Apple & Pear Australia Limited

TECHNICAL INDUSTRY RESPONSE

TO

IMPORTATATION OF APPLES FROM NEW ZEALAND

REVISED DRAFT IRA REPORT

FEBRUARY 2004

COMMISSIONED BY

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TABLES

FIGURES

GLOSSARY OF ABBREVIATIONS

ALCM	Apple Leafcurling Midge
APAL	Apple and Pear Australia Limited
AQIS	Australian Quarantine and Inspection Service
BA	Biosecurity Australia
BHL	Brownheaded Leafroller
CM	Codling Moth
CMB	Citrophilus Mealybug
DAFF	Department of Agriculture Fisheries and Forestry
DFAT	Department of Foreign Affairs and Trade
DIRA	Draft Import Risk Analysis
DSB	Dispute Settlement Body
E. amylovora	Erwinia amylovora
ERM	European Red Mite
GBC	Grey Brown Cutworm
GFF	Garden Featherfoot
GHL	Greenheaded Leafroller
Handbook	Import Risk Analysis Handbook DAFF 2003
IFP	Integrated Fruit Production
IGR	Insect Growth Regulator
IPM	Integrated Pest Management
IRA	Import Risk Analysis
IRAAP	Import Risk Analysis Appeals Panel
IRAT	Import Risk Analysis Team
ISPM	International Standard Phytosanitary Measure
LBAM	Light Brown Apple Moth
N. galligena	Nectria galligena
NLR	Native Leafroller
NZFT	New Zealand Flower Thrips
OFM	Oriental Fruit Moth
OSS	Oystershell Scale
QUT	Queensland University of Technology
R&D	Research and Development
RAP	Risk Analysis Panel
RDIRA	Revised Draft Import Risk Analysis
REB	Registered Export Block
TWG	Technical Working Group
WB	Wheat Bug
WTO	World Trade Organisation

SECTION 1: EXECUTIVE SUMMARY

1. EXECUTIVE SUMMARY

Comparison of the RDIRA with a detailed analysis by experts has revealed flaws in the mathematical model used to estimate risk. This critique of the mathematical models begs the question of whether, in its current form, the RDIRA can now be accepted as an accurate method of risk assessment for this and future IRA's.

The analysis by technical experts has also exposed significant differences in the quantitative estimates of risk for specific pests and pathogens in the importation pathway. In most instances risk estimates published in the RDIRA are consistently LOWER than those assigned by the industry's technical experts.

This means that the unrestricted risk calculated for each of the pests and diseases is, in most cases, higher than that reported in the RDIRA. The implication is that more rigorous mitigation measures will be required if Bisosecurity Australia is going to meet Australia's ALOP.

In view of these deficiencies it is considered that the RDIRA should not be approved in its current form as the reference document for importation of apples from New Zealand.

<u>Specific Recommendations.</u>

A. Methods of Risk Assessment.

There are significant methodological problems with the procedures and approach adopted by the RDIRA. These make the outcomes of the Pest Risk Assessment and Pest Risk Management Steps scientifically indefensible as it currently stands. Conclusions drawn in the document about risks before and after risk management procedures are not likely to adequately reflect either the nature of current scientific understanding or expert opinion. The main reasons are that

- The uncertainty in expert opinion is not adequately assessed for model inputs, and is not satisfactorily carried throughout the model. As a result, the output distribution for the probability of entry, establishment or spread is quite arbitrary, and measures based on 50th or 95th percentiles have no sound basis.
- Conditional probabilities are not adequately explained or acknowledged. In particular, probabilities associated with importation steps are conditional on the particular pathway being considered. This has not been taken into account, leading to errors in estimating the likelihood of some importation steps. It is necessary to elicit values for each importation step for each different pathway, unless it is demonstrated that the value is the same for each pathway. Expert opinion must be elicited after clear instruction about the nature of conditional probabilities, that prior points in the pathway must be assumed to have already taken place. There is some evidence that this has not been observed, for instance in the Pest Risk Management for Fire Blight (refer to Section 11).
- The assumption of independence in many aspects of the modelling is inadequate to capture the actual way that fruit might be contaminated, the clustering that may occur in transportation, the subsequent discard of waste fruit, or escape of flying insects. This leads to overestimation of inspection efficacy, an over estimate of the precision of final estimates, and is likely to under estimate the probability of exposure and subsequent disease establishment.

- Modelling based on a unit of one apple forces experts to judge likelihoods that are very low. It is known that people are poor at accurately estimating such likelihoods. It also forces them to judge likelihoods out of the context in which they are familiar. For example it would seem more reliable to judge the likelihood of insects escaping from a pallet of apples, rather than from a single apple. Until the points above are satisfactorily addressed, the conclusions of the RDIRA must remain questionable.

B. Qualitative assessments of risk for pests and diseases

Risk was assessed for each of the pests and diseases at each step in the importation pathway. Where possible, judgements were backed by relevant scientific reports for the specific organism. In the absence of such specific data, information from studies on related organisms was used or in the absence of any available data conservative judgements were made based on the precautionary principle.

This process was applied to the risks of entry, distribution, establishment and spread and the results compared with those contained in the RDIRA. Differences between the judgements of risk in RDIRA and those of the separate analysis by experts were justified.

The overall assessments of unrestricted risk for each of the pests and diseases are at least one or two levels higher than those published in the RDIRA. For example technical experts assessed *E. Amylovora* and *N. galligena* as **HIGH** and **MODERATE** respectively whereas the RDIRA records the unrestricted risk for both diseases as LOW.

Similarly the unrestricted risk for all pests, except for Apple Leafcurling Midge, was assessed as **LOW**, whereas the RDIRA indicates risks negligible for Oriental Fruit Moth, European Red Mite, Oystershell Scale, Garden Featherfoot and Grey-brown Cutworm.

Three other pests, Native Leafroller, New Zealand Flower Thrips and Mealybugs, were assessed as having unrestricted risks one level higher than VERY LOW, as proposed in the RDIRA.

C. Risk Mitigation

Risk mitigation measures proposed to reduce levels of unrestricted risk specified in the RDIRA are not considered to be effective. Experts strongly recommend the need for more rigorous measures especially if the higher estimates of unrestricted risk are accepted.

Technical analysis considers there are likely to be significant deficiencies over the effectiveness of orchard and pre-clearance inspection as risk mitigation measures, of chlorine as a disinfectant and cool chain as a de-vitalising treatment.

An outstanding problem is that analysis of the specific details of risk mitigation measures is not possible because these are not available. The intention is that they will be published in a draft work plan and it is understood that the proposed work plan will be made available for comment prior to approvals for its publication. Analysis of the work plan is considered essential and industry believes it is an integral part of the RDIRA and questions why Biosecurity Australia has failed to include this within the RDIRA.

D. Risk Analysis and Matrix

- Why was the Likelihood of certain not included in Table 11 and utilised in the appropriate areas of the RDIRA?
- Table 11 presents a dilemma with regards the individual Likelihoods and the specifically allocated probability intervals. ‘HIGH’ has a probability interval of 0.7 to 1 and ‘MODERATE’ has a probability interval of 0.3 to

0.7. Given that a probability of any particular aspect of the process gives a probability figure of 0.7 is the likelihood 'MODERATE' or 'HIGH?

- With Biosecurity Australia indicating that they will, in all cases take the most conservative position, it is logical to expect that when a probability falls into such a category ie., 0.7, the likelihood will always be 'HIGH'.
- The Unrestricted Risk calculation of the Likelihoods of entry, establishment and spread for the principal pest of concern – Fire Blight – was increased by a factor of three based on the category likelihoods scale used by Biosecurity Australia. The restricted risk was determined to be a category level of LOW using Biosecurity Australila's terminology. This level is higher than the very LOW risk required to meet Australia's ALOP.
- A rigorous and reliable mathematical method of Risk Analysis is required. Only when the risks have been reliably determined and published can informed public comment be requested and received.
- The RDIRA cannot be finalised without clear evidence that any proposed levels of reduction can be achieved and how symptom freedom, chlorine and/or cold storage would do so.
- The Risk Management measures for Fire Blight proposed by the RDIRA are not supported by evidence in the RDIRA to give a plausible assessment of the Import Risk.
- At best the level for Restricted Annual Risk for the pathogen responsible for Fire Blight would be **'HIGH'** which is not sufficient to meet Australia's appropriate level of protection.
- Given that none of the pests or diseases within the RDIRA have any impact with regards 'Human Life', this aspect of the review model should be deleted from the assessment of consequence. The use of an irrelevant impact with a low score presents a false result.
- The critique by representatives of the USDA – Aphis (on the banana IRA) support industry criticism of the Risk Matrix model and methodology including:
  1) The overlapping of ranges
  2) Precision of scale within Table 11
  3) Bias towards achieving a 'LOW' or Lower result
  4) Using assumptions to all pest types
  5) Utilization of sub-components within the pathway

E. New Science

Technical experts assessed the areas in which new science was relevant or bodies of current science had not been adequately considered within the RDIRA. The main areas of new science are

- In the light of recent advances in bacterial research several mechanisms of bacterial survival have been explored. It is known that bacteria do not act in isolation in the process of infection but a mechanism called quorum sensing is employed to maximize the success of surface colonisation. Quorum sensing is a bacterial communication mechanism to coordinate expression of specific genes in a cell density-dependent manner (Whitley *et al*. 1999). Recently it has been reported that Erwinias too employ such a mechanism in a similar manner to other bacteria (Byers *et al.* 2002). Recent evidence suggests that quorum-sensing pathways converge with starvation-sensing pathways to regulate cell entry into stationary phase (Lazazzera 2000).

- Epiphytic survival is characterised by extreme fluctuations of environmental factors. Those factors are known to induce some stress responses. In response to stress such as low nutrient conditions, temperature or pH bacteria (1) produce EPS substances and (2) activate the sigma factor (σ) (Kim and Beer 2000). *P. syringae* has been observed to produce EPS as a response to desiccation stress (Keith and Bender 1999).

- In the process of infection a number of virulence factors are used to permit colonization. Type III pillus and EPS production contribute to the virulence of *E. amylovora* (Wei *et al* 2000), and it is known that those structures participate in biofilm (aggregate) formation (Costerton *et al.* 1995). Biofilms bind cells, organic and inorganic materials to each other, and to a variety of substrata. Their tightly formed structure reduces antimicrobial activity ie. antibiotics, promotes bacterial adhesion, prevents bacterial dehydration and promotes extended survival. A dense EPS matrix (biofim) triggered by a stress response and formed through EPS production maximises bacterial survival by increasing nutrient concentrations (Costerton *et al.* 1995).

- The formation of aggregates on plants has major implications for bacterial colonization and survival in harsh surface environments and provides them with a mechanism to modify the immediate environment of the bacteria in this habitat (Lindow and Brandl *et al.* 2003). The production of EPS, a major part of the bacterial aggregate matrix, benefits epiphytic survival (Morris and Monier 2003). Biofilm is an effective way for delivering extracellular enzymes, and provides an effective way of drawing nutrients from the plant (Lindow and Brandl 2003).

- Bacterial biofilm (aggregate) formation has not been researched with respect to *E. amylovora*; however, it is important to recognize that a pathogen known to produce biofilms, (*P. syringae*) shares with *E. amylovora* a stress response mechanism triggered by a sigma factor σ (Janisewicz *et al.* 1999).

- In short, bacteria may enter a dormant state and aggregate structures may enhance survival. Unless direct investigation is performed, naturally occurring viable bacterial populations may not be detected due the non culturable state of bacteria in that state. Hale and Taylor (1999) and Roberts (2002) did not employ direct investigation techniques. Their results leave unanswered the question whether viable but non-culturable bacteria were present. This points to the importance of employing both direct and indirect methods for detecting *E. amylovora* and significantly qualifies the conclusions proper to be drawn from such indirect studies.

- In an endeavour to establish the possibility of the bacteria *Erwinia amylovora* expressing an ability to be viable and non-culturable Apple and Pear Australia Limited and The Australian Government through R&D funding from Horticulture Australia Ltd commissioned the following research project:

AP02017 – "Can Erwinia amylovora exist in a viable, but non-culturable state".

This project is being conducted by:

Associate Professor Lindsay Sly
Head

Department of Microbiology and Parasitology
University of Queensland

Early results from this project indicate that the researchers have been able to "*establish viable but non-culturable fire blight bacteria*".
and
"*They have bacteria treated with copper and saline which are not growing on media, but which show up as 'live' using a stain technique which differentiates between live and dead cells on the basis of cell membrane being intact or not".*

Those survival mechanisms are important factors that must be considered when assessing E. *amylovora* survival on mature apples. None of those mechanisms has been considered in the RDIRA.

F. PATHWAYS

In an unrestricted risk with fruit being:

(a) treated and packed 'off-tree'
(b) taken from orchards certain to have Fire Blight
(c) chlorine being used at the standard pack house procedure, and
(d) not being subject to cold storage.

the scenario would present a very likely and real situation whereby a large quantity of fruit infected / infested with one or more of the quarantine pests and /or diseases enter Australia having received minimal treatment.

Under a conservative approach this scenario should be the basis for **all** further considerations and statistical calculations.

Higher volumes of fruit will enter via Pathway 1 (P1) and lower volumes via Pathway 2 (P2). This results in an alteration of table 14 so that the proportion of imported apple fruit utilised in urban / orchard based pack houses and re-packer would be **HIGH**.

G. ERWINIA AMYLOVORA

- The concept of a disease triangle depicting the interaction between the host, pathogen and the environment is fundamental to the discipline of plant pathology. For disease to occur all components of the triangle must be present, with the environment being favourable for infection and development of the disease.

- Realistically, the steps comprising 'entry' should end with the release of the imported apples. Steps in the distribution of the imported apples should not be included as a component of 'entry' especially the transfer of the pathogen to a susceptible host.

- There are still gaps in the understanding of the manner and means by which *E. amylovora* is transferred to its host.

- The possible entry of the Fire Blight bacterium *E. amylovora*, into Australia with New Zealand apples is primarily the most important single event occurring in the pathway associated with the importation.

- Chlorine treatment is a risk mitigation measure and as a result cannot and should not be considered as part of the unrestricted risk.

- The conclusion that, the probability of transfer of *E. amylovora* from waste discarded at the utility point to susceptible host was assessed as negligible is considered unrealistic as it has been based largely on results of experiments done with artificially inoculated fruit and on speculation about availability of nutrients in the calyx and rapid decline of bacterial cell numbers. However, according to Hildebrand (1939) *E. amylovora* cells remain viable in dried natural ooze for 15 – 25 months and in bacterial strands for 12 months.

- Based on work by scientists and members of the APAL technical panel, the calyx end of the apple is an area of great concern with regards to the infiltration of bacteria.

- The subject of infection of the core tissues of the apple fruit by *E. amylovora* has received very little attention in the RDIRA.

- Resistance to *E. amylovora* to streptomycin is becoming increasingly widespread in countries having Fire Blight.

- A most serious effect than the inability to control Fire Blight because of streptomycin resistance of the pathogen would be the transmissibility of the resistance genes from *E. amylovora* to human and animal bacterial pathogens.

- Inconsistencies clearly indicate the unreliability of determining whether or not mature fruit is infested/infected based on the presence or absence of Fire Blight symptoms in the source orchards.

- In Australia with the availability of susceptible hosts in abundance, and areas with weather conditions particularly favourable for Fire Blight, sufficient levels of inoculum (of *E. amylovora*) will become available, even with a LOW risk estimate, to complete the Disease Triangle, leading to establishment and spread of the disease, if apples from New Zealand were to be imported.

H. NECTRIA GALLIGENA

A critical examination of the evidence presented to justify the estimated risk for the various steps in the importation and distribution pathways has led to the revision of some of the RDIRA estimates and these are shown in the Table provided in the text. The reasons for the changes are indicated briefly in that Table and are also discussed in more detail in the text.

- In some instances it has not been possible to make an objective assessment of the risk due to lack of precise information on the epidemiology of European Canker in New Zealand. In such cases, a more conservative approach should be adopted in revising the IRA estimate in those areas that the RDIRA has failed to adopt a conservative approach that is not in accordance with Australia's accepted level of protection.

- Gaps in the available information on European Canker in relation to its epidemiology and control in New Zealand have been highlighted and discussed in detail in the text.

- It is evident from the literature that European Canker caused by the fungus *Nectria galligena* is one of the most economically damaging diseases of apple. In Europe there are reports that the severity of epidemics is increasing (Huberdeau, 1996; Schmitz *et al*., 1996). With the exception of Australia, where it has been eradicated, *N. galligena* is present in almost all regions of apple production (CABIa, 2003). The disease has been recorded in many tree and shrub species and all apple cultivars are susceptible. Both young and old trees can be affected. In young orchards loss of trees due to canker may exceed 10%, and in some instances requiring replanting of the whole plantation. Also losses of 10-60% of fruit due to storage rot have also been recorded (Swinburne, 1970; McCartney, 1967).

- The disease has been reported to occur in all of the major apple growing regions of New Zealand but more comprehensive surveys are necessary to determine the incidence and severity of the disease in these areas. The absence of the disease in orchards/ blocks claimed to be disease free needs more compelling evidence.

- The view that the disease is not important in areas below 1000mm rainfall is too simplistic (MAFNZ, 2004) as the distribution of rainfall and the number and duration of wet periods, prior to harvest in particular, are critical factors that need investigation. Also, data on the seasonal pattern of spore dissemination would assist in determining the level of fruit infection/infestation, if any, and formulate effective control measures.

- It is important to remember that that the disease does not occur in Australia and there are apple-growing areas in the country with favourable climate for disease establishment and spread. Furthermore, besides Tasmania, no other country has been able to eradicate the disease and the additional cost of control could be substantial, especially for growers in Western Australia where apple scab does not occur. Even in the other States apple scab sprays alone would not be sufficient to control European Canker effectively.

- The impact on wild and amenity plants of an incursion of *N. galligena* into Australia needs to be more carefully considered following a detailed survey of their distribution and proximity to utility points and waste disposal sites in view of the high value the Australian community places on its forest and garden environments. The manner in which waste is disposed at the various utility points and dumping sites also requires investigation.

- If the revised estimates for overall probability of entry, establishment and spread and consequences are used and the unrestricted annual risk recalculated, it would be HIGH, which means more rigorous risk mitigation measures are required to reduce risk to an acceptable level for the export of fruit. The principal reason for the HIGH estimate for risk is the likely threat to aspects of the environment if an incursion of *N. galligena* occurred. In these circumstances, the establishment of pest free areas for sourcing export fruit, to the satisfaction of the Australian fruit industry, appears to be the best option.

I. INTEGRATED FRUIT PRODUCTION

- Integrated Fruit Production (IFP) as practised in New Zealand results in increased quarantine risks because it allows previously suppressed secondary pests, such as Apple Leaf Curling Midge, to increase.

- Industry has not been able to access the New Zealand Integrated Fruit Production Manual and therefore has been denied the opportunity to offer a full and comprehensive review and report on a document referenced in the RDIRA and considered an integral part of the decision making process of the IRAT.

J. PESTS

- Risk Analysis Model.
  The risk analysis model used in the RDIRA is a statistically convenient tool, but has many inherent shortcomings, and there are problems in the way it has been applied in the RDIRA:

- The focus of the model on a single infested fruit and what happens to it is biologically unrealistic. This abstraction ignores the reality that pests function as populations, not as individuals. Population scenarios likely to result in establishment of new pests in Australia are ignored. (This issue is discussed in detail in this review for the Greenheaded and Brownheaded Leafrollers, and Codling Moth).

- The model is built around the unrealistic assumption that establishment of new apple pests will only come from waste fruit generated at each step on the distribution pathway. While waste is important, there are other similarly important, and in some cases, more important pathways that are dismissed.

- The risk analysis in the RDIRA generally uses a 'high' probability as the highest level (midpoint 0.85) when, in many cases, the actual probability is close to 1, or 'certain'. This use of 'high' forces population reductions along pathways that do not occur in reality.

- The model also creates anomalies for pests with restricted distributions in New Zealand, such as Oystershell Scale, which occurs only in the Otago and Canterbury regions. The analysis should be run only for fruit from affected areas, as it will move through the system together, while the model implies it will be diluted among all New Zealand apples.

