with a strong yolk colour (most important) and no blood/meat spots. Egg distribution channels should enable eggs to arrive on the supermarket shelf with a firm albumen.

At the current time proprietary brand label eggs are loosing market share to un-differentiated generic product (consumers perceive 'that an egg is an egg' in the Australian market place), consumers are not receiving the superior quality eggs that they require and producers are missing out on premium prices and subsequent profits.

Identification of Research Benefits

A schematic of potential future benefit flows resulting from implementation of this levy payer funded research is shown in Figure 5.1.

Figure 5.1: Potential Benefits to Levy Paying Egg Producers and the Aust Community



Egg Producer Benefits

Egg producer benefits are realised from the implementation of this research through the production and delivery of premium egg lines with a strong yolk colour (most important quality factor) on a consistent basis via a proprietary owned brand. Consistent egg colour is achieved through addition of a low cost natural colouring to layer feed.

Egg Supply Chain Benefits

The egg supply chain will be unconcerned about a shift to superior egg quality delivered via a proprietary owned brand. Margins are consistent between generic and proprietary owned branded product.

Australian Consumer Benefits

Implementation of this research will deliver Australian consumers eggs that consistently meet their quality requirements. This research project shows that consumers are willing to pay for this improvement.

These benefits are considered in the cluster evaluation.

Approach to the Cluster Evaluation

The Economic Base Case

At the current time Australian consumers see no meaningful difference between eggs and are generally shopping on price. Brand loyalty is weak with only 4% of the market recognising and remaining loyal to any one proprietary brand (Blue Moon Research and Planning 2007 in AECL 2007).

Given this market situation, owners of generic egg labels (also known as private-label or store branded eggs) have realised a market opportunity: most consumers think that an egg is an egg – no matter what

the brand. Since 2000 these brand owners and egg buyers have launched new brands, set purchasing terms to egg producers, discovered that the egg industry is willing to sell eggs at lower price points and as a result, have offered cheaper, generic-label eggs to their shoppers. The market share of generic-label eggs has increased from 19% in 2000 to 62% in 2007 (AC Nielsen 2007 in AECL 2007).

Over this same period the average retail price of generic-label eggs has increased from $2.58 per dozen in 2000 to $2.90 per dozen in 2007, representing an increase of 12%. If pricing was to maintain parity with CPI, average prices would need to have increased from $2.58 to $3.31 per dozen. If egg producers supplying generic labels had 'passed on' the additional cost of feed price increases caused by an extended drought, prices would need to have been considerably higher. Egg producers supplying generic labels have failed to maintain their pricing position (data sourced from AC Nielsen 2007 and reported in AECL 2007).

Over the period 2000 to 2007, egg producers marketing branded eggs have seen their average price increase from $2.75 per dozen in 2000 to $4.16 per dozen in 2007 an increase in average price of 51% (AC Nielsen 2007 in AECL 2007). This price increase has been at the expense of market share – see Table 5.4 below.

Table 5.4 Base Case Retail Price and Market Share, Generic and Branded Eggs

Label	Price 2000 ($' dozen)	Price 2007 ($' dozen)	Market Share 2000 (%)	Market Share 2007 (%)
Generic-brand	2.58	2.90	19	62
Proprietary-brand	2.75	4.16	81	38

Source: AC Nielsen 2007 in AECL 2007

The period 2000 to 2007 has seen the growth in generic labels and the expense of proprietary brands with the result that the Australian egg category has become a commodity business. There is no meaningful brand presence, no product differentiation and the lowest price has become the market for all eggs. In other words, generic label brands have cannibalised proprietary egg sales – resulting in a decline in category revenue. The supply chain is immune to this change, maintaining its margins regardless of the brand sold, producers have 'worn the cost' of egg market commoditisation. Table 5.5 shows the value lost in the category.

