Australian Government

Biosecurity Australia

Generic Import Risk Analysis Report for Chicken Meat

Final Report

Part B

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Foreword

This import risk analysis report is issued in four parts:

- Part A contains a brief summary of the import risk analysis (IRA).
- Part B contains background material, an explanation of the method used in the IRA, and a report of the Hazard identification and Hazard refinement steps.
- Part C contains the detail of the assessments for each of the identified hazards, together with the proposed risk management measures, and Health Certification requirements.
- Part D contains appendices with comments received from stakeholders in earlier stages of the risk analysis process, and further explanatory or background material.

This document is Part B

It contains background material on access requests for chicken meat, and on Australia's rights and obligations in accordance with the World Trade Organisation (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). Part B also contains background material on the potentially affected Australian industries. The method used for the risk analysis is explained in detail, including sections on the hazard identification and hazard refinement steps, and presents the conclusions of the hazard refinement process. Finally Part B contains an explanation of the method used in the risk assessment process.

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Glossary of Terms and Abbreviations

AAHL	Australian Animal Health Laboratory
AAS	Avian adenovirus splenomegaly
ABARE	Australian Bureau of Agricultural and Resource Economics
ABPM	Animal Biosecurity Policy Memorandum
ACMF	Australian Chicken Meat Federation
ACT	Australian Capital Territory
AECL	Australian Egg Corporation Limited
AEIA	Australian Egg Industry Association (now AECL)
AGID	Agar Gel Immunodiffusion Test
AI	Avian influenza
ALOP	Appropriate Level of Protection
AMPV	Avian metapneumovirus
APMV	Avian paramyxovirus
AQIS	Australian Quarantine and Inspection Service
AQPM	Animal Quarantine Policy Memorandum
AQRC	Australian Quarantine Review Committee
ARAZPA	Australian Regional Association of Zoological Parks and Aquaria
AUSVETPLAN	Australian Veterinary Emergency Plan
BA	Biosecurity Australia, a prescribed agency within the Agriculture, Fisheries and Forestry portfolio
BAPM	Biosecurity Australia Policy Memorandum
BP	Backyard poultry (refers to the low biosecurity poultry exposure group)
CELO	Chicken Embryo Lethal Orphan (virus)
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CP	Commercial poultry (refers to the medium biosecurity commercial poultry exposure group)
DAFF	Australian Government Department of Agriculture, Fisheries and Forestry
DEW	Australian Government Department of the Environment and Water Resources – formerly the Department of Environment and Heritage (DEH)
DEWHA	Australian Government Department of the Environment, Water, Heritage and the Arts (formerly DEW)
DIVA	Differentiating Infected from Vaccinated Animals
DoHA	Australian Government Department of Health and Ageing
EAD	Emergency animal disease
EDS	Egg Drop Syndrome
EEE/WEE/VEE	Eastern, Western and Venezuelan equine encephalomyelitis
EHEC	Enterohaemorrhagic *Escherichia coli*
EID	Egg infectious dose
EMS	Environmental Management Services

EPA	Environmental Protection Authority
EU	European Union
FAdV	Fowl adenovirus
FAO	Food and Agriculture Organization of the United Nations
FSANZ	Food Standards Australia New Zealand
FSC	Australia New Zealand Food Standards Code
Generic IRA	An import risk analysis relevant to all exporting countries. The generic IRA does not consider the disease status or data of individual countries, but is based on estimates of the most likely situation in an hypothetical infected country. Country-specific data may be considered at a later date should appropriate data from prospective exporting countries be supplied.
HA	Haemagglutinin
HEV	Haemorrhagic Enteritis virus
HI	Haemagglutination Inhibition
HP	Highly pathogenic
HPNAI	Highly Pathogenic Notifiable Avian Influenza
HPS	Hydropericardium syndrome
IBDV	Infectious Bursal Disease Virus
IBV	Infectious Bronchitis virus
ID	Infectious dose
IgG	Immunoglobulin G
IgM	Immunoglobulin M
ILT	Infectious Laryngotracheitis
ICPI	Intra-cerebral pathogenicity index
IVPI	Intravenous pathogenicity index
ICON	AQIS Import Conditions database
IPPC	International Plant Protection Convention
IRA	Import risk analysis
JE	Japanese encephalitis
LPNAI	Low pathogenicity notifiable avian influenza (H5 and H7 subtypes)
LPAI	Low pathogenicity avian influenza (subtypes other than H5 and H7)
MDCK	Madin-Darby Canine Kidney II (MDCK II) cells (cell-culture)
MOU	Memorandum of understanding
MSDV	Marble Spleen Disease virus (of pheasants)
NAHIS	National Animal Health Information System
NAI	Notifiable avian influenza
NAMAC	National Arbovirus and Malaria Advisory Committee – a subcommittee of Communicable Diseases Australia within the Department of Health and Ageing
NAQS	Northern Australia Quarantine Strategy
NAS	Non-avian species
NDV	Newcastle Disease virus
NSW	New South Wales

NT	Northern Territory
OIE	World Organisation for Animal Health (formerly known as the Office International des Epizooties)
OIE Code	OIE Terrestrial Animal Health Code
PALEEES	Partial annual likelihood of entry, exposure, establishment and spread
PAREEES	Partial annual risk of entry, exposure, establishment and spread
PCR	Polymerase chain reaction
PLE	Partial likelihood of exposure
PLEEES	Partial likelihood of entry, exposure, establishment and spread
PLES	Partial likelihood of establishment and spread
PRNT	Plaque reduction neutralisation test
RIRDC	Rural Industries Research and Development Corporation
RT-PCR	Reverse transcriptase-polymerase chain reaction
SCARM	Standing Committee on Agriculture and Resource Management
SPA	Serum plate agglutination
SPF	Specific pathogen free
SPS	Sanitary and Phytosanitary
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures
TWG	Technical Working Group
USA	United States of America
USDA-FSIS	United States Department of Agriculture Food Safety and Inspection Service
WB	Wild Birds (refers to the wild birds exposure group)
WNV	West Nile Virus
WTO	World Trade Organization

Introduction

This section outlines:

- The legislative basis for Australia's biosecurity regime
- Australia's international rights and obligations
- Australia's appropriate level of protection and risk management
- Import risk analysis
- Policy determination

Australian Legislation

The *Quarantine Act 1908* and its subordinate legislation, including the *Quarantine Proclamation 1998*, administered by the Australian Government Department of Agriculture, Fisheries and Forestry (DAFF), provide the legislative basis of human, animal and plant biosecurity in Australia.

Some key provisions are set out below.

Quarantine Act: Scope

Subsection 4 (1) of the *Quarantine Act 1908* defines the scope of quarantine as follows.

In this Act, quarantine includes, but is not limited to, measures:

(a) for, or in relation to:

> *(i) the examination, exclusion, detention, observation, segregation, isolation, protection, treatment and regulation of vessels, installations, human beings, animals, plants or other goods or things; or*
>
> *(ii) the seizure and destruction of animals, plants, or other goods or things; or*
>
> *(iii) the destruction of premises comprising buildings or other structures when treatment of these premises is not practicable; and*

(b) having as their object the prevention or control of the introduction, establishment or spread of diseases or pests that will or could cause significant damage to human beings, animals, plants, other aspects of the environment or economic activities.

Section 5D of the *Quarantine Act 1908* covers the level of quarantine risk.

A reference in this Act to a level of quarantine risk is a reference to:

(a) the probability of:

> *(i) a disease or pest being introduced, established or spread in Australia or the Cocos Islands; and*
>
> *(ii) the disease or pest causing harm to human beings, animals, plants, other aspects of the environment, or economic activities; and*

(b) the probable extent of the harm.

Section 5D of the *Quarantine Act 1908* includes harm to the environment as a component of the level of quarantine risk.

Environment is defined in Section 5 of the *Quarantine Act 1908,* in that it:

includes all aspects of the surroundings of human beings, whether natural surroundings or surroundings created by human beings themselves, and whether affecting them as individuals or in social groupings.

Quarantine Proclamation

The *Quarantine Proclamation 1998* is made under the *Quarantine Act 1908*. It is the principal legal instrument used to control the importation into Australia of goods of quarantine (or biosecurity) interest. The Proclamation empowers a Director of Quarantine to grant a permit to import.

Section 70 of the *Quarantine Proclamation 1998* sets out the matters to be considered when deciding whether to grant a permit to import:

Things a Director of Quarantine must take into account when deciding whether to grant a permit for importation into Australia

(1) In deciding whether to grant a permit to import a thing into Australia or the Cocos Islands, or for the removal of a thing from the Protected Zone or the Torres Strait Special Quarantine Zone to the rest of Australia, a Director of Quarantine:

> *(a) must consider the level of quarantine risk if the permit were granted; and*
>
> *(b) must consider whether, if the permit were granted, the imposition of conditions on it would be necessary to limit the level of quarantine risk to one that is acceptably low; and*
>
> *(c) for a permit to import a seed of a kind of plant that was produced by genetic manipulation – must take into account any risk assessment prepared, and any decision made, in relation to the seed under the Gene Technology Act; and*
>
> *(d) may take into account anything else that he or she knows that is relevant.*

Development of Biosecurity Policy

As can be seen from the above extracts, the legislation establishes the concept of the level of biosecurity (quarantine) risk as the basis of decision-making under Australian quarantine legislation.

Import risk analyses (IRAs) are a significant contribution to the information available to the Director of Animal and Plant Quarantine – a decision maker for the purposes of the Quarantine Act and the Quarantine Proclamation. Import risk analysis (IRA) is conducted within an administrative process – known as the IRA process. Changes to the import risk analysis process announced by the Australian Government in late 2006 were implemented on 5 September 2007, when regulations made under the Quarantine Act 1908 formally took effect. Under transitional arrangements, announced in Biosecurity Australia Policy Memorandum 2007/20, a number of

IRAs (including the chicken meat IRA) which were well underway or nearly complete, will be finished under the pre-regulated process, as described in the IRA Handbook 2003[1].

The purpose of the IRA process is to deliver a policy recommendation to the Director of Animal and Plant Quarantine that is consistent with Government policy and which is characterised by sound science and by transparency, fairness and consistency.

What is Import Risk Analysis?

For the purposes of animal and plant biosecurity, an IRA identifies the pests and diseases relevant to an import proposal, assesses the risks posed by them and, if those risks are unacceptable, specifies the measures that could be taken to reduce those risks to an acceptable level. These analyses are conducted via an administrative process (described in the *IRA Handbook 2003*) that involves, among other things, notification to the World Trade Organisation (WTO), consultation and appeal.

When are IRAs undertaken?

Biosecurity Australia may undertake an IRA if:

- there is no relevant existing biosecurity measure for the commodity and pest/disease combination; or
- a variation in established policy is desirable because pests or diseases, or the likelihood and consequences of entry, establishment and spread of the pests or diseases could differ significantly from those previously assessed.

Environment and Human Health

When undertaking an IRA, the Quarantine Act requires the Director of Animal and Plant Quarantine to ensure that environmental factors are considered in the decision-making process. A memorandum of understanding (MOU) is in place between Biosecurity Australia and the Department of Environment and Water Resources (now the Department of Environment, Water, Heritage and the Arts (DEWHA)) to facilitate input of advice on environmental matters in IRAs.

In the preparation of this IRA report, Biosecurity Australia consulted with the Australian Government Department of Health and Ageing (DoHA) and Food Standards Australia New Zealand (FSANZ) on the assessments for zoonotic pests or diseases that may establish in Australia's animal population through the importation of chicken meat. In relation to human health and food safety issues, the Australian Chief Medical Officer has advised Biosecurity Australia (in the course of discussion on the draft IRA report released in 2006) that officers of DoHA "…are satisfied that the list of pathogens considered in the risk assessment is complete, and that adequate provisions have been made for imported chicken meat to comply with the Food Standards Code. The officers are satisfied that there are no issues in this risk assessment that are not food related and that the management measures proposed by Biosecurity Australia to meet animal health concerns are appropriate to meet human health concerns". A number of issues raised by stakeholders after release of the draft IRA report relate to matters of human health. These were referred to DoHA for their consideration. The Eminent Scientists Group

[1] Agriculture, Fisheries and Forestry - Australia (2003) *Import Risk Analysis Handbook*, Canberra

(ESG) subsequently recommended that the matters raised by stakeholders could be more adequately addressed by DoHA.

Biosecurity Australia has advised DoHA and FSANZ that it will continue to keep them informed of the progress of the IRA, and of any permit applications to AQIS to import uncooked and cooked chicken meat following finalisation of the IRA for their consideration.

The IRA process in summary

The process consists of the following major steps:

***Initiation*:** This is the stage where the identified need for an IRA originates.

***Scheduling and Scoping*:** At this stage, Biosecurity Australia considers all the factors that affect scheduling. Consultation with States, Territories and other Commonwealth agencies is involved. There is opportunity for appeal by stakeholders at this stage.

***Risk Assessment and Risk Management*:** Here, the major scientific and technical work relating to risk assessment is performed. There is detailed consultation with stakeholders.

***Reporting*:** Here, the results of the IRA are communicated formally. There is consultation with States and Territories, and the Eminent Scientists Group. The Chief Executive of Biosecurity Australia then releases the final IRA report for a 30 day appeal period. After completion of the appeal process, the IRA report and the policy recommendations are provided to the Director of Animal and Plant Quarantine for a policy determination.

Policy Determination

The Director of Animal and Plant Quarantine makes the policy determination, which is notified publicly.

Australia's International Rights and Obligations

Biosecurity restrictions on imports must conform with Australia's rights and obligations as a WTO Member country. These rights and obligations derive principally from the WTO's *Agreement on the Application of Sanitary and Phytosanitary Measures* (SPS Agreement), although other WTO agreements may also be relevant. Specific international guidelines on risk analysis developed under the International Plant Protection Convention (IPPC) and by the World Organization for Animal Health (OIE) are also relevant.

The SPS Agreement recognises the right of WTO Member countries to determine the level of sanitary and phytosanitary protection they deem appropriate, and to take the necessary measures to achieve that protection. Sanitary (human and animal health) and phytosanitary (plant health) measures typically apply to trade in or movement of animal and plant based goods within or between countries. The SPS Agreement applies to all SPS measures that may directly or indirectly affect international trade. An SPS measure is any measure applied to protect human, animal or plant life or health within the Territory of a Member from risks arising from the entry of pests/diseases or from contaminants in food. An SPS measure may also be applied to limit other damage within the Territory of a Member from the entry of a pest.

The SPS Agreement provides, *inter alia*, for the following:

- A WTO Member country has the right to determine the level of sanitary and phytosanitary protection it deems appropriate (designated the appropriate level of protection, or ALOP)
- An importing Member has the sovereign right to take measures to achieve the level of protection it deems appropriate to protect human, animal or plant life or health within its territory
- An SPS measure must be based on scientific principles and must not be maintained without sufficient scientific evidence
- An importing Member must avoid arbitrary or unjustifiable distinctions in the levels of protection it considers to be appropriate in different situations, if such distinctions result in discrimination or a disguised restriction on international trade
- An SPS measure must not be more trade restrictive than required to achieve an importing Member's ALOP, taking into account technical and economic feasibility
- An SPS measure should be based on relevant international standards, guidelines or recommendations where these exist, unless there is a scientific justification for a stricter measure, or unless a stricter measure is required in order to achieve the importing Member's ALOP
- An SPS measure conforming to an international standard, guideline or recommendation is deemed to be necessary to protect human, animal or plant life or health, and to be consistent with the SPS Agreement
- Where a relevant international standard, guideline or recommendation does not exist or where, in order to achieve an importing Member's ALOP, a measure needs to provide a higher level of protection than accorded by the relevant international standard, such a measure must be based on a risk assessment; the risk assessment must take into account available scientific evidence and relevant economic factors
- Where risk assessment is required, risk assessment techniques developed by the relevant international organisations must be taken into account
- Where the relevant scientific evidence is insufficient, an importing Member may provisionally adopt SPS measures on the basis of available pertinent information; but in such circumstances, Members shall seek to obtain the additional information necessary for a more objective assessment of risk and review the SPS measure accordingly within a reasonable period of time
- An importing Member shall accept the measures of other countries as equivalent, if it is objectively demonstrated that the measures achieve the importing Member's ALOP
- An importing member shall recognise the concepts of pest- or disease-free areas and areas of low pest or disease prevalence, and shall take into account, inter alia, the level of prevalence of specific diseases or pests, the existence of eradication or control programmes, and appropriate criteria and guidelines which may be developed by the relevant international organisations.

Australia's Appropriate Level of Protection (ALOP)

The SPS Agreement defines the concept of an 'appropriate level of sanitary or phytosanitary protection (ALOP)' as the level of protection deemed appropriate by the WTO Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory.

Like many other countries, Australia expresses its ALOP in qualitative terms. Australia's ALOP, which reflects community expectations through government policy, is expressed as providing a high level of sanitary or phytosanitary protection whereby risk is reduced to a very low level, but not to zero. This definition of ALOP, and its illustration by way of the risk estimation matrix shown below in Figure1, was endorsed by Primary Industries Ministerial Council on 2 May 2002 (Primary Industries Ministerial Council 2002).

Figure 1. Risk estimation matrix

Likelihood of entry, exposure, establishment and spread	Consequences of entry, exposure, establishment and spread					
	Negligible impact	*Very low*	*Low*	*Moderate*	*High*	*Extreme impact*
High likelihood	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Moderate	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Low	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk	High risk
Very low	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk
Extremely low	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk
Negligible likelihood	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk

NOTE: The band of cells in Table 1 marked 'very low risk' represents Australia's ALOP.

The cells of the risk estimation matrix contain the qualitative descriptors which apply to the product of different degrees of likelihood[2] and different levels of consequences — termed 'risk'. When interpreting the risk estimation matrix, it should be remembered that, although the descriptors for each axis are similar ('low', 'moderate', 'high' etc), the vertical axis refers to *likelihood* and the horizontal axis refers to *consequences*.

[2] The terms "likelihood" and "probability" are synonymous. "Probability" is used in the *Quarantine Act 1908* while "likelihood" is used in the WTO SPS Agreement. These terms are used interchangeably in this IRA report.

Risk Management and SPS Measures

Australia's animal and plant health status is maintained through the implementation of measures to facilitate the importation of products while protecting the health of people, animals and plants.

Australia bases its national measures on international standards where they exist and where they deliver the appropriate level of protection from pests and diseases. However, where such standards do not achieve Australia's level of biosecurity protection, or relevant standards do not exist, Australia exercises its right under the SPS Agreement to take appropriate measures, justified on scientific grounds and supported by risk analysis.

Proposal to import chicken meat

This IRA is being undertaken in response to requests from the Governments of Denmark, New Zealand, Thailand, the United States of America (USA), Malaysia, China, and Brazil for access for chicken meat into Australia. However, the outcomes of this IRA will be applicable to the importation to Australia of chicken meat from any country.

Until relatively recently, the importation of live birds, poultry meat and most poultry products into Australia was prohibited. Only canned poultry products, which met specified requirements in their preparation, were permitted. Conditions for cooked uncanned poultry meat from New Zealand, which has a similar disease status to Australia, were promulgated on 12 December 1989. Conditions for the import of cooked uncanned chicken meat from the USA, Denmark and Thailand were developed in 1998. To date, no imports have occurred under these conditions. The import of fresh or frozen chicken meat is currently not allowed from any country.

Administration of the IRA Process

Timetable

The steps to complete this IRA are listed in the section 'Further Steps in the Import Risk Analysis Process' later in this document.

Progress Reports

Progress of the present IRA has been notified to stakeholders as follows:

Animal Quarantine Policy Memorandum (AQPM) 1998/97 of 10 December 1998 announced commencement of the IRA and sought comment on the proposed approach to the IRA. Subsequently it was decided, taking the comments received into account, that the IRA should be conducted using the approach which was then referred to as 'non-routine'. This approach required the formation of a Risk Analysis Panel (now referred to as the Import Risk Analysis team) which would include expert members from outside Biosecurity Australia. AQPM 1999/68 of 11 October 1999 invited comment on the scope of the IRA and membership of the risk analysis panel to undertake the IRA. After consideration of comments received, the Executive Director of the Australian Quarantine and Inspection Service (AQIS) confirmed the approach for this IRA and nominated members for the IRA team. This decision was notified to stakeholders in AQPM 2000/23 of 28 April 2000. Appeals were received concerning the membership of the team. After due consideration, these were not upheld by the Secretary of the Department of Agriculture, Fisheries and Forestry (DAFF) and stakeholders were advised of this in AQPM 2000/34 on 19 July 2000.

Animal Biosecurity Policy Memorandum (ABPM) 2000/43 of 11 September 2000 reported on progress of the IRA, including the first meeting of the IRA team on 1 August 2000. The uncooked chicken meat IRA *Issues Paper* was released for public comment in July 2001, under ABPM 2001/16. Comments received from stakeholders in response to the *Issues Paper* are included in this *IRA Report* in Part D at Appendix 1. A further report (ABPM 2002/22)

was issued in May 2002, outlining progress of the IRAs of eggs and egg products and chicken meat. In January 2003, the *draft Method for Risk Assessment* was released to stakeholders, under cover of ABPM 2003/01. Comments received in response to the *draft Method for Risk Assessment* are included in Part D at Appendix 2.

In April 2006, Biosecurity Australia Policy Memorandum (BAPM) 2006/10 advised stakeholders of the revised IRA team membership, with Dr Mike Nunn being appointed as Chair of the IRA team after the death of David Banks in 2005. Dr Robyn Martin, General Manager of Animal Biosecurity, also joined the IRA team.

The draft IRA report was released for stakeholder comment in June 2006 under BAPM 2006/18. In response to requests from some stakeholders, in August 2006 BAPM 2006/22 announced a one month extension to the comment period. BAPM 2006/30, issued in October 2006, informed stakeholders that the comment period had closed and that Biosecurity Australia had received 21 submissions from stakeholders, and advised of the next steps in the IRA process leading to publication of the final IRA report.

Scope

This IRA considers quarantine risks that may be associated with the importation to Australia of uncooked chicken meat from any country. The IRA will include assessment of all potential disease agents that may be introduced to Australia via the importation of chicken meat, and risk management options, which may include cooking and other meat processing techniques. It has been prepared in response to applications made by Denmark, USA, Thailand, New Zealand, Brazil, China and Malaysia, seeking access for chicken meat into Australia.

In this IRA, chicken meat is defined as:

'the whole or part of the carcass of any domestic chicken (Gallus gallus) (but excluding the head, feathers, and all offal other than the liver, heart, gizzard, neck and feet), which has been slaughtered in an abattoir that meets standards at least equivalent to those contained in the 'Australian Standard for Construction of Premises and Hygienic Production of Poultry Meat for Human Consumption' (Food Regulation Standing Committee 2006).

In accordance with the SPS Agreement, IRAs assess risks to human, animal and plant life or health. Under Australian administrative arrangements, Biosecurity Australia provides advice to the Director of Animal and Plant Quarantine in relation to the life or health of animals and plants, while risks to human health are the responsibility of DoHA. Risks to human health associated with the consumption of imported chicken meat or chicken meat products are assessed by FSANZ. Biosecurity Australia consulted with DoHA and FSANZ on public health issues and with DEWHA in relation to environmental issues associated with the importation of chicken meat, during the preparation of this IRA.

Imported chicken meat must comply with the Imported Food Control Act 1992 and the Australia New Zealand Food Standards Code (FSC) in its entirety. Under the Imported Food Control Act 1992, AQIS may inspect, or inspect and conduct an analysis of imported chicken meat to determine its compliance with the FSC. Details of inspections and analyses currently required under the Imported Food Control Act were notified to industry in Imported Food Notice 03/08. A copy of this notice, so far as is relevant to the import of chicken meat, is reproduced in Part D at Appendix 3.

In relation to human health and food safety issues, the Australian Chief Medical Officer has advised Biosecurity Australia (in the course of discussion on the draft IRA report released in 2006) that officers of DoHA "..are satisfied that the list of pathogens considered in the risk assessment is complete and that adequate provisions have been made for imported chicken meat to comply with the Food Standards Code. The officers are satisfied that there are no issues in this risk assessment that are not food related and that the management measures proposed by Biosecurity Australia to meet animal health concerns are appropriate to meet human health concerns". A number of issues raised by stakeholders after release of the draft IRA report relate to matters of human health. These were referred to DoHA for their consideration.

Biosecurity Australia has consulted with DEWHA in relation to risks to the environment associated with the importation of chicken meat. A summary of disease agents identified as hazards in uncooked chicken meat, and their potential effects on native Australian wildlife species, has been included in Part D at Appendix 4. Appendix 4 was provided at the request of DEWHA and is intended as a guide for that Department in assessing whether they would require further risk assessment over and above that proposed by Biosecurity Australia for animal production reasons. The Appendix summarises the hosts which are known to be susceptible to the disease agent, the possible clinical effects in native wildlife, and whether or not the IRA is recommending risk management for this disease agent.

Import Risk Analysis team

The membership of the IRA team is as shown in Table 1 below.

Technical Working Groups

The members of the IRA team appointed three Technical Working Groups (TWGs) to assist with the preparation of this IRA. The TWGs were comprised of experts with particular knowledge and expertise relevant to consideration of the risks posed by the following disease agents:

- Newcastle disease virus
- Infectious bursal disease virus (IBDV)
- Bacterial pathogens.

Where, during the consideration of the above mentioned disease agents, the IRA team felt that the scientific information available to them was insufficient or inconclusive, the members of the relevant TWG were requested to provide their expert opinion, and the reasoning or relevant reference material that led them to hold those opinions. The members of the IRA team considered all responses received from the TWG members, as well as all other information available to them, in making their assessments.

The membership of the TWGs for Newcastle disease, infectious bursal disease and bacterial pathogens are shown in Tables 2, 3, and 4 respectively.

Table 1. Membership of the IRA team.

Name	Organisation/Position	Expertise
Dr Mike Nunn (Chair 2005-)	Biosecurity Australia – Principal Scientist Animal Biosecurity	Animal health policy advice and scientific analysis
Dr Robyn Martin	Biosecurity Australia – General Manager Animal Biosecurity	Animal quarantine policy / practice
Dr David Banks (Chair 2000–2005)	Biosecurity Australia	Animal quarantine policy / practice
Dr Andrew Turner	Consultant	Avian and viral diseases, exotic disease control
Dr Harvey Westbury	Australian Animal Health Laboratory (AAHL)	Avian disease, virology, epidemiology and poultry research Resigned in December 2002
Professor Peter Coloe	Royal Melbourne Institute of Technology University	Food microbiology
Dr Paul Gilchrist	Consultant	Avian and viral diseases

Table 2. Newcastle Disease Virus TWG

Name	Organisation/Position
Dr Andrew Turner *(Chair)*	Chicken meat IRA team member
Dr Clive Jackson	Poultry disease consultant
Dr Dennis Alexander	Virologist with expertise in Newcastle disease – United Kingdom
Professor Peter Spradbrow	Veterinary virologist with expertise in Newcastle disease

Table 3. Infectious Bursal Disease Virus TWG

Name	Organisation/Position
Dr Paul Gilchrist *(Chair)*	Chicken meat IRA team member
Professor Joseph Giambrone	Professor of Poultry Science, Auburn University, United States, with expertise in IBDV
Dr Tom Grimes	Poultry disease consultant
Dr Jagoda Ignjatovic	Virologist with expertise in IBDV, AAHL

Table 4. Bacterial Pathogens TWG

Name	Organisation/Position
Professor Peter Coloe *(Chair)*	Chicken meat IRA team member
Professor Tom Humphrey	Microbiologist with expertise in *Salmonella* – United Kingdom
Professor Alan Frost	Veterinary microbiologist
Dr Marion Healy	FSANZ
Ms Dianne Davos	Australian Salmonella Reference Laboratory
Dr Glenn Browning	Deputy Dean, University of Melbourne Veterinary Faculty; bacteriology expertise

Other associated research

Biosecurity Australia commissioned a member of the IRA team to conduct a literature review covering the susceptibility of migratory waterfowl and other native and feral bird species to avian influenza virus, Newcastle disease virus (NDV) and IBDV (Gilchrist 2005). This information is relevant to the assessment of likelihood of establishment and spread of these viruses, following possible importation with chicken meat. Copies of the original literature reviews are available from Biosecurity Australia on request.

Biosecurity Australia commissioned research to be undertaken at the Australian Animal Health Laboratory (AAHL) in Geelong, on the transmissibility of IBDV in chicken meat derived from commercial vaccinated meat chickens. The results of this research were taken into account in assessing the risks associated with IBDV in imported chicken meat. Copies of the reports of this work are available from Biosecurity Australia on request.

Following consideration of comments received from stakeholders on the draft IRA report, Biosecurity Australia has commissioned research into the inactivation of avian influenza viruses. The risk management recommendations in this report for HPAI and LPNAI will be considered in light of the research findings.

Ensuring consistency within and between IRAs

To assist in ensuring consistency of approach within and between IRAs, Biosecurity Australia arranged for members of the IRA team to attend a workshop covering the administrative process and technical methods to be used for this IRA, before formally commencing work on the risk analysis. In addition to the members of the chicken meat IRA team, this workshop included members of other IRA teams who were commencing work at around the same time.