- Real data is missing from most of the analysis of the distribution and establishment pathways. This part of the analysis is largely conjectural and lacks credibility. Detailed examination of the 'pest specific estimates' on these pathways indicates many are very unrealistic.

- **<u>Host Plants</u>**
  - The RDIRA generally underestimates the availability of host plants in Australia for polyphagous pests such as the Greenheaded and Brownheaded Leafrollers, Grey-brown Cutworm, Native Leafroller,

New Zealand Flower Thrips, European Red Mite, Mealybugs and Oystershell Scale.

- The RDIRA provides little detail on the rationale for its judgements on the distribution of hosts of *E. Amylovora* and other quarantine pests and diseases around utility points.

- In assigning qualitative risk estimates for distribution, the level of risk should change with the intensity of distribution of hosts. This has not been accounted for in the RDIRA and the judgements are questioned.

- Case studies within the Adelaide Hills region establishes a high number of host plants in close proximity to commercial orchards, commercial packing houses, retailers and waste points.

- Host Plants can be in the form of:
  a) derelict orchards
  b) feral plants along roadside, creeks and within national parks
  c) plants in home gardens
  d) plants in street scapes in communities and in townships within a particular region

- All species known to be polyphagous should be regrouped as having a high probability of finding host plants no matter where they may escape in Australia.

- The RDIRA makes surprisingly little use of United States Department of Agriculture data derived from preclearance inspections of New Zealand apples. This data would allow more rigorous assessment of the risks of entry for pests, and would provide a check on the Import Risk Analysis methodology.

- This review reassessed the probabilities of entry, distribution, establishment and spread for eleven pest species considered in the RDIRA. All had revised unrestricted annual risks of entry above Very Low, Australia's Appropriate Level Of Protection (ALOP).

- **<u>Specific Pests</u>**
  Review of the risk analysis for pests in the RDIRA found:

  Apple Leaf Curling Midge ("ALCM")
  - Apple Leaf Curling Midge represents a high risk in that it not only has the potential to occur as multiple individuals on a single fruit, but it is also winged. Hence, it is possible for a single discarded piece of infested fruit to initiate an infestation and that fruit does not have to be close to hosts.

  - It is concluded that the Import Risk Analysis is inappropriate for this pest. The high level of quarantine interceptions by USDA on New Zealand apples shows the unrestricted risk for this pest should be much higher than the 'LOW' rating given in the RDIRA. This indicates the risk analysis methodology has given an unrealistic outcome in this case. Standard fruit inspection will not provide adequate risk mitigation for this species. Higher levels of inspection and/or fumigation of shipments are required.

Garden Featherfoot ("GFF")
The analysis for probability of entry in this review was assessed as very **'LOW'**, by contrast to 'EXTREMELY LOW' in the RDIRA. The revised unrestricted annual risk of entry of **'LOW'** is also above the level of 'EXTREMELY LOW' assessed by the RDIRA

Grey-brown Cutworm ("GBC")
This review considers the probability of entry for GBC to be **'VERY LOW'** rather than 'EXTREMELY LOW' as in the RDIRA. The RDIRA also greatly underestimates the probabilities of establishment and spread for this polyphagous species, such that the revised unrestricted annual risk of entry is **'LOW'** rather than 'NEGLIGIBLE'.

Greenheaded ("GHL") and Brownheaded Leafrollers ("BHL")
This review found that the probability of entry for GHL and BHL was 'VERY LOW', in agreement with the RDIRA. However, this scenario could change rapidly in these species if resistance to pesticides becomes more widespread. Also, the probabilities of establishment and spread derived in the RDIRA are greatly understated, such that the revised unrestricted annual risk of entry is **'LOW'** rather than 'VERY LOW'.

Native Leafroller ("NLR")
The RDIRA has handled the analysis of NLR very poorly, with several logical inconsistencies. It is considered that the probability of entry for NLR is **'VERY LOW'** by contrast with 'EXTREMELY LOW' in the RDIRA. It is also considered that the likelihood of establishment and spread for this species has been underestimated. The revised annual risk of entry is **'LOW'** rather than 'VERY LOW'.

New Zealand Flower Thrips ("NZFT")
The analysis in this review gave a probability of entry of very low, by contrast to extremely low in the RDIRA. In addition, the probabilities of establishment and spread for this species are grossly underestimated, such that the revised unrestricted annual risk of entry is low, rather than very low as in the RDIRA.

Codling Moth ("CM")
This is the only insect for which the RDIRA has given a higher probability of entry, 'LOW', than this review, **'VERY LOW'**, showing a major inconsistency in the way this pest has been treated in the RDIRA. Also by contrast to the other pests, the unrestricted annual risks calculated in this review and the RDIRA are both 'LOW'.

European Red Mite ("ERM")
ERM has given the same probability of entry in this review as in the RDIRA. However, the likelihoods of distribution, establishment and spread are higher in this review giving a much higher unrestricted annual risk of entry of **'LOW'** versus 'NEGLIGIBLE' in the RDIRA.

Citrophilus Mealybug ("CMB")
CMB represents a higher quarantine risk than most pests considered in the RDIRA. This review considers the probability of entry to be **'LOW'** by

contrast to ‘VERY LOW’ in the RDIRA. The unrestricted annual risks of entry are also **‘LOW’** and ‘VERY LOW’ in the RDIRA.

Oriental Fruit Moth (“OFM”)
This review agrees with the RDIRA for probability of entry of this pest, but gives a lower unrestricted annual risk of entry, **‘LOW’**, than the RDIRA, ‘NEGLIGIBLE’.

Oystershell Scale (“OSS”)
It is considered that the risk analysis methodology is inappropriate for Oystershell Scale, which only occurs in the south of the South Island of New Zealand, representing about five percent of the New Zealand apple crop. When the appropriate subsample of fruit is analysed, a much higher probability of entry, **‘LOW’**, is generated than that in the RDIRA, ‘EXTREMELY’. The revised unrestricted annual risk of entry is **‘LOW’**, by contrast to ‘NEGLIGIBLE’ in the RDIRA.

Wheat Bug (“WB”)
The Import Risk Analysis methodology is totally inappropriate for this pest which does not attack apple fruit at all. It would have been better to analyse by pallet units, rather than by fruit. On the basis of pallets, a probability of entry of **‘LOW’** is generated, rather than ‘VERY LOW’ as in the RDIRA. The analysis of establishment and spread for WB is also highly flawed.

K PERSONAL COMMUNICATIONS

- Cold storage, according to basic principles of biology, would only prolong the survival of bacteria with very little or no reduction in numbers.
- Control programs utilized with orchards around the world to control Fire Blight would add substantial cost to Apple/Pear production in Australia if the industry was forced to introduce them as a result of an outbreak of Fire Blight.
- The high incidence of Apple Leafcurling Midge being found in apples entering the USA from New Zealand highlights the ineffective nature of the ‘measures’ implemented by New Zealand. This puts into question the measures proposed by Biosecurity Australia within the RDIRA.
- The incidence of Wheat Bug found on produce coming into Australia highlights the ineffective nature of ‘measures’ required of New Zealand producers / exporters and puts in question the measures proposed by Biosecurity Australia within the RDIRA.
- Practical experience of Apple/Pear Growers further reinforces the belief that in all regional areas there are numerous and widespread host plants therefore increasing the chances of Fire Blight becoming established.

L GENERAL COMMENTS

- There is no clarification from Biosecurity Australia that **all issues** (800-1000) raised as part of the review of the 2000 Draft Import Risk Analysis have been adequately and appropriately considered within the 2004 Revised Draft Import Risk Analysis document.

- The Most important stakeholders within the process – the Apple and Pear Growers – are extremely frustrated with the process and have been totally disenfranchised from the activities of the Import Risk Analysis Team. This has been reflected in each and all public forums held across Australia.

- Industry is seeking a full review of the Import Risk Analysis process with consideration to:
  a) Removing the current 60 day comment period because it is totally inadequate for stakeholders to undertake a professional and adequate review of large and comprehensive documents.
  b) Establishing a process which allows greater independent peer review to objectively assess the validity of both industry submissions and the Import Risk Analysis reports compiled by Biosecurity Australia.

- While industry would agree that communications and transparency have improved since the release of the previous Draft Import Risk Analysis the process needs to be further developed and improved.

- There is a strong feeling of distrust between the Apple & Pear Industry and Biosecurity Australia which does not allow a fully open and transparent system. The situation can only be overcome through a full review of the Import Risk Analysis process.

- Biosecurity Australia should be divided into two separate and distinct divisions – one dealing exclusively with Import applications into Australia and the other dealing with market access for Australian products

- There has been a long list of economically significant organisms that have breached Australia's quarantine barriers in the last 20 years, including:
  - Red Imported Fire Ant
  - Western Flower Thrip
  - Poinsettia White Fly
  - Oriental Fruit Fly
  - Palm Thrips
  - Red-Banded Mango Caterpillar
  - Currant Lettuce Aphid
  - Giant African Snail
  - Black Sigatoka of Bananas
  - Wheat Streak Mosaic Virus
  - Potato Spindle Tuber Viroid
  - Olive Knot Disease

  Which put into question either the Import protocols established for produce entering Australia and/or the inspection procedures being utilized by the Australian authorities.

- The Import Risk Model Framework, while appearing to be rigorous and all-encompassing, does not facilitate the incorporation of Pest and Disease biology and population dynamics into the Risk Analysis

- There is little, if any consideration in the RDIRA about the potential effects of breaking the Cool Chain on the likelihood of escape by winged insects. It appears to be assumed that the Cool Chain will always be maintained, but this is not necessarily so. – Refer to Figure 3.1.

- Other issues which have not been covered in detail by this Technical Submission, but require further consideration by the Import Risk Analysis Team (IRAT) include:-

  a) Pest/disease outbreaks in close proximity to registered export blocks.
  b) Symptom removal prior to inspection.
  c) Historical incidence/outbreaks of Quarantine pests/diseases within New Zealand and other Countries.
  d) Movement of pests/diseases during harvesting, transport and cold storage.
  e) Movement of pests/diseases during packing and transporting
  f) Inspection of 600 pieces of fruit at the point of entry.
  g) The issue of trash has not been considered in sufficient depth in the RDIRA with particular consideration to its significance as a vector for pests and/or diseases.
  h) The issue of handling errors and illegal acts have not been taken into account despite the fact that WTO has specifically ruled that both may be taken into account.
  i) Visual inspection of orchards is given as a risk mitigation factor when it is clear that visual inspections will not detect small Fire Blight cankers or European Canker lesions

- Industry has been denied the fundamental right to access each and all documents / papers / reports / communications detailed within the RDIRA. The transparency of the process, while improved, has failed in that relevant papers and references within the RDIRA have not been made available to some stakeholders to review. These include the New Zealand Industry IFP Manual and protocols/ procedures relating to the use of chlorine.

RECOMMENDATIONS

It is recommended that:

- Biosecurity Australia develops a more appropriate risk analysis model that realistically takes account of the population dynamics of pests and diseases.

- Biosecurity Australia establishes an expert panel to reanalyse the risks associated with the importation of New Zealand apples in the light of the many inadequacies in the RDIRA revealed by this and other reviews.

- Biosecurity Australia obtains from New Zealand MAF, the results of all USDA preclearance inspections of export apples for the last three years in order to validate the probabilities of entry in the RDIRA, and makes the data available to the Australian industry.

- Preclearance inspections be implemented in New Zealand for export apples to Australia using the USDA-MAF (2004) model.

Table 1.1 Summary of Importation steps in the RDIRA, the assessment of their likelihoods by APAL compared with those by BA, and justification for change of BA's assessments by APAL for FIRE BLIGHT

Importation Step	**Risk in 2000 IRA**	**Risk in 2004 IRA**	**Recommended Risk**	**Justification**
Imp 1		High (0.85)	High (0.85)	Risk rating is the same as in the RDIRA
Imp 2		Very low (0.0255)	Moderate (0.5)	As the orchard is infected the fruit will be infected/infested by endophytic and epiphytic (surface and calyx) *E. amylovora.* As this assessment is for unrestricted risk orchards that may be both infected and infested. Therefore, fruit harvested will have a substantial level of infection. Low levels of *E. Amylovora* populations reported in the literature cited in the RDIRA is due to indirect techniques being used to isolate the bacteria from fruit calyxes and surfaces. These methods detect only planktonic bacteria and not embedded and attached bacteria
Imp 3		Very low (0.0255)	Low (0.175)	As the fruit in the orchard is already infected to some degree cross contamination will occur during picking and handling of fruit. During picking the pickers' hands will come in contact with leaves carrying epiphytic bacteria; these may be transferred to some of the clean fruit. Contamination can also occur from pickers' bags and from bins.
Imp 4		Moderate (0.5)	High (0.85)	RDIRA refers to reduction of bacterial numbers by long term cold storage. Cold storage should not be considered here as the assessment is for unrestricted risk. In any case, cold storage would only prolong survival. Washing in water dump will spread the bacteria from surface infestations and contaminations (not calyx infections/infestations) to clean apples. Low levels of chlorine used in packing houses (unrestricted risk) may have very little or no effect in killing the bacteria.
Imp 5		Very low (0.0255)	Moderate (0.5)	Washing in water dump will spread the planktonic bacteria from surface infestations and contaminations (not calyx infections/infestations) to clean apples. Bacterial numbers will progressively build up in the dump water. Chlorine is not routinely used in some packing houses. Chlorine is used at a rate too low to be effective. Grime built up will bind the chlorine reducing the concentrations further.
Imp 6		High (0.85)	Certain (1)	The bacteria are certain to survive as palletisation, quality inspection, containerisation and transportation have no effect at all on the bacteria
Imp 7		Negligible (0.0000005)	Negligible (0.0000005)	Some cross contamination is unavoidable, but with due care taken this will be minimal.
Imp 8		High (0.85)	Certain (1)	The minimum border procedures do not have any steps or measures that would reduce or otherwise affect the bacteria, and, therefore, the bacteria are CERTAIN to survive.
Probability of Importation		Very low (0.0255)	Moderate (0.684)	

Of the 8 steps the only step where a reduction in the likelihood could occur is Imp 2. This is not because of any particular procedure in this step, but because of the fact that not all fruit even from an orchard with severe symptoms is likely to be infected. For assessment of unrestricted risk orchards cannot be selected based on absence of symptoms. Imps 3, 5 and 7 only ADD further bacteria. Imps 4, 6 and 8 have no effect at all on the bacterial levels already there on or in the fruit.

Table 1.2 Summary of the Review of the Estimate of Unrestricted Risk for European Canker

Pathway components	Risk in 2004 IRA	Recommended Risk	Justification
Importation step			
Imp 1	Low	Moderate	Disease occurs in all districts; robust evidence needed on incidence and severity; rainfall in more than 40% of export area favourable for disease; all varieties grown susceptible; high levels inoculum can occur at low disease incidence.
Imp 2	Very Low	Low/Low*	Heavy reliance on apple scab sprays for control; more information needed on seasonal changes in sporulation and quantitative estimate of latent fruit infection.
Imp 3	Negligible	Low/Low*	Detailed studies on conidia production required; inoculum level at harvest critical.
Imp 4	Very Low	Certain/Low*	None of the treatments will have any effect on latent infection; effect of high-pressure washing on spores trapped in calyx and calycine and stem-end sinuses not known
Imp 5	Extremely Low	Extremely Low	
Imp 6	Moderate	Certain/Certain*	Same as in 4 above
Imp 7	Negligible	Negligible	
Imp 8	High	Certain/Low*	Same as in 4 above
Distribution Proximity to Exposure groups- Wild and amenity plants (Table 32)	Very low	Low	Amenity plants widely distributed and close to all utility points; wild plants though scattered not far away; both groups contain many host species
Establishment Amenity and wild plants (Page 143)	Moderate	High	Amenity and wild plants widely distributed; rainfall in some areas of apple production close to or more than 1000mm; fungus prolific in spore production and inoculum available throughout the year
Spread Amenity and wild plants (Page 144)	Moderate	High	Same as above
Establishment or spread (PPES) (Table 35)	Low	High	Same as above
Consequences Human life or health	Omit	---	No known record of *N. galligena* causing any injury to human life. This criterion should apply to animal diseases only.
Environmental effects	E	F	Community values highly its environment; as *N. galligena* has a wide host range its effect on the Australian ecosystem can be very significant
Control or eradication	D	E	Insidious disease; difficult to eradicate; control expensive; possible impact on other industries eg canning fruit in Victoria

* Latent Infection/Infestation

Table 1.3 Reassessment of Risk of Entry for Apple Leafcurling Midge, *Dasineura mali*

Importation Step	**Risk in 2000 IRA**	**Risk in 2004 IRA**	**Recommended Risk**	**Justification**
Imp 1		High	Certain	The New Zealand literature indicates that all surveys for ALCM have found it in all orchards surveyed (Tomkins *et al*., 1994; Smith and Chapman, 1995). The probability of occurrence is therefore 1.
Imp 2		Low	Low	Up to 20 percent of fruit may be infested with ALCM at harvest (Burnip *et al*., 1998). This is a 'high' level of infestation in entomological and industry terms, but must be classified as low according to Table 11 of the 2004 RDIRA for the purposes of the risk calculations.
Imp 3		Very Low	Very Low	This estimate is considered reasonable, but is not based on any data.
Imp 4		Moderate	High	The estimate of moderate in the 2004 RDIRA is not based on any data. It is assumed that the fruit sorting staff would remove about half the infested fruit. However, ALCM pupae are small, hidden in the calyx, or at the stem base, and would be nearly impossible to see as the fruit moves quickly along the grading line. It is more likely that a high proportion of infested apples would escape detection. This is supported by the high proportions of infested samples (60%) found by detailed USDA inspections of New Zealand apples.
Imp 5		Negligible	Very low	High levels of leaf infestations by ALCM regularly occur in New Zealand orchards, of the order of 50 to 93 percent (Tomkins *et al*., 1994), 26 to 62 percent (Smith and Chapman, 1995) and 18 to 69 percent of shoots (Smith and Chapman, 1997). This indicates that leaf material introduced to the pack house with picked fruit has at least a moderate chance of containing ALCM. Mature larvae dislodged from these leaves, in say the dip tank, may attach themselves to an apple stem or calyx and pupate. The chance of this happening is considered to be much greater than negligible and a rating of very low is recommended.
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce ALCM infestation levels. On the contrary, it is likely that all but a very few pupae would survive, so that the likelihood is close to certain. This is supported by the relatively high levels of ALCM detected in USDA inspections of packed New Zealand fruit (see above).
Imp 7		Negligible	Negligible	This estimate is considered reasonable, but is not based on any data.
Imp 8		High	Certain	The likelihood of survival of ALCM through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the RDIRA that would reduce survival through this step.
Probability of Entry	Moderate	Low	(High) (Low)	The recommended risk of high for the overall probability of entry is not based on putting the recommended risks for steps 1 to 8 through the risk analysis calculations. (By multiplying the midpoints of the likelihoods, a Probability of Entry of low is obtained). It is based on the inescapable logic that sixty percent of Lots of New Zealand apples inspected by USDA procedures were found to be infested by ALCM (see above). Clearly, the moderate rating of risk of entry given in the 2000 DIRA is closer to reality than the 2004 rating, but is still too low.

Table 1.4 Reassessment of Risk of Entry for the Garden Featherfoot, *Stathmopoda horticola*.