Table 5.5 Loss in Value resulting from Egg Category becoming a Commodity Business ($ million per annum)

	Current Value Based on 2000 Market Shares	Current Value Based on 2007 Market Shares
Value of generic-brand sales	37.2	121.4
Value of proprietary -brand sales	227.6	106.8
Total Value	**264.8**	**228.2**

Source: AC Nielsen 2007 in AECL 2007
NB: Assumes consistent retail sales volume of 67.5 million dozen (AC Nielsen 2005/06)

Some $36.6 million per annum in value ($264.8 million less $228.2 million) has been stripped from the Australian egg category between 2000 and 2007.

Implementation of research findings i.e. strong yolk colour and brand development, will recover some of this loss in value for egg producers who develop proprietary brand sales.

Estimation of Cluster Benefits

Capture of the 15% premium for supply of the ideal egg is the principal benefit originating from this project. This benefit is quantified using the following data:

- Not all producers in the industry will develop proprietary lines to complement generic sales nor will it be possible to shift all production into the premium category.
- Industry consultation reveals that 'early movers' are already taking up research findings and best estimates are that 30% of industry retail sales will move to branded production incorporating research findings.
- Uptake will be quite rapid and will be complete by 2009.
- Adopters will shift the retail price for their premium lines from the current generic price of $2.90 dozen ($1.62 dozen farm gate) to $3.34 dozen ($1.86 dozen farm gate).

The value of proprietary label product incorporating research findings and marketed to retail is shown in Table 5.6.

Table 5.6 Benefit Estimate – Sale of Branded Product Incorporating Research Findings ($'million per annum)

	Quantum
Retail sales volume (million dozen)	67.5
Sales of branded product incorporating research findings (%)	30
Premium for branded product with research findings ($/dozen)	0.24
Gross Benefit 2009 ($ million per annum)	**4.9**

Source: AC Nielsen 2007 in AECL 2007

The annual total benefit is $4.9 million in 2009.

Estimating Cluster Costs

Research Costs

Research costs total $286,310 (see Table 2) and were incurred by levy payers in 2006/07. All research costs are included in the cost benefit analysis.

Implementation Costs

Implementation of the findings of this project results in only modest additional costs for producers. Operational costs are incurred for adopting producers to alter the amount of natural colouring agent added to generic and premium lines, redesign operational systems to grade out strong yolk colour lines and marketing effort to reposition some of their current brand offering as premium, proprietary branded product. Most of this cost will be production manager time and an allowance of $2,000 pa per adopting producer is made. The 30% of industry retail sales that constitute proprietary branded product will be supplied by the 10% of the industry's producers (72 egg farmers) who recently attended AECL 'how to' marketing workshops aimed in part at uptake of project research findings.

An industry wide implementation cost of $144,000 (72 farms at a cost of $2,00 per farm) is incurred.

Testing the Cluster Counterfactual

The counterfactual, the benefit that would have been produced if investment in the project had not been made, is tested through the following questions.

Would the research have occurred without AECL investment (i.e. does the research address a market failure)?

The research would not have occurred without AECL investment. There was no incentive for the links in the supply chain (grading, transport, distribution centre and store) to research and address consumer sensory requirements. Commodity sales are just as valuable to the supply chain as branded product

sales. Only consumers and producers loose utility from the commoditisation of the egg market. Furthermore, it is unlikely that the cost of consumer sensory research could have been funded by an individual or group of producers. Basic research of this nature could not be funded in this industry outside of AECL.

Were the benefits simply brought forward as a result of AECL investment?

No there is insufficient incentive for the research to be completed, and available for the whole industry, outside the current funding model.

Has an efficient use of funds occurred because of the funding model/public private partnership?

An efficient use of funds has occurred because of the public private partnership funding model. The presence of matching public monies has provided incentive for an industry levy and investment in projects of this nature. In the absence of the current model, it is likely that this type of 'basic' research on the egg category would not have occurred. Producers would have been more interested in short term and 'quick fix' promotion.

Is AECL an efficient model for research delivery?