Where there were issues of relevance to more than one IRA, the IRA team held joint IRA team meetings, as a further means of ensuring consistency of approach. During the period of preparation of the *draft IRA report*, the IRA team met jointly with the IRA team for eggs and egg products, and also with the IRA team for live psittacine birds.

In 2002, members of the chicken meat and egg and egg products IRA teams undertook visits to poultry establishments and processing plants in South Australia, in order to ensure that members of the teams had a contemporary view of poultry industry processes and practices.

At all times, the IRA team remained aware of the need for consistency in the risk assessment, and where necessary had regard to the existing body of quarantine policy as a guide to interpretation of Australia's ALOP.

Australia's current quarantine policy for imports of chicken meat

Imports of cooked chicken meat from New Zealand have been permitted for a number of years, subject to conditions on the cooking temperature and time. Cooked chicken meat from New Zealand must have been cooked by a process sufficient to raise the minimum core temperature of the product to comply with one of the following time/temperature combinations:

- 70 °C for 30 minutes
- 75 °C for 5 minutes
- 80 °C for 1 minute.

Since August 1998, the importation of cooked chicken meat from Denmark, Thailand and the USA has been permitted, again subject to quarantine restrictions. Cooked chicken meat from Denmark, Thailand or the USA must have been cooked by a process sufficient to raise the minimum core temperature of the product to comply with one of the following time/temperature combinations:

- 74 °C for 165 minutes
- 75 °C for 158 minutes
- 76 °C for 152 minutes
- 77 °C for 145 minutes
- 78 °C for 138 minutes
- 79 °C for 132 minutes
- 80 °C for 125 minutes.

Uncooked chicken meat is not currently permitted from any country.

Domestic arrangements

The Australian Government is responsible for regulating the movement of animals and their products into and out of Australia, but the State and Territory Governments have primary responsibility for animal health controls within their jurisdictions. Legislation relating to resource management or animal health may be used by State and Territory government agencies to control interstate movement of animals and their products.

Chicken meat may move freely in trade between all States and Territories within Australia. Restrictions have existed from time to time, due to outbreaks of exotic disease such as virulent ND (in certain areas in New South Wales between 1998 and 2002 and in Victoria in 2002), or avian influenza (most recently in New South Wales in 1997). These outbreaks were managed by stamping out or, in the case of Newcastle disease, stamping out and vaccination.

The chicken meat industry in Australia

Industry Structure

Three large integrated companies account for about 80% of chicken meat production and processing (Australian Chicken Meat Federation 2005). The chicken meat industry is located in New South Wales (35%), Victoria (28%), Queensland (18%), South Australia (9%), Western Australia (9%), Tasmania (1 %) (Australian Chicken Meat Federation 2005). Most chicken meat production (both growing and processing) is located relatively close to the centres of consumption. In addition to the main areas around the capital cities, there is substantial regional production near Tamworth, Griffith and Newcastle in New South Wales, Mornington Peninsula, Geelong and Bendigo in Victoria, and Two Wells, Adelaide Hills and Murray Bridge in South Australia.

Contract Growing

Most chickens are grown under one of two systems – contract growing or company farms. Around 800 growers produce about 80% of total product under the contract system, which has been a feature of the industry for the past 30 years (Australian Chicken Meat Federation 2005).

Characteristics of this system are:

- Processor control of inputs and rearing specifications: processors own chickens and feed, and supply contract growers with day old chicks to be reared according to detailed specifications
- Rearing of chickens under contract: processors and contract growers enter into contracts. Growers are therefore independent contractors and not employees
- Contract growers rear the chickens and then the grown birds are picked up and transported to processing plants by the processors
- The rearing fee is a relatively small component of product costs; the cost of contract rearing contributes only 17% of the costs of producing a live meat chicken (Fairbrother 2004)
- Significant equity contributions by contract growers: these growers contribute approximately 40% of the capital investment in the industry through ownership of farms, sheds and other facilities.

Contract growing is capital intensive. Chicken growing sheds are highly specialised fixed assets and have virtually no alternative use. Stability and predictability in growing arrangements underpin investment in the industry.

Company Farms

Approximately 20% of birds are grown on farms owned and operated by processing companies.

Employment/Growth

Nationally, the chicken meat industry directly employs about 40,000 people, mainly in outer metropolitan and semi-rural areas. There is a strong industry connection with retail activity and outlets for chicken meat, including fast food, catering and restaurant sectors, with direct and indirect employment supported by the chicken meat industry accounting for around 120,000 jobs (Larkin et al. 2001).

Economic Data

The Australian Bureau of Agriculture and Resource Economics (ABARE) forward estimate for poultry meat production in 2007-08 was 847 kilotonnes (ABARE 2007). In 2005, Australian production was 817 kilotonnes (ABARE 2006). Chicken meat consumption per person is projected to increase to 39.1 kg per person in 2007-2008 (ABARE 2007).

Characteristics of Domestic Trade

The chicken meat industry produces a range of fresh, frozen and cooked products. Raw products in the form of fresh and frozen whole birds account for 50% of the market. Raw value-added products in the form of cut up chickens – breasts, legs, thighs and other specialty lines are produced both bone-in and de-boned for a total market share of 30%. Other value-added products include ready to cook and fully cooked products and represent 20% of the market (Jeff Fairbrother, Australian Chicken Meat Federation, personal communication 2002; Andreas Dubs, Australian Chicken Meat Federation, personal communication 2005).

The industry supplies its products to four market segments:

- supermarkets 40%
- take away outlets 25%
- food service industry 25%
- all others 10%.

The food service industry includes restaurants, hotels, caterers, hospitals, armed services, canteens and similar type operations. The ‘all others’ category includes butcher shops, specialty chicken shops, and other small retail outlets.

Characteristics of International Trade

Only approximately 10% of world poultry production enters the export trade, with the majority of chicken meat being consumed in the country of origin (Larkin et al. 2000). However, forecasts of world poultry production, and exports of poultry products, are optimistic, and significant growth in the poultry industry worldwide is predicted in the medium term (Larkin et al. 2000).

Five major producers, (Brazil, USA, the European Union, China and Thailand), dominate world trade in chicken meat. Brazil is the largest exporter, with forecast exports of 2,900,000 metric tonnes in 2006, followed by the USA with forecast exports of 2,404,000 metric tonnes

in 2006 (USDA-FAS 2006). In world terms, Australia is a very small exporter, with exports of approximately 20 kilotonnes in 2004–05 (ABARE 2006).

Exports of Australian Chicken Meat

In 2000–01, exports accounted for only 1.8% of turnover in the chicken meat industry (Anonymous 2002), with some export markets closing in response to Newcastle disease outbreaks in New South Wales and Victoria. Poultry meat exports are forecast to remain under 23 kilotonnes in 2005–06 (ABARE 2006). Major export markets are Hong Kong/China, South Africa and the Pacific Island nations. Access to these markets was severely compromised by the 1998, 2000 and 2002 Newcastle disease outbreaks.

There is a growing export market for Australian breeding stock. Potential growth of this market, however, will depend, among other things, on the continued absence of major poultry diseases in the Australian breeder flock.

Other Potentially Affected Australian Animal Industries

The egg industry

There are about 480 commercial egg producers in Australia, with a national flock size of around 15.8 million (Dubs 2005). Deregulation of egg marketing arrangements, which commenced in 1989, has led to easier entry into the industry and an increase in farm size.

Approximately 39% of egg production is located in New South Wales, 23% in Victoria, 22% in Queensland, 8% in Western Australia, 5% in South Australia, 2% in Tasmania and 1% in the Northern Territory (Dubs 2005). The principal areas of industry concentration are on the outskirts of Sydney and Melbourne. Secondary areas of industry concentration are on the Darling Downs (Queensland), near Tamworth (New South Wales), and on the outskirts of Perth (Western Australia). Other areas of industry concentration are in the outskirts of Brisbane (Queensland), the Hunter Valley (New South Wales), the Gawler/Murray Bridge area of South Australia, near Young (New South Wales), Bendigo and Geelong (Victoria).

It is believed that 6–7% of Australian households keep poultry (Agriculture and Resource Management Council of Australia and New Zealand 1996). It is estimated that about 10% of all eggs are produced by small operators or backyard producers.

Commercial egg production is a highly specialised, capital intensive industry with little opportunity for capital substitution. Capital in the form of sheds and grading floors has a long economic life. It is estimated that 5,600 people are directly or indirectly employed in the industry (Ms N Komis, Australian Egg Industry Association, 2003, personal communication).

The commercial egg production industry has 3 components. These are:

- On-farm aspects which includes the breeding of layer stock, hatching, pullet rearing and layer farms
- Grading, packing, sales and distribution
- Egg products manufacturing, sales and distribution.

These activities are often vertically integrated. There is an increasing trend to integrate, especially as far as pullet rearing and egg production are concerned. There may also be integration back to feed milling. There is usually no integration with other sectors of agriculture, although a very small proportion of producers are involved in grain growing.

Many producers have combined the growing, layer and egg grading operations and supply both wholesale and retail markets. Some producers and backyard operations sell table eggs directly to the public.

Egg Products Manufacturing

Processed egg products make up 15% of market share (Australian Egg Corporation Limited 2005). Liquid, frozen and spray dried products are manufactured at processing plants. These products may be in whole or separated form. Small volumes of specialised egg products are also manufactured. There are five major plants in Australia located at Newcastle and Griffith (New South Wales), Melbourne (Victoria), Perth (Western Australia), and Adelaide (South Australia).

Economic Data

Domestic retail sales of shell eggs were estimated at $550 million in 2000. The value of exports (shell egg and egg products) is just over $2 million (Australian Egg Corporation Limited 2003).

Characteristics of Domestic Trade (Egg Industry)

There is a trend away from the sale of eggs in shell through retail outlets towards the processed food and food service sectors. There is also a trend to increased egg products manufacturing. An estimated 65% of eggs are sold in shell form through supermarkets and other retail outlets, 20% are sold to the food service sector and 15% are transformed into manufactured egg products (Australian Egg Corporation Limited 2005). Egg products to the equivalent of 4.9 million dozen shell eggs are imported annually at an estimated value of $3 million (Australian Egg Corporation Limited 2003).

Characteristics of International Trade (Egg Industry)

A relatively small proportion of shell eggs and egg products is also exported. However, trends towards freer trade and the use of egg products at the expense of shell eggs should mean underlying growth in the international egg products trade.

Turkeys, ducks, and other game birds

All Australian States have a small game-bird industry, with New South Wales and Victoria being the largest production centres. The majority of Australia’s game bird population, including duck, turkey, quail, squab, guinea fowl, pheasant, partridge and geese, are processed in domestic processing plants. There are export-approved processing plants for game birds in New South Wales and Victoria, and further processing plants in Queensland, Western Australia and Victoria awaiting licensing (Leech et al. 2003).

Approximately 17 million game birds were processed in Australia in 2001–02, with quail, duck and turkey accounting for 95%. The majority (77%) of Australia’s 4.7 million turkeys

are produced by large, vertically-integrated chicken meat companies, with the remainder being produced by large independent growers or smaller producers in each state. A single New South Wales company accounts for about 75% of the 6.5 million quail processed in Australia each year, with smaller producers in New South Wales, Victoria and South Australia. Duck production occurs in most states, with two companies producing most of the Pekin type duck for the restaurant and hospitality sectors. Squab producers are located in Queensland, New South Wales and Victoria, while pheasant, guinea fowl, partridge and geese producers are concentrated mainly in New South Wales and Victoria (Leech et al. 2003).

The retail value of the game bird market is estimated at $290 million per year (Leech et al. 2003). Export markets have been severely compromised by outbreaks of Newcastle disease in New South Wales and Victoria in recent years.

Ratite industry

While relatively small compared with the chicken meat and egg industries, the Australian ratite industry had grown in recent years. Significant export markets had been developed for ratite meat, before restrictions on access due to outbreaks of Newcastle disease in New South Wales and Victoria.

Pigeon fanciers

While it is not a large or well-organised industry in Australia, there are a number of individuals who have put considerable resources into developing international markets for racing and show pigeons. Restrictions on exports from New South Wales and Victoria due to outbreaks of Newcastle disease in those States have caused financial losses to some pigeon breeders.

Avicultural community and zoological gardens

The aviculture community in Australia covers a wide spectrum of the population, from individuals with a single pet bird, to commercial enterprises worth millions of dollars. The most recent available figures from the Australian Bureau of Statistics (ABS) on pet ownership in Australia (1994) indicate that 16% of households in Australia keep pet birds, with 35% of bird-owners keeping three or more birds (Australian Bureau of Statistics 1995).

Zoological gardens keep a wide range of avian species, many of which are of great value, and some of which are listed as endangered species. The Australian Regional Association of Zoological Parks and Aquaria (ARAZPA), whose aims and objectives include cultural enhancement, conservation and education, represents zoological gardens.

Native birds and the environment

Australia has significant populations of native birds, many of which do not occur naturally elsewhere. The conservation value of native birds is extremely high, but is difficult to measure. Some of Australia's native species have been shown by overseas experience to be susceptible to the major exotic diseases of poultry. The potential effects of an outbreak of exotic disease in our wild bird populations are difficult to estimate. In making policy recommendations to AQIS, (the agency responsible for administering the *Quarantine Act 1908* and subordinate legislation), Biosecurity Australia must give due consideration to the protection of wildlife and the environment. Biosecurity Australia consulted with the DEWHA

during the development of the *IRA Report*. A table showing environmental considerations is included in Part D at Appendix 4.

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Under the World Organisation for Animal Health (OIE) Terrestrial Animal Health Code (the OIE Code), IRAs for animals and animal products are based on the following procedures:

- Hazard identification
- Risk assessment, incorporating:
  - release assessment
  - exposure assessment
  - consequence assessment
  - risk estimation
- Risk management
- Risk communication.

While hazard identification, risk assessment and risk management tend to occur consecutively within the context of a particular IRA, risk communication occurs in an on-going and iterative manner throughout the process, and includes both formal and informal consultation with stakeholders. The release of this Final IRA report forms part of the risk communication process.

The method adopted by Biosecurity Australia for performing import risk analysis conforms to that recommended by the OIE, and is described in summary above. The method for, and results of, hazard identification are described below. The methods for risk assessment (consisting of release assessment, exposure assessment, consequence assessment and risk estimation) and risk management are described in detail in the Section of this document entitled 'Method for Risk Assessment'. Individual disease risk assessments and risk estimates are reported separately, in Part C of this IRA report.

Proposals for risk management, for those diseases for which the risk estimate exceeds Australia's ALOP, are described in Part C of this report in the section entitled 'Risk Management'.

Method for hazard identification

Hazard identification is described in Article 2.2.2 of the OIE Code (see Appendix 7), as a classification step that is undertaken to identify pathogenic agents, or clearly defined strains of pathogenic agents, that could be associated with the importation of a commodity. Agents thus classified are termed 'potential hazards'.

The OIE Code states that, to be identified as a potential hazard, a pathogenic agent should comply with *all* of the following criteria:

- The pathogenic agent should be 'appropriate' to the animal species to be imported, or from which the commodity is derived
- The pathogenic agent could produce adverse consequences in the importing country
- The pathogenic agent may be present in the exporting country[3]

[3] The OIE Code also states that ' *... the evaluation of the veterinary services, surveillance and control programs and zoning and compartmentalisation systems are important inputs for assessing the likelihood of hazards being present in the animal population of the exporting country ...*'

- The pathogenic agent should not be present in the importing country. If present, the pathogenic agent should be associated with a notifiable disease, or should be subject to control or eradication measures.

For this IRA, hazard identification was initiated by generating a comprehensive list of disease agents likely to be relevant to the importation of chicken meat. The list includes those disease agents associated with OIE-listed diseases and known to be carried by domestic chickens, and any other agents considered relevant to chicken meat. The list was subsequently refined by applying to each disease agent, the four criteria stated above. If reasons for the inclusion/exclusion of particular pathogenic agents were not clear cut, these agents were retained on the list and were examined in the formal risk assessment.

Hazard identification

The list of potential hazards outlined below was compiled from the list of diseases notifiable to the OIE, and a list of the causative agents for other diseases considered to be of importance to the importation of chicken meat.

OIE-listed disease agents

Notifiable avian influenza (NAI) viruses

Newcastle disease (ND) virus

Avian infectious bronchitis virus (IBV)

Avian infectious laryngotracheitis virus (ILT)

Duck hepatitis virus

Pasteurella multocida

Salmonella Gallinarum

Infectious bursal disease virus (IBDV)

Marek’s disease (MD) virus

Mycoplasma gallisepticum

Mycoplasma synoviae

Chlamydophila psittaci

Salmonella Pullorum

Avian Metapneumovirus

Japanese encephalitis (JE) virus

West Nile virus (WNV)

Eastern equine encephalomyelitis/Western equine encephalomyelitis/Venezuelan equine encephalomyelitis (EEE/WEE/VEE) viruses

Salmonella Enteritidis

Multidrug resistant (MDR) *Salmonella* Typhimurium

Other disease agents

Haemophilus paragallinarum	Avian encephalomyelitis virus
Borrelia anserina	Avian leucosis virus
Group 1 Fowl Adenoviruses	Group 2 Avian adenovirus
Group 3 Avian adenovirus	Fowl pox virus
Avian nephritis virus	Quinolone-resistant *Campylobacter jejuni*
Chicken infectious anaemia agent	Duck enteritis virus
Goose parvovirus	Enterohaemorrhagic *Escherichia coli*
Muscovy duck parvovirus	*Mycoplasma meleagridis*
Mycoplasma iowae	*Ornithobacterum rhinotracheale*
Riemerella anatipestifer	Avian reovirus
Reticuloendotheliosis virus	Transmissible proventriculitis virus
Turkey coronavirus	*Mycobacterium avium*
Avian Paramyxovirus-2	Avian Paramyxovirus-3
Internal parasites	External parasites

Hazard refinement

Brief discussions substantiating decisions to retain or reject pathogenic agents as 'hazards' to be further considered in the IRA, are provided in the *Uncooked Chicken Meat Import Risk Analysis Issues Paper* (ABPM 2001/16). This document was distributed to registered stakeholders in July 2001, and is available from Biosecurity Australia (website or by direct contact[4]).

In response to comments from stakeholders, and following discussion in IRA team meetings, there were several alterations to the original hazard list. Brief explanations of these alterations are given below. Table 5 illustrates the process of hazard refinement used in arriving at the final hazard list.

Disease agents included in the Hazard List since release of the Technical Issues Paper

A number of disease agents were added to the list of potential hazards after the release of the *Issues Paper*, and arboviruses were added to the list of potential hazards after release of the *Draft Generic Import Risk Analysis Report for Chicken Meat*. These disease agents were included after consideration of comments received from a number of sources, and after evaluation of the current scientific literature. They are discussed in greater detail in Part C of

[4] Available at http://www.daff.gov.au/ba/ira/current-animal/chicken-meat or from Biosecurity Australia, GPO Box 858, Canberra, ACT 2601; animal@biosecurity.gov.au; Phone +61 2 6272 4465; Fax number +61 2 6272 3399

this IRA report in the section on Risk Assessments. The following information is included in order to clarify the reasons for inclusion in the Hazard List.

Low pathogenicity notifiable avian influenza (LPNAI) viruses (H5 and H7)

Agent affects domestic chicken

There are numerous reports in the scientific literature of H5 and H7 LPNAI outbreaks in domestic chickens (Akey 2003; Capua and Alexander 2004; Capua and Marangon 2000; Dunn et al. 2003; Henzler et al. 2003; Lu et al. 2004; Marangon et al. 2003). Large scale epizootics of H5 and H7 subtypes of LPNAI may increase the probability that HPNAI viruses will emerge by mutation (Garcia et al. 1996). In 2005, the OIE identified all H5 and H7 avian influenza (AI) viruses as NAI viruses (World Organisation for Animal Health (OIE) 2004).

Potential for transmission in chicken meat

LPNAI infection may lead to respiratory disease, decreased egg production and increased flock mortalities (Swayne and Halvorson 2003). Affected birds shed the virus in the faeces and respiratory secretions (Lu and Castro 2004). Thus, contamination of the carcass could occur via the airsacs, lungs and from the intestinal tract during evisceration of infected carcasses.

Potential for adverse consequences

LPNAI infections may lead to respiratory disease, decreased egg production and increased mortalities. There is accumulating evidence that highly pathogenic AI viruses may arise from LPNAI viruses infecting chickens or turkeys. ‘It can be assumed that all H5 and H7 viruses have this potential and mutation to virulence is a random event’ (Alexander 2003b).

Occurrence in Australia

Highly pathogenic H7 viruses were isolated from commercial chickens in Australia in 1976, 1985, 1992, 1995 and 1997 (Swayne and Suarez 2000). On each occasion the outbreak was eradicated by stamping out.

Reasons for inclusion in Hazard List

LPNAI viruses satisfy the criteria for inclusion in the hazard list in that they affect domestic chickens; there is potential for transmission in or on contaminated chicken meat; adverse consequences are likely if the viruses become established in Australian commercial poultry, and the disease agents are not believed to be present in Australian commercial poultry. The definition of NAI viruses was reviewed by the OIE in 2005, and all H5 and H7 viruses in poultry are now notifiable.

Salmonella Arizonae

Agent affects domestic chicken

This group of salmonellae is comprised of 415 different antigenic types (Davos 2001). Arizonosis is primarily a disease of young turkeys, although chickens can be affected both naturally and experimentally. The two serotypes commonly reported in turkeys and chickens are serovars 18:Z_4,Z_{23} and 18:Z_4,Z_{32}, although isolates of 18:Z_4,Z_{23} are now rare (Shivaprasad et al. 1997).

Potential for transmission in chicken meat

Transmission of the bacteria is similar to that occurring with all types of motile *Salmonellae*. Infected adult poultry may become intestinal carriers and shed the bacteria for long periods (Shivaprasad et al. 1997). The presence of *S.* Arizonae has been documented in chicken meat samples overseas (Bidarte 1990; Izat, Kopek, and McGinnis 1991).

Potential for adverse consequences

The bacteria invade the blood stream, especially in young poultry. Clinical signs include diarrhoea, leg paralysis, twisted neck, pasting of the down around the vent and blindness. Nervous signs including convulsions may occur (Silva, Hipolito, and Grecchi 1980). The disease can cause high mortality and morbidity in the young, and while clinical signs are rare in adult birds, decreased egg production and hatchability may occur. Chicks are most susceptible within the first few days of life, but remain so to 3–4 weeks of age and mortality rates of 32–50% have been reported (Shivaprasad et al. 1997).

Occurrence in Australia

While Arizonosis occurs worldwide, the serovar 18:Z_4,Z_{32} which causes Arizonosis in poultry has never been isolated either from human or non-human sources in Australia (Davos 2001).

Reasons for inclusion in Hazard List

S. Arizonae serovar 18:Z_4,Z_{32} satisfies the criteria for inclusion as a hazard in that it can affect domestic chickens; there is potential for transmission of the agent in infected imported chicken meat; there is potential for adverse consequences if the disease agent becomes established in Australian commercial poultry (especially turkey flocks), and the agent is considered to be exotic to Australia.

Avian Paramyxovirus-2 (APMV-2)

Agent affects domestic chicken

APMV-2 has been isolated from chickens, turkeys, passeriformes, psittacines, ducks and rails from numerous geographic locations (Europe, Africa, Asia, South America and North America) (Alexander 1987; Ritchie 1995a). Epizootiological evidence suggests that APMV-2 infections are most common in passeriformes in most parts of the world. Infections in chickens may be asymptomatic or can be associated with mild respiratory disease, reduced egg production or severe mortality (Ritchie 1995a). Disease may be complicated by secondary bacterial infections.

Potential for transmission in chicken meat

APMV-2 may lead to respiratory disease. Virus is shed in respiratory secretions and in the faeces. Thus, contamination of the carcass could occur via the airsacs, lungs and from the intestinal tract during evisceration of infected birds.

Potential for adverse consequences

In chickens, infections may be subclinical, or can be associated with mild respiratory disease or reduced egg production. APMV-2 infections have been reported to be more severe in turkeys

than in chickens, and there has been a report of severe respiratory disease, sinusitis, elevated mortality, and low egg production in turkey flocks infected with APMV-2 complicated by the presence of other organisms (Alexander 2003a). There have been outbreaks of APMV-2 disease in turkeys in a number of countries such as in Israel, and Canada (Lipkind et al. 1979; Lang, Gagnon, and Howell 1975). In the Israel outbreak, morbidity reached 100% while mortality fluctuated from 5–90%.

Occurrence in Australia

APMV-2 has not been reported in Australia and it is not notifiable in this country.

Reasons for inclusion in Hazard List

APMV-2 satisfies the criteria for inclusion in that it can affect domestic chickens; there is potential for transmission of the agent in infected imported chicken meat; there is potential for adverse consequences if the disease agent becomes established in Australian commercial poultry (especially turkey flocks), and the agent is considered to be exotic to Australia.

Avian Paramyxovirus-3 (APMV-3)

Agent affects domestic chicken

There are two groups of APMV-3 strains, one consisting mainly of turkey strains such as APMV-3/turkey/Wisconsin/68, and the other comprising strains isolated from companion birds such as APMV-3/parakeet/Netherlands/449/75. The two groups can be differentiated using monoclonal antibodies (Anderson et al. 1987). APMV-3 has been isolated from psittacine and passerine birds. All strains isolated from psittacine birds show closer serological relationships to each other than to the turkey isolates (Alexander et al. 1982).

Until recently, naturally occurring symptomatic infections of domestic chickens with APMV-3 were not reported. However, a psittacine variant of APMV-3 was isolated from domestic chickens in Israel with clinical signs of respiratory disease and post-mortem evidence of pericarditis, perihepatitis, airsacculitis and pneumonia (Shihmanter et al. 2000).

Potential for transmission in chicken meat

There is little information on the spread of the APMV-3 virus. It is assumed to be through respiratory secretions and faeces as for Newcastle disease virus. The presence of lesions in the lungs and around the liver in infected chickens suggests that carcasses could be infected or become contaminated during processing.

Potential for adverse consequences

The APMV-3 virus has been recovered from asymptomatic chickens and turkeys as well as from birds with respiratory disease. Affected flocks in Israel had a morbidity rate of 30% with mortality ranging from 3–5% (Shihmanter et al. 2000).

In turkeys, APMV-3 causes a mild respiratory disease but is generally manifested by marked drops in egg production (Alexander 2003a).

Occurrence in Australia

APMV-3 has not been reported in Australia and is not notifiable.

Reasons for inclusion in Hazard List

APMV-3 satisfies the criteria for inclusion in that it can affect domestic chickens; there is potential for transmission of the agent in infected imported chicken meat; there is potential for adverse consequences if the disease agent becomes established in Australian commercial poultry (especially turkey flocks), and the agent is considered to be exotic to Australia.

Avian Infectious Bronchitis virus (IBV)

Agent affects domestic chicken

Infectious bronchitis is an acute, highly contagious viral respiratory disease of chickens. The disease is generally regarded as being restricted to chickens, but a similar virus has also been isolated from pheasants with respiratory signs and depression of egg production (Cavanagh and Naqi 2003).

Potential for transmission in chicken meat

Infected chickens have serous, catarrhal, or caseous exudate in the trachea, nasal passages and sinuses, and the virus persists in the intestinal tract for many weeks after infection (Alexander and Gough 1977). Airsacs may appear cloudy or contain caseous exudate and there may be small areas of pneumonia. Some nephrotoxic infections produce swollen pale kidneys (Cavanagh and Naqi 2003), and other strains show tropism for the reproductive tract (Crinion and Hofstad 1972). Presence of the organism in carcasses derived from infected chickens is therefore possible. The presence of airsacculitis can lead to condemnation of carcasses during processing.

Potential for adverse consequences

Infectious bronchitis is an OIE-listed disease. The disease causes poor weight gain and feed conversion efficiency, and can lead to declines in egg production and egg quality (Cavanagh and Naqi 2003).

Occurrence in Australia

Avian infectious bronchitis occurs throughout the world and is prevalent in all poultry-raising areas of Australia (Ignjatovic and Sapats 2000). Comparison of strains from different parts of the world indicates that strains from a particular geographic area are more closely related to each other than to strains from other regions (Ignjatovic and Sapats 2000). Currently produced Australian vaccines are unlikely to protect Australian birds if they were infected with strains of IBV from Europe, the United States, or Asia (Ignjatovic and Sapats 2000).

Reasons for inclusion in Hazard List

Avian infectious bronchitis was not initially included in the Hazard List, on the basis that the disease is endemic in Australia. However, although IBV is distributed world-wide, incursions of unrelated IBV from other regions of the world into Australia would necessitate the introduction of new vaccines, and lead to higher costs of management (Ignjatovic and Sapats 2000). Accordingly, IBV has now been included in the hazard list for further evaluation.

Haemophilus paragallinarum

Agent affects domestic chicken

Infectious coryza is an acute infectious disease of chickens caused by *Haemophilus paragallinarum* (Reece, Beddome, and Barr 1986).

Potential for transmission in chicken meat

Outbreaks in broiler chickens have resulted in condemnations of carcasses due to airsacculitis (Droual et al. 1990). This indicates that the importation of carcasses from infected chickens may lead to the introduction of the agent (Reece, Beddome, and Barr 1986).

Potential for adverse consequences

The disease causes economic loss due to poor growth performance in growing birds and marked reduction (10–40%) in egg production in layers (Reece, Beddome, and Barr 1986).