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		Very low	High	The lack of information on the polyphagy of this species makes it very difficult to assess this importation step with any certainty. The nominated likelihood of ‘Very low’ is at best subjective. The Garden Featherfoot (GFF) is a widespread species, with a high likelihood of being present in all orcharding districts. On this basis a likelihood of High is recommended.
Imp 2		Extremely low	Very low	The lack of references to this species in the New Zealand apple pest management literature strongly suggests it is never a serious pest and has not been intercepted by quarantine inspections of export fruit. However, it has been recorded as feeding on apples on the North Island. On this basis, a rating of ‘Very low’ is most appropriate.
Imp 3		Very low	Negligible	The rating of ’Very low’ in the RDIRA is hard to understand. The supporting statements indicate transfer of larvae between fruit would virtually never occur. Such transfers, if they occurred, would not result in a net increase in the number of infested fruit. The most appropriate rating is ‘Negligible’.
Imp 4		Very low	Low	The feeding location of larvae of GFF in the stem or calyx end of fruit suggests it may not always be removed by brushing or washing. However, the relatively large size of its cocoon or silken feeding shelter indicates the majority would be removed by sorters on the packing line. Nevertheless, a likelihood of very low is probably too great a reduction in the population for this step.
Imp 5		Negligible	Negligible	The reasoning in the RDIRA for the rating of ‘Negligible’ is accepted.
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce GFF infestation levels. On the contrary, it is likely that all but a very few eggs would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	Since larvae are highly unlikely to move between fruit, and would not cause an increase in infestation levels if they did, this likelihood is considered reasonable.
Imp 8		High	Certain	The likelihood of survival of GFF through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the IRA that would reduce survival through this step.
Probability of Entry	Low	Extremely low	Very low	The above assessment, when entered into the risk analysis model using the midpoint probabilities, gives a Probability of Entry for GFF of ‘very low’.

Table 1.5 Reassessment of Risk of Entry for Grey-brown Cutworm, *Graphania mutans*.

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		Low	Certain	GBC is polyphagous, occurs throughout New Zealand and is present in all apple growing regions. There is no data to indicate it is absent from any orchards. The supporting data for a low rating in the RDIRA is not relevant to Importation Step 1; rather it relates indirectly to Step 2.
Imp 2		Very low	Very Low	The data in the IRA under Importation Step 1 indicates damage levels due to GBC varies from about 2 to 10 percent (Wearing *et al*., 1994; Burnip *et al*., 1995; Wearing, 1996). However, damage does not equate to the presence of larvae at harvest, most larvae will have left the fruit long before harvest. The critical issue is the presence of eggs on fruit laid by moths late in the season. There is no data with which to evaluate egg loads on fruit, except the anecdotal contention of Wearing *et al*., (1994) that 'the presence of eggs on fruit is a potential quarantine problem for export organic apples, although the incidence appears to be rare'. The only data on incidence of Noctuid eggs on New Zealand fruit appears to be through quarantine interceptions (Burnip *et al*., 1995), which demonstrate that detectable levels of egg laying occur.
Imp 3		Extremely low	Negligible	Since eggs are highly unlikely to move between fruit, and few larvae are likely to be present, this likelihood is considered too high. There is only likely to be one larva per fruit, so that any larvae moving between fruit will not increase the percentage of fruit infested.
Imp 4		Very low	Moderate	While any larvae on the fruit are likely to be removed by washing and brushing, there are unlikely to be many larvae on the picked fruit. The most likely scenario is for eggs to be laid around the calyx of the fruit pre-harvest (Wearing *et al.*, 1994, Burnip *et al.*, 1995). Photos of GBC eggs in the NZ Hortnet Bugkey (Hortnet) show the eggs laid against the calyx. Most, if not all, eggs laid in this location will survive pack house procedures.
Imp 5		Negligible	Negligible	Since eggs are highly unlikely to move between fruit, and few larvae are likely to be present, this likelihood is considered reasonable.
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce GBC infestation levels. On the contrary, it is likely that all but a very few eggs would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	Since eggs are highly unlikely to move between fruit, and few larvae are likely to be present, this likelihood is considered reasonable.
Imp 8		High	Certain	The likelihood of survival of GBC through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the RDIRA that would reduce survival through this step.
Probability of Entry	Low	Extremely low	Very Low	The Probability of Entry of GBC in the 2004 IRA of 'Extremely low' is considered unreasonable. The assessment presented here agrees with that in the 2000 DIRA, and is more consistent with the findings of GBC eggs in New Zealand export fruit by quarantine inspections.

Table 1.6 Reassessment of Risk of Entry for Leafrollers, *Planotortrix* and *Ctenopseustis* species.

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		High	Certain	This group of insects is widespread throughout New Zealand. Survey and monitoring data from numerous IFP and other trials in apples indicates one or other of these species is nearly always detectable in all orchards in New Zealand (Wearing, 1995; Shaw *et al.*, 1994; Walker *et al.*, 1997, 1998).
Imp 2		Very low	Very low	Reported average rates of larval infestation at harvest support the likelihood of very low at this step (Walker *et al.*, 1998). The likelihood of 'Very low' is considered reasonable.
Imp 3		Very low	Negligible	There is no quantitative information upon which to base an estimate at this step. However, the rating in the RDIRA is considered to be much too high, since there is only likely to be one larva per infested fruit, the transfer of larvae between fruit will not increase the overall percentage of fruit infested.
Imp 4		High	High	This rating is also considered reasonable, although data is lacking. Contrary to the supporting statements on p. 224 in the RDIRA, it is unlikely that fruit sorters on the packing line would see leafroller entry holes in fruit because a), entry is through the calyx and the hole would not be visible, and b), the washing and brushing processes would remove most of the silk and frass making detection difficult.
Imp 5		Extremely low	Negligible	There is no quantitative information upon which to base an estimate at this step. However, the rating in the RDIRA is considered to be too high, since there is only likely to be one larva per infested fruit, the transfer of larvae between fruit will not increase the overall percentage of fruit infested.
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce leafroller infestation levels. On the contrary, it is likely that all but a very few larvae would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	This estimate is considered reasonable, but is not based on any data.
Imp 8		High	Certain	The likelihood of survival of leafrollers through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the RDIRA that would reduce survival through this step.
Probability of Entry	High	Very low	Very low	The Probability of Entry assessed here agrees with that in the RDIRA, and is much lower than that assessed in the 2000 DIRA. This assessment depends entirely on one report by Walker *et al.*, (1998) that larval levels at harvest in fruit from IFP blocks are very low. In addition there do not appear to have been many quarantine interceptions of leafrollers, but this is unverified.

Table 1.7 Reassessment of Risk of Entry for the Native Leafroller, *Pyrgotis plagiatana*

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		Very low	High	The lack of detailed information on the distribution and biology of this species makes it very difficult to assess this importation step with any certainty. The nominated likelihood of 'Very low' is at best subjective. The Native Leafroller (NLR) appears to be a widespread polyphagous species, with a high likelihood of being present in all orcharding districts. On this basis a likelihood of High is recommended.
Imp 2		Very low	Very low	The lack of references to this species in the New Zealand apple pest management literature strongly suggests it is never a serious pest. However, the fact that it has been found in quarantine inspections of export fruit indicates it is present below economic levels, say consistently less than 0.1 percent. On this basis, a rating of 'Very low' is most appropriate.
Imp 3		Extremely low	Negligible	The rating of 'Extremely low' in the RDIRA is possibly an overestimate. Transfers of larvae between fruit, if they occurred, would not result in a net increase in the number of infested fruit. The most appropriate rating is 'Negligible'.
Imp 4		High	Moderate	The finding of NLR in preclearance checks in New Zealand (RDIRA, 2004) indicates it can pass undetected through the pack house. If the larvae feed on the outside of fruit, the likelihood of them surviving washing, brushing and grading is low to very low. If, on the other hand, they feed internally, the likelihood is more appropriately low to moderate. To be conservative, a likelihood of moderate is recommended.
Imp 5		Negligible	Negligible	The reasoning in the RDIRA for the rating of 'Negligible' is accepted.
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce NLR infestation levels. On the contrary, it is likely that all but a very few eggs would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	Since larvae are highly unlikely to move between fruit, and would not cause an increase in infestation levels if they did, this likelihood is considered reasonable.
Imp 8		High	Certain	The likelihood of survival of NLR through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the RDIRA that would reduce survival through this step.
Probability of Entry	Low	Extremely low	Very low	The above assessment differs from the finding in the IRA finding that the Probability of Entry for NLR is 'Extremely low'.

Table 1.8 Reassessment of Risk of Entry for New Zealand Flower Thrips, *Thrips obscuratus*

Importation Step	**Risk in 2000 IRA**	**Risk in 2004 IRA**	**Recommended Risk**	**Justification**
Imp 1		High	Certain	New Zealand Flower Thrips (NZFT) is a widespread, abundant polyphagous insect that would certainly occur in all New Zealand apple orchards. It is principally a pest of stonefruit, citrus, cutflowers and asparagus (McLaren and Fraser, 1998).
Imp 2		Negligible	Extremely low	NZFT is not considered to be a pest of New Zealand apples. It occurs on flowers in spring, but disappears from the trees after a spring generation, the adults preferring other plants when apple flowering is over. The presence of NZFT on fruit is likely to be incidental, more a result of insects resting in transit. The occurrence of NZFT on apples is likely to be higher where apple blocks adjoin other hosts such cutflowers or stonefruit. Given that NZFT may be present on fruit as a contaminant, a likelihood of ‘Extremely low’ is recommended.
Imp 3		Very low	Very low	There are records of NZFT on apples and these are considered to represent accidental contamination of fruit from adjacent hosts such as stonefruit. This may occur on fruit in bins in transit from the orchard to the packing shed. Such contamination might result from insects flushed from hosts on the orchard floor, windrows or other plants, and would result in only a very low likelihood of an individual fruit being infested.
Imp 4		Extremely low	Extremely low	The arguments presented in the RDIRA in support of an ‘extremely low’ rating at this step are accepted.
Imp 5		Negligible	Extremely low	
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce NZFT infestation levels. On the contrary, it is likely that all but a very few insects would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Very low	The adults of NZFT are quite mobile and there is more than a negligible likelihood of redistribution among fruit if they are a) present and b) disturbed. An increase in the numbers of fruit infested could occur if some fruit had more than one thrips on them. A likelihood of ‘very low’ is recommended.
Imp 8		High	Certain	The likelihood of survival of NZFT through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the RDIRA that would reduce survival through this step.
Probability of Entry	High	Extremely low	Very low	The Probability of Entry presented here is higher than that in the 2004 RDIRA, based on a midpoint analysis. The 2000 DIRA Probability of Entry was based on false assumptions that apple fruit was attractive to NZFT, as stonefruit is.

Table 1.9 Reassessment of Risk of Entry for Codling Moth, *Cydia pomonella*

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		High	Certain	Codling moth (CM) occurs in all New Zealand apple growing districts, is a major pest of apples and would certainly be present in all orchards.
Imp 2		Low	Very low	The supporting statements presented in the RDIRA for a ‘low’ rating are uncritically stated and the last dot point in particular vastly overestimates the likelihood of CM infestations in picked fruit in New Zealand commercial orchards. A rating of ‘Very low’ is more realistic. (Note also that damage levels were used for these likelihoods and that damage does not equal infestation; much damage at harvest is old and the larva has either been killed, or left the fruit).
Imp 3		Negligible	Negligible	The arguments presented in the RDIRA for a ‘negligible’ rating are accepted.
Imp 4		High	Moderate	The ‘high’ likelihood given in the 2004 RDIRA for CM infested fruit passing through the packing house processes is an overestimate. CM infested fruit has obvious external damage that would generally not be overlooked on the grading line. A significant proportion of infested fruit would be graded out. Only those fruit where CM entered through the calyx would be likely to be missed.
Imp 5		Negligible	Negligible	The arguments presented in the RDIRA for a ‘negligible’ rating are accepted.
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce CM infestation levels. On the contrary, it is likely that all but a very few larvae would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	The arguments presented in the RDIRA for a ‘negligible’ rating are accepted.
Imp 8		High	Certain	The likelihood of survival of CM through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the IRA that would reduce survival through this step.
Probability of Entry	Not assessed	Low	Very low	The assessment for Probability of Entry presented here is below that in the 2004 RDIRA. The likelihood adjustments made above reflect the true commercial situation, and are very different to those in the RDIRA, two critical ones of which are quite unrealistic.

Table 1.10 Reassessment of Risk of Entry for European Red Mite, *Panonychus ulmi*

Importation Step	**Risk in 2000 IRA**	**Risk in 2004 IRA**	**Recommended Risk**	**Justification**
Imp 1		High	Certain	European Red Mite (ERM) is the principle mite pest of New Zealand apples. It occurs in all apple growing areas and would certainly be present in all orchards.
Imp 2		Low	Very low	The likelihood of 'Low' in the RDIRA is considered to be an overestimate for well managed orchards. A likelihood of very low is considered more realistic.
Imp 3		Very low	Very Low	The likelihood of 'Very low' in the RDIRA is accepted as reasonable, but for an additional reason to that advanced in the IRA. Contamination of fruit by ERM is mainly by winter eggs. These are laid by females influenced by declining food resources, or the onset of lower temperatures in autumn. Some females may be present on fruit at picking and may transfer between fruit in the picking bags or field bins resulting in some egg laying on additional fruit
Imp 4		Low	High	ERM eggs are very small, and while they are easy to see on fruit when present in large numbers, the small numbers likely to be present on fruit in most orchards, or the more lightly infested fruit from problem orchards, would be very difficult to detect on the packing line. It is highly likely that most lightly infested fruit would pass through packing shed sorting without being detected. In addition, while packing house processes such as washing and brushing may remove some winter eggs, they are unlikely to greatly reduce the percentage of infested fruit, since multiple eggs will be present on most fruit.
Imp 5		Negligible	Negligible	The RDIRA likelihood for this step is accepted.
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce ERM infestation levels. On the contrary, it is likely that all but a very few eggs would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	The arguments presented in the RDIRA for a 'negligible' rating are accepted.
Imp 8		High	Certain	The likelihood of survival of ERM through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the RDIRA that would reduce survival through this step.
Probability of Entry	Not assessed	Very low	(Low)	The reassessment presented here does not agree with the outcome in the 2004 RDIRA. It is considered the Probability of Entry is 'Low', rather than 'Very low'.

Table 1.11 Reassessment of Risk of Entry for Mealybugs, *Pseudococcus calceolariae* and *Planococcus mali*

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		High	High	Since Citrophilus Mealybug (CMB) is a much more significant pest species than *Planococcus mali*, it is the most likely to be present on export apples. CMB is absent from the southern parts of the South Island of New Zealand, so its likelihood of being present in an individual orchard is considered to be 'High', rather than 'Certain' which has been allocated to most other pests in this report.
Imp 2		Low	Low	The likelihood of 'Low' allocated in the 2004 RDIRA is considered reasonable.
Imp 3		Very low	Very low	While mealybugs are mobile insects and have the potential to move between fruit in the picking bags or bins, there is no data to indicate how great this movement may be. If mealybugs are sensitive to disturbance they may disperse widely and multiply the infestation. If, as seems more likely, they simply hang on more tightly, there will not be a great redistribution and the RDIRA rating of 'Very low' is reasonable.
Imp 4		Low	Moderate	A proportion of mealybugs in the calyx and stem ends of fruit, where most of them will be, will be removed by the washing and brushing processes in the pack house. However, while the numbers of CMB will be reduced, the percentage of infested fruit may not significantly decline, since many mealybugs on each fruit will be unaffected. Furthermore, it is likely most of the remaining mealybugs will not be detected as fruit pass quickly down the packing line. The likelihood of detection would be proportional to the number and size of the mealybugs present. Large infestations are likely to be removed by sorters, while the more numerous small infestations and individuals are likely to be overlooked. A rating of 'Moderate' is recommended. The rating of 'Low' in the RDIRA on the basis that CMB comprises only about one third of the mealybugs present is false logic, since the step refers only to CMB, not all mealybugs.
Imp 5		Extremely low	Extremely low	The likelihood in the RDIRA for this step is accepted.
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce CMB infestation levels. On the contrary, it is likely that all but a very few insects would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	The arguments presented in the RDIRA for a 'negligible' rating are accepted.
Imp 8		High	Certain	The likelihood of survival of CMB through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the RDIRA that would reduce survival through this step.
Probability of Entry	Moderate	Very low	Low	The reassessment presented here does not agree with the outcome in the 2004 RDIRA. It is considered the Probability of Entry is 'Low', rather than 'Very low'.

Table 1.12 Reassessment of Risk of Entry for Oriental Fruit Moth, *Grapholita molesta*

Importation Step	**Risk in 2000 IRA**	**Risk in 2004 IRA**	**Recommended Risk**	**Justification**
Imp 1		Low	Moderate	Oriental Fruit Moth (OFM) is confined to the North Island, where it occurs in the main orcharding districts, but may not be present in all orchards. It is likely to be present in a third to one half of New Zealand apple orchards. Therefore a rating of 'Moderate' is more appropriate.
Imp 2		Very low	Very low	The likelihood of 'Very low' in the RDIRA is considered reasonable at this step.
Imp 3		Negligible	Negligible	The likelihood of 'Negligible' in the RDIRA is considered reasonable at this step.
Imp 4		High	Moderate	The RDIRA suggests most infested fruit would pass undetected through the grading and packing step. This is unlikely to be the case, given that there is usually some external evidence of the presence of a larva in the fruit. This evidence includes frass and an entrance hole, and possibly some visible subsurface tunnelling. It is possible that the entrance hole could be difficult to see if near the calyx or stem end, or that a young larva may not yet have a large hole. On this basis the likelihood is assessed as 'Moderate'.
Imp 5		Negligible	Negligible	The likelihood of 'Negligible' in the RDIRA is considered reasonable at this step.
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce OFM infestation levels. On the contrary, it is likely that all but a very few larvae would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	The arguments presented in the RDIRA for a 'Negligible' rating are accepted.
Imp 8		High	Certain	The likelihood of survival of OFM through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the RDIRA that would reduce survival through this step.
Probability of Entry	Not assessed	Very low	Very low	This assessment agrees with that in the RDIRA.

Table 1.13 Reassessment of Risk of Entry for Oystershell Scale, *Diaspidiotus ostreaeformis*

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		Very low	High	Oystershell Scale (OSS) is the main scale pest on apples in the southern parts of the South island of New Zealand. It is absent from the major apple growing area of Nelson in the north of the North Island, and is confined to Canterbury and areas south of it. It is therefore likely to be absent from 95 percent of New Zealand's production areas. This analysis considers only fruit from infested areas, where Imp 1 will have a 'high' likelihood.
Imp 2		Very low	Low	The rating appropriate here is for harvested fruit from orchards in the south of New Zealand where the scale occurs, not all orchards as in the RDIRA. A rating of 'Low' is considered more appropriate than 'Very low' (see discussion above).
Imp 3		Extremely low	Very low	The logic employed in the RDIRA to assign an 'Extremely low' rating at this step is faulty. It is irrelevant that the majority of the infestation is on the bark since Imp 3 considers only the fate of those that are on the fruit. Therefore, there is greater than an 'Extremely low' likelihood that some redistribution of crawlers will occur while the fruit is in the picking bag and field bin. This is considered more likely to be 'Very low'.
Imp 4		Moderate	High	The logic behind the allocation of 'Moderate' at this step in the RDIRA is also faulty. There is no doubt that the pack house processes of washing and brushing will reduce scale numbers on fruit. However, since fruit will be infested by multiple insects and that some scale are likely to remain on most fruit, the percentage of infested fruit will not greatly change. In addition, the small size of the scale insects means that low numbers of scales on fruit are less likely to be detected during grading, and lightly infested fruit, which are likely to be the majority, will not be removed. A rating of 'High' is more appropriate.
Imp 5		Negligible	Negligible	The RDIRA rating of 'Negligible' is accepted.
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce OSS infestation levels. On the contrary, it is likely that all but a very few scales would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	The arguments presented in the RDIRA for a 'negligible' rating are accepted.
Imp 8		High	Certain	The likelihood of survival of OSS through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the RDIRA that would reduce survival through this step.
Probability of Entry	Not assessed	Extremely low	Low	The reassessment presented here does not agree with the outcome in the 2004 RDIRA. It is considered the Probability of Entry is 'Very Low', rather than 'Extremely low', however, this is based on multiplication of likelihood midpoints rather than use of the risk analysis model.

Table 1.14 Reassessment of Risk of Entry for Wheat Bug, *Nysius huttoni*.