AECL is an efficient model for research delivery. In this instance AECL was able to work with the researcher to scope an appropriate project that delivered outcomes of benefit to producers and consumers.

Does the presence of AECL increase the resultant adoption rate?

Yes the presence of AECL increases resultant adoption rates. Research outcomes are developed and communicated through various AECL channels including a series of national training workshops targeting egg marketing.

Would the research have been completed overseas and been available to Australia anyway?

Possibly, however its believability and therefore adoption level is increased if it is completed in Australia and the findings are published on Australian consumer requirements.

Would substitute technologies have been developed?

Substitute technologies are not relevant in this instance.

Are there sufficient incentives for voluntary groups to get together and complete the research?

Voluntary groups are unlikely to fund this style of 'basic' consumer research preferring instead 'quick fix' investments in promotion.

Additionality

Additionality refers to the spillovers that are conditional on public support for AECL. In this instance the spillover benefits are relatively modest and are limited to the additional consumer satisfaction achieved through the availability of eggs that meet sensory requirements. There are no environmental or health spillover benefits or costs associated with this project.

Capacity/Incentive to Invest in Absence of Levy and Public Contribution

Given the 'basic' or fundamental nature of this research and the likely requirement for promotion funding it is unlikely that the project would have been commissioned in the absence of the levy and a public contribution.

Results and Sensitivity Testing

Project cost benefit analysis was completed using the Guidelines for Evaluation (May 2007) prepared by the CRRDCC. Results are summarised in Table 5.7.

Table 5.7 Cost Benefit Analysis, Consumer Sensory Research Findings

	Net Present Value (5% real discount rate)	Benefit Cost Ratio (1:x)	Internal Rate of Return (%)	Cost (present value of all funds invested)
Low sales branded product (10% production, 36 producers)	$12.7 million	13.64	153%	$1 million
Mean sales branded product (30% production 72 producers)	$41.8 million	23.60	266%	$1.8 million
High sales branded product (40% production 100 producers)	$55.7 million	23.70	291%	$2.5 million

Source: AgEconPlus analysis

The project yields a very strong result for industry. A Net Present Value (NPV) for industry of $42 million is realised using the 'core' data set and a real discount rate of 5%.

The sensitivity of this result to changes in 'core' data is also shown in Table 7. A reduction in the take up rate of this research by half the number of producers accounting for only 10% of total production still delivers a very healthy outcome for industry – a NPV of $12.7 million.

Conclusion

1ECSR consumer sensory research and implementation through branded product is an R&D hero project with returns for industry of present value $42 million for a present value outlay of $2.5 million.

6. Cluster 4: Ullage Audit, Solutions Development and Implementation

Cluster Identification

This cluster analysis addresses AECL's investment in understanding the causes of ullage in the supermarket supply chain and the formulation and implementation of solutions.

Ullage is defined as the lack; deficiency; amount by which a quantity is short of a full measure. Ullaged, an adjective, means not the full measure (Hutchinson Encyclopaedia, 2007). In the Australian retail industry ullage has come to mean the loss of salable product through the supply chain from production to handover to the end consumer at retail point of sale. Ullage is concerned with breakage of eggs and damage to their packaging from the grading floor, through transportation, to the distribution centre, to back of store and in retail display.

The cost of ullage right through the supply chain, including retail point of sale is borne by egg producers. Supermarkets and other supply chain participants make claims on egg producers for the number of eggs that have been ullaged.

AECL has invested in three linked projects to address ullage in the egg supply chain, they are:

- Audit of ullage in NSW Coles/BiLo stores;
- Audit of grading floors; and
- Audit of distribution centres.

Cluster Description and the Problem Being Addressed

These three linked projects were undertaken in late 2004 in NSW and Victoria over a two-week period. Audits were completed in twenty-eight regional and metropolitan Coles and BiLo stores. The supply chain was divided into four areas: grading floor; transport to distribution centre; transport from distribution centre to store; and in-store. Comprehensive audits were completed in all four parts of the supply chain.