Occurrence in Australia

Infectious coryza has a worldwide distribution and is present in Australia. Although vaccines are available, genetically different strains of *Haemophilus paragallinarum* exist overseas, against which local vaccines may not provide protection (Blackall 1999).

Reasons for inclusion in Hazard List

Infectious coryza was not initially included in the Hazard List on the basis that the disease is endemic in Australia (Soriano et al. 2001; Soriano et al. 2004). However, incursions of genetically different serovars from other regions of the world into Australia may necessitate the introduction of new vaccines, and lead to higher management costs (Blackall 1999). Accordingly, infectious coryza has now been included in the hazard list for further evaluation.

Mycoplasma iowae

Agent affects domestic chicken

The natural host of *Mycoplasma iowae* is the turkey but infections in chickens are not uncommon (Al-Ankari and Bradbury 1996; Bradbury and Kleven 2003).

Potential for transmission in chicken meat

M. iowae causes mild airsacculitis, leg deformities, tenosynovitis and stunting in experimentally inoculated chickens. The organism may persist in joints and tendon sheaths, and may therefore be present in the chicken carcass (Bradbury and Kelly 1991).

Potential for adverse consequences

M. iowae causes embryo mortality and decreased hatchability in turkey flocks. The extent of the decrease in reproductive performance is widely variable, ranging from zero to a severe and prolonged depression of production (Bradbury and Kleven 2003). *M. iowae* has been isolated from the hock joints of chickens in a flock with persistent lameness problems (Bradbury et al. 1990). Although there is no indication that natural infection of chickens is of economic significance (Bradbury and Kelly 1991), introduction of the organism to Australia could result

in severe economic losses to the turkey industry. The organism has been recovered on occasion from wild birds (Bradbury and McCarthy 1984), indicating that wild birds may serve as a vector to transfer the infection from chicken to turkey flocks.

Occurrence in Australia

M. iowae has not been reported in Australia.

Reasons for inclusion in Hazard List

M. iowae was not initially included in the Hazard List. However, as this organism has not been reported in Australia, may be present in the carcasses of infected chicken and has the potential for adverse consequences in the poultry industry, it has been included in the Hazard List.

Mycoplasma synoviae

Agent affects domestic chicken

Mycoplasma synoviae causes infectious synovitis and sometimes upper respiratory disease of chickens and turkeys (Stipkovits and Kempf 1996). While chickens, turkeys and guinea fowls are the natural hosts of *M. synoviae*, ducks, geese, pigeons, Japanese quail and red-legged partridges have also been found to be naturally infected. Pheasants and budgerigars have been shown to be susceptible to infection following artificial inoculation (Kleven 2003).

Potential for transmission in chicken meat

M. synoviae infection can cause infectious synovitis with organisms being isolated from affected joints and tendon sheaths. Airsacculitis also occurs, resulting in increased condemnation of chicken carcasses (Kleven 2003). *M. synoviae* can be isolated from the joints of birds that appear to be unaffected by clinical disease (Morrow et al. 1990) and therefore, the potential exists for infected birds to be processed at the abattoirs and not removed during ante-mortem or post-mortem inspection.

Potential for adverse consequences

M. synoviae infection causes infectious synovitis, primarily in 4–12 week old hosts. Clinical signs include lameness, with a morbidity of 5–15% or more, and mortality up to 10%. A respiratory form of the disease also occurs, characterised by respiratory signs, lameness, retarded growth, increased mortality and variably decreased egg production (Stipkovits and Kempf 1996).

Occurrence in Australia

Some strains of *M. synoviae* are present in Australia (Morrow et al. 1990). *M. synoviae* is not presently a notifiable disease agent in Australia.

Reasons for inclusion in Hazard List

Wide variations occur among *M. synoviae* strains in pathogenicity and tissue tropism (Stipkovits and Kempf 1996). *M. synoviae* was added to the OIE list of notifiable diseases in 2005 (World Organisation for Animal Health (OIE) 2005). Therefore, *M. synoviae* was retained in the Hazard List for further risk assessment.

Avian Reovirus (viral arthritis/tenosynovitis)

Agent affects domestic chicken

Avian reoviruses have been associated with a variety of diseases in chickens, turkeys, ducks, geese, American woodcock and psittacine species. Disease syndromes that have been associated with reovirus infections include viral arthritis/tenosynovitis, stunting syndrome, respiratory disease, enteric disease and malabsorption syndrome (Rosenberger 2003).

Potential for transmission in chicken meat

Horizontal transmission of reovirus infection appears to be mainly by faecal contamination, although the virus can be excreted from both respiratory and gastrointestinal tracts for at least 10 days post-inoculation (Rosenberger 2003). Avian reovirus has been found to persist in the tissues of chickens for many weeks, with virus being present in the hock joints for at least 13 weeks after experimental infection (Jones 1996). Therefore, infected chicken carcasses could serve to introduce exotic pathogenic strains to Australia.

Potential for adverse consequences

The importance of reovirus infections throughout the world varies widely from region to region (Jones 1996). Economic losses due to reovirus infection are largely related to crippling effects of arthritis/tenosynovitis and a general lack of performance. Performance problems include diminished weight gains, poor feed conversion and reduced marketability (Rosenberger 2003).

Occurrence in Australia

Reoviruses have been isolated from chickens in Australia (Rosenberger and Olson 1997; Spradbrow and Bains 1974; Kibenge et al. 1982; Hussain and Spradbrow 1981; Bagust and Westbury 1975). However, Australian strains appear to be of low virulence (Meanger et al. 1997).

Reasons for inclusion in Hazard List

At least 12 different vaccines containing reovirus are registered for use in the United States (Eagly 2001; Schering Plough Animal Health 2002), and vaccination of commercial poultry is common. Currently, no reovirus vaccines are registered for use in Australia. This suggests that reovirus infections are more problematic in United States commercial poultry than is currently the case in Australia. Introduction of exotic strains into Australian commercial poultry may lead to the need for management changes, including vaccination. Reovirus was therefore retained for further risk assessment.

Arboviruses

Agent affects domestic chicken

Two families of arboviruses have been identified as causes of disease in poultry and game birds: the *Togaviridae*, which includes Eastern Equine Encephalomyelitis (EEE) virus, Western Equine Encephalomyelitis (WEE) virus and Highlands J (HJ) virus, and the *Flaviviridae*, which includes West Nile Virus (WNV), Japanese Encephalitis (JE) virus and Israel turkey meningoencephalitis (IT) virus (Guy and Malkinson 2003).

Potential for transmission in chicken meat

Arboviruses are transmitted between susceptible vertebrate hosts by blood-feeding arthropods. However, oral transmission of some arboviruses can occur between some species of animals, via feather-picking, cannibalism or predation (Ritchie 1995b; Komar 2003).

Potential for adverse consequences

EEE virus, WEE virus, and WNV are OIE-listed disease agents. While these viruses are rarely associated with clinical disease in chickens, they can cause disease and death in some other species of birds, and they can cause serious and sometimes fatal neurological disease in humans and horses.

Occurrence in Australia

EEE virus, WEE virus and IT virus have not been reported in Australia. Kunjin virus, a subtype of WNV, is present in Australia (Hayes 2001). In 1995, JE virus was first detected in the Torres Strait islands, and in 1998 a single human isolation was made in mainland Queensland (Endy and Nisalak 2002). Simultaneously, pigs in the Cape York area of northern Queensland were shown to have seroconverted to JE virus. Seroconversions of sentinel pigs have been regularly documented in the Torres Strait islands, but no further locally acquired human cases have been documented on the Australian mainland (Liu et al. 2006).

Reasons for inclusion in Hazard List

Arboviruses were not initially included in the Hazard List, because these viruses are primarily transmitted by arthropod vectors. There is no evidence that the epidemiological spread of these viruses has been associated with trade in chicken meat, or that transmission of arboviruses from chicken meat to humans or animals occurs. However, oral transmission of some of these viruses has been documented between some species of animals. Therefore, after consideration of stakeholder submissions, the IRA team agreed to evaluate the evidence for transmission of arboviruses in chicken meat.

Disease agents removed from the Hazard List since release of the Technical Issues Paper

Enterohaemorrhagic *Escherichia coli* (EHEC)

Escherichia coli is a common inhabitant of the intestinal tract of warm-blooded animals, including humans and birds. *E. coli* colonises the intestinal tract at or shortly after birth (Bettelheim 1996) and while most strains are harmless to the host, some strains are capable of causing host-specific disease. Enterohaemorrhagic *E. coli* (EHEC) are strains of *E. coli* capable of producing toxins and colonising the intestinal tract of susceptible humans (World Health Organization 2001). Although *E. coli* O157:H7 is most commonly reported in association with haemorrhagic enteritis/colitis in humans, non-O157 strains are being increasingly recognised as causes of human disease.

Agent affects domestic chicken

Colibacillosis refers to localised or systemic infection caused by *E. coli*. In poultry, colibacillosis is typically a secondary disease occurring when host defences have been

impaired, for example by viral infections or environmental stressors (Barnes, Vaillancourt, and Gross 2003). *E. coli* infections of poultry have been associated with colisepticaemia, chronic respiratory disease, cellulitis, peritonitis, salpingitis and other diseases, and can cause significant economic losses to the industry, including high carcass condemnation rates (Yogaratnam 1995). Most *E. coli* serotypes isolated from poultry are pathogenic only for birds. However, chickens are susceptible to experimental colonisation with EHEC, including *E. coli* O157:H7, an organism pathogenic for humans (Stavric, Buchanan, and Gleeson 1993). Farm-reared poultry have not been identified as carriers of *E. coli* O157:H7 (Doyle 1991). In a study on the prevalence of Shiga-like toxin-producing *E. coli* in seven species of domestic animals, ruminants were the most common carriers and the organisms were not isolated from faecal samples of chickens (Beutin et al. 1993).

Potential for transmission in chicken meat

Ruminants, particularly cattle, are considered to be the major reservoir of EHEC (Bettelheim 2001). Other domestic species such as pigs, cats and dogs are also natural reservoirs (Djordevic et al. 2001). Ground beef and raw milk have been implicated as sources of infection during most reported outbreaks of disease in humans (Doyle 1991).

A survey of retailed raw meats, including poultry, revealed *E. coli* O157:H7 in 2–4% of ground beef, 1.5% of pork, 1.5% of poultry and 2% of lamb sampled (Doyle and Schoeni 1987). It was not clear from that study if the foods had become contaminated during processing and handling, or if food-producing animals other than cattle are also carriers of the organism (Doyle 1991). Several studies suggest that chickens, exposed at the correct age with the correct dose of EHEC, could become asymptomatic carriers and reservoirs of infection (Beery, Doyle, and Schoeni 1985; Stavric, Buchanan, and Gleeson 1993; Schoeni and Doyle 1994).

Contaminated water sources, person-to-person contact and raw vegetables have also been associated with EHEC transmission in humans (Doyle 1991; World Health Organization 2001).

There is considerable scientific research regarding the spread of *E. coli* and, while the food chain is very important (Bettelheim et al. 1977), person-to-person spread is probably more relevant in its introduction (Bettelheim et al. 1983). Due to increased global travel, it is more likely that exotic strains will be introduced into Australia through infected people than via the food chain.

Potential for adverse consequences

EHEC has not been documented to cause naturally occurring disease in birds, and most reservoirs of the organism are asymptomatic carriers. Experimentally-infected chickens continued to shed the bacteria for up to 10 months, but apparently remained asymptomatic throughout the 10 month duration of the study (Schoeni and Doyle 1994). The principal concern with introduction of exotic EHEC strains is, therefore, that of human public health.

E. coli O157:H7 is a strain within the EHEC group of *E. coli* bacteria that can be highly pathogenic to man. There are an estimated 73,000 cases and 61 deaths in the United States due to *E. coli* O157:H7 each year (CDC 2001). Infection results in haemorrhagic colitis, with complications such as haemolytic uraemic syndrome (HUS) and thrombocytopaenic purpura developing in some susceptible patients including the young and elderly. It is estimated that up to 10% of EHEC patients will develop HUS and, of these, 3–5% will die.

Occurrence in Australia

EHEC strains were first isolated from human patients in Australia in 1983 (Bettelheim 1996). EHEC strains have been isolated in Australia from cattle and sheep (Hornitzky, Bettelheim, and Djordevic 2000; Bettelheim, Hornitzky, and Djordjevic 2001). No reports were found of EHEC strains occurring in Australian poultry.

Reasons for exclusion from the Hazard List

It is acknowledged that EHEC, transmitted through food products, can produce serious outbreaks of human disease. However, the management of human pathogens in food (whether imported or domestically produced) is the responsibility of FSANZ. Products intended for human consumption may undergo a separate assessment by FSANZ to determine the public health risks. Imported food must comply with the *Imported Food Control Act 1992* and the *Food Standards Code* developed under the *Food Standards Australia New Zealand Act 1991*. AQIS may inspect, sample, hold and test imported food based on issues of public health, including microbial agents or residues of public health concern, and compliance with the *Food Standards Code*. This control represents an equivalent level of monitoring and inspection to that currently applied to domestically produced chicken meat and products.

If EHEC were introduced into poultry flocks via imported chicken meat, it is unlikely that any effect on bird health or production would be detected, and no change in vaccination, management or processing would occur. EHEC is not an OIE-listed disease agent and is not subject to controls within Australia. Introduction of exotic strains is more likely to occur through human carriers entering Australia than via imported meat. No restrictions are placed on people entering Australia in relation to EHEC.

For the reasons outlined above, EHEC has been excluded from the Hazard List.

Quinolone-resistant *Campylobacter jejuni* – Campylobacteriosis

Campylobacter jejuni is one of the leading causes of human food-poisoning world-wide (Tauxe 2000a; Sack et al. 2001). *C. jejuni* is a gram-negative, spiral, uniflagellate, motile, thermophilic bacterium that commonly colonises the intestinal tract of poultry, other food-producing animals and domestic pets (Shane 1997). It may also be found in unchlorinated water sources and unpasteurised dairy products (Tauxe 2000b).

In humans, infection with *C. jejuni* causes enteritis that may be complicated by severe dehydration and other side effects, including reactive arthritis and Guillain-Barré Syndrome, a neurological complication leading to flaccid paralysis (Altekruse et al. 1999). In the last three decades, increasing levels of antibiotic resistance have been documented in *C. jejuni* isolates around the world (Anonymous 1999). Bacterial resistance has been linked to the use of antimicrobials in food-producing animals, particularly in poultry. In those countries in which the quinolone group of antibiotics may be administered to poultry, there is evidence of increased prevalence of quinolone-resistant strains in poultry and poultry products (Anonymous 1999; Lucey et al. 2002). Quinolones are not registered for use in poultry in Australia and there have been few isolates of quinolone-resistant *C. jejuni* from people in this country (Tauxe 2000a; Binotto, McIver, and Hawkins 2000).

Agent affects domestic chickens

Poultry serve as primary reservoir hosts of the thermophilic campylobacters *C. jejuni*, *C. coli*, and *C. lari* (Shane 1997). These organisms have also been isolated from turkeys, ducks, game birds, wild birds, rodents, houseflies, cockroaches and other species.

Potential for transmission in chicken meat

Campylobacteriosis in humans is frequently associated with the preparation and consumption of poultry meat (Hartog, de Wilde, and de Boer 1983), although other sources of infection include raw milk, contaminated water sources, red meat, family pets and contact with infected humans (Shane 2000). Chicks are colonised by *C. jejuni* within the first few weeks of life, with infection spreading rapidly throughout the flock (Shane 1997). Contamination of uninfected flocks can occur during transport of poultry to the processing plant, and within the processing plant via the processing steps of scalding, plucking, evisceration and chilling (Hartog, de Wilde, and de Boer 1983; White, Baker, and James 1997; Shane 2000). Most retail poultry is contaminated with *C. jejuni* (Altekruse et al. 1999).

Potential for adverse consequences

C. jejuni usually colonises the avian intestinal tract without causing clinical signs or pathology (Evans 2001). If infection of young poultry is accompanied by clinical signs, these are usually limited to depression and diarrhoea (Shane 1997). However, asymptomatic infection is common, and there is no recognised clinical syndrome associated with *C. jejuni* infection in chickens (Evans 2001; Shane and Stern 2003).

Human campylobacteriosis is often associated with the handling and preparation of raw poultry products, and the consumption of undercooked poultry or foods that have been cross-contaminated with poultry products. In humans, *C. jejuni* infections lead to gastroenteritis, which may be accompanied by bloody diarrhoea, bacteraemia, and septic arthritis. Disease appears to be more frequent and severe in immunocompromised patients. Death from campylobacteriosis is rare, but more common in the elderly, infants and patients with underlying illnesses. Guillain-Barré syndrome and reactive arthropathy (Reiter syndrome) are uncommon but serious complications of infection (Altekruse et al. 1999). Infection with quinolone-resistant strains of *C. jejuni* complicates the treatment of human patients requiring antibiotic treatment for diarrhoea-related illnesses, as quinolones are frequently the drugs of choice for the treatment of severe undifferentiated diarrhoea.

Occurrence in Australia

C. jejuni is commonly found in Australian poultry flocks and poultry meat, and is a recognised cause of human gastrointestinal illness in Australia (Miflin and Templeton 2002). Fluoroquinolones are not registered for use in poultry in Australia and many Australian *Campylobacter* isolates remain susceptible to fluoroquinolones (Tauxe 2000a). However, quinolone-resistant strains of *C. jejuni* have been isolated from the stools of Australian patients with gastroenteritis returning from overseas (Binotto, McIver, and Hawkins 2000), and in a small number of cases that may have been locally-acquired (Sharma et al. 2003).

Reasons for exclusion from the Hazard List

C. jejuni, while acknowledged as a human pathogen, is not an agent that readily causes disease in poultry flocks. The management of risks associated with human pathogens in food is the

responsibility of FSANZ. Products intended for human consumption may undergo a separate assessment conducted by FSANZ to determine the public health risks. Imported food must comply with the *Imported Food Control Act 1992* and the *Food Standards Code* developed under the *Food Standards Australia New Zealand Act 1991*. AQIS may inspect, sample, hold and test imported food based on issues of public health, including microbial agents or residues of public health concern, and compliance with the *Food Standards Code*. This provides an equivalent health standard to that applied domestically.

C. jejuni is a ubiquitous organism, present in commercial chickens world-wide, including Australia. If the organism were introduced into poultry flocks via imported chicken meat, it is unlikely that any effect on bird health or production would be detected. Campylobacteriosis is not an OIE-listed disease and is not subject to controls within Australia.

There are no identifiable separate strains of *C. jejuni* overseas that could be readily differentiated from Australian endemic strains, and quinolone-resistant strains of *C. jejuni* have already been identified in Australian human patients.

For these reasons, quinolone resistant *C. jejuni* was excluded from the Hazard List.

Table 5. Hazard refinement

Disease agent	**Hazard identification criteria (Yes/No)**				**Retain for risk assessment (Yes/No)**
	Agent infects domestic chicken	**Potential for transmission via chicken meat[1]**	**Capable of adverse impact[2]**	**Occurrence in Australia[3]**	
OIE-listed disease agents					
Highly pathogenic avian influenza virus	YES	YES	YES	NO	YES
Low path. notifiable avian influenza virus (H5 & H7)	YES	YES	YES	NO	YES
Newcastle disease virus	YES	YES	YES	NO[4]	YES
Avian infectious bronchitis virus	YES	YES	YES	YES[5]	YES
Avian infectious laryngotracheitis virus	YES	YES	YES	YES	NO
Duck hepatitis virus	NO	NO	YES	NO	NO
Pasteurella multocida	YES	YES	YES	YES	NO

Disease agent	Hazard identification criteria (Yes/No)				Retain for risk assessment (Yes/No)
	Agent infects domestic chicken	Potential for transmission via chicken meat[1]	Capable of adverse impact[2]	Occurrence in Australia[3]	
Salmonella Gallinarum	YES	YES	YES	NO	YES
Infectious bursal disease virus	YES	YES	YES	YES[5]	YES
Marek's disease virus	YES	NO	YES	YES	NO
Mycoplasma gallisepticum	YES	NO	YES	YES	NO
Mycoplasma synoviae	YES	*YES*	YES	YES[5]	YES
Chlamydophila psittaci	YES	NO	YES	YES	NO
Salmonella Pullorum	YES	YES	YES	NO[6]	YES
Avian metapneumovirus	YES	YES	YES	NO	YES
EEE/VEE/WEE viruses[7]	YES	YES[8]	YES	NO	YES
West Nile virus	YES	YES[8]	YES	NO	YES
Japanese encephalitis virus	YES	YES[8]	YES	YES[9]	YES
Salmonella Enteritidis	YES	YES	YES	NO[10]	YES
Multidrug resistant strains of *Salmonella* Typhimurium	YES	YES	YES	NO[11]	YES
Other diseases/agents					
Haemophilus paragallinarum	YES	YES	YES	YES[5]	YES
Avian encephalomyelitis virus	YES	YES	YES	YES	NO
Borrelia anserina	YES	NO	YES	YES	NO
Salmonella Arizonae	YES	YES	YES	YES[12]	YES
Avian leucosis virus	YES	NO	YES	YES	NO

Disease agent	Hazard identification criteria (Yes/No)				Retain for risk assessment (Yes/No)
	Agent infects domestic chicken	Potential for transmission via chicken meat[1]	Capable of adverse impact[2]	Occurrence in Australia[3]	
Group 1 fowl adenovirus serotype 1	YES	YES	YES	NO	YES
Group 1 fowl adenovirus serotype 4	YES	YES	YES	NO	YES
Group 1 fowl adenovirus serotype 8	YES	YES	YES	YES	NO
Avian adenovirus Group 2	YES	YES	YES	NO	YES
Avian adenovirus Group 3	YES	YES	YES	YES	NO
Fowl pox virus	YES	YES	YES	YES	NO
Avian nephritis virus	YES	YES	YES	YES	NO
Antibiotic-resistant *Campylobacter jejuni*	YES	YES	YES	YES	NO
Chicken anaemia virus	YES	YES	YES	YES	NO
Duck enteritis virus	NO	NO	YES	NO	NO
Goose parvovirus	NO	NO	YES	NO	NO
Enterohaemorrhagic *Escherichia coli* (EHEC)	YES	YES	YES	YES	NO
Muscovy duck parvovirus	NO	NO	YES	NO	NO
Mycoplasma meleagridis	NO	NO	YES	YES	NO
Mycoplasma iowae	YES	YES	YES	NO	YES
Ornithobacterium rhinotracheale	YES	YES	YES	NO	YES
Riemerella anatipestifer	YES	NO	YES	YES	NO

Disease agent	Hazard identification criteria (Yes/No)				Retain for risk assessment (Yes/No)
	Agent infects domestic chicken	Potential for transmission via chicken meat[1]	Capable of adverse impact[2]	Occurrence in Australia[3]	
Avian reovirus	YES	YES	YES	YES[5]	YES
Reticuloendotheliosis virus	YES	NO	YES	YES	NO
Transmissible proventriculitis virus	YES	YES	YES	YES	NO
Turkey coronavirus	NO	NO	YES	YES	NO
Mycobacterium avium	YES	YES	YES	YES	NO
Avian Paramyxovirus-2	YES	YES	YES	NO	YES
Avian Paramyxovirus-3	YES	YES	YES	NO	YES
Internal parasites	YES	NO[13]	YES	YES	NO
External parasites	YES	NO[14]	YES	YES	NO

Legend:

1. *Potential for transmission via chicken meat*: Chicken meat could potentially serve to transmit the pathogen to susceptible Australian animals.

2. *Capable of adverse impact*: The pathogenic agent (or a clearly identified strain of the pathogenic agent) could potentially produce adverse consequences in susceptible humans or animal/bird species in the importing country.

3. *Occurrence in Australia:* The pathogenic agent (or a clearly identified strain of the pathogenic agent) should not be present in the importing country. If present, the pathogenic agent is associated with a notifiable disease, or is subject to an official control or eradication program.

4. Virulent Newcastle disease virus of Australian origin has occurred in Australia, but has been eradicated.

5. Although the disease occurs in Australia, more pathogenic serotypes are known to exist overseas, which have not been reported in Australia.

6. Australian commercial poultry are considered to be free of *S.* Pullorum. There has been no isolation of the agent in Australia for greater than 10 years.

7. Eastern equine encephalomyelitis (EEE) virus; Western equine encephalomyelitis (WEE) virus; Venezuelan equine encephalomyelitis (VEE) virus.

8. Oral transmission of some arboviruses occurs between some species of animals. The IRA team is not aware of evidence that arboviruses have been transmitted from commercially produced chicken meat to animals or humans. However, after consideration of stakeholder submissions on the draft IRA report, a chapter examining the scientific literature on arboviruses was added to the draft final IRA report (see Part C of this IRA report).

9. One human case of Japanese encephalitis acquired on the Australian mainland has been reported, and there has been serological evidence of exposure in sentinel and surveyed pigs on Cape York Peninsula.

10. A few isolations of *S*. Enteritidis from commercial poultry have occurred, most recently in Queensland in 2005. Affected flocks were subject to control measures and intensive monitoring, and no further isolations have occurred since July 2006.

11. *S.* Typhimurium occurs commonly in Australia, but multi-drug resistant strains, as defined in Part C of this report, have not been reported in Australian commercial poultry.

12. Some serotypes of *S.* Arizonae occur in Australia. *S*. Arizonae serovar 18:Z4,Z32 is considered to be exotic.

13. Intestinal parasites will be removed during the evisceration process; tissue-based parasites (e.g. Sarcocystis species) are unlikely to be transmitted in chicken meat because of their complex life cycles requiring specific hosts (Bermudez 2003).

14. External parasites will be removed during the defeathering process.

Conclusions: hazard identification

On the basis of these discussions, the following disease agents were retained for further consideration in the IRA.

OIE-listed disease agents

Notifiable avian influenza viruses

Newcastle disease virus

Avian infectious bronchitis virus

Exotic strains of infectious bursal disease virus, including very virulent and exotic antigenic variant strains

Salmonella Gallinarum

Salmonella Pullorum

Mycoplasma synoviae

Avian metapneumovirus (Turkey rhinotracheitis virus)

Salmonella Enteritidis

Multidrug resistant *Salmonella* Typhimurium

Other disease agents

Haemophilus paragallinarum

Salmonella Arizonae

Group 1 fowl adenovirus, serotype 1

Group 1 fowl adenovirus, serotype 4

Group 2 avian adenovirus

Mycoplasma iowae

Ornithobacterium rhinotracheale

Avian reovirus

Avian paramyxovirus-2

Avian paramyxovirus-3

EEE/WEE/VEE virus

West Nile virus

Japanese encephalitis virus

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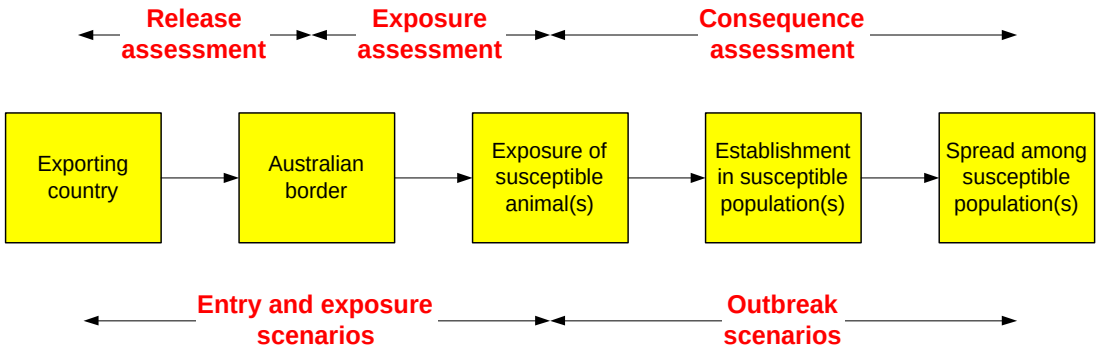
Risk assessment is defined in the OIE Code as:

… an evaluation of the likelihood and the biological and economic consequences of entry, establishment or spread of a pathogenic agent within the territory of an importing country.

The method adopted by Biosecurity Australia for performing import risk analysis conforms to that recommended by the OIE. The method for, and results of, hazard identification are described in the previous section. The methods for risk assessment (consisting of release assessment, exposure assessment, consequence assessment and risk estimation) are described in detail below. The steps involved in the risk assessment are illustrated in Figure 2.

Figure 2. Components of a risk assessment



The likelihood that a pathogenic agent will enter an importing country and the likelihood that susceptible animals will be exposed to that agent were determined through a ‘release assessment’ and an ‘exposure assessment’, respectively.

The ‘consequence assessment’ as depicted in Figure 2 includes two components. The first involves an assessment of the likelihood of establishment and spread of an introduced pathogenic agent, while the second involves an assessment of the biological and economic consequences of introducing a pathogenic agent.

The release assessment, exposure assessment and the first component of the consequence assessment described above are concerned with the likelihood of entry, establishment and spread of a pathogenic agent, while the second component of the consequence assessment is concerned with the biological and economic consequences of entry establishment and spread. The risk assessment for each identified agent concluded with ‘risk estimation’, the combination of the likelihoods and consequences, and yielded the unrestricted risk estimate.