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		Very low	Certain	The distribution of *N. huttoni* throughout New Zealand, its wide host range, and often high abundance, indicate that it is likely to be present in every orchard.
Imp 2		Extremely low	Very low (fruit); Moderate (bins)	The RDIRA likelihood of 'Extremely low' is not based on any data, indicating this estimate is subjective and may be too low. However, the most likely route for infestation of fruit shipments is insect invasion of bins in the orchard, or when placed outside the packing shed (Sale, 2003). A likelihood of moderate, with the bin as the unit of infestation, is considered more appropriate (see discussion above).
Imp 3		Low	Low (fruit); Moderate (pallets)	High infestation levels of bugs on low weeds in the orchard may result in movement of bugs into bins where they would shelter between the slats or amongst the fruit. This could also happen for bins of freshly picked fruit left outside the packhouse, if the pack house apron is weedy. The rating of moderate is based on the bin as the unit of infestation rather than an individual fruit (see discussion above).
Imp 4		Very low	Very low (fruit)	The likelihood of 'Very low' assigned at this step is subjective, since no quantitative supporting data is presented, however, is accepted as reasonable.
Imp 5		Negligible	Low (fruit); Moderate (pallets)	While it is reasonable to consider most bugs would be removed from fruit during washing, brushing or waxing in the pack house, it is likely that recontamination could occur during packing due to the mobility of this insect. Bugs that lodged in bins or among fruit would be disturbed during bin tipping and other processes, and would likely fly out into the pack house with some settling in or on cartons of fruit. At the carton level a rating of low is considered reasonable, which would become moderate for a pallet of cartons.
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce Wheat Bug infestation levels. On the contrary, it is likely that all but a very few larvae would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Low (fruit); Moderate (pallets)	The main routes of Wheat Bug contamination appear to be movement of bugs to shelter in the cracks and joints of bins and pallets in contact with infested weeds outside the pack house, or on the pack house floor. In the latter case disturbed bugs flying or crawling in the pack house will likely seek shelter in pallet stacks waiting to be transported or stored.
Imp 8		High	Certain	The likelihood of survival of Wheat Bug through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the RDIRA that would reduce survival through this step.
Probability of Entry	Not assessed	Very low	Very low (fruit) Low (pallets)	

Table 1.15 Summary of results of reassessment of likelihoods in the 2004 New Zealand Apple Import Risk Assessment.

Pest species	Probability of Entry		Unrestricted Annual Risk	
	IRA	**This Review**	**IRA**	**This Review**
Pests for all of Australia				
Apple Leafcurling Midge	Low	Low	Low	(High)*
Garden Featherfoot	Extremely low	Very low	Negligible	Low
Grey-brown Cutworm	Extremely low	Very low	Negligible	Low
Leafrollers	Very low	Very low	Very Low	Low
Native Leafroller	Extremely low	Very low	Very low	Low
New Zealand Flower Thrips	Extremely low	Very low	Very low	Low
Wheat Bug	Very low	(Low)*	Moderate	-*
Pests for Western Australia				
Codling Moth	Low	Very low	Low	Low
European Red Mite	Very low	Very low	Negligible	Low
Mealybugs	Very low	Low	Very low	Low
Oriental Fruit Moth	Very low	Very low	Negligible	Low
Oystershell Scale	Extremely low	Low	Negligible	Low

* See text

SECTION 2: PREAMBLE

2. PREAMBLE

2.1 PREVIOUS STAKEHOLDER COMMENTS

In response to the Draft Import Risk Analysis ("**DIRA**") released for public comment in October 2000, the Australian Apple / Pear Industry prepared and tabled a large number of submissions.

These submissions came from a wide variety of stakeholders including the National Apple & Pear Association, State Industry organisation, State Government Departments and/or agencies, Local Government, Businesses and private individuals. It has been estimated that between 800 and 1,000 issues were raised through these submissions. Subsequently these issues were combined into 130 major topics and released as a report titled "Importation of apples from New Zealand: Scientific Review Paper" (July 2002).

Our understanding is that all these issues have been considered as part of this Revised Draft Import Risk Analysis ("RDIRA") released in February 2004 but there is no clarification on this by Biosecurity Australia ("BA").

As detailed in the RDIRA *"after evaluating the stakeholder comments received on this draft and on the recommendations of a Senate Committee established to look into this IRA, Biosecurity Australia established an Import Risk Analysis panel in October 2001 to progress this IRA".*

The release of the RDIRA in February 2004 is the result of the work undertaken by the Import Risk Analysis Team **("IRAT")**.

2.2 CONSULTATION

Following the release of the initial Draft Import Risk Analysis in October 2000 and the process that followed, many stakeholders within the process complained about the lack of consultation and transparency within the process. This issue was highlighted during the Senate Committee hearings. With the decision to establish the Risk Analysis Panel **("RAP")** in January 2002 there was a conscious decision by Biosecurity Australia to improve the level of consultation and transparency.

The Australian Apple and Pear Industry undertook some positive actions to assist in this process.

Some of the actions undertaken since January 2002 included:

a) Regular meetings between senior representatives of the Department of Agriculture, Fisheries and Forestry **("DAFF")**, Biosecurity Australia and Apple and Pear Australia Limited **("APAL")**.

b) A two-day workshop was conducted in Melbourne in July 2002. Participants included Australian and New Zealand representatives from State Governments, National Governments, Apple Growers and related industries (Page 2, RDIRA).

c) Apple and Pear Australia Limited and the Australian Government utilised

R & D funds through Horticulture Australia Limited to conduct an R & D project which established a technical position for the Industry.

This project resulted in a technical link being developed between the Industry and the IRAT.

Trevor Ranford was engaged as the Project Manager.

Through this position there was a process established that allowed:

(1) Exchange of technical information,

(2) Access to the public file maintained in Canberra

(3) Access to the approved minutes of the RAP meetings, and

(4) General dialogue between industry and the Biosecurity Australia staff working on the Apple IRA.

During the recent Biosecurity Australia Roadshow to present the RDIRA to the stakeholders, reference was regularly made of the openness and transparency of the process.

Notwithstanding what was implemented following the release of the initial DIRA in October 2000, the individual Apple / Pear Grower – **The Most Important Stakeholder in This Whole Process** – has been left frustrated and totally disenfranchised from the activities of the IRAT and the process undertaken. This process has been reflected within the public forums held across Australia.

Some of the aspects of the process causing this frustration include:

a) **A Process that lacks true Independence**

At the Primary Industries Ministerial Council held on the 19th May 2004, the Council "Reaffirmed its endorsement of Australia's Science Based Import Risk Assessment (IRA) process. Ministers supported the independence and professionalism of scientists involved in the IRA process. Ministers reaffirmed the importance of this scientific independence in the Biosecurity process. Ministers noted that scientists involved in the IRA process are independent and are not representing their jurisdiction. Council also agreed that scientists, in preparing their draft and final reports, should have the opportunity to incorporate their various views. Ministers also noted that under WTO guidelines only scientific aspects are to be considered in the IRA process. Ministers stated however that Australia must sustain its strong appropriate level of protection. Ministers also noted the importance of protecting regional pest and disease freedom" (PIMC5. Communiqué, 19 May 2004)

Industry would completely support the "independence and professionalism of scientists" and the importance of this scientific independence in the Biosecurity process" **but** strongly believes this is not being achieved under the current process.

The current situation is that:

1) **Biosecurity Australia undertakes both Import and Market Access applications.** Industry believes that this is a definite disadvantage to the Australian Industry as each aspect requires different process, skills and objectives.

   For sound and scientific rigour the two processes – Import applications into Australia and Market Access for Australian Produce – should be undertaken by two separate groups within Biosecurity Australia

2) **The Risk Analysis Panel is a panel established and managed by Biosecurity Australia and not independent of Biosecurity Australia and the policies and philosophies of the Department of Agriculture, Fisheries and Forestry.** A truly 'Independent Panel' would be one outside of Biosecurity Australia and employed under contract to undertake the process.

3) **Biosecurity Australia and their Risk Analysis Panel undertake the review of the submissions prepared by stakeholders**
   Representatives from Biosecurity Australia during their recent Roadshow have continuously indicated that they believe they have done a good job in reviewing the science and preparing a document that is conservative under Australia's ALOP, the measures are very strong and robust and that it offers the most trade restrictive protocol for the importation of apples from New Zealand.

   In other words, they are convinced that they have a process that is accurate, sound and beyond reproach.
   Given the position of both Biosecurity Australia representatives and the members of the RAP that attended the Roadshow, industry does not believe the stakeholder submissions will be received and reviewed with any level of independence.

   As has been recommended by a number of industry meetings around Australia, industry supports the call for a "process of independent peer review panels, to objectively assess the validity of both industry submissions and Import Risk Analysis reports compiled by Biosecurity Australia"

4) **The Department of Agriculture, Fisheries and Forestry of which Biosecurity Australia is a section, undertakes the appeal process.**
   Again there is no independence in the process because any and all appeals are heard by a panel and/or individual employed within DAFF.

5) **Only limited transparency**
   While the level of communication and transparency has improved over the past 2 ½ years there have been and continues to be times when stakeholders have not been able to access relevant information and/or documents.

   In the past, material relating to:

a. The Japan / USA WTO dispute,
b. Reports from New Zealand MAF, and
c. Documents / information collected by Biosecurity Australia / RAP members during visits to New Zealand have not been made available.

More recently a request for additional information on:

a. The New Zealand IFD manual
b. New Science
c. Distribution of Pests
d. Reports from the technical working groups

was sent to Bill Roberts, Chair of the RAP on 31st May 2004. A response from Dr Brian Stynes (16th June 2004) resulted in receiving some material.
In relation to the IFP Manual the response received was as follows:-
"The IFP manual is the property of New Zealand Pipfruit Ltd (PNZ). Biosecurity Australia has been informed by New Zealand Ministry of Agriculture and Forestry that PNZ do not wish to release the document in entirety."

The reality is that transparency has improved but stakeholders have not been kept fully involved in the process. Biosecurity Australia continues to protect some information which leads industry to the conclusion that the process is only partially transparent and that industry cannot either be trusted or is seen as the 'enemy'.

Industry members have also been denied access to documents relating to the application of Chlorine within New Zealand. The document appears to be under a restrictive release by the New Zealand authorities/industry.

While Industry would agree that communications and transparency have improved since the release of the previous DIRA the process needs to further develop. The feeling within industry is further reflected in the following resolution coming from grower meetings

"That the Apple Industry and community has no confidence in Biosecurity Australia's ability to conservatively and objectively assess the risk of serious pests and diseases entering Australia by way of Apple imports"

There is still a feeling of distrust between industry and Biosecurity Australia which does not truly allow a fully open and transparent system. This situation can only be overcome through a full review of the Import Risk Analysis Process.

b) **The 60 day response time for stakeholders to consider a draft IRA**

While industry appreciated the decision for an extension of an additional 60 days the reality is that for any stakeholder to do justice to the 800 page document, 60 or 120 days is an inadequate time frame and totally unacceptable.

The Australian Apple and Pear Industry, through APAL, has committed extensive time and resources to reviewing the RDIRA but an appropriate and comprehensive response would not have been achieved within 60 days. Even with the extension, the resources have been fully stretched to achieve the best possible review and technical response.

Given what is at stake for the individual apple / pear growers, the total industry, regional communities and the economy this 60 day response time needs urgent review.

SECTION 3: INTRODUCTION

3. INTRODUCTION

3.1 TECHNICAL PANEL

With the release of the RDIRA in February 2004, APAL established a panel of experts to assist with the technical review of the document, including the risk matrix, the relevant pests and diseases and suggested import measures and the science related to each of these areas.

In addition, the technical review panel has considered gaps in the science and any new science that has not been considered within the RDIRA.

The individuals that have contributed to the discussions and preparation of this industry technical report are:

<u>Technical Experts</u>

Dr Colin Bower PhD	Consultant Entomologist
Dr Irena Carmichael BSc Hon, PhD	Consultant Microbiologist
Dr Navaratnam Shanmuganathan	Consultant Plant Pathologist
Dr Peter Merriman	Consultant
Professor Tony Pettitt	Head, School of Mathematical Science QUT
David Pullar	David Pullar & Associates, Consultant in Horticulture and Environmental Science
Dr Robert Reeves PhD	QUT
Dr Satish Wimalajeewa BSc Special (Hons) (Cey), PhD (Calif)	Consultant Plant Pathologist

<u>Project Manager</u>

Trevor Ranford B.Sc, DipMP (AIMSA), CPMgr.

<u>Additional Members</u>

Additional input was received from:

John Corboy	Chair, Fire Blight Task Force
Jon Durham	Managing Director, Apple and Pear Australia Limited
Alma Reynolds	Executive Officer – Operations Apple and Pear Australia Limited

3.2 REVIEW PROCESS

This review was conducted at the request of Apple and Pear Australia Limited. It provides an independent appraisal of the scientific and logical basis for the conclusions reached in the RDIRA for the proposed importation of apples from New Zealand. In particular, the aims of this review were:

1. to evaluate the scientific basis for estimates of risks of entry for quarantine pests / diseases used in the risk analysis equations
2. to determine whether the risk analysis methodology has been applied consistently within and between analyses
3. recommend any changes needed to the risk values for entry, establishment, spread and consequences

4. recommend any additional risk mitigation measures required to reduce the risk levels to meet the ALOP of very low

3.3 OVERVIEW

Australia is free of many pests and diseases that attack important food and ornamental plants in other parts of the world. In large part this has been due to the isolated nature of Australia as an island continent, but also to quarantine policies and procedures that have limited the numbers of exotic pests and diseases able to establish in this country. However, in recent years it has become increasingly difficult and costly to maintain effective quarantine barriers to the entry of unwanted organisms. Increased air travel by Australians to and from overseas, rising tourism and greater trade have all made it more difficult to exclude pests and diseases. Despite the best efforts of the Australian Quarantine and Inspection Service **(“AQIS”)**, there is a long list of economically significant organisms that have breached Australia’s quarantine barriers in the last 20 years.
Among the most serious of these are the

- Red Imported Fire Ant,
- Western Flower Thrips,
- Poinsettia White Fly,
- Oriental Fruit Fly,
- Palm Thrips,
- Red-banded Mango Caterpillar,
- Currant Lettuce Aphid,
- Giant African Snail,
- Black Sigatoka of bananas,
- Wheat Streak Mosaic Virus,
- Potato Spindle Tuber Viroid, and
- Olive Knot disease.

Some pests and diseases are amenable to eradication if caught early enough, but others are not and quickly become fully established.

More recently, moves to free up world trade have increased pressures to allow entry of food products that have historically been excluded because they come from areas infested with serious pests and diseases. Australia, as a champion of the free trade movement through the Cairns Group and other fora, must be seen to be freeing up its own borders as well as seeking greater access through others. The resulting inevitable increase in importation of foreign grown food carries increased risks for the introduction of unwanted organisms. It is undeniable that over time these processes will lead to the entry of new pests, diseases and weeds into Australia. International trading rules and phytosanitary agreements allow countries to reduce, but not eliminate, these risks through quarantine protocols.

This appraisal of the New Zealand apple RDIRA will commence with some general comments on pest control in New Zealand apples, leading to general conclusions that will be applied throughout the evaluation. Following this, each pest of quarantine concern will be considered in detail following the process adopted in the 2004 RDIRA. At the same time differences between the conclusions reached in the earlier 2000 DIRA and the current 2004 RDIRA will be evaluated.

3.3.1 Distribution in New Zealand

Most of the pests/diseases of quarantine concern are native New Zealand species that have adopted apples as a host. Most of these insects are widespread in New Zealand, or belong to groups of similar species that are common throughout New Zealand, e.g. the Greenheaded and Brownheaded Leafrollers. Where the literature states that a species or group of species occurs throughout New Zealand, it is reasonable to conclude they are certain to occur in every New Zealand orchard, even if in very low numbers. This logic has not been applied in the RDIRA, rather it has been considered that the probability of occurrence of such pests is 'high', and for some even 'low' or 'very low'. In the RDIRA 'high' ranges from 0.7 to 1 with a midpoint of 0.85, which is here considered far too low for widespread, common pests.

3.3.2 Host Range

Many of the pests/diseases of quarantine concern are also polyphagous, i.e. they are capable of utilising many host plants and this lack of host specificity is one of the reasons they have been able to utilise apples as a host. Such insects have a high probability of finding a suitable host if transferred to a new environment such as Australia. Therefore, all species known to be polyphagous should be regarded as having a reasonably high probability of finding host plants no matter where they may escape in Australia. Many garden plants and broad-leaved weeds are likely alternative hosts that could allow establishment to occur. There is little consideration in the RDIRA of the host potential of broad-leaved weeds, which are ubiquitous in Australia. In this review, broadly polyphagous species will be regarded as likely to establish and spread irrespective of the utility point to which they are distributed.

3.4 FACTORS CONTRIBUTING TO HIGH QUARANTINE RISK

The RDIRA is primarily structured around the Risk Analysis Model, which in turn is based on the fate of a theoretical single piece of infested fruit. This framework, while appearing to be rigorous and all-encompassing, does not facilitate the incorporation of pest and disease biology and population dynamics into the risk analysis. It is very difficult to think about pest biology in the context of a single piece of fruit. In other words, biological reality has been sacrificed for statistical convenience. Pests function as populations, not as single individuals, as would often be associated with a single piece of infested fruit. Nowhere does the RDIRA discuss in overall terms the factors that constitute high risk from a biological viewpoint, although some are mentioned under the discussion for individual pests. The following attempts to identify the key characteristics of pests that contribute to high quarantine risk.

The risk factors vary for different steps along the importation and distribution pathways and are summarised below for two quite distinct groups; those that usually infest fruit as single individuals, and those that may have multiple individuals per fruit.

3.4.1 Single Individuals per Fruit

The following characteristics represent the highest quarantine risks for insects that inhabit the fruit singly:

- They spend their larval stages inside the fruit where they feed and grow. The infestation may not be obvious without cutting the fruit open.
- They enter the fruit through the calyx so that the entry hole is difficult to detect on the sorting line in the pack house, allowing them to pass through.
- They are capable of active flight. This is necessary for them to find mates and host plants after arrival in Australia.

- They are polyphagous and hence have a wide range of potential host plants available for establishment.

Insects with these characteristics are typically moths, and include the Greenheaded and Brownheaded Leafrollers (*Planotortrix* ssp. and *Ctenopseustis* ssp., respectively), Oriental Fruit Moth (*Grapholita molesta*) and Codling Moth (*Cydia pomonella*). Such insects will only establish if at least two moths, a male and a female, escape at the same place at about the same time, and there are host plants in the vicinity. The main risk scenario for these pests is escape from points where bulk fruit is being stored, repackaged or processed. Only under these circumstances is it likely that several insects may escape at similar times. Another necessary requirement is for the cool chain to be broken, such that insect development and activity can occur. This will be a major constraint in well managed operations since maintenance of the cool chain is essential for preserving fruit quality. Pests that inhabit fruit singly and need to mate in order to reproduce are less likely to establish as a result of being discarded as a single fruit by a consumer, than pests that can have multiple individuals per fruit.

3.4.2 Multiple Individuals per Fruit

The following characteristics represent the highest quarantine risks for insects that may have multiple individuals on the fruit:

- They are very small and hence many individuals can inhabit sheltered places like the stalk and calyx cavities. Being lodged deep in the stalk or calyx cavities at least partially protects them from pack house processes such as high pressure washing and brushing.
- They are hard to see (cryptic), which makes them difficult for sorters to detect on the packing line, allowing them to pass through.
- They may or may not be capable of flying.
- They are polyphagous and hence have a wide range of potential host plants available for establishment.
- Infestation of fruit by multiple individuals in the stem end or calyx regions increases the likelihood that fruit will remain infested after routine pack house procedures. This is because while high pressure washing and brushing may remove a moderate proportion of individuals, a high proportion of infested fruit will remain infested, albeit with lower pest numbers. There does not appear to be any readily available data with which to test this.

Such insects include the eggs of European Red Mite (*Panonychus ulmi*) and Grey-brown Cutworm (*Graphania mutans*), all life-cycle stages of sedentary species such as Oystershell Scale (*Diaspidiotus ostraeiformis*) and Mealybugs (*Pseudococcus calceolariae* and *Planococcus mali*), and Apple Leafcurling Midge (*Dasineura mali*). All but the last of these are flightless and will require placement of infested fruit very close to a host plant. The scenario of highest risk for these species is discarding of an apple core into a patch of hosts by a consumer, or possibly dumping of bulk waste fruit in or near an orchard.