Eight main causes of ullage were identified, they were:

1. Condensation weakening outer cartons;
2. Upsizing eggs without upsizing cartons;
3. Back of store storage from incorrect store ordering;
4. Pallets stacked too high;
5. Egg boxes not handled as fragile;
6. Different shaped outer boxes making pallets difficult to stack;
7. Already damaged egg cartons used during the grading process; and
8. Damaged product due to grading floor machine errors.

Action plans were subsequently put in place by AECL and the industry to reduce ullage in the egg supply chain.

Funding for the Project Cluster

Egg producer levy funding for the cluster contributed through AECL managed research along with research organisation and other contributions are shown in the table.

Table 6.1 Project Cluster Funding by Year and Source ($)

	AECL	Research Organisation	Other	Total
Audit – Coles/BiLo				
2004-05	$106,260	0	0	$106,260
Audit – Grading Floor				
2004-05	$35,379	0	0	$35,379
Audit – Distribution Centre				
2004-05	$54,500	0	0	$54,500

Source: AECL Project Database

The grand total of direct project costs was $196,079.

Project Outcomes and Research Benefits

Project Outcomes

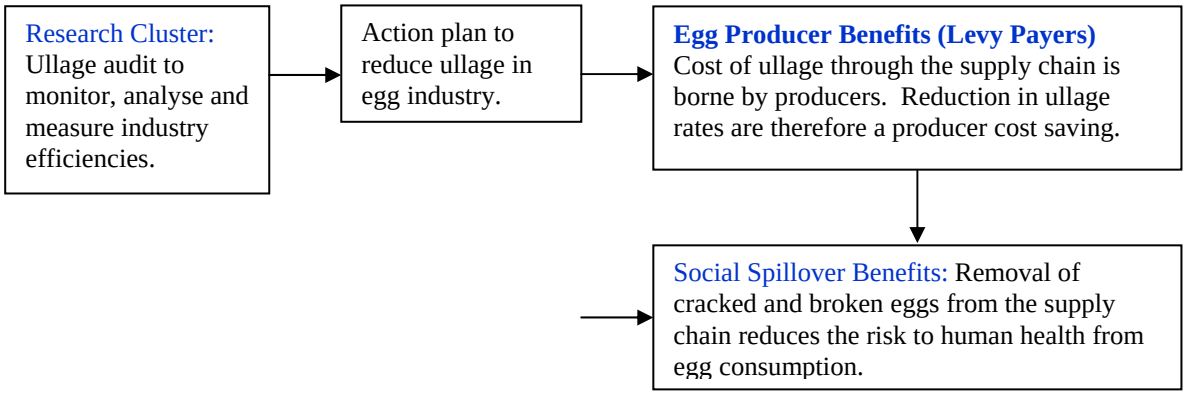
AECL and industry have formulated and implemented an action plan to address each of the eight major causes of ullage in the egg supermarket supply chain. The action plan addresses each of the eight major causes:

1. Condensation weakening outer cartons
   - Solution: pallets bound with materials that don't capture moisture. Two proprietary materials have been tested, approved and adopted by the majority of the industry.
2. Upsizing eggs without upsizing cartons
   - Solution: upsize egg cartons when using upsided eggs. The majority of the industry has increased the carton sell size for 70g+ eggs (which account for 1% of the market).
3. Back of store storage from incorrect store ordering
   - Solution: the Retail Category Management (RMC) project was developed by AECL to redress correct ordering, storage, handling, stock rotation and hygiene of eggs at store level. The RMC project has taken place at Coles/BiLo in Victoria, NSW and Queensland.
4. Pallets stacked too high
   - Solution: Outer cartons should not be stacked higher than 5 rows. Egg producers have adopted this rule and are delivering product into distribution centres stacked 5 rows high.
5. Egg boxes not handled as fragile
   - Solution: the production of an egg handling procedures information resource. As part of this solution new artwork for outer packaging has been developed, as well as an interim stocker for pallets. The artwork has been approved and adopted by the majority of the industry. It labels eggs as fragile and stipulates that outers should not be stacked higher than 5 rows.
6. Different shaped outer boxes making pallets difficult to stack
   - Solution: industry standards for both outer and inner packaging. Industry working towards equal pallet configurations between producers.
7. Already damaged egg cartons used during the grading process
   - Solution: issue at one grading floor detected. This is covered by Egg Corp Assured and has since been resolved.
8. Damaged product due to grading floor machine errors.
   - Solution: grading floor quality control. Egg Corp Assured covers this.