The principle of a ‘generic’ risk assessment

This IRA is ‘generic’, in that the risks associated with the importation of chicken meat from *any* exporting country have been considered. In order to carry out release assessments that are relevant to all exporting countries, two assumptions were made:

1. That if a disease agent were present in a country, it would be present at the highest sustainable flock-level and within-flock level prevalence. This assumption was based on the

premise that prevalence would be dictated by epidemiological characteristics of the disease, and is, by nature, dynamic and thus may differ from country to country, and through time within countries. This assumption allowed generic assessment to be carried out, and allowed some diseases to be eliminated from further consideration on the basis that they would not present a risk in excess of Australia's ALOP, even if present at the highest sustainable prevalence in the exporting country.

2. That any chicken meat which may be considered for importation into Australia will be produced under conditions at least equivalent to those set out in the relevant Australian Standard. This risk analysis could have been performed without this assumption, but this would have been unrealistic, since product which does not meet minimum Australian standards would not be permitted for sale in this country and therefore would not be a viable import commodity. In this context, the 'relevant Australian standard' includes:
    - the *Australian Standard for Construction of Premises and Hygienic Production of Poultry Meat for Human Consumption (FRSC Technical Report No. 1: AS 4465:2005)* (Food Regulation Standing Committee 2006).
    - the *Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption (SCARM Report 80: AS4696: 2002)* (Standing Committee on Agriculture and Resource Management 2002).

Of these documents, *the Australian Standard for Construction of Premises and Hygienic Production of Poultry Meat for Human Consumption*, which describes Australia's domestic requirements for the ante-mortem, slaughter and processing procedures relevant to the production of poultry meat for human consumption, is of key importance. The primary objective of this document is to ensure food derived from poultry is safe and wholesome, rather than the control of animal disease. However, the basic hygiene controls detailed in the Australian Standard will provide some level of control of the spread of animal disease, and this is taken into account in the estimation of the likelihood of release. The effects of the requirements detailed in the Standard on particular steps in the release pathway are discussed further in the description of the release assessment.

Because of the generic nature of this risk analysis, the IRA team has based its evaluation of the likelihood of release on their estimates of the most likely situation in an infected country. Where exporting countries can provide specific data on their particular disease status, the IRA team will reconsider the release assessment based on that data so that country specific circumstances are considered in determining whether measures are required.

Evaluating and reporting likelihood

The quantitative likelihood model

A semi-quantitative likelihood model, incorporating a combination of quantitative and qualitative analysis, was used in this IRA to represent pathways relevant to the importation and utilisation of chicken meat, the disposal of chicken meat waste, and the possible exposure of susceptible animals in Australia. Such models are valuable in that they provide assistance with understanding of complex systems, and they can be used as a guide to predict the behaviour of the system when circumstances change (e.g. when new products are imported, or when alternative risk management options are employed).

The semi-quantitative model used in this IRA provided for the following important technical facilities:

- a framework upon which to base the logical structure of each assessment
- evaluation of the effect of the 'volume of trade' during a specified period
- accommodation of 'uncertainty' and 'natural variation' in the likelihood estimate assigned to individual steps in pathways.

However, no model can accurately represent the full complexity of a biological system. The IRA team considered that the quantitative model developed for this IRA provided a useful representation of the major pathways for entry, exposure, establishment and spread of exotic disease via imported chicken meat. It was not intended that the model accurately represent every possible pathway. At all times the IRA team members were aware of the need to assess model outputs against their own expert judgement and, where inconsistencies arose between the model outputs and IRA team expectations, the reasons for such inconsistencies were investigated and resolved to the satisfaction of team members. The conclusions reported for each disease represent the considered opinions of the IRA team, after consideration of the output of the quantitative model and any other relevant material.

A framework upon which to base the logical structure of each assessment

Assessments in this IRA were carried out according to carefully described importation and distribution scenarios, and a rigorous evaluation of consequences. Consequently, the assessments were complex and multifaceted, and required a framework that ensured all elements were combined in a transparent and consistent manner. One of the principal benefits of the quantitative spreadsheet-based model is that it provides such a framework.

Evaluation of the effect of the 'volume of trade' during a specified period

It is to be expected that as the volume of trade in a commodity during a prescribed period increases, so too will the likelihood of at least one introduction of a disease. Because the volume of trade in a prescribed period affects likelihood, it will also affect risk.

Without a quantitative framework it would be difficult to investigate and to demonstrate transparently or consistently the effect that projected volume of trade may have on the risks associated with the importation of chicken meat.

Accommodation of uncertainty and natural variation in the likelihood estimate assigned to individual steps in pathways

One of the requirements of an assessment is that any uncertainty and natural variation in individual estimates be incorporated. This is important because quantitative assessments may otherwise appear to convey a degree of 'precision' that is not present in either the underlying science, or in the model parameter being estimated. Uncertainty in the estimates for each of the model parameters was represented in the limits of the probability distribution chosen to represent that parameter.

Representing expert judgements and quantitative data

Each step in the quantitative model was estimated, and subsequently represented, using one of two interchangeable approaches. Where *quantitative* data or other scientific evidence relating to probabilities or estimates of other numeric quantities such as counts and volumes were available, probability distributions derived from the data were used. Where sufficient evidence was not available to allow the use of probability distributions derived from the data, a simple Uniform probability distribution representing a *qualitative* expert judgement of probability or likelihood was used.

Modelling qualitative expert judgment

Quantitative data were not available to support many of the probabilities assigned to the pathway steps considered in this analysis. Likelihoods assigned to these steps were therefore based on expert judgements and modelled using the qualitative descriptors described in Table 6.

Table 6. Nomenclature for qualitative likelihoods

Likelihood	Descriptive definition
Certain	The event would definitely occur
High	The event would be very likely to occur
Moderate	The event is equally likely to occur or not occur
Low	The event would be unlikely to occur
Very low	The event would be very unlikely to occur
Extremely low	The event would be extremely unlikely to occur
Negligible	The event would almost certainly not occur
Zero	The event would not occur

In order to ensure consistency in the usage and interpretation of these terms and definitions, and to provide a framework under which they could be logically and transparently combined, the 0–1 interval for likelihood was divided into the following categories (Table 7). Events considered certain to occur were assigned a likelihood of one (1), and those certain not to occur were given a likelihood of zero (0).

In choosing boundaries for qualitative likelihoods, it was important to provide a system that could be adopted by those whose task it is to review scientific evidence and estimate likelihoods. It was also important to ensure that the categories are neither overly precise nor constrictive, nor so broad as to lose the precision that may have been present in the original body of scientific evidence. Accordingly, it is *not* critical that the categories are of equal width, or that they are assigned according to a predefined arithmetic or logarithmic scale. Overall, the emphasis is on useability and, once defined, a system that would enable experts to use the corresponding terms and definitions (Table 6) consistently.

Likelihoods described under this nomenclature were subsequently combined using a spreadsheet-based simulation model. This model was constructed in Microsoft Excel, and run using the spreadsheet add-on software, @Risk (© 2001, Palisade Corporation, USA).

This was achieved by representing each of the six likelihood categories (excluding 'certain' and 'zero') as a 'Uniform probability distribution' (abbreviated 'Uniform distribution'). A Uniform probability distribution (also called a Rectangular probability distribution) is one that has a maximum and minimum value, but for which the continuous spectrum of values in between these limits each occurs with the same probability.

Table 7. Likelihood ranges and qualitative likelihood categories

Likelihood	Minimum	Maximum
Certain	1	
High	> 0.7	$\rightarrow$1
Moderate	> 0.3	$\rightarrow$0.7
Low	> 0.05	$\rightarrow$0.3
Very low	> 0.001	$\rightarrow$0.05
Extremely low	> 10^{-6}	$\rightarrow$0.001
Negligible	> 0	$\rightarrow$ 10^{-6}
Zero	0	

For example, an expert presented with the descriptors and probability ranges shown above might consider 'the likelihood that an infected animal will be sent to slaughter' to be 'low'.

In making this choice, the expert would have considered the likelihood to be less than the broad band representing an approximately even (moderate) probability, but not so low as to be in a range dominated by small fractions of a percent.

The parameters of each of these six Uniform distributions (their maximum and minimum values) were obtained from the boundaries of the corresponding probability category. These Uniform distributions are shown in Table 8.

Thus, a likelihood described by an expert presented with the descriptors and probability ranges shown above as 'Low', will be represented using a Uniform probability distribution with parameters, minimum = 0.05 and maximum = 0.30.

This would imply that the true likelihood might fall anywhere in the range 0.05 to 0.30, but that no particular value in this range is considered by the analyst to be more likely than any other.

Table 8. Uniform distributions and qualitative likelihood categories

Likelihood	Distribution
High	L ~ Uniform (0.7, 1)[5]
Moderate	L ~ Uniform (0.3, 0.7)

[5] This abbreviated syntax for likelihood (L) should be read as '*L is distributed uniformly between 0.7 and 1*'.

Low	L ~ Uniform (0.05, 0.3)
Very low	L ~ Uniform (0.001, 0.05)
Extremely low	L ~ Uniform (10^{-6}, 0.001)
Negligible	L ~ Uniform (0, 10^{-6})

Modelling quantitative data

Quantitative data on a probability, or on estimates of other numeric quantities such as counts and volumes, were modelled either as a point estimate or, more commonly, as a probability distribution. The shape and parameters of this distribution depended on the nature of the variable being modelled and the completeness of available data. The uniform distribution has been described above. Another distribution used in this IRA is the triangular distribution. A triangular distribution is the most commonly used distribution for modelling expert opinion (Vose 2002). It is defined by its minimum, most likely and maximum values. It is commonly used for modelling expert opinion because it is easy for experts to think about the three defining values, and the effect of changes in these values can easily be envisaged. It may also be described as RiskTriang (minimum, most likely value, maximum). In the text of this document, the triangular distribution is generally described as the most likely value, with minimum and maximum values being the most likely value ± 10%, unless stated otherwise.

Summary: evaluating and reporting likelihood

The likelihood component of this analysis was based on a semi-quantitative model. Simple Uniform probability distributions and Triangular distributions were used to represent expert judgements, depending on the information available. More precise probability distributions were available for use, where quantitative data of sufficiently high quality were available.

The likelihood model is considered to be ‘stochastic’, because probability distributions rather than point estimates were used to represent likelihoods, proportions and other model inputs (such as volume of imports of chicken meat). The output of a stochastic model is also a distribution, rather than a point estimate. While algebraic methods have been developed for determining the probability distribution functions of some combinations of variables, such methods quickly become extremely complex and cannot usually be considered as a practical solution (Vose 2002). Therefore the stochastic model was developed to use Monte Carlo simulation techniques. Monte Carlo simulation methods offer a number of advantages over other methods of implementing stochastic models (Vose 2002). These advantages include:

- The distributions of the models parameters do not have to be approximated in any way
- Correlations and other inter-dependencies can be modelled
- The level of mathematics required to perform a Monte Carlo simulation is quite basic
- The computer does all the work required in determining the outcome distribution
- Software is commercially available to automate the tasks involved in the simulation
- Greater levels of precision can be achieved by simply increasing the number of iterations to be calculated

- Complex mathematics can be included if required (e.g. power functions, logs etc) with no extra difficulty
- Monte Carlo simulation is widely recognised as a valid technique so its results are more likely to be accepted
- The behaviour of the model can be investigated with great ease
- Changes to the model can be made very quickly and the results compared with previous models.

The software used for the implementation of this model was @Risk, developed by Palisade Corporation.

Interpretation of the output probability distributions from the stochastic model was based on the correlation with Biosecurity Australia's likelihood categories (see above). Because risk analysis models include a substantial number of linearly multiplied likelihoods, and because of the nature of the likelihood ranges often used (and their probability distribution), the simulation output will resemble a strongly skewed Lognormal distribution. The median value of this distribution provides a true reflection of the likelihood model from which the output distribution is derived, and therefore the median value (50th percentile) was taken and the particular likelihood range within which this value falls was reported. The more extreme percentiles of the output distribution (e.g. the 95th or 99th percentile) also represent uncertainty, but should not be equated with commonly reported confidence limits. Rather, they represent the tails of the probability distribution, and can be considered to be somewhat arbitrary outliers. It would not be appropriate to cite such outliers as the outputs of a likelihood model.

Release assessment

Release pathways for chicken meat

Release assessment describes the process used to estimate the likelihood that a disease agent will enter Australia through the importation of chicken meat. The 'biological pathway', or ordered sequence of steps undertaken in sourcing, processing and exporting a commodity, is termed its 'release scenario'. The initiating step for the release scenario for chicken meat was the sourcing of slaughter-age poultry in the exporting country, and the end-point was 'the arrival in Australia' of infected or contaminated chicken meat.

The pathway diagram for chicken meat is significantly influenced by the probability of contamination of chicken carcasses by intestinal tract contents and respiratory secretions during processing.

The steps identified by the IRA team in the release assessment are illustrated in Figure 3 and Figure 4.

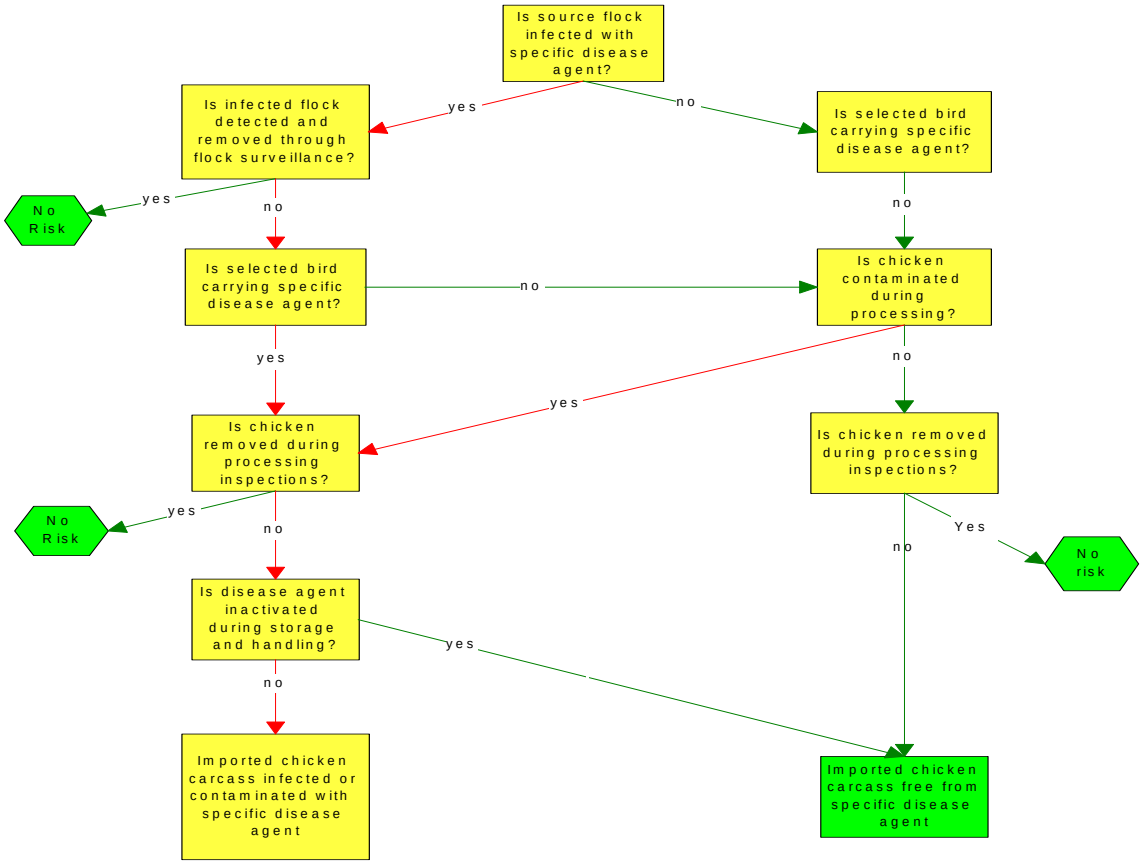
Steps and step-likelihoods associated with the importation of chicken meat are shown in the expanded pathway diagram in Figure 4. This diagram is more complex than Figure 3 as it describes each separate set of events that may result in an imported carcass being either infected or contaminated, or not.

Likelihoods assigned to individual steps in the release scenario were evaluated and reported using the terms and definitions in Table 6. Likelihoods are 'conditional', i.e. based on the assumption that all the previous steps in the pathway under consideration have been fulfilled.

Likelihoods ascribed to events, or steps, in Figure 4 are labelled Rel_1 to Rel_8. These likelihoods are summarised in Figure 4, and discussed individually in the following text.

In the following discussion of the steps in the release pathway, it is necessary to acknowledge that the likelihood of each of the individual steps will vary from country to country, or from zone to zone, depending on the disease status of the country or zone, and the actual level of implementation and effectiveness of the relevant standards for disease surveillance and monitoring, and hygienic processing in the country. For the purpose of generic risk assessment, it was assumed that standards equivalent to those applying in Australia are effectively implemented. Effectiveness of individual country veterinary services[6] will be considered in the development of country specific conditions, to ensure that this assumption is sound.

Figure 3. Release pathways for chicken meat



[6] Animal Quarantine Policy Memorandum (AQPM) 1999/41 provides details of the processes used to assess the effectiveness of overseas country veterinary authorities, and other matters relating to approval of countries to export to Australia. This document is included in this report as Appendix 5.

Figure 4. Expanded pathway diagram for chicken meat

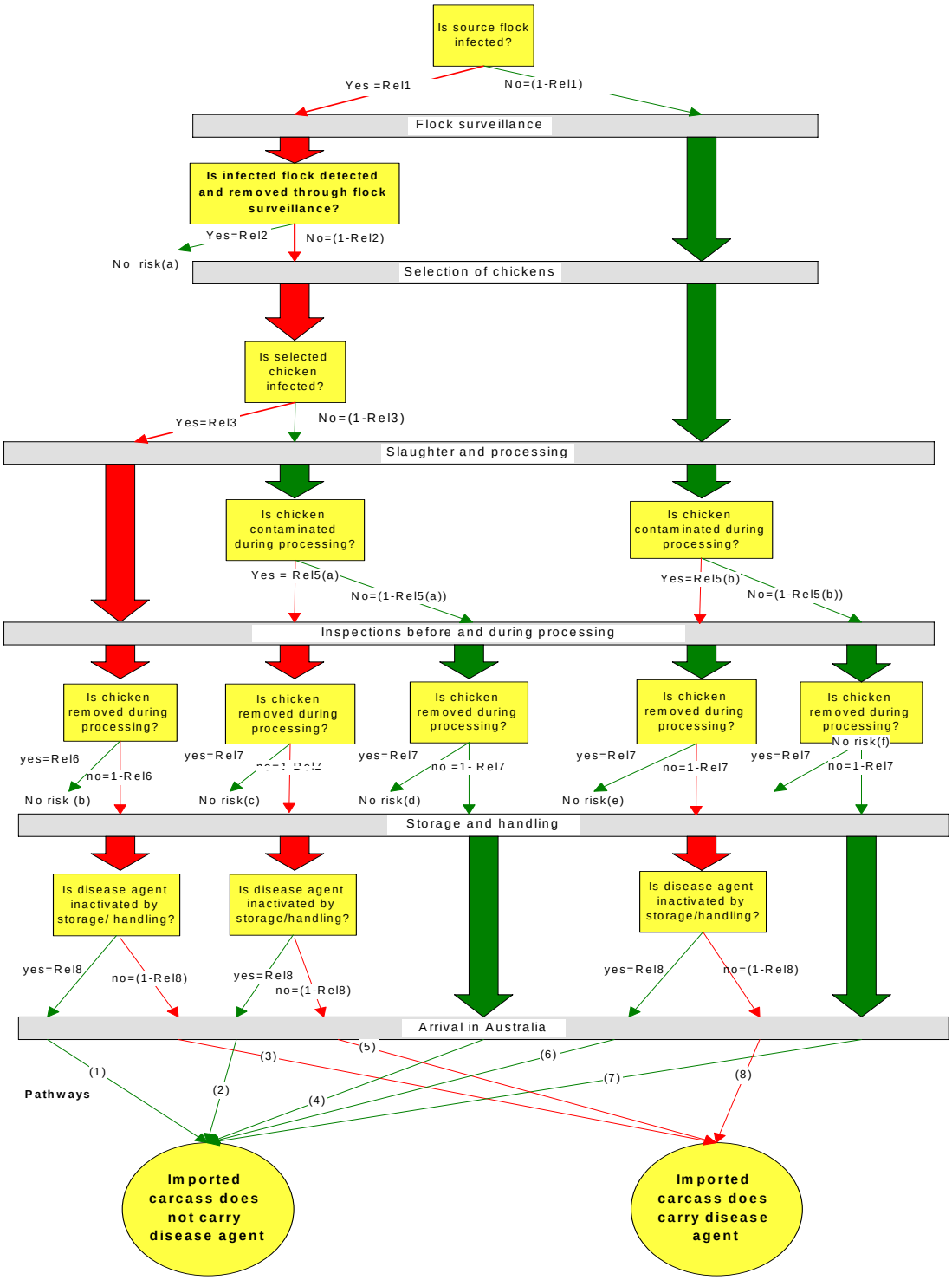


Table 9. Steps in the importation of chicken meat

Likelihood	Description
Step Rel_1	The likelihood that a disease agent is present in the source flock (i.e. between flock prevalence)
Step Rel_2	The likelihood that a disease agent will be detected as a result of routine flock surveillance, and the flock removed from the food production pathway
Step Rel_3	The likelihood that an individual bird selected from an infected flock is infected (i.e. within flock prevalence)
Step Rel_4[1]	The likelihood the carcass will be cross-contaminated during slaughter and processing with material from other carcasses, including those tissue or materials in which the disease agent tends to be localised (Background cross-contamination rate).
Step Rel_{5a}	The likelihood that an uninfected carcass derived from an *infected* flock will become contaminated with the particular disease agent during slaughter and processing
Step Rel_{5b}	The likelihood that an uninfected carcass derived from an *uninfected* flock will become contaminated with the particular disease agent during slaughter and processing
Step Rel_6	The likelihood that the carcass of a bird that was *infected* prior to slaughter will be removed as a result of inspections before or during processing, as specified in the *Australian Standard for the Construction of Premises and Hygienic Production of Poultry Meat for Human Consumption*
Step Rel_7	The likelihood that the carcass of a bird that was *not infected* prior to slaughter (whether contaminated during de-feathering and evisceration or not) will be removed as a result of inspections before or during processing, as specified in the *Australian Standard for the Construction of Premises and Hygienic Production of Poultry Meat for Human Consumption*
Step Rel_8	The likelihood that a pathogen in an infected/contaminated carcass would be inactivated during storage, further processing and transport to Australia

[1] Rel_4 does not appear explicitly in Figure 4, but is used in the calculation of Rel_{5a} and Rel_{5b}

Step Rel_1: Selection of flock

The likelihood assigned to this step (Rel_1) represents the prevalence of infected flocks within the country from which chicken meat will be sourced (i.e. between flock prevalence). Regardless of the causative agent, flock prevalence is likely to fluctuate with changes in disease dynamics within an infected country (the number of infectious animals, the number of susceptible animals, the potential for adequate contact or transmission, etc). A range of environmental, human and epidemiological factors will in turn influence this.

Given its dynamic nature, the flock prevalence of each identified disease was modelled conservatively by adopting a value considered the highest prevalence sustainable in an endemically infected country or zone. Flock prevalence is discussed further within the risk assessment for each identified pathogenic agent.

Step Rel_2: Surveillance of flock

The likelihood assigned to this step (Rel_2) represents the probability that a flock infected with a particular disease agent will be detected and removed from the food production system as a result of routine health surveillance. Factors contributing to this likelihood will include the regulatory status of the disease in the source country, the within-flock prevalence of disease and the presence and severity of clinical signs.

Step Rel_3: Selection of individual bird

The likelihood assigned to this step (Rel_3) represents the prevalence of infected birds within an infected flock (i.e. within-flock prevalence). Given the large number of human, environmental and epidemiological factors that will influence flock-level disease dynamics, this likelihood is unlikely to be stable within any given flock, or consistent among infected flocks. For this reason, the within-flock prevalence of each identified disease was modelled conservatively by adopting a value considered to represent the highest prevalence sustainable within an endemically infected flock. Within-flock prevalence is discussed further in the risk assessment for each identified pathological agent.

Steps Rel_4: Background cross-contamination rate

The likelihood assigned to this step (Rel_4) represents the background cross-contamination rate during slaughter and processing and applies to cross-contamination with material from other carcasses, especially those tissues in which the disease agent tends to localise. Rel_4 is used to calculate the likelihoods of cross-contamination of a carcass with infectious agent (Rel_{5a} and Rel_{5b}). It does not appear explicitly in Figure 4 but contributes to both Rel_{5a} and Rel_{5b}.

Key factors influencing Rel_4 are:

- Design and operational characteristics of the processing plant. Aspects of the design of the processing plant, the level of management and the incorporation of quality assurance programs may strongly influence the level of contamination occurring within the premises. The use of such equipment as spin chillers ensures that there is a high likelihood of contact between individual carcasses, so that cross-contamination is probable. In addition, the decontamination practices are of importance. In some instances, premises are decontaminated at the completion of processing of poultry from each flock. In others, premises are decontaminated at the end of each working day. This means that, in some cases, poultry from an uninfected flock could become contaminated if they were processed after an infected flock, and before decontamination of the premises. This IRA is ‘generic’ and, as such, the standards of construction and operational practices of each potential source country need to be considered. However, for the purposes of unrestricted risk estimation, it will be assumed that the standards applicable in Australia, as documented on page 48, are implemented as a minimum. Where a potential exporter believes that standards in their country are so different from those applicable in Australia as to make a significant difference to the level of risk involved, Biosecurity Australia will reassess the risks based on an assessment of the effectiveness of that country’s standards.
- Tissue tropism. While some disease agents may be relatively evenly distributed throughout the carcass, others may localise leading to higher levels of the agent in particular organs or tissues. The degree of contact these organs or tissues have with

other carcasses, either directly or indirectly via equipment or staff, will influence the likelihood of cross-contamination.

- Characteristics of the organism. The contamination rate will also be affected by the resistance of the organism to environmental factors such as temperature, chlorine (in processing plant water supplies) and other disinfectants. Highly resistant organisms have a greater chance of surviving in the processing plant environment than less resistant organisms, and therefore have a higher likelihood of contaminating other carcasses.

Steps Rel_{5a} and Rel_{5b}: Slaughter and processing

The likelihoods assigned to these steps (Rel_{5a} and Rel_{5b}) represent the probability that disease-free birds sourced from infected and uninfected flocks (respectively) will be contaminated by the disease agent of concern during slaughter and processing.

Key factors influencing this probability are:

- Infection status of the flock. Carcasses from a flock infected with a particular disease agent have a higher likelihood of cross-contamination with that agent, than do carcasses from an uninfected flock processed on the same processing line. However, birds from an uninfected flock may be processed after those from an infected flock, and before decontamination of the premises. If this is the case, individual birds from the uninfected flock may be contaminated with material from the infected flock. However, these birds are relatively less likely to be contaminated than individuals from an infected flock – thus the need to distinguish in the pathway diagram between steps Rel_{5a} and Rel_{5b}.
- Prevalence of infection within an infected flock. For some disease agents, the prevalence of infection will have a strong effect on the degree of contamination of premises, and the likelihood that an uninfected bird will become contaminated during processing. In other cases, the prevalence of diseased birds may be less important than the load of organisms in each infected individual, and the ability of the organism to survive conditions in processing.

The likelihood of contamination of a carcass from an infected flock can be derived from two variables – a 'contamination' term (Rel_4) which is related to the structure and operation of the processing plant, as well as the nature of the disease agent, and the organs in which the disease agent might be present; and the likelihood that other birds in the flock will be infected (Rel_3). Rel_{5a} can therefore be calculated as follows:

$$Rel_{5a} = Rel_4 \times Rel_3$$

Rel_{5b} can be calculated in a similar manner, but needs to take account of the likelihood that any infected flock will have been processed on the same day as the uninfected flock. Rel_{5b} is, therefore, related to the between flock prevalence (Rel_1), within flock prevalence (Rel_3) and the likelihood that a flock infected with a particular disease agent will not be detected and removed from the food production system as a result of routine health surveillance (Rel_2). Therefore Rel_{5b} can be calculated as follows:

$$Rel_{\mathbf{5b}} = Rel_{\mathbf{4}} \times Rel_{\mathbf{3}} \times (1-Rel_{\mathbf{2}}) \times Rel_{\mathbf{1}}$$

Steps Rel_6 and Rel_7: Inspections – ante-mortem and post-mortem

The likelihoods assigned to these steps (Rel_6 and Rel_7) represent the probability that an infected or uninfected bird (respectively) will be removed as a result of routine ante-mortem and post-mortem inspections, as described in FRSC Technical Report No. 1, *The Australian Standard for Construction of Premises and Hygienic Production of Poultry Meat for Human Consumption (AS4465: 2005).*

The likelihood that an *infected* bird will be removed at ante-mortem inspection will be determined by the severity of clinical signs, as well as the background rejection rate amongst birds presented for slaughter. The likelihood that an *uninfected* bird will be removed is simply related to the background rejection rate. Given the nature of the ante-mortem inspection at processing plants, this likelihood was considered to be close to zero.