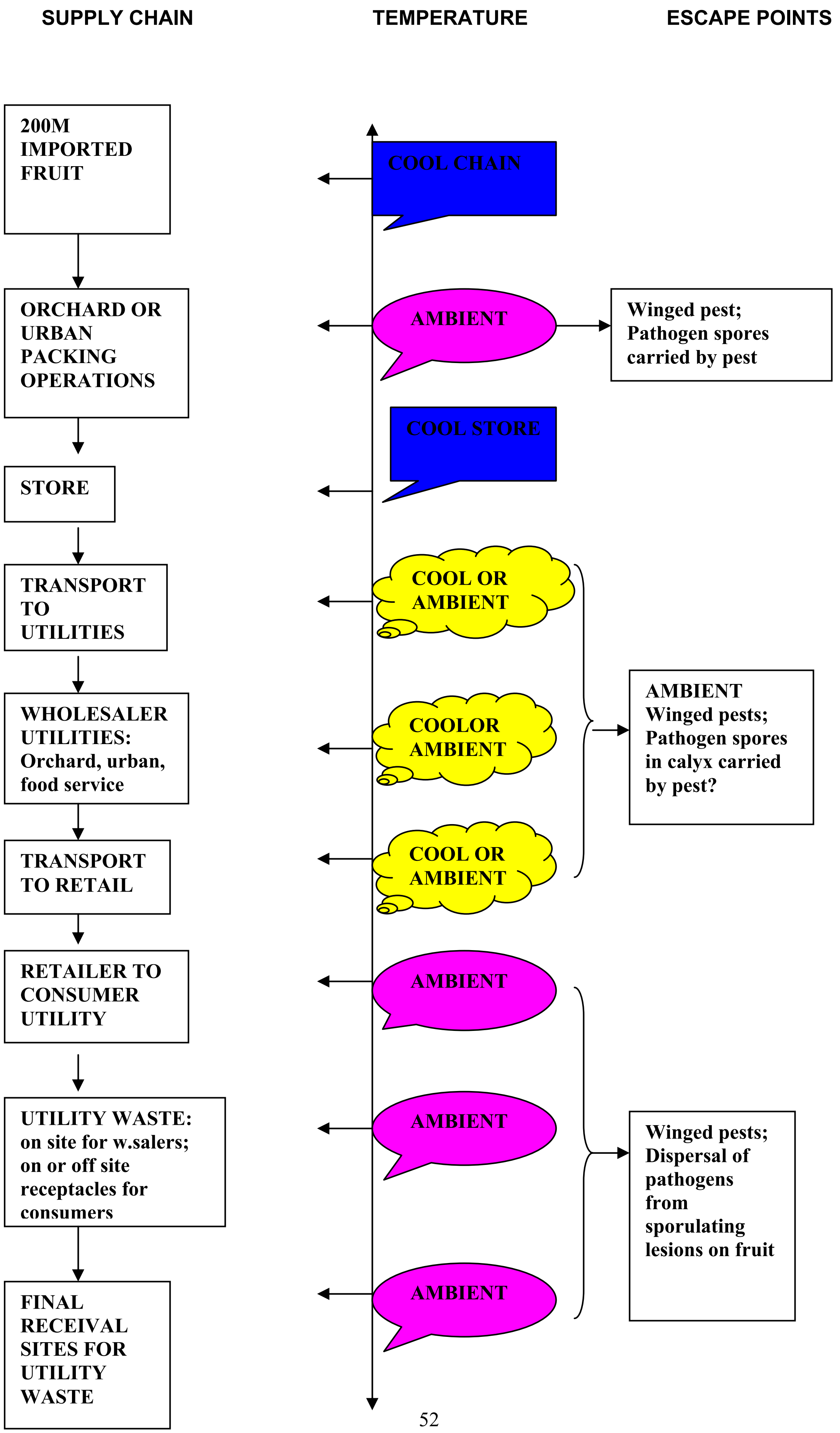
Apple Leafcurling Midge represents a particularly high risk in that it not only has the potential to occur as multiple individuals on a single fruit, but is also winged. Hence, it is possible for a single discarded piece of infested fruit to initiate an infestation, and that fruit does not have to be as close to apples as for the wingless pests. On the other hand, Apple Leafcurling Midge is not polyphagous, being host specific on apples, so that establishment can only occur if there are apple or crabapple trees in the vicinity of an infested discarded fruit or waste dump.

The above scenarios have been considered and applied to the risk analysis model in the RDIRA in this review.

3.5 COOL CHAIN

There is little, if any, consideration in the RDIRA about the potential effects of breaking the cool chain on the likelihood of escape by winged insects. It appears to be assumed that the cool chain will always be maintained, but this is not necessarily so. Figure 3.1 indicates the points along the distribution pathways where the cool chain may be broken allowing pests to resume development, escape from the fruit or emerge from pupae. This risk has been very much downplayed in the RDIRA, with the escape of winged insects from non waste fruit being regarded as ‘extremely rare’. Figure 3.1 indicates there may be many opportunities along the distribution pathway for insect development to continue and for winged insects to escape. Some of these escape points are missing from the RDIRA risk analysis model altogether, particularly the transport steps.

Figure 3.1 IDENTIFICATION OF PEST ESCAPE POINTS IN RELATION TO SUPPLY CHAIN, WASTE STREAM AND ASSOCIATED TEMPERATURES



SECTION 4: NEW SCIENCE

4. NEW SCIENCE

The RDIRA is considered to have missed important developments in contemporary bacteriology which are shedding new light on methods of experimenting with bacteria and the survival on host plants.

In addition new work has been undertaken with regards the existence of host plants in the vicinity to commercial orchards, urban and commercial wholesale packing facilities, and home gardens. This work highlights the existence of large number of derelict orchards, wild and feral host plants and host plants in home gardens. In addition it highlights that the assessments made within the RDIRA are greatly underestimated and the IRAT failed to implement a truly conservative judgement.

4.1 VIABLE BUT NON CULTURABLE

4.1.1 Quotation of Peter Stephens previous documentation

The aspect of viable but non-culturable bacteria was raised as an issue relevant to *E. amylovora* by Peter Stephens, then a scientist at the Queensland Department of Primary Industries as part of the previous Draft IRA.

Peter Stephens offered comment and then offered a range of scientific evidence that needed further consideration. The following is a quote of his work previously tabled but not considered by BA.

> **"Comment One**
> **The majority of evidence used in the memorandum to suggest that apples derived from symptomless orchards are free of *E.amylovora* is possibly inaccurate, due to these studies not considering the existence of viable, but non-culturable cells of E.amylovora.**
>
> The papers of Dueck (1974), Hale *et al*. (1987), Roberts *et al*. (1989), van der Zwet (1990), Clark *et al*. (1993) and Hale *et al* (1996) are used in the memorandum to justify that apples derived from symptomless orchards will not possess the fireblight bacteria (*Erwinia Amylovora*). This claim is used to calculate that P1 (probability of entry of *E.amylovora*) = negligible, which in turn is used to calculate that the overall final restricted risk for fire blight entering and establishing in Australia = very low. This overall risk is judged by AFFA as being acceptable to allow the import of New Zealand apples into Australia.
>
> The papers of Dueck (1974) Hale *et a*l. (1987), Scholberg *et al*. (1988), Roberts *et al*. (1989) and van der Zwet (1990), in assessing the incidence of *E. amylovora* in apple tissue relied upon *E.amylovora* being able to actively grow on artificial media Detection limits were assessed using viable culturable cells.

The papers of Clark *et al*. (1993) and Hale *et al* (1996) also relied upon growth of *E.amylovora* on nylon membranes, prior to using DNA hybridisation. In these 2 reports, the methodology of Hale and Clark (1990) was used. Samples of apple suspensions were first streaked into nylon membranes supported on artificial medium. Membranes were incubated for 3 days at 27C. DNA was liberated from the resulting bacterial colonies and hybridised with the ^{32}P-labelled probe to assess the incidence of *E.amylovora*. Although a detection limit of 10^1 to 10^2 colonies per calyx was claimed using the ^{32}P-labelled probe (Hale *et al*, 1990), this was measured using culturable cells, capable of multiplying on the membrane on which the apple-suspension was streaked.

Each of these papers therefore relied upon growth of *E.amylovora* on artificial media to detect the presence of this bacteria. Where *E. amylovora* was not recorded in apple tissue, the authors concluded that *E.amylovora* was not present. However, this may not be the case.

The problem with this evidence

None of the papers used in the memorandum took into account that *E.amylovora* may form a viable, but non-culturable state. In this state, bacteria can enter a condition approaching dormancy, during which they cannot be cultured using standard laboratory techniques, but are still viable. Each of these papers relied upon the bacteria being in a culturable state (including those papers that utilised DNA hybridisation to detect *E.amylovora*). Non-culturable, but viable cells were therefore unlikely to have been detected. Should *E.amylovora* be shown to exist in a viable, but non-culturable state, the methodology used in each of these papers may have therefore under-estimated the size of the population of E.amylovora present in apples derived from symptomless orchards.

Although there is no published evidence indicating whether or not *E. amylovora* can enter a viable, but non-culturable state, there is large amount of evidence suggesting that other gram negative bacteria can convert to this state. This evidence comes from 17 edited papers in international journals, which suggest that at least 16 bacteria can convert to a viable, but non-culturable state. For example Ghezzi and Steck [FEMS Microbiology Letters 30 (1999), 203-208] demonstrated that *Xanthomonas campestris* pv. *campestris* (causative agent of black rot in brassicas) can enter a viable, but non-culturable state, when the bacteria were nutrient starved and that copper sulphate facilitated this process. Other papers that have shown that bacteria can also revert to a viable, but non-culturable state include:

1) Leung *et al*, (1999) Detection of Sphigomonas spp. In soil by PCR and sphingolipid biomarker analysis. Journal of Industrial Microbiology and Biotechnology. 23, 4-5, 252-260

Demonstrated the possibility of the presence of viable, but non-culturable Sphingomonas spp. in soil.

2) Lippi *et al*. (2000) Effect of salinity and starvation survival of a tropical *Rhizobiuim* strain. Biology and Fertility of Soils 20:4, 276-283.

Demonstrated a high percentage of viable, but non-culturable cells of a tropical Rhizobium strain when they were subjected to both starvation and salinity

3) Alexander *et al*. (1999) The viable, but non-culturable condition is inducted by copper in *Agrobacterium tumefaciens* and *Rhizobium leguminosarum*. Applied and Environmental Microbiology 65:8 3754-3756.

Demonstrated that copper can induce nutrient starved Agrobacterium tumefaciens and Rhizobium leguminosarum cells to become viable, but non-culturable.

4) Marsh *et al*. (1998) Quantitative molecular detection of *Salmonella typhimurium* in soil and demonstration of persistence of an active but non-culturable population. FEMS Microbiology Ecology 27:4, 351-363.

Provided evidence of a significant proportion of s.typhimurium cells in soil as being uncultured by active cells.

5) Davies *et al*. (1995). beta-D-galactosidase activity of viable, non-culturable coliform bacteria in marine waters. Letters in Applied Microbiology 21:2, 99-102.

Demonstrated that beta-D-galactosidase activity could be detected in Escherichia coli even when no culturable cells were detected. Suggested that the activity of this inducible enzyme over time more closely reflected the number of viable non-culturable cells present.

6) Magarinos *et al*. (1994) Evidence of a dormant but ineffective state of the fish pathogen *Pasteurella piscicida* in seawater and sediment. Applied and Environmental Microbiology 60:1, 180-186.

Comparing acridine orange direct counts and culturable cells in sea water and sediment microcosms, demonstrated that P. piscicida can enter a viable but non-culturable state.

7) Sakai *et al*. (1995) Survival of the fish pathogen *Edwardsiella tarda* in sea water and fresh water. Bulletin of the European Association of Fish Pathologists, 14:6, 188-190.

Concluded that E. tarda can transform into a viable but non-culturable form in water.

8) Pedersen and Jacobsen (1993). Fate of *Enterobacter cloacae* JP 120 and *Alcaligenes eutrophus* AEO106 (pRO101) in soil during water stress: effects of culturability and viability. Applied and Environmental Microbiology 59:5, 1560-1564.

Demonstrated a fraction of E. cloacae and A.eutrophus existed in a viable non-culturable state in air-dried soil.

9) Jorgensen *et al*. (1994). Effects of starvation and osmotic stress on viability and heat resistance of *Pseduomonas fluorescens* AH0. Journal of Applied Bacteriology 77:3, 340-347.

In this study viable cells were considered to have an active electron transport system. Osmotically stressed P.fluorescens maintained a high viability, whereas culturability was rapidly lost.

10) Morgan *et al*. (1997) Survival of *Xenorhabdus nematophilus* and *Photorhabdus luminescens* in water and soil. Journal of Applied Microbiology 83:6, 665-670.

Demonstrated the presence of viable, but non-culturable cells in sterile water, "indicated that cells may survive longer than anticipated in the environment and remain undetectable using standard microbiological methods"

11) Pickup *et al*. (1996). The postponement of non-culturability in *Aeromonas salmonicidae*. Journal of Fish Diseases 19:1, 65-74.

Demonstrated that A.salmonicidae can become non-culturable, but viable after inoculation in fresh water.

12) Turpin *et al*. (1993) Viable but non-culturable *Salmonellas* in soil. Journal of Applied Bacteriology 74:4, 421-427.

Results suggested the presence of viable, but non-culturable cells of Salmonellas in non-sterile soil.

13) Binnerup *et al*. (1993) Detection of viable, but non-culturable *Pseudomonas fluorescens* DF47 in soil using a microcolony epifluorescence technique. FEMS Microbiology Ecology 12:2, 97-105.

Results suggested the presence of viable, but non-culturable cells of P.fluorescens in soil, represent c 20% of the initial population.

14) Dunstall *et al*. (1993) Viable but non-culturable bacterial forms in water. Milk Indusry London 95: 10, Technical and Processing Supplement 9.

States that Campylobacter jejuni (cause of acute enteritis in humans) "is able to survive for long periods in a viable but non-culturable form that is not amenable to certain detection methods"

15) Rollins (1988) Characterisation of growth, decline and the viable but non-culturable state of *Campylobacter jejuni*. Dissertation Abstracts International B-Sciences and Engineering 48:8 2210-2211.

Demonstrated that uninfected chickens given non-culturable cells of C.Jejuni became culture positive. Concluded that "evidence supports the hypothesis that non-culturable C.jejuni can maintain viability and pathogenicity for extended periods and under certain conditions, revert to the culturable state".

16) Berryl *et al*. (1991) Effect of heat shock on recovery of *Escherichia coli* from drinking water. Water Science and Technology 24:2, 85-88.

Demonstrated the presence of viable but non-culturable cells of E.coli in sterile tap water. Heat shock allowed bacteria to regain their ability to grown on artificial media.

References (2), (3) and (9) state that the viable, but non-culturable state can be induced in certain bacteria by conditions of starvation +osmotic stress or copper. With copper being regularly applied to apple trees at budburst and the sugar content / osmotic stress in apples increasing with the age of fruit, *E.amylovora* is likely to encounter the conditions which can induce the viable, but non-culturable state in apples during the growing season.

The DPI argues that due to:

(1) The large amount of evidence suggesting that gram negative bacteria may survive longer than anticipated in the environment and remain undetectable using microbiological methods which rely upon active growth of the bacteria.

(2) The lack of data on whether *E.amylovora* can convert to this state

(3) The possible consequences of allowing symptomless apples containing high numbers of viable, but non-culturable *E.amylovora* into Australia.

That the probability of entry (P1) be altered from 'negligible' to 'low' until it is demonstrated that *E.amylovora* cannot convert to a viable, but non-culturable state. ”

4.1.2 New research Project

In an endeavour to establish the possibility of the bacteria *E. amylovora* expressing an ability to be viable and non-culturable Apple and Pear Australia Limited and The Australian Government through R&D funding from Horticulture Australia Ltd commissioned the following research project:

AP02017 – “Can *Erwinia amylovora* exist in a viable, not non-culturable state”.

This project is being conducted by:

Associate Professor Lindsay Sly
Head
Department of Microbiology and Parasitology
University of Queensland

Early results from this project indicate that the researchers have been able to *“establish viable but non-culturable Fire Blight Bacteria”.*

And

“They have bacteria treated with copper and saline which are not growing on media, but which show up as 'live' using a stain technique which differentiates between live and dead cells on the basis of cell membrane being intact or not.”

Currently, the ability of these non-culturable but viable Fire Blight bacteria to revert to culturable state *in vivo* is being tested by inoculating immature apple fruit. As the *E. amylovora* culture being used in the studies is a non pathogenic strain symptoms of fire blight may not develop following inoculation. However, a hypersensitive reaction may occur if these bacteria revert to the culturable state when in contact with the nutrient supply in the fruit. This research is continuing and further results are anticipated over the coming period

4.2 EPIPHYTE, BIOFILM AND SIGMA FACTOR - THE METHODS OF PEST SURVIVAL:

The methods by which *E. amylovora* survives have not been adequately considered and investigated within the RDIRA and this is seen as important within the area of survival of the bacteria on the surface of apples, in orchards and on pack house equipment.

4.2.1 Artificial contamination and challenge testing of *E. amylovora*.

To assess the growth and survival ability of bacteria, researchers often use a challenge study which aims to mimic the natural conditions in which bacteria grow but where impediments to growth are then imposed. Such studies are well recognized; however, the results of such studies ought to be considered in conjunction with naturally occurring infection studies.

It is desirable that artificial inoculation studies are undertaken in parallel with studies of natural contamination so as to test the validity of the experimental design and to scrutinise how closely the artificial system resembles naturally occurring infection.

The structure of bacteria provides part of the explanation for the inconsistency of results obtained from artificial inoculum studies and those obtained from naturally occurring bacteria. The stability of the *E. amylovora* bacterial cell is associated with the cell envelope, and in particular the stability of the bacterial capsule and fatty acids. The bacterial capsule and fatty acids are known as ultra structures. The age of the culture and the composition of the growth medium influence cell envelope ultra structures (Cassano *et al.* 1988). The process of harvesting *E. amylovora* into a nutrient poor medium would inhibit bacterial motility and, therefore, survival (Raymundo and Ries 1981). Naturally occurring bacteria are not affected by these deficiencies and are protected by EPS, and are capable of surviving the storage temperatures (van der Zwet 1990).

In plant pathology the issue of bacterial attachment and aggregate formation has gained more attention as the understanding has increased of the implications for bacterial survival (Lindow and Brandl 2003). Biofilm or aggregate formations provide protection from UV, bacteriophages, desiccation (Geider 2000), environment conditions, plant defences and antimicrobial agents (Sapers 2001); (Ryu and Beuchat 2004). The aggregate/biofilm formation may provide an additional reason why artificially inoculated bacteria behave differently to naturally occurring bacteria.

Sapers (2001) demonstrates that bacterial aggregates and the ability of bacteria to internalize the apple surface has an effect on the efficacy of any washing treatment. Any unattached bacteria occupying an exposed surface site which are inoculated for a relatively short period of time would act as planktonic bacteria on the surface of the apple and be more vulnerable to treatment.

Challenge testing presupposes the replication of natural conditions of bacterial infection and survival. Rather than replicate natural infection, artificial inoculation studies can involve processes which disturb fundamental cell structure, increasing the vulnerability of bacterial cells to survival challenges. **It cannot be assumed that artificially inoculated bacteria replicate aggregation and biofilm formation if that be a fact of significance which advantages/distinguishes naturally occurring bacterial survival.**

Further, in response to temperature or antimicrobial washing **naturally occurring** bacteria may trigger the survival responses discussed in our report and within the extracts below. In short, bacteria may enter a dormant state and aggregate structures may enhance survival. Unless direct investigation is performed, naturally occurring viable bacterial populations may not be detected due to the non culturable state of bacteria in that state. Hale and Taylor (1999) and Roberts (2002) did not employ direct investigation techniques. Their results leave unanswered the question whether viable but non-culturable bacteria were present. This points to the importance of employing both direct and indirect methods for detecting *E. amylovora* and significantly qualifies the conclusions proper to be drawn from such indirect studies.