Identification of Research Benefits

A schematic of benefit flow resulting from levy payer funded research is shown in Figure 1 below.

Figure 6.1: Potential Benefits to Levy Paying Egg Producers and the Aust Community



Egg Producer Benefits

The cost of ullage though the supply chain is borne by egg producers. Retailers monitor ullage through the supply chain and deduct payments to producers for shortfalls in eggs sold at retail. A reduction in ullage rates is therefore a producer cost saving.

Social Spillover Benefits

Removal of cracked and broken eggs from the supply chain reduces the opportunity for bacteria to contaminate retail packages. Bacteria with the potential to cause human sickness include, but are not limited to *Salmonella spp, Bacillus cereus, Listeria monocytogenes* and *Staphylococcus aureus*.

Approach to the Cluster Evaluation

The Economic Base Case

The ullage audit revealed the source and percentage of total egg breakages through the grocery/retail supply chain, Table 6.2.

Table 6.2: Source of Total Egg Breakages Across the Supermarket Egg Supply Chain

Grading Floor	Transportation	Distribution Centre	In-Store
At grading floor before distribution	From grading floor to back door of the DC	From the DC to the back door of store	Within the store to customer
20.16%	4.54%	21.12%	54.18%

Source: AECL Ullage Audit Update (2007)

Industry data indicates that the average ullage rate across the grocery/retail supply chain is 3%. In 2005/06 grocery/retail sales volume was 67.5 million dozen eggs. Egg producers, the ultimate bearers of ullage costs, therefore did not receive payment for a total of 2 million dozen eggs. These eggs have a farm gate value of $1.62 per dozen. The total cost of ullage to Australian egg producers supplying the grocery/retail sector is $3.28 million pa.

A percentage of these base case costs have been saved through implementation of ullage audit research findings.

Estimation of Cluster Benefits

Eventually ullage audits and action plans will cover all industry supply chains. AECL research is planned through to 2008. In 2007 outcomes have been implemented across one of the large supermarket chains which accounts for sales of approximately 15 million dozen eggs per annum. From 2009 these benefits will be available to the other large supermarket chain, which accounts for estimated sales of 20 million eggs per annum. By 2011 the balance of the supply chain (sales of 32.5 million dozen pa) will have adopted research outcomes.

Industry advice is that implementation of ullage research outcomes has resulted in a decrease in average ullage rates of 0.5%. The benefit includes allowances for both high ullage and low ullage Australian states (longer and shorter supply chains) and parts of this supply chain where only some of the research results are applicable. For example interstate egg transport has always been on pallets stacked to a maximum of 5 cartons high and one supermarket chain has always used 5 carton stacking as a specification for all its transportation. The benefit of implementing ullage research is quantified using the following data:

- The research is implemented by a single grocery/retail supply chain with sales of approximately 15 million dozen eggs pa in 2007 (stage one implementation), the second grocery/retail supply chain supplying 20 million dozen eggs adopts research findings in 2009 (stage two implementation) and the rest of the sector adopts in 2011 (stage three implementation).
- Reduction in ullage rate of 0.5% i.e. average ullage rate decreases from 3% to 2.5%.
- The farm gate value of eggs no longer cracked or broken through the supply chain is $1.62 dozen.