The likelihood that an *infected* or *contaminated* bird will be removed at post-mortem inspections will depend on the severity of pathological lesions or contamination seen, and is therefore related to the individual disease under consideration. The likelihood that an *uninfected* bird will be removed is related to the background rejection rate at post-mortem inspection.

The background rejection rate for chicken carcasses in Australian processing plants was reported by industry sources (Fairbrother 2003) to be approximately 0.75%. Therefore the likelihood that an uninfected carcass would be removed at processing was considered to be 0.0075. This was modelled as a triangular distribution, with most likely value of 0.0075, and maximum and minimum values 10% above and below the most likely value, respectively.

Step Rel_8: Storage, further processing and transport

The likelihood assigned to this step (Rel_8) represents the probability that a pathogen in an infected/contaminated carcass would be inactivated during storage, further processing and transport to Australia. Packaging and storage requirements will be at least the equivalent of those outlined in the *Australian Standard for Construction of Premises and Hygienic Production of Poultry Meat for Human Consumption* (Food Regulation Standing Committee 2006). It is difficult to be prescriptive about the period of storage prior to the arrival of the commodity in Australia, since this may vary substantially among chicken meat products, consignments and exporting countries. It is reasonable, however, to expect that the period of storage will be at least 2–3 days for fresh products, and longer for frozen products.

It is also difficult to be prescriptive regarding the temperature during storage and it is likely that a substantial proportion of imported chicken meat will be frozen. It is, however, stated in the *Australian Standard for the Hygienic Production and Transportation of Meat and Meat Products for Human Consumption (SCARM Report 80)* (Standing Committee on Agriculture and Resource Management 2002) and in the *Australian Standard for Construction of Premises and Hygienic Production of Poultry Meat for Human Consumption* (Food Regulation Standing Committee 2006) that the surface temperature of carcasses should not be more than 7 °C, and that the internal temperature of meat other than carcasses should not be more than 5 °C within 12 hours of stunning. Frozen product should be reduced in core temperature to at least –15 °C within 96 hours of stunning and should not be derived from thawed product (Food Regulation Standing Committee 2006). Since exporting countries must comply with these or equivalent conditions, they were adopted in the IRA as a conservative benchmark. This likelihood is discussed further within the assessment for each identified pathogenic agent.

Release pathways

Each group of steps that leads to an imported carcass being infected or contaminated with a disease agent is considered a discrete 'pathway'.

- Pathways numbered 1, 2, 4, 6, and 7 in Figure 4 describe events that lead to an imported carcass that is not infected or contaminated with a disease agent
- Pathways numbered 3, 5 and 8 in Figure 4 describe sets of events that lead to an imported carcass that is infected or contaminated with a disease agent
- The remaining pathways are denoted 'no risk (a)', 'no risk (b)', etc, and describe events that lead to the removal of a selected bird from the overall scenario. Some of these ('no risk' (d), 'no risk' (f)) represent the background rejection rate (i.e. negative birds removed for any reason). These need to be taken into account to ensure that the final outcome accurately reflects the likelihood that any imported carcass is infected.

Calculation of the likelihood of entry

Calculation of the likelihood of entry is summarised in Table 10.

It can be seen from this table that the 'unit' chosen for the likelihood of entry was 'meat derived from the single carcass'. This unit also provided the basis for the exposure assessments. Meat from the carcass of a single bird was chosen to be the unit for these assessments since:

- the infection status of an individual bird forms the basis for disease dynamics in a population
- the concept of a carcass, or a 'carcass equivalent', provides a simple and intuitive unit upon which estimates incorporating the volume of trade can be based.

The IRA team recognises that the levels of viruses or bacteria in different portions of a carcass may vary, depending on the nature of the disease agent being studied. Where necessary within the scope of this IRA, these differences were taken into account during discussion of individual diseases. In particular, this may affect the likelihoods of the various steps in the release pathway, if risk management measures are implemented based on allowing the import of only specified portions of the carcass.

Table 10 describes, in mathematical terms, the likelihood of importation (entry) of a carcass carrying a disease agent through each of the pathways outlined in Figure 4. The purpose is to estimate the likelihood that an individual imported carcass is infected or contaminated with the disease agent of concern. The likelihood of this importation is dependent on the likelihood of a carcass remaining or becoming contaminated or infected during processing.

Exposure assessment

Exposure assessment describes the process that was used to estimate the likelihood that a susceptible animal in Australia will be exposed to the disease agent imported in a contaminated[7] chicken carcass. It takes into account the groups of animals most likely to be affected by disease agents carried in chicken meat, as well as the possible pathways by which exposure of these groups of animals could occur.

[7] The term 'contaminated carcass' will be used to refer to an infected/contaminated carcass derived from an infected chicken or a carcass which has been cross-contaminated at some stage with the disease agent.

Table 10. Calculation of the likelihood of entry

Likelihood	Calculation / description
RE_{final}	**The likelihood that the imported carcass will be carrying a disease agent** **= $RE_{contaminated}$ / RE_{import}**
$RE_{contaminated}$	The likelihood that any individual carcass will be infected and imported = $Path_3 + Path_5 + Path_8$
RE_{import}	The likelihood that any individual carcass will be imported = $Path_1 + Path_2 + Path_3 + \ldots. Path_8$
$Path_1$	The likelihood that an individual carcass will be imported through pathway 1 = $Rel_1 \times (1–Rel_2) \times Rel_3 \times (1–Rel_6) \times Rel_8$
$Path_2$	The likelihood that an individual carcass will be imported through pathway 2 = $Rel_1 \times (1–Rel_2) \times (1–Rel_3) \times Rel_{5a} \times (1–Rel_7) \times Rel_8$
$Path_3$	The likelihood that an individual carcass will be imported through pathway 3 = $Rel_1 \times (1–Rel_2) \times Rel_3 \times (1–Rel_6) \times (1–Rel_8)$
$Path_4$	The likelihood that an individual carcass will be imported through pathway 4 = $Rel_1 \times (1–Rel_2) \times (1–Rel_3) \times (1–Rel_{5a}) \times (1–Rel_7)$
$Path_5$	The likelihood that an individual carcass will be imported through pathway 5 = $Rel_1 \times (1–Rel_2) \times (1–Rel_3) \times Rel_{5a} \times (1–Rel_7) \times (1–Rel_8)$
$Path_6$	The likelihood that an individual carcass will be imported through pathway 6 = $(1–Rel_1) \times Rel_{5b} \times (1–Rel_7) \times Rel_8$
$Path_7$	The likelihood that an individual carcass will be imported through pathway 7 = $(1–Rel_1) \times (1–Rel_{5b}) \times (1–Rel_7)$
$Path_8$	The likelihood that an individual carcass will be imported through pathway 8 = $(1–Rel_1) \times Rel_{5b} \times (1–Rel_7) \times (1–Rel_8)$

Exposure groups

The term ‘exposure group’ denotes a category of animal (whether based on its species or the manner in which it lives or is managed) that may be susceptible to one or more of the pathogenic agents considered in the risk assessments. Three broad groups of animals that may be directly exposed to chicken meat scraps were identified.[8]

- Non-poultry avian species, including
  - Wild birds and
  - Aviary, zoo and pet birds and pigeons
- Poultry (chickens, turkeys, ducks, geese), game birds, (pheasant, guinea fowl and quail) and farmed ratites (emus and ostriches) including:

[8] In this context, the term *direct exposure* was taken to mean exposure resulting from the direct consumption of contaminated chicken meat.

  - Backyard, free-range commercial poultry and ratites kept in conditions of low biosecurity
  - Commercial poultry, such as layers and meat chickens, kept in medium biosecurity establishments
  - Genetic stock kept in high biosecurity premises.
- Susceptible non-avian species, and species such as rodents and pigs that are either fed scraps or have a propensity for scavenging, and zoo animals that may be fed imported chicken meat.

Each of the identified exposure groups might also be exposed to imported disease agents through a range of 'indirect' routes. For example, wild birds may be in contact with backyard poultry that have consumed contaminated meat scraps. Indirect exposures were considered in the assessment of 'establishment and spread' scenarios (i.e. 'outbreak' scenarios), and are discussed elsewhere in the document (see Consequence Assessment).

Exposure groups are illustrated in Figure 5. The steps involved in exposure of these groups are discussed in detail and are illustrated in Figure 6.

Wild birds

Wild birds may act as hosts or vectors for many of the disease agents being considered in this IRA. Wild birds are most likely to gain access to contaminated imported chicken meat through scavenging meat scraps at refuse dumps. The IRA team recognises that wild birds also may access discarded waste in public parks and from backyards (for example, on compost heaps, in pet food bowls etc), but these were considered to be relatively minor routes of exposure. Therefore, factors to be considered in the exposure pathway for wild birds include:

- the likelihood of discarded meat scraps from the imported contaminated carcass being accessible to wild birds
- the likelihood of such scraps containing an infectious agent after exposure to light, putrefaction and the environment
- the susceptibility of scavenging species to the disease agent under consideration
- the likelihood that wild birds would consume a sufficient quantity of the meat scraps to initiate infection.

The availability of chicken meat waste at refuse dumps depends on the distribution of imported chicken meat to households, food service establishments (restaurants, take-away outlets etc) and meat processors and retailers, which is illustrated in Figure 6.

Aviary and zoo birds

Aviary biosecurity varies considerably, from low biosecurity aviaries, in which there is frequent indirect contact with other birds at shows or pet shops, and with wild birds or backyard poultry, to medium biosecurity premises in which breeding stock are kept.

The main groups of birds kept as pets or in aviaries include:

- Common pet and aviary birds, such as the psittacines and finches, which consume seeds, fruits and nuts

- Pet birds such as magpies and crows, which may be undergoing rearing or rehabilitation, and which may be fed raw or cooked meat scraps. These birds may be released into the wild once mature or recovered from injury, or they may escape.
- Raptors kept in rehabilitation centres, possibly for release into the wild. These birds would be fed raw meat product, which may include chicken meat scraps (Noah's Ark Wildlife Coalition Inc. 2004).

Of these groups, only the meat-eating birds were considered to be at risk of *direct* exposure to disease agents carried in contaminated imported chicken meat. The feeding of contaminated chicken meat scraps to meat-eating pet or rehabilitating birds may result in disease in those birds. However, the IRA team considered that the number of households that would keep meat eating birds was so low that this group could be excluded as a significant source of risk of exposure of susceptible Australian species.

Common pet birds are normally fed seeds, nuts and fruits, and would be unlikely to consume chicken meat scraps.

The IRA team acknowledges that zoological parks keep many species of birds, some of which are meat-eaters. In response to comments received from stakeholders following release of the draft IRA report, Biosecurity Australia made enquiries with major Australian zoos regarding the feeding of poultry products to zoo animals. Responses to these enquiries indicate that chicken products fed to meat-eating zoo birds are mostly in the form of whole chicks or older birds culled by domestic producers. Chicken cuts or mince form a minor part of the diet of meat-eating zoo birds, making it unlikely that a significant proportion of imported chicken meat would become available to zoo birds.

Therefore, the IRA team considered that aviary, zoo and pet birds could be excluded from the risk analysis as a direct exposure group.

Low biosecurity poultry

This exposure group includes backyard poultry, free-range commercial poultry, and ratites. Backyard poultry are at risk of direct exposure through the feeding of kitchen scraps, which might include imported chicken meat scraps. These birds may also be fed commercial chicken feeds that could contain rendered meat meals derived from imported chicken meat. The likelihood that a quantity of chicken meat scraps from an imported carcass, sufficient to induce infection, would be fed to backyard poultry depends on a number of other factors, including the distribution of imported chicken meat in the domestic market and the proportion of households that keep backyard poultry.

The term ‘free-range poultry’ was applied to commercial poultry with outdoor access, which are considered likely to be exposed to rodents and wild birds. In general, biosecurity for free-range poultry is low.

Ratites were also included in this group because they are generally farmed under conditions of low biosecurity with access to wild birds and rodents. Therefore, although at low risk of direct exposure to imported chicken meat, commercial free-range poultry and ratites are at risk of indirect exposure via wild birds.

Medium biosecurity commercial poultry

It is unlikely that medium biosecurity commercial poultry would gain direct access to imported chicken meat scraps. However, it is possible that rendered waste from processing of imported chicken carcasses may be incorporated in poultry feed, leading to exposure of commercial poultry.

Figure 5. Exposure groups for imported chicken meat

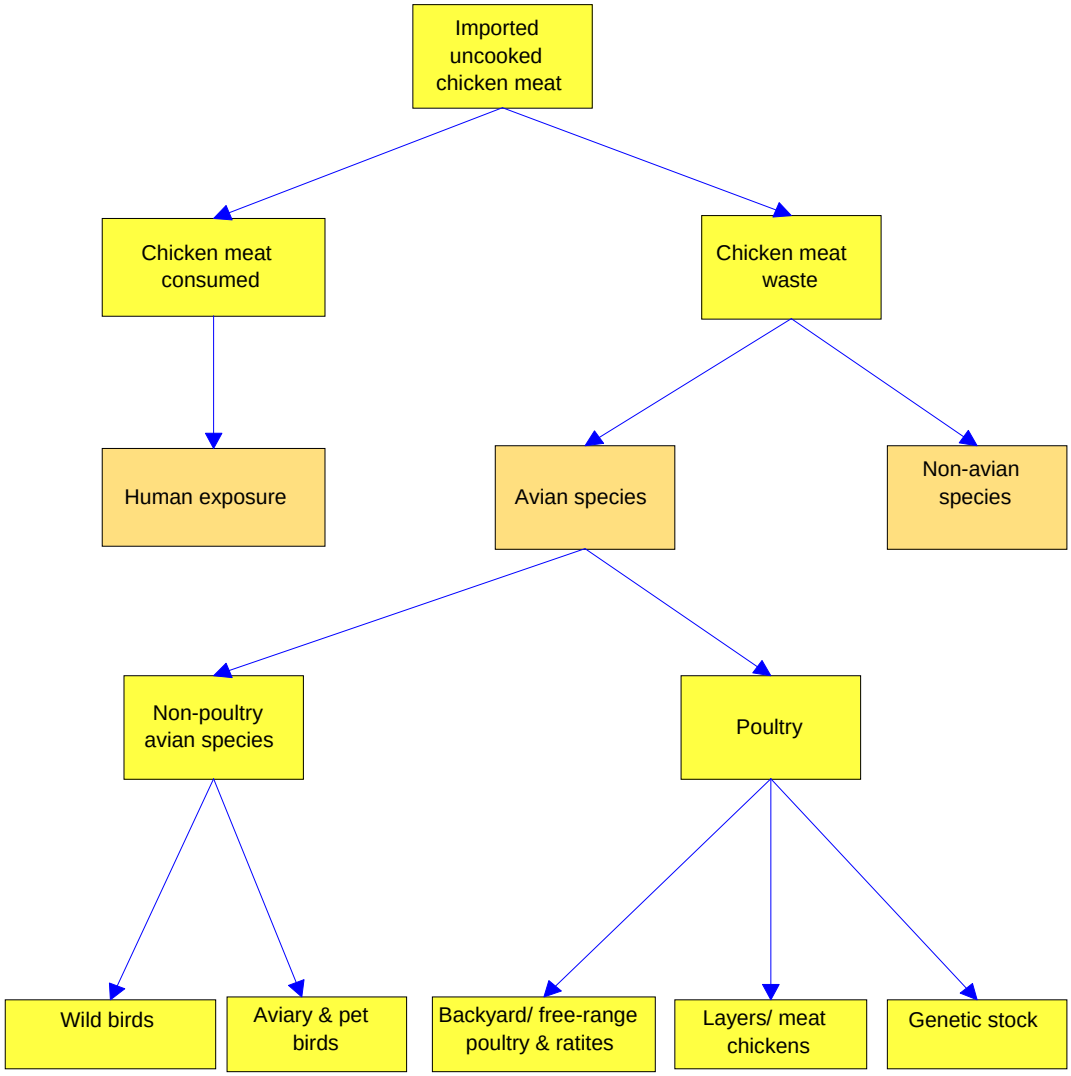
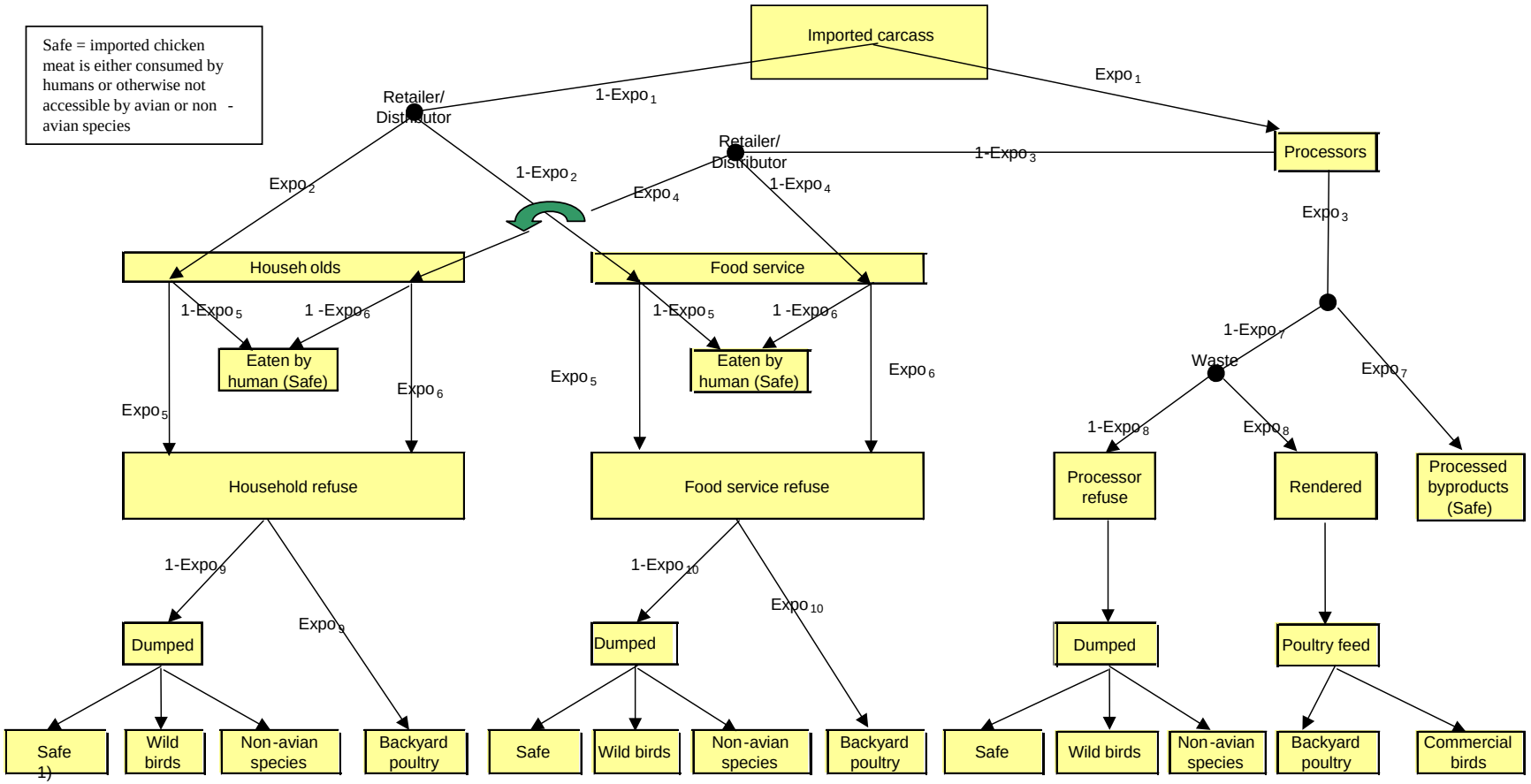


Figure 6. Pathways for exposure



The IRA team considered that the most feasible route for the direct exposure of medium biosecurity commercial poultry to imported carcass components is through the feeding of rendered processing waste from the manufacture of processed goods. Rendering in Australia utilises both wet and dry procedures, although in either case the minimum temperature is engineered to be 100 °C to 145 °C, to destroy potential hazards (Spooncer 2001).[9] The IRA team concluded that the likelihood that the agents considered in this IRA will survive the rendering process was negligible. However, there have been numerous cases of rendered material containing pathogenic agents, following post-processing contamination. The likelihood of post-processing contamination is dependent on the nature of the agent involved, and is discussed in the individual disease risk assessments.

Non-avian species

This exposure group is less clearly defined than the avian exposure groups. Some non-avian species may be at risk of exposure to disease agents in infected chicken meat. This group excludes humans, which are not considered at risk from the ingestion of meat waste for the purposes of this risk assessment, but includes species such as rats, domestic carnivores, feral pigs and other scavenging animals that might be infected or act to transmit the disease agent. Few of the disease agents affecting chickens are directly transmissible to other species. However, this likelihood is considered in the assessment of each disease.

The IRA team acknowledges that zoological parks keep a range of non-avian carnivorous species that may be fed poultry products. In response to comments received from stakeholders following release of the draft IRA report, Biosecurity Australia made enquiries with major Australian zoos regarding the feeding of poultry products to zoo animals. Furthermore, the IRA team examined the hazard list to determine which of the disease agents were likely to present a risk to zoo animals consuming imported contaminated chicken meat. The IRA team concluded that the only disease agents likely to present an unacceptable risk to zoo carnivores were avian influenza viruses and Salmonellae species. These disease agents were identified in the draft IRA report as requiring risk management measures in order to achieve Australia's ALOP, and the IRA team considered that the increase in risk associated with the feeding of non-avian carnivores in zoos was unlikely to increase the level of risk management required. Therefore, while acknowledging that the stakeholder comments are valid, the IRA team does not believe that there needs to be any change to the risk assessment document.

High biosecurity genetic stock

Genetic stock used in the commercial poultry industry is generally housed in high biosecurity complexes to reduce the chances of disease incursions. The birds are kept isolated from other flocks, and from rodents and wild birds. The most likely route of exposure of this stock would be through the feeding of contaminated poultry feed containing rendered product. High biosecurity genetic stock are, however, normally fed a heat-treated crumbled or pelleted feed containing vegetable (rather than animal) protein sources. Where animal protein sources are used, the raw materials are rendered and diluted before being incorporated into pelleted feed. These processes should ensure that the risk to high biosecurity genetic stock is negligible.

[9] An Australian Standard for rendering has been published: *Australian Standard for Hygienic Rendering of Animal Products* (*SCARM Report* 76, 2001 (Standing Committee on Agriculture and Resource Management 2001). Rendering plants will be encouraged by State Governments to comply with this standard.

The IRA team considered that it is unlikely that an exotic disease would become established in high biosecurity genetic stock as a direct result of importation of chicken meat. Although spread of the disease agent between sheds on the same high biosecurity farm might occur, spread to other premises was considered highly unlikely. Therefore, this exposure group was not considered further in the exposure assessment. Any indirect exposure of genetic stock was accounted for in the consequence assessment.

Exposure pathways

The ordered sequence of steps required for the exposure of susceptible animals to a pathogenic agent associated with imported chicken meat, is termed an 'exposure pathway'. Likelihoods assigned to steps in the exposure assessment were represented using the terms and definitions shown in Table 6.

- The *initiation point* for an exposure pathway will be the release of infected or contaminated chicken meat or chicken carcass from the point of entry into Australia
- The *endpoint* will be the exposure of susceptible animals in Australia to a quantity of contaminated imported chicken meat sufficient to initiate infection.

The method for exposure assessment set out here calculates likelihoods for the major pathways, since the IRA team considered that these represent the greatest quarantine risk. It is considered that the risk management measures necessary to mitigate the major risk pathways will also be sufficient to manage the minor risk pathways. For example, if off-shore treatments are sufficient to reduce the risk posed by imported meat to the point where it can be released in Australia without further controls, then the packaging material in which the product was transported can also be released without further controls. In cases where on-shore treatment may be required, this will have to be carried out at quarantine-approved premises or under quarantine control, with procedures in place to manage the risks posed by these major and minor pathways.

Calculation of likelihood of exposure for the identified exposure groups

In order to calculate the likelihood that susceptible Australian species would be exposed to and ingest imported chicken meat, and would become infected with an exotic disease as a result, it was necessary to define a number of variables. These can be grouped into three categories: distribution variables, exposure group-dependent variables, and pathogen-dependent variables.

Distribution variables

No data were available on the actual distribution of imported chicken meat, since current quarantine requirements prohibit the import of fresh and frozen chicken meat. Conditions for the import of cooked chicken meat exist, but to date, no imports have occurred. Therefore, no data were available to accurately determine the distribution of imported chicken products. Therefore, for the purposes of risk estimation, it was necessary to assume that processors, households and food service establishments (restaurants, cafes, take-away fast food outlets, etc) would have access to imported product. This assumption is important since it is clear that susceptible animals in Australia might gain access to scraps of imported chicken meat generated by any one or more of these groups. It was further assumed that the proportions of imported product used by these groups would be similar to those for locally produced product.

Chicken meat was defined earlier as a whole or part of the carcass of any domestic chicken, but excluding the head, feathers and offal (other than the liver, heart, gizzard, neck and feet). For the purposes of this risk assessment, the commodities considered to be associated with the greatest risk were whole carcasses, because of the greater potential for generating scraps, and the commodities of least risk were boneless cuts. For this reason, it was initially assumed that imports would consist of whole carcasses or portioned whole carcasses. Where the model showed that importation of whole carcasses was associated with an unacceptable risk of disease introduction, risk management options that were examined included importing only bone-in portions or boneless cuts, or pathogen reduction methods such as cooking.

Steps and step-likelihoods associated with the distribution and dispersal of chicken meat after importation are shown in Figure 6. This diagram is more complex than Figure 5, as it must depict a number of different pathways that can lead to various exposure groups having access to imported chicken meat. The individual step likelihoods depicted in Figure 6 are described in Table 11. The assumptions used in assigning values to these exposure likelihoods are discussed in detail in the following section.

Step $Expo_1$: The likelihood that the imported chicken carcass will be further processed in Australia

Note that the value of $Expo_1$ varies with the type of product imported (i.e. whole carcasses vs. bone-in or boneless cuts), since bone-in and boneless cuts have already been processed off-shore prior to importation, and are therefore less likely to be further processed on arrival than are whole carcasses. For the purposes of the unrestricted risk estimate, the value of $Expo_1$ will be based on the import of whole chicken carcasses. Importation of bone-in or boneless cuts will be considered under risk management.

Imported whole carcasses

It is anticipated that imported whole carcasses will be distributed directly:

- to processors for further processing and subsequent distribution to retailers or food service establishments or
- to distributors and retailers who will subsequently on-sell to households or the food service industry.

Raw product, such as whole carcasses and portioned whole carcasses, currently accounts for 50% of domestic production, with raw, value-added product, including fillets, crumbed pieces etc, comprising 30%, and cooked, further processed products 20% (J. Fairbrother, Australian Chicken Meat Federation, pers. comm. July 2002; A. Dubs, Australian Chicken Meat Federation, pers. comm. September 2005). Value-added and cooked products therefore comprise 50% of market distribution, and were assumed to have been initially distributed to or produced by processors, while raw products were distributed to households (via retailers) and the food service industry (e.g. restaurants, take-away food stores).

If the distribution of imported carcasses is similar to that for domestically produced product, it is estimated that 50% of whole carcasses would undergo further processing, with the remainder going to households and the food service industry. Based on this information, the likelihood that imported chicken carcasses would be further processed in Australia (referred to as $Expo_1$ in the model) was considered to be 50%. This value was expressed as a Triangular distribution, with 0.5 as the ‘most likely’ value and the minimum and maximum as 10%

above and below the most likely figure. This meant that, by subtraction, the likelihood that imported product would not be further processed in Australia ($1–Expo_1$) was approximately 50%.

Step $Expo_2$: The likelihood that the imported contaminated carcass, if not further processed in Australia, would be purchased by a household

Chicken meat produced domestically, both processed and unprocessed, is currently distributed to retail sale (supermarkets, small retailers and butchers), take away and food service sectors. These sectors account for approximately 50%, 25% and 25% respectively, of domestic production.

If it is assumed that most chicken meat sold through retailers is purchased by households, it can then be estimated that 50% of chicken meat is ultimately distributed to households, and 50% to food service establishments including take-away food stores.

Since both processed and unprocessed product was seen to be distributed evenly between households and food service establishments, the likelihood that imported product not further processed in Australia would be purchased by a household ($Expo_2$ in the model) was considered to be 50%. Again, this was modelled as a Triangular distribution with the most likely value being 0.5 ± 10%. By subtraction, the likelihood that product not further processed in Australia would be purchased by a food service establishment ($1–Expo_2$) was approximately 50%.

Step $Expo_3$: The proportion of a carcass, if further processed in Australia, which becomes scrap or waste

A whole carcass (without neck or giblets) consists of approximately 57% lean meat, with the remainder of the carcass comprising fat, skin and bone (Lin et al. 2002). Skin may or may not be discarded as scrap. If imported carcasses are further processed into boneless cuts, a conservative estimate of waste from processing of a whole chicken carcass was 40% of carcass weight. Carcass weight was estimated at 1.7kg (Australian Chicken Meat Federation 2005).