4.2.2 The following specific science has been drawn from the body of this submission:

The ability of *E. amylovora* to survive as an epiphyte is not mentioned in the RDIRA under the establishment factor “the method of pest survival”. However, as mentioned in Part B of RDIRA, there is a range of opinions on the subject.

Steiner (2001) considers *E. amylovora* to be a competent epiphyte. According to Paulin (1997) there is increasing evidence that *E. amylovora* is able to survive in the xylem vessels as an endophyte for several years. This is a very important point that must be considered in relation to picking orchards for sourcing apples for export to Australia. An orchard may carry endophytic infection but remain apparently symptoms free for several years and may be picked as an export orchard not knowing that it is infected.

While some researchers have found it to be a poor epiphyte others consider it to be a reasonably successful epiphyte (Calzolari *et al* 1982; van der Zwet, Zoller and Thomson, 1988; Crepel *et al* 1996; Steiner, 2001).

In Imp 3 an outline of research data is provided concerning epiphytic survival. Epiphytic survival is characterised by extreme fluctuations of bacterial populations and may select for traits enabling plant surface survival including survival on the surface of fruits.

Many epiphytes occur in large bacterial aggregates. Such aggregates can constitute between 30-80% of the total bacterial population on certain plants (Lindow and Brandl *et al.* 2003).

A trait which enhances bacterial survival on plant surfaces is the ability to attach in a protective environment (Romanstchuk *et al.* 1996). Burnett *et al.* (2000) has identified the following attachment sites on apples: the waxy cuticle, lenticels, calyx and the floral tube. The calyx has been observed to provide a site of attachment for *E. amylovora* (Hale *et al.*1987; van der Zwet 1990).

If bacterial species are to form aggregates, the presence of flagella or pili and EPS production is required (Romanstchuk *et al.* 1996). *E. amylovora* is known to possess Hrp pilus (Roine *et al.* 1997) and EPS production (Geider 2000).

In response to stress, bacteria (1) produce EPS substances and (2) activate the sigma factor (σ). *P. syringae* has been observed to produce EPS as a response to desiccation stress (Keith and Bender 1999). The sigma factor can be triggered by low nutrient conditions (Kim and Beer 2000).

Survival for several weeks in the apple calyx suggests that *E. amylovora* adapts for survival. *Salmonella* has also been found to be able to survive on and in tomato fruits over the period of blooming and then fruit setting (Guo *et al.* 2001).

Contact with a surface is known to stimulate bacterial synthesis of exopolysacharide in a reversible manner and this effect can take place independently of changes in growth conditions (Vandevivere and Kirchman 1993). A dense EPS matrix triggered by a stress response and formed through EPS production maximises bacterial survival by increasing nutrient concentrations (Costerton *et al.* 1995).

The formation of aggregates on plants has major implications for bacterial colonization and survival in harsh surface environments and provides them with a mechanism to modify the immediate environment of the bacteria in this habitat (Lindow and Brandl *et al.* 2003). The production of EPS, a major part of the bacterial aggregate matrix, benefits epiphytic survival (Morris and Monier 2003). Biofilm is an effective way for delivering extracellular enzymes, and provides an effective way of drawing nutrients from the plant (Lindow and Brandl 2003).

Bacterial biofilm (aggregate) formation has not been researched with respect to *E. amylovora*; however, it is important to recognize that a pathogen known to produce biofilms, (*P. syringae*) shares with *E. amylovora* a stress response mechanism triggered by a sigma factor σ (Janisewicz *et al.* 1999).

E. amylovora shares characteristics with other highly virulent bacteria, *Escherichia coli* and *Salmonella*. Each produces σ factor known as the master regulator of the phenotypic properties associated with the stationary phase and tolerance to a variety of physical, chemical and other factors including low temperature (Hengge-Aronis, 2000).

The general stress tolerance induced by stationary phase/starvation is primarily due to the effects of regulated proteins, although morphological and physiological changes are likely to contribute to the stress-tolerance phenotype (Hengge-Aronis 2000). Moreover, σ regulated proteins mediate the expression of the virulence operon in *Salmonella* (Robbe-Saule *et al.*1997) and genes of pathogenic *E. coli* that encode for a Type III secretory system (Beltrametti *et al.* 1999) with consequent effects upon the virulence of these bacterial pathogens. Similarly, *E. amylovora* induces the production of secretion type III system and the production of virulence proteins in response to common stress factors: low nutrient, low temperature and low pH environment (Wei *et al.* 2000). It is possible, and cannot be excluded, that *E. amylovora* populations on apple surfaces may enter a stationary phase/starvation phase and therefore be stress-tolerant.

In *P. syringae* it was discovered that *hrp* genes play an important role in the fitness of that micro-organism and intact type III secretion apparatus is required for the growth, and possibly survival, in the phyllosphere (Hirano *et al.* 1999; Hirano *et al.* 1997). The homology of *E. amylovora* and *P. syringae* has been discussed in detail by Bogdanove *et al.* (1998).

The implications of such a survival mechanism are illustrated by E. *coli* and its highly successful transfer by fruits flies to wounded apples (Janisiewicz *et al*. 1999). Other flies are also known to successfully transfer a dose of inoculum. With *E. amylovora* such transfer does not need to occur to another wounded apple. Inoculum growth occurs much faster when *E. amylovora* is transferred to nutrient rich sites such as the stigma or wounded leaf. However, epiphytic survival and infection can occur on intact shoots and leaves or even wooden boxes (Crepel *et al*. 1996; Ceroni *et al*. 2004).

The above comments on the methods of pest survival point to the obvious conclusion that an orchard free of symptoms is not necessarily free or even low in bacterial infestation/infection. Visual inspection alone is, therefore, not enough to ensure that the harvested fruit would carry only minimal populations of E*. amylovora*. It would be necessary for statistically representative samples be tested using a sensitive detection technique to ensure that the apple exported to Australia would not carry more than minimal numbers of bacteria that would be able to comply with BA's ALOP.

4.3 HOST PLANTS WITHIN AUSTRALIA

4.3.1 Exposure Groups

The RDIRA provides little detail on the rationale for its judgements on the distribution of hosts of *E. amylovora* and other quarantine pests and diseases around utility points. In many cases which involve orchard, urban or semi urban environments this can be estimated. For example in urban environments hosts will be found in most gardens, parks and open land. It is possible to estimate with reasonable accuracy the intensity of distribution around the urban utility. Similar approaches can be used for orchard environments and semi urban areas.
In assigning qualitative risk estimates for distribution, the level of risk should change with the intensity of distribution of hosts. This seems not to have been accounted for in the RDIRA and the judgements are questioned. The case studies listed below provide further evidence of the need to develop estimates based on sound industry knowledge of wholesale handling points for apples and the ecology of hosts in urban environments.

Within the RDIRA, probability of distribution is considered as a major part of the pathway. Page 61 makes reference to the term 'Exposure Group' and identifies the following"

> "Susceptible commercial fruit crops
> Susceptible Nursery Plants
> Susceptible Household and Garden Plants, including Weed Species, and
> Susceptible wild (Native and Introduced) and Amenity Plants including Susceptible Plants Growing on Farmland"

Page 67 references the IPPC criteria for establishment or spread and the RDIRA says:

> "Availability of suitable hosts, alternate hosts and vectors in the PRA areas.
>
> Whether hosts and alternate hosts are present and how abundant or widely distributed they may be, whether hosts and alternative hosts occur within sufficient geographic proximity to allow the pest to complete its life cycle, whether there are other plant species, which could prove to be suitable hosts in the absence of the usual host species,……….."

Pages 99 to 109 including tables 26, 27 and 28 offers a range of judgements regarding the proportion of utility points near host plants susceptible to *E. amylovora*; probability of exposure of susceptible host plants; and partial probabilities of distribution.

Similar documentation is presented for each of the major pests within the RDIRA

The RDIRA is inadequate in it fails to understand and highlight the actual situation within the apple/pear growing regions of Australia

4.3.2 New Research

Recent work by Creeper & Nicholson (2003) within South Australia indicated that:

"Derelict orchards and feral trees present a significant biosecurity threat to the industry from a number of perspectives."

"Primarily this paper seeks to identify the best methods of locating derelict pome orchards and feral trees and to identify current data availability and requirements."

The initial focus outlined in this paper is the Lenswood Region, as it is the main commercial production area of the State. However, other areas such as the Riverland and the South East may be investigated in later stages. The principles and recommendations from this paper will generally also be applicable to these areas.

The paper defines the hazard in the following manner:

"For the purposes of this paper, derelict or abandoned orchards may be defined as those not currently actively managed, particularly in relation to pest and disease control. Feral apple trees refer to those not deliberately planted, and have germinated either on roadsides, other properties and /or among other vegetation".

"Derelict orchards not only enable residual untreated codling moth populations to exist, but also act as a significant biosecurity threat to the Pome fruit industry in South Australia. These orchards pose a significant threat to any Fire Blight eradication effort should an outbreak occur in the future, which has the potential to devastate the industry"

Key issues from the report are:

1. *In addition to increasing Codling Moth control costs, derelict orchards and feral host trees also undermine efforts to control other pests and diseases. These orchards also represent significant biosecury threat, particularly in relation to any potential Fire Blight outbreaks".*

2. *"Derelict orchards and feral apple trees represent a major barrier for the reduction in insecticide use by the Pome industry."*

3. *"The management or removal of derelict orchards and feral trees will contribute to the future access of the SA Pome fruit Industry into export markets currently unavailable".*

From the initial report two case studies were conducted with the Lenswood growing region:

Case Study 1
Apple grower, packer domestic and interstate supplier and exporter within the Adelaide Hills. Approximately 20 km from the Central Business District of Adelaide.

The site includes a:
Commercial orchard are of 5.0ha
Mature packing facility
Major distribution facility for apples going to the domestic, interstate and international markets

The business is an approved supplier of apples to at least one of the major retail supermarket chains as well as many independent retailers within Adelaide and South Australia.

Case Study 2
Pear Grower, Packer, Domestic and Interstate Supplier and Exporter within the Adelaide Hills

Approximately 30km from the Central Business District of Adelaide

The site includes:

Commercial Pear orchards of 31 ha
Major packing facility
Major distribution facility for pears going to the domestic, interstate and international markets.

This business is an approved supplier of pears to at least one of the major retail supermarket chains as well as may independent retailers within Adelaide and South Australia

4.3.3 Conclusions

The attached maps and tables detail the level of derelict orchards feral plants and host plants in home gardens and on roadsides in the zones of 300m, 600m and 1km from the commercial orchard.

These case studies would be typical of all other major commercial orchards and/or packing houses within the Adelaide Hills Region and within other regions throughout Australia

A snapshot of the Adelaide Hills Region is as follows:

a) A number of large retail supermarkets within 5kms of commercial orchards and packing facilities

b) Feral plants that are along roadsides, creeks and within National Parks that form ‘ribbons’ from Metropolitan Adelaide into and through the Commercial Growing Regions within the Adelaide Hills

c) Many urban dwellers and hobby farms scattered throughout the Commercial Growing Region and in close proximity to both commercial orchards.

d) An Apple / Pear Industry which is highly vertically integrated industry with many commercial growers having major infrastructure including cool storage and packing facilities. They supply fruit through the marketing chain

(1) Through their own wholesale agency within the Adelaide Produce Market

(2) Directly to the major retail supermarket chains

(3) Directly to Independent fruit shops

e) There are 10 growers / packers within the Adelaide Hills region who supply apples / pears to the three retail supermarket chains – Woolworths, Coles/BiLo and Foodland.

As suppliers to the major retail supermarket chain it is a very likely scenario that they would import, store, re-pack and distribute imported fruit as part of their role as category manager for apples/pears.

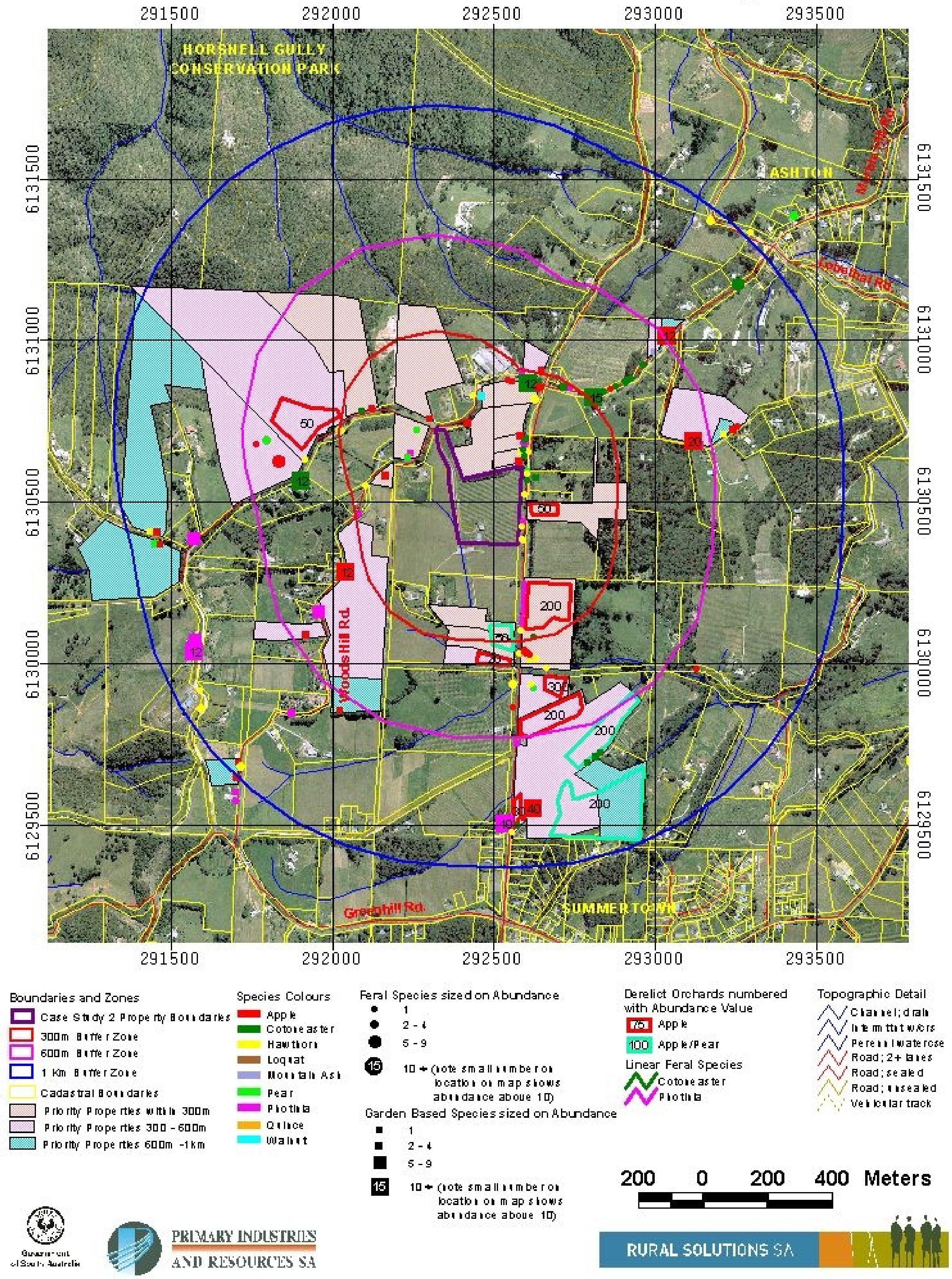
Again this 'snapshot' would be typical of growing regions in cities like Perth, Melbourne, Sydney and Hobart.

This 'snapshot' offers a far different position than is outlined within the RDIRA.

4.4 REFERENCES:

Creeper, D and Nicholson, H (2003).
Examining Removal and Management Strategies: Derelict Pome Orchards in South Australia

CASE STUDY 1: APPLE & PEAR PEST SPECIES
Hosts Mapped Within 1km of Property



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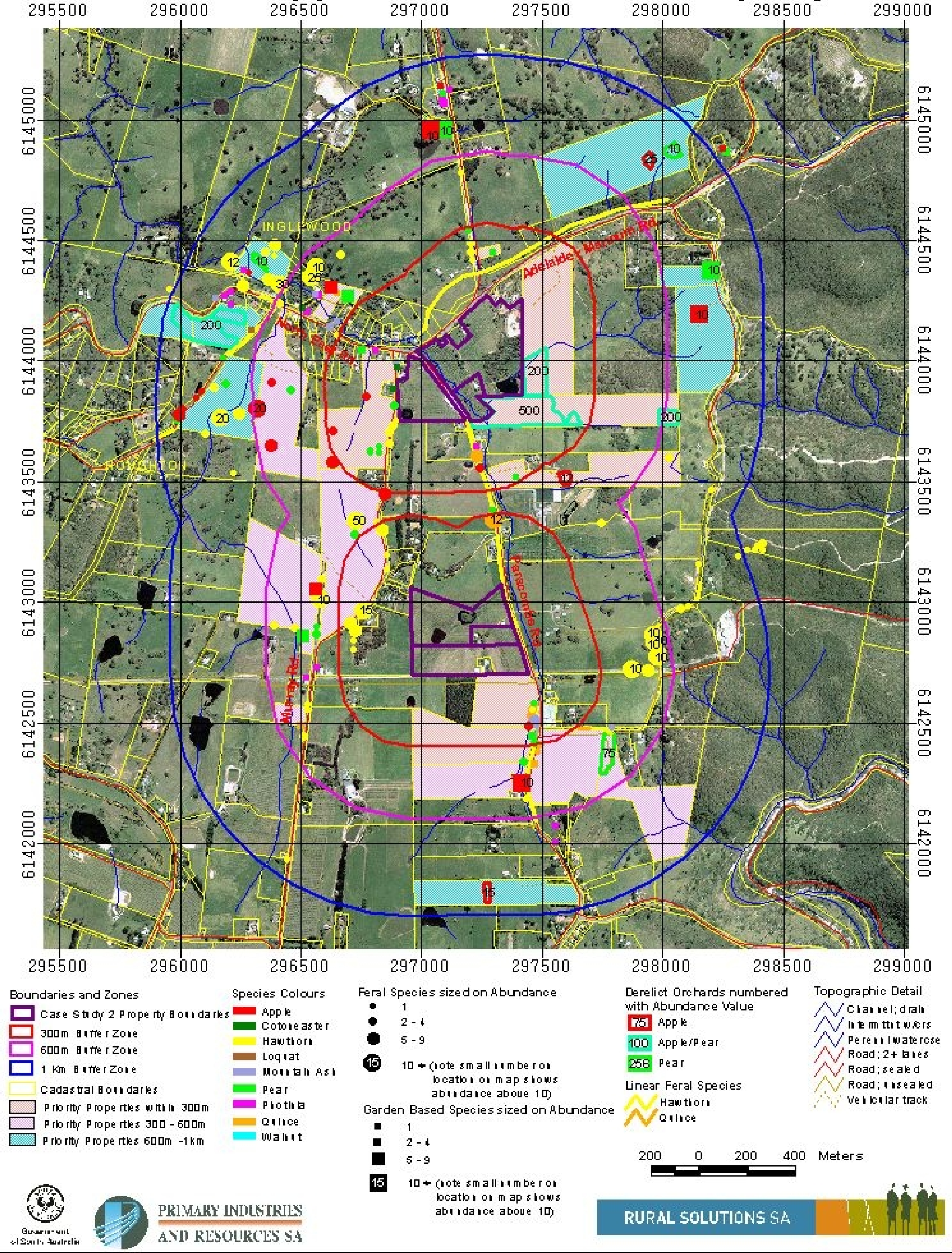
CASE STUDY 2: APPLE & PEAR PEST SPECIES
Hosts Mapped Within 1km of Property



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CASE STUDY 1 - ASHTON
# of orchards = 1
# of orchardists = 1
Commercial orchard area = 5.0 ha