The annual producer benefit from implementing ullage research findings is $121,500 pa in 2007, an additional $162,000 pa in 2009 and a further $263,250 pa in 2011.

Estimating Cluster Costs

Research Costs

Research costs total $196,079 (see Table 1) and were incurred by levy payers in 2004/05.

Implementation Costs

Costs associated with implementing ullage audit outcomes including extension of finds to stages two and three include:

1. Establishment and ongoing operation of AECL's Supply Chain Enhancement Industry Consultative Committee (ICC). The ICC ensures research recommendations are relevant to industry and advises on their implementation.
   - Annual costs for ICC operation are $7,500. The ICC will operate for the period through to at least 2011.
2. Pallet wrapping with a tested and approved proprietary film to prevent cartons absorbing moisture.
   - Purchase of an appropriate wrapping machine in year one of implementation of each stage (2007, 2009 and 2011) at $50,000 per unit. Operating costs for film for the new machines are less than current carton wrapping costs. No ongoing additional operating cost is incurred.
   - Stage one implementation requires 3 machines, stage two requires 4 machines and stage three, for smaller individual supply chains, uses hand application of the new approved proprietary film and no machines are purchased.
3. Upsizing egg cartons for jumbo (>70g) eggs.

- Large eggs which account for 1% of production are simply packed in existing 'ten packs' rather than the traditional dozen pack. No additional cost is incurred.

4. Egg boxes not handled as fragile.
   - Artwork on boxes modified at a very minor cost to better emphasis the fragile nature of the product.
5. Pallet stacking to a maximum of 5 rows.
   - Pallet stacking to a maximum of 5 rows reduces transport pallet averages from 48 to 40 and adds 0.6 cents per dozen to the cost of transport in the supply chain.
   - Stage one implementation will result in an additional annual cost of $90,000, stage two additional transport cost will be zero – this supply chain already employs 5 row stacking and stage three will be $195,000.

Significant costs are incurred to implement the ullage research cluster.

Testing the Cluster Counterfactual

The counterfactual, the benefit that would have been produced if investment in the project had not been made, is tested through the following questions.

Would the research have occurred without AECL investment (i.e. does the research address a market failure)?

The research addresses a market failure. There was no incentive for the links in the supply chain (grading, transport, distribution centre and store) to research and address the causes of ullage on their own. Ullage costs were simply passed back to producers who accepted reduced payments as part of the cost of doing business. It is possible that some of the larger producers in the industry may have undertaken ullage reduction work on their own. However, research outcomes would not be available to the whole industry and producers, acting on their own, would have been less likely to secure the through chain cooperation secured by AECL and its Supply Chain Enhancement Industry Consultative Committee.

Were the benefits simply brought forward as a result of AECL investment?

No there is insufficient incentive for the research to be completed, and available for the whole industry, outside the current funding model.

Has an efficient use of funds occurred because of the funding model/public private partnership?

An efficient use of funds has occurred because of the public private partnership funding model. The presence of matching public monies has provided incentive for an industry levy and investment in projects of this nature. In the absence of the current model, it is likely that the research findings would only be available to the industry's larger players and the benefits generated would have been at a lower level.

Is AECL an efficient model for research delivery?

AECL is an efficient model for research delivery. In this instance AECL was able to work with the researcher to scope an appropriate project that delivered outcomes of benefit to industry. Research cost was a relatively modest $196,000.

Does the presence of AECL increase the resultant adoption rate?

Yes the presence of AECL increases resultant adoption rates. Research outcomes are developed and communicated through AECL's Supply Chain Enhancement Industry Consultative Committee.

Would the research have been completed overseas and been available to Australia anyway?

The project addressed an 'Australia specific' supply chain issue. The causes of ullage, in this instance, were unique to Australian supply chain conditions.

Would substitute technologies have been developed?

The research was about auditing existing practices/technologies and applying 'off the shelf' solutions. Overseas substitute technologies would not have been possible in this instance. With this said, proprietary pallet wrap film, developed overseas, was applied as part of the ullage reduction solution.