Bone-in breasts and legs (thigh and drumstick) consist of approximately 70% lean meat, with the remaining 30% comprising differing proportions of skin, fat and bone. The proportion of the original carcass which must be removed in order to achieve a final bone-in product with this proportion of lean meat to waste was calculated as follows:

(1) Let the proportion of lean meat in the whole carcass be X. From the paragraph above, X=0.57

(2) Let the proportion of waste in the whole carcass be (1-X)

(3) Let the proportion of the whole carcass removed in processing into bone-in cuts be Y

(4) Then the proportion of waste in the bone-in product A is (1-X)-Y/(1-Y)

(5) From above, A = 0.3

(6) Solving these equations for Y provides an estimate of approximately 0.18 or 18%.

If it was assumed that approximately half of imported whole carcasses further processed in Australia would be processed into boneless pieces, and half into bone-in pieces, the total waste produced during processing ($Expo_3$) is approximately 29%.

For whole carcasses, $Expo_3$ was expressed as a triangular distribution, with a most likely value of 0.29. Maximum and minimum values were considered to be the most likely value, ± 10%, respectively.

Step $Expo_4$: The likelihood that product from the imported contaminated carcass, if further processed in Australia, will be purchased by a household

Based on the data for domestically produced chicken meat, it was assumed that chicken products produced by Australian processors from imported chicken carcasses would be distributed evenly to households and the food service industry. Therefore, the likelihood that chicken processed in Australia will be purchased by a household ($Expo_4$) was modelled as a Triangular distribution, with the most likely value being 0.5. Maximum and minimum values were considered to be the most likely value ± 10%, respectively.

Step $Expo_5$: The proportion of a carcass, not further processed but purchased by the end user, which becomes scrap

A whole carcass (without neck or giblets) consists of approximately 57% lean meat, with the remainder of the carcass comprising fat, skin and bone (Lin et al. 2002). Skin may or may not be discarded as scrap. Therefore, the proportion of waste produced from consumption of imported whole carcasses was estimated as 40%. For whole carcasses, $Expo_5$ was expressed as a triangular distribution, with a most likely value of 0.4. Maximum and minimum values were considered to be the most likely value ± 10%, respectively.

As was the case for $Expo_1$ above, for the purposes of the unrestricted risk estimate, the value of $Expo_5$ will be based on the import of whole chicken carcasses. Importation of bone-in or boneless cuts will be considered under risk management.

Step $Expo_6$: The proportion of processed chicken meat, derived from a carcass and purchased by the end user directly or indirectly from the Australian processor, that becomes scrap

Bone-in breasts and legs (thigh and drumstick) consist of approximately 70% lean meat, with the remainder comprising differing proportions of skin, fat and bone. A conservative estimate of waste from household consumption of imported bone-in chicken cuts was 30%. Boneless cuts consist of approximately 12–22% skin and fat (Lin et al. 2002). Assuming that skin and fat is not always discarded before consumption; waste from consumption of imported boneless cuts ($Expo_5$) was estimated at 10%.

An overall estimate of waste from consumption of bone-in and boneless cuts ($Expo_6$), after combining household and food service distribution was approximately 21%. This parameter was modelled as a Triangular distribution, with the most likely value being 0.21. Maximum and minimum values were considered to be the most likely value ± 10%, respectively.

Step $Expo_7$: The proportion of scraps produced during the processing of chicken in Australia that would be incorporated in highly processed by-products

It was estimated that 50% of imported product would be distributed to meat processors for processing into boneless and bone-in cuts, smallgoods etc, with approximately 5% of the trimmings from the processing operations being processed into by-products ($Expo_7$). $Expo_7$ was modelled as a Triangular distribution, with the most likely value being 0.05. Maximum and minimum values were considered to be the most likely value ± 10%, respectively.

By-products are incorporated into a range of thermally processed goods, such as pet foods, stocks, flavourings and so on. These products are considered to pose negligible risk because of the high level of processing, and are not considered further.

Step $Expo_8$: The proportion of waste produced during the processing of chicken in Australia that will be rendered and incorporated in chicken feed

After the processing of waste into by-products (Step $Expo_7$), the remainder of the waste will be discarded for rendering into stock feed, including poultry meal, or as refuse. These are considered further because of the potential for exposure to susceptible species. Of this remaining waste, 90% ($Expo_8$) is likely to be rendered. $Expo_8$ was modelled as a triangular distribution, with most likely value of 0.9. Maximum and minimum values were considered to be 10% above and below the most likely figure.

Step $Expo_9$: The proportion of household waste, derived from chicken meat, that will be fed to low biosecurity poultry

The proportion of households that keep backyard poultry, and the proportion of those households that would feed scraps to their poultry determined the likelihood of exposure of low biosecurity poultry to scraps of imported chicken meat. At the last estimate, the proportion of households keeping backyard poultry was 6–7% (Agriculture and Resource Management Council of Australia and New Zealand 1996). Given that there has probably been a decline in the number of householders keeping backyard poultry since this figure was estimated, this proportion was estimated at 6%. To account for the uncertainty in this parameter, it was modelled as a triangular distribution, with most likely value of 0.06. Maximum and minimum values were considered to be 10% above and below the most likely figure.

The IRA team considered it would be highly likely that a consumer of chicken meat who keeps backyard poultry would also feed scraps to them. Following the system outlined in Table 8, this was modelled as a Uniform distributions with a minimum value of 0.7 and maximum value of 1.0. Therefore, Step $Expo_9$, the likelihood that household waste derived from imported chicken meat will be fed to low biosecurity poultry was calculated as the product of the proportion of households that keep chickens multiplied by the likelihood that those households would feed scraps to the chickens. Using the nomenclature employed in the software package @Risk, this can be written as $Expo_9$ = RiskTriang (0.05,0.06,0.07) x RiskUniform (0.7,1.0).

Table 11. Distribution variables

Likelihood	Description	Estimate
Step $Expo_1$	The likelihood that the imported contaminated chicken carcass will be further processed in Australia	Carcass: 0.5 {RiskTriang(0.5 ± 10%)}
Step $Expo_2$	The likelihood that the carcass, if not further processed in Australia, would be purchased by a household	0.5 {RiskTriang(0.5 ± 10%)}
Step $Expo_3$	The proportion of a carcass, if further processed in Australia, that becomes scrap or waste	0.29 {RiskTriang(0.29 ± 10%)}
Step $Expo_4$	The likelihood that product from the carcass, if further processed in Australia, will be purchased by a household	0.5 {RiskTriang(0.5 ± 10%)}
Step $Expo_5$	The proportion of a carcass, if not further processed but purchased by the end user, that becomes scrap	Carcass: 0.4 {RiskTriang(0.4 ± 10%)}
Step $Expo_6$	The proportion of processed chicken meat, derived from a carcass and purchased by the end user directly or indirectly from the Australian processor, that becomes scrap	0.21 {RiskTriang(0.21 ± 10%)}
Step $Expo_7$	The proportion of scraps produced during the processing of chicken in Australia that would be incorporated in highly processed by-products	0.05 {RiskTriang(0.05 ± 10%)}
Step $Expo_8$	The proportion of waste produced during the processing of chicken in Australia that will be rendered and incorporated in chicken feed	0.9 {RiskTriang(0.9 ± 10%)}
Step $Expo_9$	The proportion of household waste, derived from chicken meat, that will be fed to low biosecurity poultry	0.051 {RiskTriang(0.05,0.06,0.07) x high (RiskUniform(0.7,1)}
Step $Expo_{10}$	The proportion of food service waste, derived from chicken meat, that will be fed to low biosecurity poultry	0.0105 {RiskTriang(0.05,0.06,0.07) x low (RiskUniform(0.05,0.3)}

Step $Expo_{10}$: The proportion of food service waste, derived from chicken meat, that will be fed to low biosecurity poultry

It was assumed that the proportion of food service establishment owners/employees that keep backyard poultry would be the same as for the general population (approximately 6%). However, the IRA team determined that the likelihood of scraps from food service establishments being fed to backyard poultry was low, because they assumed that owners of food service establishments would be more aware of local government restrictions on disposal of waste, and that this would reduce the likelihood that this waste would be fed to low biosecurity birds. As described above, this can be written as RiskUniform (0.05,0.3). Therefore, Step $Expo_{10}$ was estimated as RiskTriang (0.05,0.06,0.07) x Low(RiskUniform (0.05,0.3)).

Calculated Distribution Variables

Table 12 shows calculations of the likelihood that imported chicken meat will follow each of the distributions pathways depicted in Figure 6. It is recognised that Figure 6 and Table 12 describe a modelling convenience, and that the pathways depicted and the calculations outlined in Table 12 provide only an approximation of the real likelihood. However, the members of the IRA team believe that the most likely pathways of entry and exposure of pathogens are those involving direct access to the imported product by a susceptible animal. It is recognised that other, less likely, pathways, such as mechanical transmission of pathogens via fomites (especially contaminated packaging material), or movement of humans exposed to imported products, and the exposure of scavenging species to imported product as a result of disposal on compost heaps, transport accident and so on, exist. The IRA team believed that the pathways described are by far the most likely. This, together with the fact that a conservative approach has been taken throughout the modelling process, led the team to believe that modelling the less likely and more obscure pathways would have little impact on the final outcome.

Table 12. Calculated exposure variables

Likelihood	Calculation / description
FOODSERVICEREFUSE	The likelihood that material from the imported contaminated chicken carcass (or carcass equivalent) will discarded as refuse by a food service establishment *FOODSERVICEREFUSE = ((1 – $Expo_1$) x (1 – $Expo_2$) x $Expo_5$) + ($Expo_1$ x (1–$Expo_3$) x (1 – $Expo_4$) x $Expo_6$)*
HOUSEHOLDREFUSE	The likelihood that material from the imported contaminated chicken carcass (or carcass equivalent) will be discarded as refuse by a household *HOUSEHOLDREFUSE = ((1– $Expo_1$) x $Expo_2$ x $Expo_5$) + ($Expo_1$ x (1–$Expo_3$) x $Expo_4$ x $Expo_6$)*

Likelihood	Calculation / description
PROCESSORREFUSE	The proportion of material produced by an Australian processor from imported chicken that will be discarded as refuse *PROCESSORREFUSE = $Expo_1$ x $Expo_3$ x (1 – $Expo_7$) x (1 – $Expo_8$)*
RENDERED	The likelihood that material from the imported contaminated chicken carcass (or carcass equivalent) is rendered, incorporated in commercial poultry feeds and subsequently fed to susceptible species. *RENDERED = $Expo_1$ x $Expo_3$ x (1 – $Expo_7$) x $Expo_8$*
BP_{refuse}	The likelihood that material from the imported contaminated chicken carcass (or carcass equivalent) will be discarded as refuse that may be accessible to low biosecurity poultry *BP_{refuse} = (HOUSEHOLDREFUSE x $Expo_9$) + (FOODSERVICEREFUSE x $Expo_{10}$)*
WB_{dump}	The likelihood that material from the imported contaminated chicken carcass (or carcass equivalent) will be discarded in refuse and accessible to wild birds *WB_{dump} = (HOUSEHOLDREFUSE x (1–$Expo_9$)) + (FOODSERVICEREFUSE x (1–$Expo_{10}$)) + PROCESSORREFUSE*
NAS_{dump}	The likelihood that material from the imported contaminated chicken carcass (or carcass equivalent) will be discarded as refuse and accessible to non-avian species *NAS_{dump} = (HOUSEHOLDREFUSE x (1–$Expo_9$)) + (FOODSERVICEREFUSE x (1–$Expo_{10}$)) + PROCESSORREFUSE*

Exposure group dependent variables

The exposure group dependent variables relate to the likelihood that individuals from the exposure group will scavenge, and ingest, the material that is available to them. These variables and their estimated values are as defined in Table 15 and the assumptions used in assigning values to these exposure group-dependent variables are detailed below.

BP_{access}: The likelihood that low biosecurity poultry will ingest the discarded chicken meat, if available to them

The IRA team considered that the likelihood that low biosecurity poultry would ingest refuse that was available to them was very close to certain (=1).

$BP_{rendered}$: The proportion of commercial poultry feed that will be fed to low biosecurity poultry

It was acknowledged that there was a high likelihood that commercial poultry feed would be fed to low biosecurity poultry. Ratites, which are also included in the low biosecurity poultry exposure group, are fed rations that do not contain meat meal (Dr D. Black, Moama Veterinary Clinic, NSW, pers. comm. February 2006). Therefore, commercial ratite feeds were not included when estimating $BP_{rendered}$. Assumptions regarding the likelihood that wastes from imported material will be incorporated into commercial poultry feeds are outlined below.

Australia's commercial poultry flock is estimated at 92 million, based on a layer flock size of approximately 13 million, meat chicken flock size at any one time of 73 million (Animal Health Australia 2005), and breeder flock size of approximately 6 million (Dubs 2005). The 2004 Animal Health Australia annual report (Animal Health Australia 2005) estimates backyard egg production at around 26 million dozen per annum. These figures suggest a backyard layer population in excess of 1 million birds. With the addition of fancy poultry and immature chickens, the backyard poultry population could be estimated at more than 1.2 million. In addition, it is estimated that 5% of Australia's 13 million commercial layers, or 0.65 million birds, and around 2% of meat chickens, or 1.5 million birds, are kept in low-biosecurity production systems (Animal Health Australia 2005; Australian Chicken Meat Federation 2005).

In addition, Australia produces approximately 17 million game birds per year (Leech et al. 2003). These are made up of quail, ducks, turkeys, squabs, pheasants, guinea fowl, partridges and geese. Data provided in Leech et al (2003) relating to the number of each species, and their growing periods and reproductive rates are reproduced in Table 13. The data in Table 13 allow the calculation of the approximate average number of production birds in the flock at any point in time, and the number of breeding stock required to maintain this production level. These calculations are outlined in Table 14, and from the table it can be seen that the average population of game birds in Australia is approximately 3 million. Game birds are kept as either free range or barn-raised birds (George Arzey, New South Wales Department of Primary Industries, pers. comm, May 2007). If approximately equal distribution is assumed between free range and barn-raised game birds, approximately 1.5 million birds will be added to the low biosecurity exposure group.

Therefore the size of the low biosecurity poultry exposure group, excluding ratites, was estimated at around 4.85 million birds, made up of 3.35 million chickens and 1.5 million game birds. The total poultry population of Australia was estimated at 95.2 million birds made up of 92 million chickens and 3.2 million game birds. It was assumed that free-range commercial flocks would be fed commercial poultry feed, and that most backyard poultry flocks would be fed some commercial poultry feed in addition to scraps.

The proportion of commercial poultry feed fed to low biosecurity poultry, including backyard and free-range poultry ($BP_{rendered}$), was therefore estimated at approximately 0.05 (5%), and was modelled as a triangular distribution with most likely value = 0.05. Maximum and minimum values were considered to be the most likely value ± 10%, respectively.

Table 13. Total annual numbers of game bird species and reproductive performance

Species	Total number	Growing period (weeks)	Season	Birds/breeder /year
Quail	6,500,000	5	All year	130
Duck	5,000,000	7	All year	135
Turkey	4,700,000	13	All year	71
Squab	680,000	4	All year	14
Pheasant	60,000	16	Oct-Jan & Apr-Jul	42
Guinea fowl	40,000	14	Sept-Jan	52
Partridge	18,000	14	Sept-Dec	19
Goose	5,000	12	Aug-Dec	12
TOTAL	**17,003,000**			

Table 14. Approximate average population of production game birds, and breeding stock

Species	Growing periods/year.	Average population	No of breeders
Quail	8	812,500	50,000
Duck	6	833,333	37,037
Turkey	4	1,175,000	66,197
Squab	10	68,000	48,571
Pheasant	2	30,000	1,428
Guinea fowl	1	40,000	769
Partridge	1	18,000	947
Goose	2	2,500	416
TOTAL		**2,979,333**	**205,367**

WB_{access}: The proportion of discarded chicken meat scraps accessed and ingested by wild birds

The proportion of discarded chicken meat scraps accessed and ingested by wild birds will be determined by the following:

- the behavioural characteristics of wild birds

- the availability of alternative food sources
- the degree of familiarity that a given population of wild birds has with refuse disposal sites within their territory.

Given the range of wild birds and environments within Australia, it was difficult to be prescriptive about the role of behavioural characteristics, the availability of alternative food sources and the degree of familiarity with disposal sites. Regardless, it is well known that birds do scavenge routinely amongst human refuse and it was assumed that, within the limits of a bird's appetite, available scraps would most probably be ingested.

In assessing the likelihood that wild birds will scavenge refuse, the requirements for control of dumps will affect the access of wild birds to discarded material. It is likely that a high proportion of discarded material will be disposed of at municipal dumps, so that the likelihood of scavenging by wild birds, (or non-avian species – see later discussion) must take account of this fact.

Management of Australian refuse dumps was reviewed (on behalf of Biosecurity Australia) by Environmental Management Services (EMS). While this review considered specifically the potential for feral pigs throughout Australia to gain access to refuse, its findings on the management of refuse dumps can be extrapolated to wild birds. A part of this review is paraphrased below:

Management of refuse dumps: The management of refuse disposal in Australia is undergoing a systematic process of improvement as State/Territory Governments dictate, and local authorities implement, modern procedures. The EMS consultants found the *NSW Landfill Guidelines* produced by the NSW Environment Protection Authority (EPA) to be the most comprehensive and advanced. This document describes four issues that influence the ability of feral pigs to gain access to human refuse:

- the security of the site
- compaction of waste
- the regular covering of waste
- site capping – the final coverage of waste as a dumping area is sealed.

With the exception of site security, these factors may also be applicable to access by scavenging birds.

The *security* of a refuse disposal site, that is, fencing or enclosure, whilst significant to the exposure of feral pigs, is no barrier to scavenging by wild birds other than wild ratites.

Compaction of waste is carried out to minimise its dispersion and maximise the efficiency of land use. Compaction would also decrease the ability of animals to scavenge material that was not on the surface. The EPA recommends that sites receiving less than 50,000 tonnes per annum (the majority of sites) be compacted to 650kg/m^3 and that compaction be carried out prior to covering and site capping (see below). Wild birds would not be able to access garbage below the surface of a compacted site.

The EPA requires that a daily cover of at least 15cm be applied at all manned sites and that a cover of at least 30cm be applied to sites that will be exposed for more than 90 days without capping (see below). Since many of the higher risk rural sites will not be manned, this measure is unlikely to reduce the likelihood that birds will scavenge meat scraps on these rural sites. Birds regularly gain access to both urban and rural refuse dumps. If covering is

carried out regularly on manned urban dumps, then this may prevent a degree of scavenging by wild birds. However, all users of urban dumps in Australia will have noted large areas of recently dumped uncovered waste and, commonly, large flocks of gulls and other scavenging bird life.

Site capping is a procedure carried out to stabilise areas within a disposal facility where dumping has ceased. The EPA recommends that site capping include a seal-bearing surface, a gas drainage layer, a sealing layer, an infiltration drainage layer and a revegetation layer of at least 2.1m. The EMS consultants concluded that very few rural sites would achieve this degree of stabilisation. Where waste is not stabilised, potential exists for it to move and resurface.

When these four factors associated with the management of refuse dumps are considered *in toto*, the likelihood of access by birds is still probably greatest for urban refuse dumps in and around Australia's larger (and predominantly coastal) cities, followed by rural dumps and private disposal sites on individual rural properties.

Overall, it was concluded that a proportion of chicken meat scraps discarded in household, food service and processor refuse would be accessible to wild birds.

On the basis of the information presented above, it was assumed that the majority of refuse would be adequately disposed of at the refuse dump. However, it was estimated that 1% of waste may remain accessible to, and be ingested by, wild birds ($WB_{access} = 0.01$) after disposal. WB_{access} was modelled as a triangular distribution with most likely value of 0.01. Maximum and minimum values were considered to be the most likely value ± 10%, respectively.

NAS_{access}: The proportion of discarded chicken meat scraps accessed and ingested by non-avian species

In a similar manner to that described for WB_{access} (above), it was estimated that 1% of waste may remain accessible to, and be ingested by, non-avian species ($NAS_{access} = 0.01$) after disposal. NAS_{access} was modelled as a triangular distribution with most likely value of 0.01. Maximum and minimum values were considered to be the most likely value ± 10%, respectively.

Table 15. Estimated exposure group-dependent exposure variables

Notation	Definition	Estimates
BP_{access}	The likelihood that low biosecurity poultry will ingest the discarded chicken meat, if available to them	1 (Certain)
$BP_{rendered}$	The proportion of commercial poultry feed that will be fed to low biosecurity poultry	0.05 (RiskTriang 0.05 $\pm$ 10%)
WB_{access}	The proportion of discarded chicken meat scraps accessed and ingested by wild birds	0.01 (RiskTriang 0.01 $\pm$ 10%)
NAS_{access}	The proportion of discarded chicken meat scraps accessed and ingested by non-avian species	0.01 (RiskTriang 0.01 $\pm$ 10%)

Pathogen-dependent variables

Finally, in order to assess the likelihood that infection of an exposed susceptible individual will occur, it is necessary to consider pathogen-dependent variables. These are described in Table 16. The likelihood that a quantity of meat carrying a specific disease agent will be sufficient to initiate infection in a susceptible host will be determined by the concentration of an agent in meat at the time it is ingested, and the oral infectious dose for that agent in the susceptible species. Both these quantities vary substantially among pathogenic agents and host species. In general terms, however, it can be stated that the concentration of a pathogenic agent in or on meat will be determined by the stage and severity of the viraemia or bacteraemia in the animal from which the meat was derived, or by the severity of post-processing contamination that has occurred. The number of infectious organisms in or on individual scraps of chicken meat may also be influenced by the proportion of organisms that remain viable at the time the meat is consumed, such that the infectious load for fresh meat may be substantially different to that for discarded meat scraps. This is influenced by the disease agent's resistance to environmental degradation, and to any cooking that may have taken place before the meat was discarded. Virulence and infectivity are inherent properties of each pathogenic agent, and may also be important determinants of infectious dose.

Estimates of the sufficient quantity of contaminated chicken meat required to initiate infection were based on the best available scientific data. However, there were instances where this value was either unknown or contentious. In these situations, estimates were derived by comparing existing information with that obtained for similar pathogenic agents. As was the case for all variables in this analysis, uncertainty in this quantity was represented in the limits of each probability distribution. Individual pathogen-dependent variables are discussed in the following section.

$BP_{agentsurvival}$: The likelihood that the disease agent will remain viable after exposure to the environment over the period prior to consumption by low biosecurity poultry

The IRA team concluded that the time from feeding of scraps to consumption by low biosecurity poultry was likely to be very short, so that environmental degradation of the disease agent would be minimal. The IRA team acknowledged that some scraps would be cooked prior to disposal, but it was not possible to quantify the proportion of scraps that would be cooked, nor could they be confident that those that were cooked achieved a sufficiently high temperature for a sufficiently long period of time to inactivate pathogens of concern. The IRA team discounted the effect of cooking on this likelihood. This likelihood was therefore considered to be certain (value = 1).

$BP_{infectivedose}$: The likelihood that the amount of the contaminated chicken waste eaten by a low biosecurity bird contains sufficient disease agent to initiate infection

This likelihood will be determined by:

- the titre of the pathogenic agent in the imported carcass
- the amount of carcass waste eaten by a low biosecurity bird
- the susceptibility of the bird consuming the waste.

The titre of pathogenic agent in the imported carcass and the infectious dose necessary to cause infection in poultry are characteristics of particular disease agents and are discussed in the individual risk assessments.

$NAS_{agentsurvival}$: The likelihood that the pathogenic agent will remain viable after exposure to the environment over the period prior to consumption by non-avian species

This likelihood will reflect the agent's sensitivity to ultraviolet light, to ambient temperatures between approximately 10 °C and 35 °C [10] and to the putrefying effects of saprophytic organisms during the time the contaminated product remains accessible. As was the case when considering $BP_{agentsurvival}$, the IRA team discounted the effect of cooking on this likelihood. For some agents (e.g. enteric bacteria) multiplication of organisms may occur within chicken meat waste. It was recognised that pathogenic agents may be somewhat protected from exposure if they are sequestered within bone marrow or within substantial portions of muscle tissue. This likelihood was discussed within the assessment for each pathogenic agent.

Table 16. Estimated pathogen-dependent exposure variables

Notation	Definition
$BP_{agentsurvival}$	The likelihood that the disease agent will remain viable after exposure to the environment over the period prior to consumption by low biosecurity poultry
$BP_{infectivedose}$	The likelihood that the amount of the contaminated chicken waste eaten by a low biosecurity bird is sufficient to initiate infection
$NAS_{agentsurvival}$	The likelihood that the disease agent will remain viable after exposure to the environment over the period prior to consumption by non-avian species
$NAS_{infectivedose}$	The likelihood that the amount of the contaminated chicken waste eaten by a non-avian individual is sufficient to initiate infection
$WB_{agentsurvival}$	The likelihood that the disease agent will remain viable after exposure to the environment over the period prior to consumption by a wild bird
$WB_{infectivedose}$	The likelihood that the amount of the contaminated chicken waste eaten by a wild bird is sufficient to initiate infection
FEEDCONTAM	The likelihood that poultry feed, produced from the rendered contaminated imported carcasses, will be contaminated with the disease agent
INFECTDOSEINFEED	The likelihood that the amount of the contaminated commercial poultry feed eaten by a bird is sufficient to initiate infection

$NAS_{infectivedose}$: The likelihood that the amount of the contaminated chicken waste eaten by a non-avian individual contains sufficient disease agent to initiate infection

This likelihood will be determined by:

- the titre of the pathogenic agent in the imported carcass
- the amount of carcass eaten by the non-avian individual
- the susceptibility of the animal consuming the meat.

[10] While the ambient temperature on rural Australian refuse dumps may be as low as –10 °C or as high as 50 °C (depending on the location and the time of the year), it is reasonable to assume that most discarded meat scraps would experience mean daily temperatures between approximately 10 °C and 35 °C.

The titre of pathogenic agent in the imported carcass and the infectious dose necessary to cause infection in the target species are characteristics of particular diseases and pathogenic agents, and are discussed in the individual risk assessments.

$WB_{agentsurvival}$: The likelihood that the disease agent will remain viable after exposure to the environment over the period prior to consumption by a wild bird

As discussed under $NAS_{agentsurvival}$, this likelihood reflects the agent's sensitivity to environmental exposure factors. This likelihood and the characteristics of particular diseases and pathogenic agents are discussed within the assessment for each pathogenic agent. The IRA team agreed that, for each pathogenic agent, $WB_{agentsurvival}$ and $NAS_{agentsurvival}$ would be equal.

$WB_{infectivedose}$: The likelihood that the amount of the contaminated chicken waste eaten by a wild bird contains sufficient disease agent to initiate infection

This likelihood will be determined by:

- the titre of the pathogenic agent in the imported carcass
- the amount of carcass waste eaten by the scavenging wild bird
- the susceptibility of the bird consuming the waste.

The titre of pathogenic agent in the imported carcass and the infectious dose necessary to cause infection in the target species are characteristics of particular diseases and pathogenic agents, and are discussed in the individual risk assessments.

The amount of carcass waste eaten by a scavenging bird will be related to the amount of waste and the size and appetite of the bird in question. Numerous species of birds frequent Australian refuse dumps and other sites where human food waste is accessible (e.g. picnic areas). Of these bird species, amongst the most numerous is the silver gull (*Larus novaehollandiae*). Although birds larger and smaller than the silver gull may have access to refuse, for the purposes of this model, the silver gull was assumed to be representative of scavenging birds that would consume scraps of imported chicken meat.

It was assumed that the average silver gull, weighing 300g (Higgins and Davies S.J. 1996), would be capable of ingesting at least 54g of feed per day (based on data available for garbage intake in the larger herring gull, which consumes 0.18g of feed per gram of body weight per day (McVey et al. 1993)). These figures were used by the IRA team as a guide in estimating the quantities of material likely to be ingested by wild birds.

FeedContam: The likelihood that poultry feed, produced from the rendered contaminated imported carcasses, will be contaminated with the disease agent

This will depend on a number of factors, including the likelihood that the agent will survive the rendering process, and the likelihood that the product will be re-contaminated post-processing. Rendering in Australia utilises both wet and dry procedures, although in either case the minimum temperature is engineered to be 100 °C to 145 °C, to destroy potential hazards (Spooncer 2001).[11] The IRA team concluded that the likelihood that the agents

[11] An Australian Standard for rendering has been published: *Australian Standard for Hygienic Rendering of Animal Products* (*SCARM Report* 76, 2001(Standing Committee on Agriculture and Resource Management 2001)). Rendering plants will be encouraged by State Governments to comply with this standard.

considered in this IRA will survive the rendering process was negligible. The likelihood of post-processing contamination is dependent on the nature of the agent involved, and is discussed in the individual disease risk assessments.

InfectDoseInFeed: The likelihood that the amount of the contaminated commercial poultry feed eaten by a bird is sufficient to initiate infection

It is assumed that the average commercial chicken is able to consume 150g of feed per day, although this will vary with the age and type of chicken (meat versus layer).

In addition to the quantity of material likely to be eaten by a chicken, this likelihood is dependent on characteristics of the particular agent and is discussed further in the individual risk assessments.

Calculations for each exposure group

Wild birds

Table 17 below provides an outline of calculations used to estimate the likelihood that wild birds would be exposed to a quantity of imported chicken meat scraps derived from a contaminated carcass (or carcass equivalent), sufficient to initiate infection in a susceptible wild bird. This was termed the partial likelihood of exposure (PLE) for wild birds.