	AREA (ha)	# Surrounding DCDB	# of DCDB with hosts	# Derelict orchards	Species	GARDEN	FERAL	ROADSIDE	ORCHARD	SUM
BUFFER ZONE 1 < 300m	66.3	38	17	3	Apple	14		3	300	**317**
					Pear	2		1		**3**
					Quince					**0**
					Loquat					**0**
					Hawthorn	2	1	13		**16**
					Photinia	4		47		**51**
					Cotoneaster	26	1	5		**32**
					Walnut	3		1		**4**
					Mountain Ash					**0**
					SUM	**51**	**2**	**70**	**300**	**423**
BUFFER ZONE 2 300 - 600m	115.3	32	13	4	Apple	36	15	2	570	**623**
					Pear	1	3	2		**6**
					Quince					**0**
					Loquat			1		**1**
					Hawthorn		3	6		**9**
					Photinia	8				**8**
					Cotoneaster	27		8		**35**
					Walnut					**0**
					Mountain Ash	1				**1**
					SUM	**73**	**21**	**19**	**570**	**683**
BUFFER ZONE 3 600 - 1000m	245.7	105	13	3	Apple	63	1	2	430	**496**
					Pear	2				**2**
					Quince					**0**
					Loquat					**0**
					Hawthorn	2	1	10		**13**
					Photinia	37				**37**
					Cotoneaster	4	1	6		**11**
					Walnut					**0**
					Mountain Ash					**0**
					SUM	**108**	**3**	**18**	**430**	**559**
TOTAL	**427.3**	**175**	**43**	**10**	**TOTAL**	**232**	**26**	**107**	**1300**	**1665**

CASE STUDY 2 - INGLEWOOD
# of orchards = 2
# of orchardists = 1
Commercial orchard area = 31.0 ha

	AREA (ha)	# Surrounding DCDB	# of DCDB with hosts	# Derelict orchards	Species	GARDEN	FERAL	ROADSIDE	ORCHARD	SUM
BUFFER ZONE 1 < 300m	191.5	64	17	3	Apple		8	1	712	**721**
					Pear	8	7	8		**23**
					Quince		7	23		**30**
					Loquat					**0**
					Hawthorn		62	251		**313**
					Photinia	2				**2**
					Cotoneaster	2				**2**
					Walnut					**0**
					Mountain Ash	1	5			**6**
					SUM	**13**	**89**	**283**	**712**	**1097**
BUFFER ZONE 2 300 - 600m	215.1	45	18	1	Apple	24	33	5		**62**
					Pear	11	9	7	75	**102**
					Quince	7	7	22		**36**
					Loquat					**0**
					Hawthorn		143	184		**327**
					Photinia	9				**9**
					Cotoneaster	1				**1**
					Walnut					**0**
					Mountain Ash	5		1		**6**
					SUM	**57**	**192**	**219**	**75**	**543**
BUFFER ZONE 3 600 - 1000m	363.8	86	17	6	Apple	21	1	12	440	**474**
					Pear	22	2	3	20	**47**
					Quince					**0**
					Loquat	1				**1**
					Hawthorn		115	119		**234**
					Photinia	15				**15**
					Cotoneaster					**0**
					Walnut					**0**
					Mountain Ash	1				**1**
					SUM	**60**	**118**	**134**	**460**	**772**
TOTAL	**770.4**	**195**	**52**	**10**	**TOTAL**	**130**	**399**	**636**	**1247**	**2412**

AREA STATS

CASE STUDY 1 - ASHTON
Commercial Orchard Area = 5.0 ha

	AREA (ha)	Derelict orchards (ha) : % of zone	# Trees	Roadside infestation (m)
ZONE 1	66.3 [15.5%]	0.3 0.5 1.7 **2.5** [3.7%]	50 50 200	840
ZONE 2	115.3 [27%]	0.2 1.7 1.2 0.3 **3.4** [2.9%]	20 50 200 300	350
ZONE 3	245.7 [57.5%]	0.2 1.5 4.2 **5.9** [2.4%]	30 200 200	110
TOTAL	**427.3** [100%]	**11.8** [2.8% of total area]	**1300**	**1300**

CASE STUDY 2 - INGLEWOOD
Commercial Orchard Area = 31.0 ha

	AREA (ha)	Derelict orchards (ha) : % of zone	# Trees	Roadside infestation (m)
ZONE 1	191.5 [24.9%]	1.6 3.8 **5.4** [2.8%]	200 500	1390
ZONE 2	215.1 [27.9%]	0.2 0.7 **0.9** [0.4%]	12 75	1260
ZONE 3	363.8 [47.2%]	0.2 0.3 0.2 0.2 0.5 2.7 **4.1** [1.1%]	10 10 15 25 200 200	1250
TOTAL	**770.4** [100%]	**10.4** [1.3% of total area]	**1247**	**3900**

SECTION 5: PERSONAL COMMUNICATIONS

1. **DR SATISH WIMALAJEEWA**
2. **JOHN MORTON**
3. **‘APPLE CROP’ BULLETIN BOARD**
4. **DR COLIN BOWER**
5. **TREVOR RANFORD**
6. **DR SATISH WIMALAJEEWA**
7. **FACTIVA**
8. **HARLEIGH MASON**

5. PERSONAL COMMUNICATIONS

While undertaken the review of the RDIRA material was supplied to APAL from a range of individuals. This material has been included within the technical report because it presents points that are relevant to and/or adds to the science presented within this report.

5.1 DR SATISH C WIMALAJEEWA BSC SPECIAL (HONS) (CEY), PHD (CALIF) CONSULTANT PATHOLOGIST, VICTORIA (2004)

RISKS ASSOCIATED WITH THE IMPORTATION OF APPLES FROM COUNTRIES WHERE FIRE BLIGHT IS ENDEMIC: - A BRIEF OVERVIEW

Importation of any Fire Blight host plant material to a country free of the disease from a country, where the disease is endemic, like New Zealand, poses a serious risk to the pome fruit industry in the importing country. This is inevitable because of the extremely infectious nature of the disease. Although the importation of propagating material, whether legally or illegally, poses a much larger risk than the importation of apple fruit *per se*, propagating material is not imported on a large scale and is not widely distributed after importation like apple fruit that is imported purely for consumption. Therefore, the overall risk with the importation of fresh fruit is greater.

The greatest risk from the importation of the fruit is due to calyx infections/infestations and endophytic infections (endophytic is where the fire blight bacteria live in the internal flesh of the fruit without exhibiting any external symptoms) that originate almost exclusively in the source orchard. Although surface infestations/infections, which may occur in the source orchard as well as after harvest, also pose a risk, at least some of this risk can be reduced with suitable bactericidal treatments. However, calyx infections/infestations and endophytic infections cannot be eliminated either by chlorine treatment or by cold storage mentioned as risk management measures in the Revised Draft Import Risk Analysis (RDIRA) document on the importation of New Zealand apples. Bactericidal treatments are totally ineffective against these infections/infestations. **Cold storage, according to basic principles of biology, would only prolong the survival of the bacteria with very little or no reduction in the numbers.** Currently, there are no known methods, cost effective or otherwise, that could be used after harvest that will eliminate or reduce bacterial numbers in the calyx or in the internal tissues. Importation of such fruit in large volumes (about 200 million apples per year from New Zealand) will distribute the Fire Blight bacterium on a wide scale. A question that is often asked now is “where is the evidence to prove that Fire Blight bacteria from an infected apple could be transferred to a susceptible host to initiate an infection?”, Although countries having Fire Blight have not conducted any detailed research to answer this question, simply because they have much more potent inoculum sources to be concerned with, **that does not mean such transfer may not occur in nature**. If transfer of Fire Blight bacteria could occur in spring from over wintering cankers to blossoms, carried by flying or crawling insects, wind, rain or wind driven rain there is no reason why it cannot occur from decaying fruit carrying calyx infestations/infections or endophytic infections to flowers. There are certain volatile substances released by plant and animal tissues (known as kairomones) that would, among other functions, attract all kinds of insects to the material that emit these substances. Decaying fruit is also known to release such substances. Thus, flying insects attracted to decaying apple fruit, carrying the Fire Blight bacteria, thrown in the vicinity of a susceptible host, could easily pick up the bacteria and transfer them to susceptible sites (blossoms and succulent shoots) to initiate an infection. Such transfer may occur long before the fruit has completely decayed following invasion by saprophytic organisms. It would be naïve to think that the bacteria that is widely distributed in the country along with the apples, following importation, would simply sit in the calyx or inside the fruit without ever finding a host for its survival and perpetuation. Such a view would go against nature and all biological norms.

A further risk with the importation would be the trash that would accompany the fruit. It does not matter how hard one tries, it would be impossible to eliminate trash completely. Infected trash would bring the Fire Blight pathogen into the country with the fruit.

Quite apart from the risk of introducing Fire Blight into Australia there is another risk that is as important or even more important than introducing Fire Blight. This is the possibility of importation of strains of Fire Blight bacteria, with infested/infected apples, that are resistant to streptomycin. Streptomycin resistance in these bacteria is becoming more and more widespread in countries having Fire Blight where this antibiotic is routinely used for control. Streptomycin is widely used in New Zealand in the management of Fire Blight and resistance to this antibiotic has been found in that country. Streptomycin resistance are of two types *viz*. chromosomal based resistance and plasmid based resistance. **Although plasmid based resistance is less common than the chromosomal type it is more dangerous than the chromosomal type as the resistance genes could be easily transferred to other bacteria, some of which may be important human and animal pathogens.** Once such bacteria acquire resistance to streptomycin it will not be possible to treat diseases caused by these bacteria with streptomycin based drugs. The control of Fire Blight, if introduced into Australia, would also become difficult if streptomycin resistant strains of the bacteria flourish here **because streptomycin is the only effective plant safe pesticide available for the control of Fire Blight**.

In a country where Fire Blight is endemic the only measure that would reduce the risk to the importing country at least to some degree would be stringent orchard inspections to ensure freedom from all obvious symptoms (strikes, cankers etc). This is an enormous task that is almost impossible to achieve. Although orchard inspections are mentioned in the RDIRA document as a risk management measure, details of procedure are not given. For inspections to have any effect at least two inspections, one at full flowering and the other at harvest, would be necessary. Only those orchards with a total absence of any kind of symptoms would pass this test. The practical difficulty here would be, in the first place, to detect from ground level small (3-5 mm in diameter) but active cankers found on twigs and branches at the top of the tree. It is also very important that growers are not allowed to prune or cut out any symptoms between the first and second inspection if the orchard is to remain as an export orchard. Coupled with orchard inspections statistically representative samples of immature and mature fruit must be tested for the Fire Blight pathogen using a highly sensitive technique to ensure that the orchard is free from detectable infection.

In regard to detection it is important to bear in mind that a negative test result, implying an absence of fire blight bacteria, is not always totally accurate because of the existence of a non-culturable but viable state of the bacterium. This has now been demonstrated in preliminary work done at the University of Queensland using an attenuated (non virulent) strain of the fire blight bacterium. Furthermore, bacteria subjected to stress situations like low temperatures, low nutrient supplies (as the case may be in the calyx) and other unfavourable conditions have certain characteristics that enable them to tide over these conditions. Two of these characteristics are (a) the formation of biofilms or aggregates, and (b) the production of the sigma (σ) factor. Although biofilms have not yet been specifically researched in the case of Fire Blight bacteria, the production of the sigma factor has been investigated. Personal communications with a researcher who has been involved in studies of the sigma factor in Fire Blight bacteria in the USA indicate that it may have a role to play in their survival under conditions of stress. However, according to him, further work is needed to establish this.

Thus, from the above it is apparent that even a very sensitive detection technique may not ensure a totally infection free fruit. However, the stringent management measures outlined above may at least reduce the risk posed to a level very nearly equal to the appropriate level of protection (ALOP) for Australia.

5.2 JOHN MORTON, CHIEF FIELDMAN, OREGON CHERRY GROWERS, USA.

"Oregon and Washington states in the Northwest Region of the US are areas with Fire Blight (Erwinia a.) problems in both apple and pear. The fruit growing valleys of our districts such as the Hood River Valley in Oregon or Yakima Valley in Washington State fight a constant battle to control this organism.

Pears are the big crop in the Hood River Valley and nearly every variety is susceptible to Fire Blight in both apple and pear. The most susceptible pear varieties are Bartlett (Duchess), d'Anjou, and Bosc. We rate control measure in apple by the varieties also.

1. Very susceptible:
   a. Pink Lady
   b. Gala

2. Highly susceptible:
   a. Braeburn
   b. Fuji
   c. Granny Smith
   d. Ginger Gold

Control Programs
Outlined below are control programs our growers use to keep Erwinia a. at bay. Growers who do not follow this program will lose an entire orchard in 2-3 years time if they do not religiously follow these regimes. The orchards have to be removed because there is less than 50% of fruiting wood left after two years in our districts.

1. Warm, humid weather with spring showers initiate the infection period. In our area that would be early May (November in Australia). Warm, succulent shoots of new growth are the source of initial infection. Use of too much fertilizer, irrigation and practices that cause "good shoot growth" compound the problem of Erwinia a. infections. Temperatures of 19-27C combined with high humidity is the most susceptible time period.

2. **Walk through each row every 14 days** and remove Fire Blight strikes

3. Tools must be disinfected between cuts with alcohol or chlorine solution
4. Cuts on the strike limbs must be 30-45cm below the strike.

5. Dead, infected material must be removed immediately from the orchard floor and burned after it is cut.

Chemical Controls

1. Fall application of Copper is necessary

2. Spraying Aliette in spring is needed on Pink Lady variety

3. Frequent use of antibiotics have not been successful. Spray applications of Streptomycin or Terramycin have not been successful. Frequent applications quickly initiated resistance to these products for controlling the Fire Blight bacteria.

In summary, it is a big job to keep this “bugger” under control!! Walking through a block once or twice a year does not make control!! All of the above have to be used to maintain any hope on control. Some years are worse for infection than others due to weather conditions.”

5.3 “APPLE CROP” BULLETIN BOARD 22ND MAY 2004.

“We haven’t had the type of dieback you are talking about here in the Southeast to my knowledge but man, we’ve got Fire Blight. The strep sprays didn’t make much of a dint on my trees. Hardest hit, Scarlett O’Hara. Others hit: Pink Lady, Gala, Mutsu/M27, of course, Goldens ….Those safest … Liberty, Priscilla, W. Pride, Goldrush, Enterprise….as expected….

A year like this really let’s you see the importance of breeding for Fire Blight resistance.

BTW, everything looked fine well into bloom but we have had 2 very late frosts that I think contributed to the injury.”

Comments attributed to John Cummins.

5.4 COLIN BOWER, CONSULTING ENTOMOLOGIST, 17TH MAY 2004.

“…..that sixty percent (60%) of inspections of New Zealand apples entering the USA contain the apple leafcurling midge in the calyx.” (A comment recently made by the Trade Councillor, US Embassy in Canberra)

This means that the majority of New Zealand fruit going into the USA has unacceptable levels of this insect and it cannot be unloaded in California without fumigation. It would seem to me that this situation fully justifies the same protocol for entry into Australia. I think it would justify the mandatory fumigation of all fruit before it leaves NZ.

5.5 TREVOR RANFORD, HORTICULTURAL CONSULTANT

Recent discussions that Trevor Ranford, Project (Manager) had with an individual within the Plant Health area indicate that Wheat Bug has been detected on produce coming across the Australian borders.

This indicates that the pest will easily move on produce.

5.6 SATISH WIMALAJEEWA, CONSULTING PATHOLOGIST, 6TH MAY 2004.

"The other issue that needs to be hit very hard is kairomore attraction of insects to discarded fruit. (I have been doing clinical studies of attraction of pear pests (Codling moth and consperse stick bug) to wounded pear fruit the last few years, and know this to be a relatively new developing research area which is showing that insects have great attraction to compounds in fruits. They will immediately find discarded fruits because of these kairomones present, although the longevity of the kairomones in stored fruit needs to be studied. Insect monitoring kairomone lures are now commercially available to monitor certain insects like codling moth. This area of research was little touched in the previous effort against the New Zealand apples and I'm not sure if Japan addressed the issue in the current case."

(Information came through a personal communication with Broc Zoller BSc (Plant Pathology) with Honors., PhD (Plant Pathology). USA.)

5.7 FACTIVA (DOW JONES/REUTERS), NZPA, WELLINGTON, 17TH MAY 2004

"While business leaders called for a common border and a seamless trans-Tasman business environment at the weekend's ANZ Australia – NZ Leadership Forum, not all NZers were in agreement. Environmental lobby organisation Forest and Bird Awareness Officer, Geoff Keey, referred to the concept as 'nutty'. "Australia's pests could not only devastate NZ's forests, but they could do severe damage to our economy and health as well". He referred to the Tasman Sea as a moat and an advantage that NZ should never give away. The development of the Biodiversity Strategy for NZ is aimed at being better at keeping pests out. "We should be careful not to lay out the welcome mat for Australian pests."

(Information extracted from 'Apple and Pear World News'. Vol 7, Issue 18. 4th June 2004. Victoria, Australia.)

5.8 HARLEIGH MASON, AG & HC MASON, FOREST RANGE, SA. 3RD JUNE 2004.

"In the case of Fire Blight entering our country the chances of the disease becoming established is increased in ratio to the available suitable host plants. We consider the available host plants to be very numerous and widespread. Beside the commercial orchards of apples and pears, the back yard fruit trees, the ornamental hosts, the bountiful supply of hawthorns on the face hills, and the lavish plantings of ornamental pears by the urban Councils, all give wide opportunity for infection to occur."

This is a comment from a commercial orchardist and supports the information detailed under the Section on New Science.

SECTION 6: RISK ANALYSIS PROCESS

6. RISK ANALYSIS PROCESS

6.1 GENERAL COMMENTS

The following general comments on the Risk Analysis process adopted in the New Zealand apple IRA are the result of closely examining its application to the pests and diseases considered.

6.2 USE OF 'HIGH' LIKELIHOOD RATINGS

The 'High' likelihood (0.7 to 1) is the highest probability band used through most of the report. It has been assumed by the authors that a probability of 1 would almost certainly never occur, so it has not been used. However, the use of the 'High' likelihood introduces a more serious error. By using 'High' it is implied the highest probability is in the range of 0.7 to 1, which, while true, greatly underestimates the probability for events that have a likelihood very close to 1. In this assessment events considered to have a probability close to 1 are classified as 'Certain'.

Page 48 of the RDIRA states that "*the 0 – 1 probability interval was divided into six likelihoods (Table 11) to ensure consistency in usage and interpretation, and to provide a framework under which the likelihoods can be logically and transparently combined. Events considered almost certain to occur were assigned a likelihood of 1.*"

Given this, why was the Likelihood of 'Certain' not included into Table 11 and utilised in the appropriate areas of the RDIRA.

The effect of using 'High' instead of 'Certain' can be seen by multiplying the midpoint probabilities of several 'High' events together, eg. 0.85 x 0.85 x 0.85 = .614. By contrast, if two of these events are in reality close to 'Certain' the final probability is 1 x 0.85 x 1 = 0.85. So by using 'High instead of 'Certain' the series of steps reduces to a 'Moderate' likelihood, when in reality it should still be 'High'. While this does not always have a serious impact on the analyses, it is a logical shortcoming.

An important effect of the universal use of 'High' is that it results in greater apparent population decreases of the pests through the pathways than really happens, and this is unacceptable.

Another place in the risk analysis where a likelihood of 'certain' is more appropriate than 'high' is in Table 14, page 61 of the RDIRA for P12. It is clear that essentially all fruit arriving in the hands of consumers will go in some part to waste, either as a spoiled piece of fruit, or as a core.

Table 11 also presents a dilemma with regards the individual Likelihood and the specifically allocated Probability Intervals. 'High' has a probability interval of 0.7 to1 and 'Moderate' has a probability interval of 0.3 to 0.7. Given that a probability of any particular aspect of the process gives a probability figure of 0.7 is the Likelihood 'Moderate' or 'High'.
With Biosecurity Australia indicating that the will in all case take the most conservative position it is logical to expect that when a probability falls into such a category ie. 0.7, the likelihood will always be 'High'. One would expect that this would be the case across all other likelihood categories.