Are there sufficient incentives for voluntary groups to get together and complete the research?

While it is possible that voluntary producer groups may have got together and completed the research it is less likely that research outcomes would have been available to other supply chains or that voluntary producers would have secured the same level of supply chain support. AECL was instrumental in securing participation throughout the various links of the supply chains researched.

Additionality

Additionality refers to the spillovers that are conditional on public support for AECL. In this instance it is unlikely that the spillover benefits realised would be available in the absence of a levy, smaller producers would simply have 'missed out' and resultant human health benefits, realised through removal of cracked and potentially contaminated eggs, would have been realised at a lower level. However, a levy without matching government funds may still have been sufficient to ensure the project was completed.

Capacity/Incentive to Invest in Absence of Levy and Public Contribution

Given the commercial nature of outcomes from this research, i.e. additional returns to producers who lower ullage rates, this research might well have been completed in the absence of a public contribution.

Results and Sensitivity Testing

Project cost benefit analysis was completed using the Guidelines for Evaluation (May 2007) prepared by the CRRDCC. Results are summarised in Table 6.3.

Table 6.3: Cost Benefit Analysis, Ullage Audit, Solutions Development, Implementation

Key Parameter	Net Present Value (5% real discount rate)	Benefit Cost Ratio (1:x)	Internal Rate of Return (%)	Cost (present value of all funds invested)
Low ullage rate reduction 0.25%	$2.3 million	0.79	0%	$3.0 million
Mean ullage rate reduction 0.5%	$4.7 million	1.59	37%	$3.0 million
High ullage rate reduction 1%	$9.4 million	3.18	123%	$3.0 million

Source: AgEconPlus analysis

The project yields a favourable result for industry. A Net Present Value (NPV) for industry of $4.7 million is realised using the 'core' data set and a real discount rate of 5%. Ullage savings made by producers are greater than the costs incurred for research and the costs incurred by the supply chain, which will be passed back to producers, for implementation.

The sensitivity of this result to changes in 'core' data is also shown in Table 3. A halving of the improvement in ullage reduction attributable to this project (i.e. a reduction in ullage rates from 3% to only 2.75%) results in a negative outcome for industry – costs exceed benefits. For the project to break even a minimum ullage reduction rate of 3% is required.

Conclusion

Ullage auditing, solutions development and implementation generates a positive return for Australian egg producers.

7. Review Conclusions

The cost benefit analyses have not been able to quantify all R&D benefits to levy paying producers or the public (spillover) benefits. Where this has not been possible a detailed description of the benefit (or cost) item has been provided. However, in all instances benefits to the main beneficiary have been quantified with a measure of accuracy. Cost benefit analysis results for the four clusters are summarised in Table E.1 with the main beneficiary of the research noted and the quantum of benefit shown.

Table E.1 Cluster Evaluation Results – AECL R&D Program

Cluster	BCR (1:x)	Levy Payer NPV ($'million)	Public Spillover NPV ($'million)	Total NPV ($'million)
Salmonella	1.4	0	15	15
Cannibalism	117.0	43	0	43
Sensory	23.6	42	0	42
Ullage	1.6	8	0	8

Source: AgEconPlus analysis

Total producer levy payer investment in R&D since AECL inception in 2003 has been approximately $3.5 million. Any one of these research clusters (up to five projects in a portfolio of approximately eighty) has been sufficient to justify this investment. Total Australian Government investment in egg R&D channelled through AECL has been of a similar magnitude to levy payers (funds are matched dollar for dollar). Benefits received by the Australian community through improved health outcomes associated with the Salmonella control cluster, on its own, has been sufficient to justify public investment.

Projects, such as the Salmonella control cluster, with a primary focus on spillover benefits would not be funded outside current levy arrangements.

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Contract Appendix ProCorp Grading Floor

Contract Appendix ProCorp Distribution Centre

Contract Appendix ProCorp Audit Coles BiLo

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