Table 17. Calculating the partial likelihood of exposure and infection for a wild bird

Variable	Definition
$PLE_{(wild\ birds)}$	**The likelihood that a wild bird will be exposed to a sufficient quantity of chicken meat scraps, containing a sufficient dose of pathogenic agent from the imported contaminated carcass, or carcass equivalent, to produce infection** **= WB_{dump} x $WB_{agentsurvival}$ x $WB_{infectivedose}$ x WB_{access}**
WB_{dump}	= HouseHoldRefuse x (1–$Expo_9$) + FoodServiceRefuse x (1–$Expo_{10}$) + ProcessorRefuse
$WB_{agentsurvival}$	This will depend on individual disease agents and is discussed within each disease risk assessment
$WB_{infectivedose}$	This will depend on individual disease agents and is discussed within each disease risk assessment
WB_{access}	=RiskTriang(0.009,0.01,0.011)

PLE = Partial likelihood of exposure

The variable names listed in Table 17 are as defined above. It is important to remember that the sum of the likelihoods that wild birds will scavenge waste on dumps, that non-avian species will scavenge waste on dumps and that waste will be adequately disposed of once deposited at the dump site, must equal 1.

Low biosecurity poultry (backyard and free-range poultry and ratites)

In this IRA, the colloquial term ‘backyard poultry’ is used to describe households that keep poultry for eggs, meat or for hobby purposes. This group of poultry owners is diverse with regard to management and feeding practices and has, at least historically, been associated with a higher likelihood of feeding kitchen waste. In general, it is expected that backyard poultry will receive scraps from the household, and that this will often be supplemented with commercial grains or mixes. It is recognised that some breeding, distribution and exhibition of poultry, particularly hobby poultry, may occur.

The term ‘free-range poultry’ was applied to commercial poultry with outdoor access which are considered likely to be exposed to rodents and wild birds. In general, biosecurity for free-range poultry is low.

Ratites were also included in this group, not because they were at risk of being fed kitchen scraps, but because they are generally farmed under conditions of low biosecurity with access to wild birds and rodents. Therefore, although at low risk of direct exposure to imported chicken meat, commercial free-range poultry and ratites are at risk of indirect exposure via wild birds.

In addition, backyard poultry, free-range poultry and ratites may be exposed to imported chicken meat as a result of being fed commercial feed mixes that contain rendered meat meal. The likelihood that these rendered mixes will contain an infectious dose of a disease agent, in a quantity of meal that could be readily eaten by low biosecurity fowl, is quite small. However, for the purposes of completeness, it has been included in the model.

In a similar fashion to that outlined in the discussion of exposure of wild birds, an exposure scenario which enabled estimation of the likelihood that a flock of low biosecurity poultry would be exposed to a quantity of contaminated chicken meat sufficient to initiate infection within that flock was defined. The exposure scenario consisted of four steps, analogous to those for wild birds.

Table 18 (below) provides an outline of calculations used to estimate the likelihood that low biosecurity poultry would be exposed to a sufficient quantity of imported chicken meat scraps derived from a contaminated carcass (or carcass equivalent). This was termed the partial likelihood of exposure (PLE) for low biosecurity poultry.

Medium biosecurity commercial poultry

In this IRA, the term ‘commercial poultry’ is used to describe intensive and barn commercial layer and meat chicken flocks and other poultry (turkeys, ducks, geese, quail and game birds). ‘Medium biosecurity’ was used to describe those establishments in which poultry are confined indoors, with restricted access to rodents and wild birds. Commercial poultry are fed specialised diets designed to maximise feed conversion efficiency. While opportunistic to some degree as regards the sourcing of protein-rich substrates and other ration supplements, commercial poultry producers need to maintain consistency and quality control in a feed, and are extremely unlikely to feed unprocessed scraps.

Given this, the only feasible route for the 'direct' exposure of medium biosecurity commercial poultry to imported carcass components is through the feeding of rendered processed waste from the manufacture of processed goods.

Calculation of this likelihood is done in a similar manner to that described above for the likelihood that low biosecurity poultry will be exposed to the imported disease agent in commercial feed mixes containing meat meals (BP_2). However, in these calculations, $BP_{rendered}$ was replaced by ($1 - BP_{rendered}$) which represents the proportion of commercial poultry feed not fed to low biosecurity poultry that will be fed to medium biosecurity commercial poultry. *INFECTDOSEINFEED* was considered to be the same for this route of exposure for both low and medium biosecurity commercial poultry.

Table 18. Calculating the partial likelihood of exposure and infection for low biosecurity poultry

Variable	Definition
PLE (low biosecurity poultry)	**The likelihood that a low biosecurity bird will be exposed to a sufficient quantity of** **1) chicken meat scraps, or** **2) commercial chicken feed containing rendered chicken material,** **containing a sufficient dose of pathogenic agent, from the imported contaminated carcass or carcass equivalent, to produce infection** $= BP_1 + BP_2$
BP_1	The likelihood that a low biosecurity bird will be exposed to a sufficient quantity of chicken meat scraps derived from the imported contaminated carcass or carcass equivalent, to produce infection $= BP_{refuse} \times BP_{agentsurvival} \times BP_{infectivedose} \times BP_{access}$
BP_2	The likelihood that a low biosecurity bird will be exposed to a sufficient quantity of commercial chicken feed containing rendered chicken material derived from the imported contaminated carcass or carcass equivalent, to produce infection $= RENDERED \times BP_{rendered} \times FEEDCONTAM \times INFECTDOSEINFEED$

PLE = Partial likelihood of exposure

Table 19 (below) provides an outline of calculations used to estimate the likelihood of exposure for medium biosecurity commercial poultry. As medium biosecurity commercial poultry represent only one pathway for exposure in Australia, the likelihood is expressed as the partial likelihood of exposure (PLE) for medium biosecurity commercial poultry.

Table 19. Calculating the partial likelihood of exposure and infection for a medium biosecurity commercial bird

Variable	Definition
PLE (commercial poultry)	**The likelihood that a commercial bird will be exposed to a sufficient quantity of commercially rendered chicken feed derived from the imported contaminated carcass, containing a sufficient dose of pathogenic agent, to produce infection** = *RENDERED* x (1–$BP_{rendered}$) x *FEEDCONTAM* x *INFECTDOSEINFEED*

PLE = Partial likelihood of exposure

Non-avian species

The final exposure group is less clearly defined than those above. This group excludes humans, as they are not considered in this import risk analysis (Figure 5), but includes species such as rats, domestic and zoo carnivores and feral pigs. While steps necessary for the exposure of non-avian species (NAS) are outlined below, it is expected that the exposure assessment for this group will vary to some extent among the identified pathogenic agents.

The likelihood that susceptible non-avian species would be exposed to a sufficient quantity of imported chicken meat derived from a contaminated carcass was termed the partial likelihood of exposure (PLE) for non-avian species. Calculations for this exposure group would be equivalent to those used to calculate the partial likelihood of exposure for wild birds, with the substitution of NAS_{access} for WB_{access}, where NAS_{access} is defined as the proportion of discarded chicken meat scraps accessed and ingested by non-avian species. Once again it is important to remember that the sum of the likelihoods that wild birds will scavenge waste on dumps, that non-avian species will scavenge waste on dumps and elsewhere, and that waste will be adequately disposed of once deposited at the dumps site, must equal 1. These calculations are detailed in Table 20.

Summary: exposure assessments

The calculations described in the previous section lead to the estimation of the likelihood that each expected exposure group (wild birds, low biosecurity poultry, medium biosecurity commercial poultry, susceptible non-avian species) would be exposed to a sufficient quantity of material from the imported chicken carcass, contaminated with the specific disease agent, to initiate infection in an animal within the immediate flock, or within a local population of the relevant ‘susceptible species’. These likelihoods were termed the ‘partial likelihoods of exposure’ for the identified exposure groups. The consequences following exposure of each group are the subject of the following discussion.

Table 20. Calculating the partial likelihood of exposure and infection for non-avian species

Variable	Definition
PLE (non-avian species)	**The likelihood that a non-avian individual will be exposed to a sufficient quantity of chicken meat scraps containing a sufficient dose of pathogenic agent from the imported contaminated carcass, or carcass equivalent, to produce infection** $= NAS_{dump} \times NAS_{agentsurvival} \times NAS_{infectivedose} \times NAS_{access}$
NAS_{dump}	= HouseHoldRefuse x $(1–Expo_9)$ + FoodServiceRefuse x $(1–Expo_{10})$ + ProcessorRefuse
$NAS_{agentsurvival}$	This will depend on individual disease agents and is discussed within each disease risk assessment.
$NAS_{infectivedose}$	This will depend on individual disease agents and is discussed within each disease risk assessment.
NAS_{access}	=RiskTriang (0.009, 0.01, 0.011)

PLE = Partial likelihood of exposure

Consequence assessment

According to the *OIE Code*, a consequence assessment should '*describe the potential consequences of a given exposure, and estimate the probability of them occurring*'.

Consequence assessment describes the process which was used to analyse the likelihood and impacts of establishment and spread of disease for each of the identified disease agents (hazards).

Plausible 'outbreak scenarios' were considered for each identified exposure group. The likelihood of each outbreak scenario occurring was estimated, based on species and management or behaviour of each exposure group, and the characteristics of the disease agent. The impact for each outbreak scenario was also estimated.

Consequence assessment for chicken meat

The consequence assessment for chicken meat was undertaken by following the steps described below:

- Identification of plausible 'outbreak scenarios' for each exposure group (wild birds, low biosecurity poultry, medium biosecurity commercial poultry and non-avian species)
- Estimation of the likelihood that each outbreak scenario would occur, given that exposure of a susceptible individual had occurred (the partial likelihood of establishment and spread (PLES))
- For each outbreak scenario, estimation of the impacts of the establishment and spread of a pathogenic agent according to each direct and indirect criterion *and*

- For each outbreak scenario, combination of impacts of each individual criterion, to give an overall measure of 'impacts' for that scenario.

Outbreak scenarios

In this IRA, an 'outbreak scenario' represents a particular level of 'establishment and spread'. For the purposes of this IRA, four distinct 'outbreak scenarios' were considered and these are described in detail below. It was understood that the extent and direction of disease establishment and spread will be, in reality, both complex and continuous. However, the IRA team considered it would be impractical to model the economic impacts as a continuous variable, and this categorisation was considered to be a useful practical approximation to the real situation.

Outbreak scenarios for each of the exposure groups are outlined below. It will be noted that, for each group, the first scenario denotes 'no further establishment or spread' and since there will therefore be no impacts arising from this scenario, it is not considered in the final risk estimation. This scenario was included to ensure that the sum of likelihoods assigned to outbreak scenarios for that group would always be one.

The descriptions of outbreak scenarios use the term 'secondary spread' to describe a range of means by which disease may be transmitted from birds that have consumed contaminated meat scraps to other birds, or to other susceptible species (including humans[12]). In the terminology that is used throughout this IRA, animals infected as a result of secondary spread were considered 'indirectly exposed' to the contaminating pathogenic agent. Mechanisms for secondary spread will vary among pathogenic agents, but include direct contact, fomites, aerosol plumes, insect vectors and inadvertent human transmission. Likewise, intermediate hosts and other more complex transmission or life cycle components may be relevant.

Outbreak scenarios used for this risk assessment

Outbreak Scenario 1: Disease agent does not establish or is not recognised within the directly exposed population

The IRA team considered that for many disease agents introduced to a population by an infected individual, infection would result in a single case or a few isolated cases of infection in the exposed group, followed by elimination of the agent from the population. In many such cases, the disease would not even be recognised in the population.

However, in other cases, introduction of the agent to a population may result in colonisation of the group, but without development of clinical signs. This could occur, for instance, in cases where the directly exposed group of animals was susceptible to infection, but resistant to disease. In such cases, where the infection remains present but is not identified in the exposed group, and does not spread to other exposure groups the disease would not even be recognised in the population, and no economic impacts would accrue.

When estimating the likelihood of this outbreak scenario for each disease agent, the IRA team considered a number of factors including:

a) the infectivity and pathogenicity of the agent

[12] As stated previously, humans were considered in this IRA if relevant as a species to the epidemiology of a disease or to the consequences of exposure of other susceptible species. The likelihood and consequences of the direct exposure of humans to contaminated chicken meat were not considered.

b) method of transmission (for instance aerosol, droplet, oral, contact, or vector) of the agent
c) transmissibility, resistance and persistence of the agent
d) possibility of mechanical transmission by humans or other species, or fomites
e) species, age and immune status of the exposed host
f) behavioural characteristics or management of the host population
g) host response to infection (shedding of the agent and its duration)
h) presence of suitable vectors
i) climatic conditions.

Outbreak Scenario 2: Disease agent establishes within the directly exposed population, is identified and is eliminated by human efforts, or by natural means

A disease agent, introduced to a population by an individual infected as a result of exposure to imported chicken meat, establishes within that population, but is identified and is eliminated from the population either by human efforts at control, or by natural means.

When estimating the likelihood of this outbreak scenario for each disease agent, the IRA team considered a number of factors relating to the particular agent and the exposed population, the recognition and diagnosis of the disease, and the response to diagnosis. These included those discussed in outbreak scenario 1 as well as:

a) the morbidity rate and evident clinical signs of the disease
b) frequency and thoroughness of observation or inspection
c) level of awareness of exotic disease signs
d) mechanisms for investigation, diagnosis and reporting of the disease outbreak
e) effectiveness of existing surveillance and monitoring programs within the exposure group under discussion
f) existence and successful implementation of eradication plans for the disease agent
g) the natural epidemiology of the disease.

Outbreak Scenario 3: Disease agent establishes in the directly exposed population, spreads, including into other exposure groups if applicable, and is eliminated by human action or by natural means

A disease agent, introduced to a population by an infected individual, establishes within that population and spreads within a limited area such as a district or region, including to other exposure groups if applicable, is identified and eliminated from the population, either by human action or by natural means.

When estimating the likelihood of this outbreak scenario for each disease agent, the IRA team considered a number of factors relating to the particular agent, the exposed population, the diagnosis of the disease and the response to diagnosis. These included those discussed in outbreak scenario 2 as well as:

a) mechanisms for secondary spread of the disease agent;
b) species and levels of biosecurity in the exposed group
c) seasonal or climatic effects.

The mechanisms for secondary spread will vary among pathogenic agents, but could include direct contact, fomites, aerosol plumes, insect vectors and inadvertent human transmission.

Outbreak Scenario 4: Disease agent establishes in the directly exposed population, spreads, including to other exposure groups if applicable, and becomes endemic in Australia

A disease agent, introduced to a population by an infected individual, establishes within that population and spreads to other exposure groups if applicable. The agent is identified but eradication is judged inappropriate or eradication attempts are unsuccessful, and the disease becomes endemic in at least one geographic region in Australia.

When estimating the likelihood of this outbreak scenario for each disease agent, the IRA team considered a number of factors including but not limited to those discussed in outbreak scenario 3, and

a) options for control of the disease, and the costs and benefits of each
b) persistence of the agent
c) method of spread of the agent
d) pathogenicity of agent
e) species in the exposed group.

Estimating the likelihood of each outbreak scenario

An approximation was provided for the likelihood that each identified outbreak scenario would occur, conditional on at least one individual from the exposure group having been exposed to imported chicken meat and becoming infected as a result. This likelihood was termed the partial likelihood of establishment and spread (PLES). Since there was an individual PLES for each outbreak scenario, within each exposure group, the PLES was further identified as $PLES_{W1}$, $PLES_{W2}$, $PLES_{W3}$, and $PLES_{W4}$ for the partial likelihoods of scenarios 1–4 within the wild bird group. Similarly, $PLES_{B1}$– $PLES_{B4}$ refer to the low biosecurity poultry exposure group, $PLES_{C1}$–$PLES_{C4}$ to the medium biosecurity (commercial) poultry group, and $PLES_{N1}$–$PLES_{N4}$ to the non-avian species group.

This approximation was based on the opinions of the IRA team, after considering the nature of the disease agent concerned, the likely effectiveness of existing surveillance and monitoring programs within the exposure group under discussion, the existence or otherwise of eradication plans for the disease agent, and other relevant factors identified on a disease by disease basis.

For any given pathogenic agent and initial exposure group, the sum of the likelihoods for each outbreak scenario occurring as a result of an infected animal within that exposure group always equalled one (1). The import risk analysis team estimated the likelihoods of each of the outbreak scenarios, and these were entered into the spreadsheet model, which was designed in such a way as to ensure that the sum of the likelihoods was equal to one, while maintaining the relativity between the various estimates agreed by the IRA team.

Scenario Impacts

The establishment and spread of a disease agent may cause a number of direct and indirect impacts on biological systems. These impacts are assessed in terms of costs and can be considered in economic terms.

Direct impacts of a disease agent on host species and the environment

1. The life or health (including production effects) of production, domestic or feral animals

When evaluating the impact on this criterion for each disease agent, the IRA team considered a number of factors including:

a) the species and age affected

b) the morbidity and mortality rates of the disease (which may vary with the immune status of the flock, and carrier status)

c) the effects on growth rate, egg production, food conversion ratio or reproductive efficiency, and the duration of the effects

d) the costs of treatment or euthanasia.

2. The environment, including life and health of native animals and direct effects on the non-living environment

When evaluating the impact on this criterion for each disease agent, the IRA team considered a number of factors including:

a) the species and age affected

b) morbidity and mortality rates of the disease

c) clinical effects of the disease

d) costs of treatment or euthanasia.

Indirect impacts of a disease agent on host species and the environment

1. New eradication, control, surveillance/monitoring and compensation strategies/programs

When evaluating the impact on this criterion for each disease agent, the IRA team considered a number of factors including:

a) the response to the disease outbreak (which is influenced by whether the disease is included in the Emergency Animal Disease Response Agreement, and is notifiable in the state)

b) the costs of implementation and delivery of the program including costs of slaughter, disinfection and disposal, compensation, diagnosis and surveillance, awareness and education campaigns (recognition of disease, handling infected animals, disease in humans), changes to staffing levels

c) the costs associated with disposal of litter.

2. Domestic trade or industry impacts, including changes in consumer demand and effects on other industries supplying inputs to, or utilising outputs from, directly affected industries

When evaluating the impacts on this criterion for each disease agent, the IRA team considered a number of factors including:

a) the impacts on markets for animals and animal products
b) the changes in consumer demand
c) the costs associated with interruption of breeding programs
d) the impacts of movement restrictions on domestic trade
e) the costs arising from interference with the normal processing and marketing chain
f) the species and areas affected
g) the impacts on stock feed manufacturers, service providers, and other supply companies.

3. International trade impacts, including loss of markets, meeting new technical requirements to enter/maintain markets, changes in international consumer demand

When evaluating the impacts of this criterion for each disease agent, the IRA team considered a number of factors including:

a) the current export market for poultry and poultry products
b) the likely duration of the impact
c) the impacts of implementation of new technical requirements for poultry and poultry products (costs for new testing requirements, veterinary certification, and increased staffing)
d) the loss of economic viability of the export industry.

4. The environment, including biodiversity, endangered species and the integrity of ecosystems

When evaluating the impacts on this criterion for each disease agent, the IRA team considered a number of factors including:

a) all on-site and off-site impacts
b) the species and the age of animals affected
c) the geographical scope and magnitude of the impact
d) air or water pollution from disposal of carcasses
e) impacts of imbalance in ecosystems such as loss of biodiversity and integrity of the ecosystems, loss of threatened species, and whether the introduced disease was likely to endanger more common species
f) the frequency and duration of the action causing the harm
g) the total impact which can be attributed to that action over the entire geographic area affected, and over time (i.e. cumulative impact)
h) any synergistic effect of hazards on impact
i) reversibility of the impact
j) the sensitivity of the receiving environment (recognised environmental features of high sensitivity)

k) the degree of confidence with which the impacts of the action are known and understood.

5. Communities, including reduced tourism, reduced regional and economic viability, loss of social amenity and side effects of control measures

When evaluating the impacts of this criterion for each disease agent, the IRA team considered a number of factors including:

a) increased management inputs, and owner stress associated with loss of livelihood and welfare concerns
b) family disruption, loss of employment, decreased standard of living
c) impacts on businesses and industries supporting rural centres
d) disruption of events e.g. shows, pigeon races
e) effects on tourism, especially of zoonotic and vector-borne diseases
f) impacts of movement restrictions on social amenity
g) loss of ecotourism due to loss of wild life
h) societal values especially in relation to loss of pet birds, fancy poultry, native species.

The direct and indirect impacts described above collectively cover the *economic*, *environmental* and *social* effects of a disease — the so-called 'triple bottom line'. In assessing direct and indirect impacts, it was important to ensure that particular impacts were not accounted for more than once. In particular, the direct impacts of a disease on a native species were assessed under the criterion describing the '*environment, including the life or health of native animals and plants'*, whereas the indirect or 'flow-on' effects on the environment were assessed under the last two indirect criteria.

Describing Impacts

Two groups of qualitative descriptors have been adopted by Biosecurity Australia to describe the impact of a pest or disease on each of the identified direct and indirect criteria. These are the *Level of impact* and the *Magnitude of impact*.

Step 1: Assessing direct and indirect impacts

Each direct and indirect impact was estimated at four levels — national, state or territory, district or regional, and local— and the values derived subsequently translated into a single qualitative score (A–G). In this context, the terms 'national', 'State/Territory', 'regional' and 'local', were defined as follows.

National:	Australia-wide
State/Territory:	an Australian 'State' (New South Wales, Victoria, Queensland, Tasmania, South Australia or Western Australia) or 'Territory' (the Australian Capital Territory, the Northern Territory, the Australian Antarctic Territory and other Australian Territories)[13]
District / region:	a geographically or geopolitically associated collection of aggregates — generally a recognised section of a state, such as the 'North West Slopes and Plains' or 'Far North Queensland'

[13] This excludes the Cocos Islands

Local: an aggregate of households or enterprises — e.g. a rural community, a town or a local government area.

At each level, the magnitude of impact was described as 'unlikely to be discernible', of 'minor significance', 'significant' or 'highly significant':

- An 'unlikely to be discernible' impact is not usually distinguishable from normal day-to-day variation in the criterion
- An impact of 'minor significance' is recognisable, but minor and reversible
- A 'significant' impact is serious and substantive, but reversible and unlikely to disturb either economic viability or the intrinsic value of the criterion
- A 'highly significant' impact is extremely serious and irreversible and likely to disturb either economic viability or the intrinsic value of the criterion.

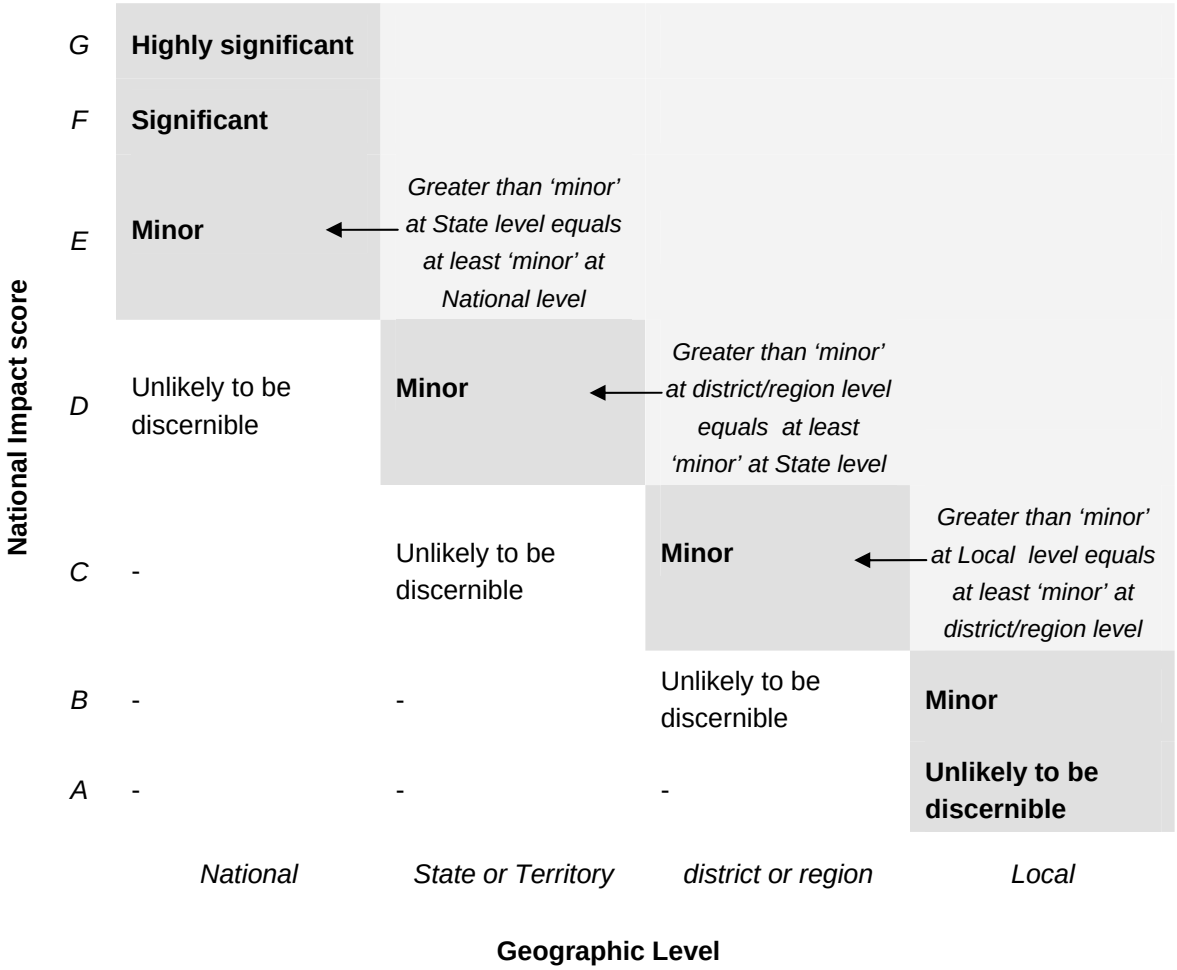
When assessing impacts, the frame of reference will be the impact of each disease agent on the community as a whole, rather than on the directly affected parties. A related consideration is the persistence of an effect. In general, the consequences will be considered greater if the effect is prolonged – as is the case if it is thought to persist for several production cycles or if restocking following eradication programmes will take several generations. If an effect is not prolonged then consequences are likely to be less serious.

Step 2: Combining direct and indirect impacts

To estimate the overall impacts of a disease outbreak on a national scale, it was necessary to combine the effects of the direct and indirect impacts on the national economy or the Australian community. The first step in this combination process was to translate each individual direct or indirect impact to an overall score (A–G) using the schema outlined in Figure 7. This was undertaken in two steps. Firstly, it was necessary to determine which of the shaded cells with bold font in Figure 7 corresponded to the level and magnitude of the particular impact. At each of the lower geographic levels, an impact more serious than 'minor' was understood to be discernible at the level above (e.g. a 'significant' impact at the State level would be considered to be equivalent to at least a 'minor' impact at National level). In addition, the impact of a disease at a given level in more than one State/Territory, district/region or local area was considered to represent at least the same magnitude of impact at the next highest geographic level.

Once the appropriate shaded cell had been selected, the appropriate overall score for the outbreak scenario could be assessed by reading the alphabetic (A–G) score from the Figure, starting at the National level and working down until the highest applicable combination of level and magnitude was reached. It is important to note that 'impact' at the National level is a different issue from 'spread of disease'. A disease may have serious consequences at the national level despite only occurring in a small area.

Figure 7. The assessment of direct or indirect impacts on a national scale[1]



[1] Shaded cells with bold font are those that dictate national impact scores. Impacts greater than 'minor' at local, district or regional level are considered to represent **at least** 'minor' impacts at the next higher geographic level.

The measure of impact obtained for each direct and indirect criterion (A–G) was combined to give the overall impacts of a disease agent. The following rules were used for the combination of direct and indirect impacts. The rules are mutually exclusive, and were addressed in the order that they appear in the list – i.e. *if the first set of conditions does not apply, the second set should be considered; if the second set does not apply, the third set should be considered; and so forth, until one of the rules applies*.

1. Where the impact of a disease with respect to any direct or indirect criterion is G, the overall impact is extreme
2. Where the impact of a disease with respect to more than one criterion is F, the overall impact is extreme
3. Where the impact of a disease with respect to a single criterion is F and the impact with respect to each remaining criterion is E, the overall impact is extreme
4. Where the impact of a disease with respect to a single criterion is F and the impact with respect to remaining criteria is not unanimously E, the overall impact is high
5. Where the impact of a disease with respect to all criteria is E, the overall impact is high

6. Where the impact of a disease with respect to one or more criteria is E, the overall impact is moderate
7. Where the impact of a disease with respect to all criteria is D, the overall impact is moderate
8. Where the impact of a disease with respect to one or more criteria is D, the overall impact is low
9. Where the impact of a disease with respect to all criteria is C, the overall impact is low
10. Where the impact of a disease with respect to one or more criteria is C, the overall impact is very low
11. Where the impact of a disease with respect to all criteria is B, the overall impact is very low
12. Where the impact of a disease with respect to one or more criteria is B, the overall impact is negligible
13. Where the impact of a disease with respect to all criteria is A, the overall impact is negligible.

Assessment of consequences to human life or health

The consequences of a pest or disease to human life or health were considered separately from its economic, environmental and social effects. This was because jurisdiction for regulation of trade on matters of human life or health does not rest with Biosecurity Australia.

In the preparation of this import risk analysis report, Biosecurity Australia consulted with the Australian Department of Health and Ageing (DoHA) and with FSANZ on the assessments for zoonotic pests or diseases that may establish in Australia's animal population through the importation of chicken meat. At the discretion of the Director of Human Quarantine, this may result in a requirement for biosecurity measures, in addition to those recommended by Biosecurity Australia for the management of animal quarantine risk, to manage the risk to human life or health associated with the importation of chicken meat.

Risk estimation

In the context of this IRA, 'risk estimation' describes the integration of likelihoods and expected consequences, with the objective of deriving an estimate of the overall risk associated with each pathogenic agent from importation of the product. Risk estimation also involves consideration of the *volume* of chicken meat likely to be imported during a prescribed period. The period chosen by the IRA team was 12 months. This was considered a sufficient period to enable evaluation of seasonal effects, but not so long as to incorporate inaccuracies that may be associated with changes in disease factors, animal factors or factors associated with trade.

Risk estimation for each identified pathogenic agent was undertaken in two stages:

- estimation of the 'partial annual risk' associated with each of the outbreak scenarios, followed by
- combination of partial annual risks to give an estimate of 'overall annual risk'

Estimation of partial annual risks

The annual risk associated with *each outbreak scenario* was obtained by:

- estimating the 'partial annual likelihood of entry, exposure, establishment and spread' (PALEEES) from the partial likelihood of entry, exposure, establishment and spread (PLEEES) of the disease for each outbreak scenario and the estimated volume of trade
- combining the partial annual likelihood of entry, exposure, establishment and spread with the corresponding estimate of impacts obtained from the consequence assessment for that outbreak scenario.

Partial likelihood of entry, exposure, establishment and spread (PLEEES)

The partial annual likelihood of entry, exposure, establishment and spread (PALEEES) is the likelihood that meat from at least one contaminated carcass will enter Australia as a result of importing chicken meat for a period of one year, resulting in exposure to and infection in a susceptible animal, and that the disease will establish or spread leading to the outbreak scenario.

To estimate the PALEEES , the partial likelihood of entry, exposure, establish and spread (PLEEES) of the disease for each outbreak scenario as a result of a single imported unit is initially calculated by the following expression:

$$PLEEES_{(Scenario\ No)} = RE_{final} \times PLE_{(exposure\ group)} \times PLES_{(scenario\ number)}$$

Where:

- RE_{final} is the result obtained from the release assessment – that is, the likelihood that an imported chicken carcass will be carrying the disease agent
- $PLE_{(exposure\ group)}$ (the partial likelihood of exposure for each exposure group) is the result obtained from each exposure assessment – that is, the likelihood that an animal in each exposure group would be exposed to a sufficient quantity of chicken meat derived from an imported contaminated carcass (or carcass equivalent) to initiate infection
- $PLES_{(scenario\ number)}$ (the partial likelihood of establish and spread for each outbreak scenario) is obtained from the consequence assessment – that is, the likelihood that the outbreak scenario would occur as a result of the initial infected animal within the exposure group.

The disease does not become established or spread in outbreak scenario 1 and therefore has no significant impact. Outbreak scenario 1 is not included in the calculation of PLEEES or PALEEES and was only included in the model for auditing purposes to ensure the sum of likelihoods assigned to each exposure group would always be one (1).

Outbreak scenarios 3 and 4 represent the outcome of disease in multiple susceptible exposure groups, regardless of the exposure group in which the first, or index case, occurred. Therefore, an overall likelihood of entry, exposure, establishment and spread for each of these outbreak scenarios ($PLEEES_{S3}$ and $PLEEES_{S4}$ respectively) can be calculated by adding the PLEEES for each exposure group, relevant to that outbreak scenario. These calculations are shown in Table 21.

Table 21. PLEEES calculations

$PLEEES_{W2}$	$= RE_{final} \times PLE_{wildbirds} \times PLES_{W2}$
$PLEEES_{W3}$	$= RE_{final} \times PLE_{wildbirds} \times PLES_{W3}$
$PLEEES_{W4}$	$= RE_{final} \times PLE_{wildbirds} \times PLES_{W4}$
$PLEEES_{B2}$	$= RE_{final} \times PLE_{lowbiosecuritypoultry} \times PLES_{B2}$
$PLEEES_{B3}$	$= RE_{final} \times PLE_{lowbiosecuritypoultry} \times PLES_{B3}$
$PLEEES_{B4}$	$= RE_{final} \times PLE_{lowbiosecuritypoultry} \times PLES_{B4}$
$PLEEES_{C2}$	$= RE_{final} \times PLE_{commercialpoultry} \times PLES_{C2}$
$PLEEES_{C3}$	$= RE_{final} \times PLE_{commercialpoultry} \times PLES_{C3}$
$PLEEES_{C4}$	$= RE_{final} \times PLE_{commercialpoultry} \times PLES_{C4}$
$PLEEES_{N2}$	$= RE_{final} \times PLE_{nonavianspecies} \times PLES_{N2}$
$PLEEES_{N3}$	$= RE_{final} \times PLE_{nonavianspecies} \times PLES_{N3}$
$PLEEES_{N4}$	$= RE_{final} \times PLE_{nonavianspecies} \times PLES_{N4}$
$PLEEES_{S3}$	$= PLEEES_{W3}+PLEEES_{B3}+PLEEES_{C3}+PLEEES_{N3}$
$PLEEES_{S4}$	$= PLEEES_{W4}+PLEEES_{B4}+PLEEES_{C4}+PLEEES_{N4}$

Where:

W2 to W4 refers to outbreak scenarios 2 to 4 as a result of an initial exposure to wild birds

B2 to B4 refers to outbreak scenarios 2 to 4 as a result of an initial exposure to low biosecurity poultry

C2 to C4 refers to outbreak scenarios 2 to 4 as a result of an initial exposure to medium biosecurity (commercial) poultry

N2 to N4 refers to outbreak scenarios 2 to 4 as a result of an initial exposure to non-avian species

S3 refers to outbreak scenario 3, regardless of exposure group initially exposed; and

S4 refers to outbreak scenario 4, regardless of exposure group initially exposed.

Volume of trade

Before partial annual likelihood of entry, exposure, establishment and spread can be calculated, the annual volume of trade must be estimated. The IRA team chose a 12 month period for the consideration of the volume of chicken meat likely to be imported. This was considered by the IRA team to be a sufficient period to enable evaluation of seasonal effects, but not so long as to incorporate inaccuracies that may be associated with changes in diseases, animal factors and trade.

Annual slaughter of poultry in Australia in 2004–05 was approximately 435.6 million (Animal Health Australia 2005). It is estimated that over 400 million of these birds were chickens, with the remainder being made up of turkeys, ducks, geese and game birds. Projected increases in Australian domestic poultry consumption were based on figures and forecasts published by the Australian Bureau of Agriculture and Resource Economics (ABARE). These publications forecast an increase of 12.7% in Australian domestic poultry meat consumption between 2004-05 and 2010-11 (ABARE 2005; ABARE 2006). With a projected increase in chicken consumption, annual slaughter of chickens was estimated at 440 million for the purposes of this IRA.

For modelling purposes, the IRA team used a most likely value for volume of trade of 176 million carcasses in its calculations. This was based on a projected market penetration figure of 40% (J.T. Larkin, pers. comm. March 2003) and the estimated annual slaughter of 440 million chickens. The estimate of 40% market penetration was derived from research and observations on international chicken meat export markets, including exports by market leaders such as the United States and Brazil. Therefore, volume of trade (vt) was modelled as a triangular distribution with most likely value of 176,000,000. Maximum and minimum values were considered to be the most likely value ± 10%, respectively. It may be possible at some point in the future to take into account a more accurate estimate of volume of trade, should an exporting country have data to show that the current estimate is overly large.

Partial annual likelihood of entry, exposure, establishment and spread

The expected number of outbreaks in each outbreak scenario can be expressed as probability of the outbreak scenario occurring, ($PLEEES_{(scenario\ number)}$) multiplied by the volume of trade. This number of outbreaks will be well represented by a Poisson distribution, where λ = $PLEEES_{(scenario\ number)}$ x volume of trade. From the properties of the Poisson distribution, the probability that the observed number of outbreaks is zero is $e^{-\lambda}$ (which can also be written as $\exp(-\lambda)$) and probability that it is greater than zero is $1-e^{-\lambda}$. Therefore it is possible to calculate, for each outbreak scenario, the likelihood that the scenario will occur at least once as a result of the import of chicken meat. These calculations are shown in Table 22.

Table 22. PALEEES calculations

$PALEEES_{W2}$	=1– exp (–PLEEESW2 x vt)
$PALEEES_{B2}$	=1– exp (–PLEEESB2 x vt)
$PALEEES_{C2}$	=1– exp (–PLEEESC2 x vt)
$PALEEES_{N2}$	=1– exp (–PLEEESN2 x vt)
$PALEEES_{S3}$	=1– exp (–PLEEESS3 x vt)
$PALEEES_{S4}$	=1– exp (–PLEEESS4 x vt)

Where:

$PALEEES_{W2}$ is the partial annual likelihoods of entry, exposure, establishment and spread for scenario 2, for the wild bird exposure group;

$PALEEES_{B2}$ is the partial annual likelihoods of entry, exposure, establishment and spread for scenario 2, for the low biosecurity poultry exposure group;

$PALEEES_{C2}$ is the partial annual likelihoods of entry, exposure, establishment and spread for scenario 2, for the medium biosecurity commercial poultry exposure group;

$PALEEES_{N2}$ is the partial annual likelihoods of entry, exposure, establishment and spread for scenario 2, for the non-avian species exposure group;

$PALEEES_{S3}$ and $PALEEES_{S4}$ are the partial annual likelihoods of entry, exposure, establishment and spread for the combined scenarios 3 and 4, respectively; and

vt = volume of trade, expressed as the noumber of carcass equivalents imported per year.

Combining partial annual likelihood with consequence

Once an estimate of the annual likelihood of entry, exposure, establishment and spread (for each of the outbreak scenarios) had been obtained, this was combined with the corresponding assessment of impacts to provide an overall estimate of the annual risk associated with each scenario. This was termed the partial annual risk of entry, exposure, establishment and spread (PAREEES).

Combination of likelihood and consequences was undertaken using the 'rules' shown in the risk estimation matrix in Figure 8 below. This required that the quantitative estimates of each PALEEES be converted back to a qualitative value, suitable for use with the matrix.

Estimation of overall annual risk

The partial annual risk of entry, exposure, establishment and spread obtained for each of the outbreak scenarios were combined to give an overall estimate of annual risk. This was undertaken using the 11 rules outlined below. The rules were mutually exclusive, and were therefore addressed in the order that they appear in the list. For example, *if the first set of conditions does not apply, the second set should be considered. If the second set does not apply, the third set should be considered ...*, and so forth until one of the rules applies.

1. Where any one partial annual risk is extreme, the overall annual risk is also considered extreme
2. Where more than one partial annual risk is high, the overall annual risk is considered extreme
3. Where any one partial annual risk is high and each remaining partial annual risk is moderate, the overall annual risk is considered extreme
4. Where a single partial annual risk is high and the remaining partial annual risks are not unanimously moderate, the overall annual risk is considered high
5. Where all partial annual risks are moderate, the overall annual risk is considered high
6. Where one or more partial annual risks are moderate, the overall annual risk is considered moderate
7. Where all partial annual risks are low, the overall annual risk is considered moderate
8. Where one or more partial annual risks are considered low, the overall annual risk is considered low
9. Where all partial annual risks are very low, the overall annual risk is considered low
10. Where one or more partial annual risks are very low, the overall annual risk is considered very low
11. Where all partial annual risks are negligible, the overall annual risk is considered negligible.

The result of this process was an estimate of the 'annual risk of introducing a given disease into Australia as a result of the decision to import chicken meat'. This was considered the final output of the risk assessment.

Figure 8. Risk estimation matrix: estimation of the partial annual risk of entry, exposure, establishment and spread (i.e. outbreak)

Partial annual likelihood of entry, exposure, establishment and spread (PALEEES)	Negligible impact	Very low	Low	Moderate	High	Extreme impact
High likelihood	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Moderate	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Low	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk	High risk
Very low	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk
Extremely low	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk
Negligible likelihood	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk

Expected impacts of entry, exposure, establishment and spread

Risk evaluation is described in the OIE Code as the process of comparing the estimated risk with a country's ALOP. ALOP was defined previously in this document as '… *the level of protection deemed appropriate by the WTO member country establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory* …'.

Australia has traditionally maintained a 'very conservative' attitude to quarantine risk. Given this, a risk that was either 'very low' or 'negligible', was considered sufficiently conservative to achieve Australia's ALOP. Australia's ALOP is shown in the risk estimation matrix (Figure 8) as the band of cells associated with 'very low' risk. This provides a benchmark for evaluating risk and determining whether risk management is required.

The use of a benchmark for evaluating risk is illustrated in the process outlined below.

- For each potential hazard, the level of risk, which takes into account likelihood and consequences, associated with the unrestricted importation of chicken meat was estimated
- The unrestricted risk was then evaluated using the risk estimation matrix (Figure 8) to determine where it fell in relation to Australia's ALOP
- If the unrestricted risk was 'negligible' or 'very low', then it was considered acceptable and further risk management was not required
- If the unrestricted risk was 'low', 'moderate', 'high' or 'extreme', then risk management strategies were identified and, for each hazard, the risk was recalculated
- Where the subsequently restricted risk derived using a particular risk management strategy was 'very low' or 'negligible', that strategy was considered acceptable.

Biosecurity measures

Biosecurity measures aim to reduce the likelihood that the importation of chicken meat from any country will lead to the entry, exposure, establishment and spread of exotic pathogenic agents in Australia. There are two means by which this may be achieved:

- Reducing the likelihood of pathogenic agents entering Australia in imported commodities by imposing conditions on one or more of the steps in the release scenario — i.e. 'pre-import measures'
- Reducing the likelihood that susceptible host species in Australia would be exposed to the pathogenic agent in a contaminated imported commodity, or in other products or waste derived from that commodity, by imposing conditions on one or more of the steps in the exposure scenario(s) — i.e. 'post-import measures'.

Pre-import measures

Steps in the release scenario that may affect the probability of entry were outlined in Figure 4. These steps are reiterated in Table 23. For each step, risk management strategies that may be suitable have been identified. In addition to risk management measures, such as country or zone freedom, or appropriate heat treatments, which are identified in the discussion below as

providing acceptable risk management, there are other steps which need to be formally evaluated.

Recognition of country or zone freedom from disease

In accordance with accepted international standards (World Organisation for Animal Health (OIE) 2006), product imported from a country or zone free of a specific disease, will be considered free of contamination with the disease agent and no import restrictions relevant to the disease will apply, subject to a satisfactory assessment of the zoning arrangements by the relevant Australian Government authority. The principles of zoning, as they apply to this IRA report, are outlined in Part D at Appendix 6. They include, but are not limited to, the following:

- the country of origin has a standard of veterinary services, diagnostic capability, disease surveillance and certification arrangements deemed satisfactory by Australian Government authorities[14]
- the disease is notifiable in the exporting country
- appropriate government veterinary health certification is provided with each importation
- zoning arrangements take account of the epidemiological situation relating to the disease in the exporting country.

Table 23. Risk management for the release assessment

Step in the release scenario	Risk management option(s)	Effect of risk management
Step Rel_1: Selection of flock	Flock freedom accreditation	Assessed on case by case basis
	Country or zone freedom from disease	Reduces risk to acceptable level
	Compartmentalisation	Assessed on case by case basis
Step Rel_2: Surveillance of flock	Flock testing[1]	Increase Rel_2 depending on the sensitivity of the test used, the prevalence of infection, and the sample size $Rel_2 = 1–(1–Rel3)^{\wedge sample\ size}$
	Flock freedom accreditation	Assessed on case by case basis
Step $Rel_{3:}$ Within flock prevalence	Flock freedom accreditation	Assessed on case by case basis

[14] Animal Quarantine Policy Memorandum (AQPM) 1999/41 provides details of the processes used to assess the effectiveness of overseas country veterinary authorities, and other matters relating to approval of countries to export to Australia. This document is included as Appendix 5.

Step in the release scenario	Risk management option(s)	Effect of risk management
Step Rel_4: Background cross-contamination rate		This depends on the nature of the processing plant and little can be done to affect this beyond requiring compliance with Australian standards or equivalent.
Steps Rel_{5a} and Rel_{5b}: Cross-contamination rate		These are calculated from other values and cannot be directly changed by risk management measures.
Step Rel_6 & Rel_7: Inspections – ante-mortem and post-mortem	Require particular inspections/tests before eligibility for export to Australia can be granted – disease specific	This would increase Rel_6 in accordance with the sensitivity of the inspection/testing regime used, but should not affect the value of Rel_7
Step Rel_8: Processing, storage and handling	Require specific off-shore or on-shore processing to ensure destruction of the pathogen of concern	Reduces risk to acceptable level

[1]As discussed in the text, flock testing was not considered to be a practical alternative, due to the very large number of samples that would need to be taken and analysed in order to provide sufficient confidence that the product would not pose a risk of disease introduction.

Off-shore and on-shore processing sufficient to inactivate agents of concern

Processing such as cooking or other treatments to reduce pathogen levels would have the effect of increasing Rel_8 (likelihood that a pathogen in an infected/contaminated carcass would be inactivated during storage, further processing and transport to Australia). Pathogen inactivation is usually measured in $\log_{10}$ reductions in infectious titre. In accordance with existing Australian quarantine policy for biological products, a product will be considered to present a 'negligible' risk of introduction of a pathogenic agent, if it undergoes processing capable of achieving a titre reduction of at least 6 logs (i.e. 10^6) before export to Australia. Where processing is undertaken on-shore, processing would be subject to appropriate controls on the siting of the processing facility at or near the port of entry, and on controls of waste material and packaging, as well as the processing of the imported meat.

Flock accreditation and compartmentalisation

Biosecurity Australia recognises that some exporting countries may wish to make a claim for access based on other risk management approaches, such as flock disease accreditation schemes or compartmentalisation. These approaches may affect disease risk and will be assessed on a case-by-case basis. The following general comments are provided as an indication of the matters that would be taken into account in consideration of a specific

application for recognition of a flock freedom accreditation scheme or a disease compartmentalisation program.

Flock accreditation by the exporting country authority must be on the basis of an official flock health monitoring program, which will provide sufficient assurance of freedom from disease, taking into consideration the epidemiology of the disease, arrangements for on-going biosecurity of the flock of origin, sensitivity and specificity of any diagnostic tests used, testing frequency, sample size and other relevant factors.

The concept of compartmentalisation is similar to that of zoning, but the boundaries of a compartment are based on the application of appropriate management systems, including biosecurity management, rather than on natural or artificial geographic barriers. The principles of compartmentalisation as published by OIE are outlined in Appendix 6. Cases in which compartmentalisation may be appropriate include the situation where disease is known to exist, for example, in a population of wild birds, but has not been reported in commercial poultry. The commercial poultry may be recognised as a free compartment, subject to an assessment of the controls in place to maintain separation between wild and commercial birds, taking into account the epidemiology of the disease under consideration. Industries featuring vertically integrated supply chains lend themselves to this concept.

Chickens from accredited flocks or free compartments must be produced, processed, packaged and shipped in such a way as to avoid cross-contamination from other products not of equivalent health status. To achieve this outcome, they may be processed in an approved facility that does not accept birds from other sources unless they are also accredited and certified as free. Alternatively, where establishments process product that is not suitable for export to Australia, a quality assurance program must be in place to ensure that poultry destined for export to Australia is kept separate from poultry/meat not eligible for export to Australia, and is handled in such a way as to ensure that there is no cross-contamination. This includes ensuring that product destined for Australia is produced following complete cleaning and sanitisation of the entire processing plant and before product not destined for export to Australia. In this case, appropriate auditable measures to ensure protection from cross-contamination will also be required.

A rigorous assessment of any application for approval of compartmentalisation or flock accreditation schemes will be undertaken to ensure that effective biosecurity measures are implemented and maintained throughout the complete chain from farm to slaughter to export. A detailed submission will need to be provided by the veterinary authority of the exporting country and Australia will conduct an on-ground assessment of the proposed compartment or flock accreditation scheme.

Flock inspection or testing

Pre-slaughter inspection or testing of flocks by suitably qualified veterinarians would increase the likelihood that a disease agent will be detected through routine disease surveillance and the flock withheld from processing for export to Australia, thereby increasing Rel_2 (the likelihood that a disease agent will be detected through routine surveillance). The extent of the increase would depend on the nature of the disease and the likely extent and nature of clinical signs, but for major diseases of concern, inspection alone is considered by the IRA team to be insufficient to ensure that Australia's appropriate level of protection is met.

Theoretically, testing of unvaccinated flocks would have the effect of increasing the value of Rel_2. The extent of the change in likelihoods is dependent on the size of the sample taken, the actual prevalence of disease in the sample (Rel_3), and the sensitivity of the test used. In situations where a test is being used, Rel_2 can be calculated as follows:

$$Rel_2 = 1 - (1 - Rel_3 \times \text{test sensitivity})^{\text{sample size}}$$

In calculating the value of Rel_2 according to the formula above, it is necessary to ensure that the value of Rel_3 is accurate, and the assumed value used for the generic IRA can not be used. The IRA team considered that this risk management method was not likely to be useful, because as the value of Rel_3 decreased to an acceptable level, the number of samples required rose to a level that was considered to be impractical. Therefore this option was not considered further.

Product sampling and testing

Random or targeted sampling and testing of shipments of imported chicken meat may be undertaken by AQIS to determine that the product meets required standards, in accordance with imported food legislation.

Measures affecting the exposure assessment

Steps in the exposure scenarios that may affect the probability of exposure were identified in *Method for Risk Assessment*. These steps are reiterated in Table 24. For each step, possible risk management strategies have been identified.

Where the unrestricted risk associated with importation of chicken meat was assessed as low or higher, various combinations of risk mitigation measures were modelled until the final risk was acceptable when compared with our ALOP.

Results of these risk mitigation processes are detailed in later sections of this report.

Importing only bone-in or boneless cuts

This would have the effect of reducing the volume of waste generated in Australia from end-users of imported product. It would also change the likelihood that product would be further processed in Australia, and therefore alter the flow of waste from the product. The amount of waste reduction, and the changes in the product distribution pathways, are detailed below.

Table 24. Risk management for the exposure assessment

Step in the exposure scenario	Risk management option	Effect of risk management
Step $Expo_1$: The likelihood that the imported contaminated chicken carcass will be further processed in Australia	Allow importation for processing under quarantine supervision only	$Expo_1$ = Certain
	Allow importation of bone-in cuts only	$Expo_1$ = 0.1 ±10%
	Allow importation of boneless, retail ready cuts only	$Expo_1$ = Zero
Step $Expo_2$: The likelihood that the imported contaminated carcass, if not further processed in Australia, would be purchased by a household		This is a function of the domestic market distribution and is unlikely to be affected by risk management
Step $Expo_3$: The proportion of the imported contaminated carcass, if further processed in Australia, that is processing waste	Allow importation of bone-in or boneless pieces only (i.e. not allow whole carcasses)	For bone-in cuts, $Expo_3$ = 0.3 ±10% *For boneless cuts, $Expo_3$ = 0 (since it was assumed that boneless cuts are not further processed n Australia)*
Step $Expo_4$: The likelihood that product from the imported contaminated carcass, if further processed in Australia, will be purchased by a household		This is a function of the domestic market distribution and is unlikely to be affected by risk management
Step $Expo_5$:The proportion of the carcass, not further processed but purchased by the end user, that becomes scrap	Allow importation of bone-in or boneless pieces only (i.e. not allow whole carcasses)	For bone-in cuts, $Expo_5$ = 0.3 ±10% For boneless cuts, $Expo_5$ = 0.1 ±10%

Step in the exposure scenario	Risk management option	Effect of risk management
Step $Expo_6$: The proportion of processed chicken meat, derived from a carcass and purchased by the end user directly or indirectly from the Australian processor, that becomes scrap		This depends on the nature of the final product and is difficult to influence. The value used for $Expo_6$ in unrestricted risk calculations is considered a reasonable average of all product types
Step $Expo_7$: The proportion of scraps produced during the processing of chicken in Australia that would be incorporated in highly processed by-products		This depends on the nature of the final product and is difficult to influence. The value used for $Expo_7$ in unrestricted risk calculations is considered a reasonable average of all product types
Step $Expo_8$: The proportion of waste produced during the processing of chicken in Australia that will be rendered and incorporated in chicken feed	Allow importation for processing under quarantine supervision only, ensuring all processing waste is treated as quarantinable waste	$Expo_8$ = certain
$BP_{infectivedose}$, $WB_{infectivedose}$, $NAS_{infectivedose}$ The likelihood that the amount of the contaminated chicken waste eaten by a low biosecurity bird, wild bird or non-avian individual (respectively) is sufficient to initiate infection	Allow importation for processing under quarantine supervision only. The level of processing required will be sufficient to ensure that the likelihood of the agent remaining viable is negligible	Reduce • $BP_{infectivedose}$ • $WB_{infectivedose}$ • $NAS_{infectivedose}$ to negligible.
$BP_{infectivedose}$, $WB_{infectivedose}$, $NAS_{infectivedose}$, FeedContam	Require specific off-shore or on-shore processing to ensure destruction of the pathogen of concern	Reduce all to negligible.

Bone-in cuts processed in the country of origin

Imported bone-in cuts would be processed in the country of origin, and it was assumed that unpopular cuts such as ribs and backs would not be imported. The IRA team considered that this would significantly reduce the proportion of imported product that would be distributed to meat processors, since they believed that it was unlikely that a partially processed product would be imported for final processing in Australia. Based on these assumptions, and those relating to the relative market share for households and food service establishments which

were discussed earlier, the IRA team made the following estimates for distribution of bone-in cuts processed in the country of origin.

Market distribution

Meat processors	10%
Households	45%
Food service establishments	45%

The likelihood that imported bone-in chicken cuts would be further processed in Australia ($Expo_1$) was therefore considered to be 10%. This value was expressed as a Triangular distribution with 0.1 as the most likely figure. Maximum and minimum values were considered to be the most likely value, ± 10%, respectively. This meant that, by subtraction, the likelihood that imported product would not be further processed in Australia ($1–Expo_1$) was approximately 90%.

The IRA team considered that the economics of the market would mean that, *when considering import of bone-in or boneless cuts,* only the higher grades of cuts, such as bone-in breasts and legs, would be imported, in preference to whole cut-up carcases. Bone-in breasts and legs (thigh and drumstick) consist of approximately 70% lean meat, with the remainder comprising differing proportions of skin, fat and bone. A conservative estimate of waste from household consumption of imported bone-in chicken cuts was 30%. For bone-in cuts, $Expo_5$ was expressed as a triangular distribution, with a most likely value of 0.3. Maximum and minimum values were considered to be the most likely value ± 10%, respectively. This value was also considered by the IRA team to represent a reasonable value for $Expo_3$ when considering the import of bone-in cuts.

Boneless cuts processed in the country of origin

Boneless cuts would be processed in the country of origin, effectively eliminating the proportion of imported product that would be distributed to meat processors, and further reducing the amount of waste generated in Australia. Based on the data for distribution of processed cuts in Australia at present, the following assumptions were made for distribution of boneless cuts.

Market distribution

Households	50%
Food service establishments	50%

Based on this information, the likelihood that imported boneless chicken cuts would be further processed in Australia ($Expo_1$) was considered to be 0%. This meant that, by subtraction, the likelihood that imported product would not be further processed in Australia ($1–Expo_1$) was 100%. Following on from the assumption that no imported boneless cuts will be further processed in Australia, no waste will be produced at processing. Therefore the value of $Expo_3$ for this risk management measure will be zero.

Boneless cuts consist of approximately 12–22% skin and fat (Lin et al, 2002). Assuming that skin and fat is not always discarded before cooking, waste from consumption of imported boneless cuts ($Expo_5$) was estimated at 0.1. Maximum and minimum values were considered to be the most likely value ± 10%, respectively.

On-shore processing under quarantine supervision

Alternatively, product may be processed after importation ('on-shore processing'), in an establishment that has entered into an approved agreement with AQIS under a quality assurance arrangement. Any processing which meets these requirements will mean that the risk is adequately managed. All inactivation procedures should be validated and verified for the product, container type, configuration and volume and be supported by appropriate standards and procedures.

Management of packaging materials

Imported chicken meat will be accompanied by various forms of packaging material, some of which will be in direct contact with the meat. There is the potential for packaging material to be contaminated with any disease agent present in or on the contained meat product. Therefore, disposal of packaging material is an important consideration.

It was assumed that, for any imported chicken meat that requires post-border risk management (such as product testing or additional processing), packaging materials will remain with the chicken meat under quarantine control. Therefore, packaging material will be treated as quarantinable waste under quarantine control upon release of the imported product for market distribution. If imported product does not require risk management, it was assumed that special disposal measures would not be required for the packaging materials.

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