6.3 INDIVIDUAL FRUIT VERSUS PACKAGE OR LOT

For statistical reasons, the risk analysis methodology is based on consideration of the probability of infestation of a single fruit and the fate of that fruit once it reaches Australia. For many pests the main risk scenario is associated with bulk lots of fruit at distribution, repackaging or retail points. The risk is multiplied with bulk fruit because there is a much higher likelihood of multiple individuals escaping at the same place, allowing them to mate, lay eggs and establish. This aspect of the population dynamics of the pests is not well covered by the Import Risk Analysis methodology and will be considered in more detail in the discussion later.
This risk is multiplied for large packers located in major orcharding districts in the regions, where large lots of New Zealand fruit may potentially go, e.g. Montague fresh at Narre Warren in Victoria and Plummers in the Adelaide Hills in South Australia. The arrival of many container or pallet loads of New Zealand apples in these areas poses a much greater risk than consumers eating single apples in the city. It is also likely that major roadside sales outlets in orcharding districts, such as Bilpin west of Sydney, will sometimes use New Zealand apples when local produce is scarce. They already source apples from other parts of Australia. The structure of the analysis makes consideration of these scenarios very difficult, such that the risks appear to have been underestimated in the probabilities applied.

The issue of the unit of analysis becomes critical for hitchhiker pests like Wheat Bug, *Nysius huttoni*, which is not a pest of apples, does not infest apples on the tree and hence is not on the fruit at harvest. It shelters in bins and pallets onto which it moves when they are placed in weedy areas during picking or temporary storage.

6.4 WASTE VERSUS OTHER SCENARIOS

On page 65 of the RDIRA it is made clear that the whole analysis is based on the assumption that host exposure in Australia will occur almost entirely through the disposal of infested/infected fruit as waste. This is an extraordinary assumption as it entirely discounts other potential, and in some cases more likely, modes of establishment. Some of these possibilities have been raised previously, but are dismissed as 'extremely rare'. This is incongruous when considered against the universal application of 'negligible' likelihoods throughout the pest tables for the 'probability of exposure of susceptible host plants from discharge or discard of a single infested apple, an escaped pest, or contaminated packaging material from different utility points'. While this heading suggests the analysis considers modes of establishment other than from waste fruit, the statement on page 65 indicates the contrary. 'Extremely rare' and negligible' would appear to be synonymous, so there is no justification for discounting the other scenarios, except for convenience.

A specific example of a pest that may emerge and disperse from sound (non-waste) fruit is Apple Leafcurling Midge. This pest forms cocoons in the stem end or calyx of fruit without damaging the fruit. It is quite likely this pest will emerge from cocoons at any stage during the distribution of fruit where the temperatures are high enough to permit insect activity and development. A similar scenario applies to leafrollers (see discussion later for these pests).

6.5 POLYPHAGOUS INSECTS AND WEEDS

The RDIRA gives very low probabilities of establishment for all pests in city areas. These probabilities are likely to be unrealistically low because it is frequently assumed that few host plants are close to the utility points. The RDIRA seems to have ignored the ubiquitous nature of weeds. Many of the New Zealand apple pests are highly polyphagous and can utilise many broad-leaved weeds. The emphasis in the RDIRA seems to be on garden plants and native species. Weeds fit into the ‘wild’ plants category, but have not been properly considered.

6.6 PESTS WITH A RESTRICTED DISTRIBUTION IN NEW ZEALAND

Some pests considered in this review are not found through all apple growing areas in New Zealand, e.g. Oystershell Scale, which is confined to the southern parts of the South Island where it is a major pest. Step one in the importation pathway of the analysis requires one to consider the likelihood of the pest being in the orchard. Because of its limited distribution, Oystershell Scale is given a likelihood of ‘Very low’ which then feeds through the entire analysis resulting in an ‘Extremely low’ Probability of Entry for this insect. This is an unrealistic approach. Some 95 percent of New Zealand apples have a zero risk of infestation by Oystershell Scale, but the other 5 percent has a relatively high risk and is likely to proceed through the marketing system together. Therefore, to eliminate this bias, the analysis should apply only to fruit from the areas where the pest occurs.

6.7 QUARANTINE INTERCEPTIONS

Surprisingly, little use has been made in the RDIRA of data on quarantine interceptions of insects and diseases on New Zealand fruit destined for the USA and other markets. Most New Zealand apples going to the USA are subject to a comprehensive preclearance inspection program in New Zealand before they are shipped (USDA-NZMAF, 2004). This program has generated vast amounts of data on the pest and disease status of New Zealand apples packed for export. This data would provide the best available estimates of the likelihood of New Zealand apples being infested with all the pests of quarantine significance considered in the RDIRA, yet this information, and other similar information from other countries, has not been specifically accessed. Cross-checking the results of the Import Risk Analysis for ‘Probability of Importation’ with USDA quarantine interception data would provide a test of the validity of the Import Risk Analysis that should be done.

6.8 LACK OF TRANSPARENCY AND PRECISION

There are many places in the RDIRA where it is stated that certain factors have been taken into account in the analysis, but there is no indication as to how this has been done. Some examples are:

- On page 65-66 it is stated that ‘The scenario of a pest escaping from the utility point could apply more to flying arthropods than to other pests. Therefore, that fact, where relevant, was taken into consideration in allocating likelihoods to determine the number of waste units that come near susceptible host plants. That is the possibility of an insect flying out early in the distribution pathway has been accommodated in the waste calculation’. There is no methodology described in the RDIRA for how this has been taken into account. However, because this event is regarded as ‘extremely rare’, it has probably been dismissed by the authors as not contributing to risk at all. This issue is discussed in detail later in this review, where it is argued that insects flying from distribution points, as opposed to waste leaving distribution points, represent a significant risk. This example indicates a greater lack of precision in the Import Risk Analyses than admitted in the methods section.

6.9 LACK OF SUPPORTING INFORMATION, CONTRADICTORY EVIDENCE AND NON SEQUITORS

There are also many places in the RDIRA where assertions are made and likelihoods presented without supporting data. There are even numerous examples of where the data or other information presented in support of a proposition actually supports the opposite interpretation. Some of the more obvious examples are:

6.10 PROBABILITIES OF EXPOSURE OF SUSCEPTIBLE HOST PLANTS FROM SINGLE INFESTED APPLES AT UTILITY POINTS

Most tables throughout the report have ‘Negligible’ for all utility point by exposure group combinations for insect pests. This is very hard to understand since the probabilities are logically not the same for all combinations. There is no explanation in the report as to how these ‘negligible’ probabilities were derived, other than to say that a pest specific estimate has been used for each utility point by exposure group combination for each pest (2004 RDIRA, Table 16, p. 65), and that these take account of the specific life history characteristics of each pest and their host range etc (2004 RDIRA, p. 63). Similar data free pest specific estimates are also used for estimating the proportions of utility points near each exposure group (2004 RDIRA, Table 16, p. 65), and the partial probability of establishment or spread for exposure group (2004 RDIRA, Table 17, p. 69).

The problem with the whole analysis surrounding utility points and exposure groups is that there is no data at all, and it is based very much on educated guesses. One has to doubt the accuracy of an analysis that is based on multiplying together several data free estimates for which the logical underpinning is not given. The multiplication of many probabilities greatly compounds the errors involved in each ‘guestimate’. The most serious effect is that if any one probability is grossly over or under ‘guestimated’, it feeds through the remainder of the analysis and exerts a large influence on the conclusion. This is most likely to happen at the low likelihood end of the scale, where underestimating of probabilities potentially exerts the largest influence on the outcome. This part of the analysis lacks credibility and throws the conclusions into serious doubt. In fact the further the analysis goes the more it departs from reality and any semblance of accuracy. Some specific examples of the problems created by this approach are given in the review of each pest species that follows.

SECTION 7: RISK ANALYSIS MODEL

7. RISK ANALYSIS MODEL

7.1 REVIEW OF THE MODEL OF IMPORTATION OF APPLES FROM NEW ZEALAND

7.1.1 Summary

A careful review of the mathematics behind the model published by BA on the web[1] has identified errors between the published conclusions in the RDIRA report and the conclusions obtained inputting the same published information to the web-based model.

The unrestricted risk calculation of the likelihood of entry, establishment and spread for the principal pest of quarantine concern - Fire Blight – was increased by a factor of three based on the category likelihood scale used by BA.

When the quarantine measures proposed by BA to manage the level of risk were examined in BA's model and elements of double counting eliminated, the restricted risk was determined to be a category level of 'low' using BA's terminology. This level is higher than the 'very low' risk rating required to meet Australia's appropriate level of protection.

The existence of errors of the order found in the RDIRA report calls into question the validity of the overall risk analysis. These errors and the methodology used to determine risk need to be reviewed in order to provide reliable and realistic calculations of the risks faced by Australia and the horticultural industries most likely to be affected by fire blight and other the pests associated with New Zealand apple imports.

A rigorous and reliable mathematical method of risk analysis is required. Only when the risks have been reliably determined and published can informed public comment be requested and received.

7.1.2 Introduction

The methods used to model the pests considered in the RDIRA have been detailed in pages 37 to 77 of the document. A total of 21 pests are categorised as quarantine pests as provided for in ISPM 11 Revision 1. These include: nine insects, one bacterium, one fungus of concern for the whole of Australia as well as five insects, one mite and one fungus to be considered for Western Australia only. In addition three insects that could contaminant apples have been considered.

Each pest categorised as a quarantine pest has been examined in a Pest Risk Assessment based on the model (reviewed elsewhere). This section of the report examines the outcomes of the models of unrestricted and restricted risk using the models developed by BA.

It should be noted that the methods used to model these risks have been developed and published by BA in 'Guidelines for Import Risk Analysis' (Draft 2001). However, following concerns at the errors identified in the revised draft IRA report on Bananas from the Philippines, Biosecurity Australia has provided a copy of the mathematical model for apples from New Zealand as an EXCEL spreadsheet titled 'BA Copy of apple IRA model'.

A review of this model and the text of the RDIRA point to serious errors in the use of the model, the underlying mathematics and the calculation of unrestricted and restricted risk for the key quarantine pests of concern to the apple industry.

The comments and observations set out below do not question BA's assessment of the likelihood categories for Imp1 to 8, for the partial probabilities of establishment or spread, nor for the assessment of consequences and the direct and indirect impacts. Comments on the validity of these inputs are made elsewhere.

7.1.3 Fire Blight

7.1.3.1 Unrestricted Risk

Pages 85 to 124 set out the input values used in the EXCEL spreadsheet model for the bacterium *E. amylovora*, the causal organism for fire blight the most critical pest of concern for the Australian apple industry. The published input values for

- Imp1 to Imp 8 in Figure 13 on page 87,
- P1-P12 from Table 14 on page 61,
- proximity proportions for the major exposure groups in Table 26 on page 100
- exposure likelihoods for the major exposure groups in Table 27 on page 101
- partial probabilities of establishment and spread in Table 29 on page 115

have been entered into the computer model provided by BA.

The resulting overall probability of entry, establishment and spread (P_{EES}) calculated by consultants to APAL has a category likelihood of 'Moderate' while that reported in Table 31 on page 124 of the RDIRA report was 'Low'. The midpoints for these category likelihoods differ by a factor of almost three. In other words the model produced a threefold difference in calculated likelihood of entry, establishment and spread for the disease fire blight.

The impact of this is that when combined with the consequences assessed as 'High' the overall unrestricted annual risk obtained using BA's EXCEL model is 'High' while that reported in Table 31 is 'Moderate'.

The RDIRA report erroneously reports the outcome of BA's own model. The effect is to grossly underestimate the overall risk from this bacterium.

7.1.3.2 Restricted Risk

Pages 469 to 476 set out the risk management strategies for Fire Blight which rely on three key quarantine measures – symptom freedom, chlorine treatment and cold storage. These three measures are expected to reduce the likelihood of contamination (Imp 5, Imp 3), bacterial survival during packing procedures (Imp 4) and the likelihood of infection/infestation at picking (Imp 2).

7.1.4 Areas free from disease symptoms

The RDIRA refers to research evidence that sourcing fruit from areas free from disease symptoms would reduce the likelihood that picked fruit is infected or infested (Imp2).

The RDIRA on page 470 notes '*The model indicates that it would change the very low likelihood rating assigned to Imp2 in the unrestricted risk assessment to extremely low.*' However, it is clear that the model makes no indication of this type. For Imp2 to be reduced to this degree a 50-fold reduction in likelihood of infection/infestation for picked fruit is implied by the midpoints of the likelihood categories given in Table 11, page 48. No firm evidence is provided to show that symptom-freedom would reduce the level of infection/infestation (including calyx or surface contamination) to a level in the range 1 in 1,000 to 1 in 1,000,000.

The RDIRA cannot be finalised without clear evidence that this level of reduction can be achieved and how symptom-freedom would do so.

The RDIRA notes that with reduced bacterial populations '*the likelihood that clean fruit is contaminated during picking or transport to the pack house (Imp3) could be expected to be reduced to extremely low*'. However, again the model does not indicate this. On the contrary, path 2 (Table 13 page 57) considers exactly the same scenario, that is, fruit from an orchard where fire blight is not present is contaminated during harvesting and transport to the pack house (Imp3). In the assessment of the unrestricted risk (page 90) Imp3 was given a likelihood of 'very low'. Clearly, other factors being equal, the same value of Imp3 should apply in both these cases. Saying that Imp3 can be reduced depending on making source orchards symptom free, implies that, in contradiction to the draft IRA model, Imp3 is dependent on the individual pathways of Table 13, and hence the presence or absence of *E amylovora* in the source orchard.

It must be acknowledged that either

1. there is an error in the description of the various pathways involving Imp3 and the assumed independence of Imp3 from the specific path, or
2. No impact can be claimed from symptom-freedom on Imp3, because if Imp3 is independent of the "pest-free" status of the orchard, it must be also be independent of the "symptom-free" status of the orchard.

The same error occurs in claiming an impact on Imp5 from symptom-freedom in the source orchard. In assessing the unrestricted risk path 3 (Table 13 page 57) Imp5 was given a likelihood of 'very low', under the implicit assumption in the model that it is independent of the presence or absence of *E amylovora* in the source orchard.

Accepting the assumptions implicit in the draft IRA model of importation pathways, the implementation of freedom from fire blight disease symptoms can only impact on Imp2 and then only when evidence that the impact can reduce the likelihood of infestation to 'extremely low' has been provided. If symptom-freedom does provide a reduction of Imp2 to 'extremely low' then the impact on the overall P_{EES} would be a 1.2-fold reduction with a small impact on the overall level risk which would be remain in the 'moderate' category.

7.1.5 Chlorine treatment

The RDIRA (page 471) notes '…*Chlorine treatment would reduce the likelihood allocated to steps Imp4 and Imp5.*' and '*…the likelihood that the pest would survive on apples following the treatment at the Imp4 stage would become low as compared to the moderate rating in the unrestricted risk….*' No evidence of how the pest management measure would be applied to achieve a 3-fold reduction in the likelihood of the presence of *E amylovora* from 'moderate' to 'low' is provided and none can be deduced from the model.

The same lack of evidence limits the claimed 50-fold impact on Imp5 from 'very low' to 'extremely low', due to chlorine treatment. There is no substantiation for the implication of these reductions that chlorine treatment is in the order of 15 times more effective against infections acquired during processing and packing at the packing house, compared to pre-existing infections. However, at best, if the impact of chlorine treatment as a single quarantine measure can be substantiated, and accepting the reductions proposed to Imp4 and Imp5, then a 4.7-fold reduction in P_{EES} would result under the revised draft IRA model. This would have a small impact on the overall level of risk, reducing it from 'high' to 'moderate', rather than 'moderate' to 'low' as reported in Table 118 on page 471.

7.1.6 Cold storage

The RDIRA (page 472) notes '*…with cold storage alone in place, the likelihood that bacteria would survive routine packing house operations would become low*'. There is no evidence provided that a 3-fold reduction from 'moderate' to 'low' can be achieved nor how the quarantine measure would differ from current (unrestricted) practices.

If the measure could be implemented and the impact on Imp4 achieved under the draft IRA model, there would be a 1.4-fold reduction in overall P_{EES} and a reduction in the overall risk (from the single measure) from 'high' to 'moderate'.

7.1.7 Combined effects of symptom-freedom, chlorine treatment and cold storage

When the three quarantine measures are employed and assuming the claimed efficacy in likelihood reduction is achieved for each measure a systems approach has been proposed by BA to achieve Australia's ALOP.

The RDIRA (page 474-5) claims that Imp2, Imp3, Imp4 and Imp5 are reduced. However, as argued above only Imp2, Imp4 and Imp5 can be reduced by the measures under the assumption implicit in the draft IRA importation model that probabilities such as Imp3 and Imp5 are independent of the specific pathways.

In addition the RDIRA (page 475) suggests '*These likelihoods* [Imp4 and Imp5] *would be further reduced if apples for export were sourced from an area free from disease symptoms.*' This statement is not correct. Imp4 describes the probability a pest will survive processing procedures in the packing house, given the previous steps in the pathway. All other factors being equal, the status of the source orchard may affect the overall number of infected apples entering the packing house, but the model implicitly assumes that procedures and management steps will act on each diseased apple equally once it arrives. In fact, one could mount the argument that if apples are sourced from a symptom free orchard, infections are more likely to be interior to the fruit surface, and thus even less likely to be effected by chlorine treatment. Imp5 is already conditional on the fact that fruit is uncontaminated at the start of processing. For it to be reduced further because of a reduction in Imp2, would be to imply that environmental contamination in the packing house would be reduced. If packing houses were restricted to processing only apples from symptom free areas, this could be true. However this measure is not considered in the restricted risk analysis.

The overall effect of the three quarantine measures is set out in Table 1

Table 7.1 Effect of symptom-freedom, chlorine treatment and cold storage on *E. amylovora*

Step	Unrestricted likelihood	Restricted likelihood
Imp2	Very low	Extremely low
Imp3	Very Low	Very Low
Imp4	Moderate	Very low
Imp5	Very low	Extremely low
PEES	Moderate	Extremely low
Risk estimate	**HIGH**	**LOW**

7.1.8 Conclusion

The risk management measures for Fire Blight proposed by the RDIRA are not supported by evidence in the RDIRA to give a plausible assessment of the import risk. If the measures can be determined to deliver the level of risk mitigation proposed for the relevant import steps in the RDIRA, then based on the evidence presented in the RDIRA and the assumptions implicit in its modelling, Imp 2, Imp3, Imp4 and Imp5 would have the values as set out in Table 1.

At best the level of risk reduction for the pathogen responsible for Fire Blight would be to 'LOW' which is not sufficiently low to meet Australia's appropriate level of protection.

7.2 OTHER COMMENTS

Other groups and/or individuals have reviewed the Import Risk Analysis Model being utilised by BA in all current and future IRA's.
One such review was undertaken on the Banana Draft IRA, and in particular the Risk Analysis Model, by two USDA-APHIS risk analysts. Comments were made to BA by Richard C Dunkle, Deputy Administrator, Plant Protection and Quarantine, on the 20th April 2004.
Ron A Sequeira (National Science Program Leader, Pathway and Risk Analysis) indicated that *"he had concerns about methodology".*

The reviewer goes on *"however, this reviewer notes that these concerns are not linked to the IRA for Bananas from the Philippines alone, but rather the concerns are about assumptions that underlie the methodology.*

The specific concern is about the mapping of ranking criteria to probabilities. There are several assumptions that are of concern but there are also potentially more insidious aspects that are also of concern (eg., concern 2).

Concern 1. Basic Assumptions
First, the assumptions about pest features. The use of a ranking system that establishes discrete criteria to be associated with pest features is not unusual. The USDA, for example, uses a ranking system including numerical equivalents which it then uses to come up with final relative index. The use of such indexing methods assures consistency across applications and also ensures transparency and repeatability. The fact that the assumptions that the same categories apply to all pest types in the same manner is a concern for all such ranking schemes. For example, the difference between a "low' and a "very low" for a nematode may contrast markedly with the same evaluation for an arthropod or vectored-virus. Whereas a low likelihood of spread for a nematode may have a specific significance to a nematologist. And further, the difference between low and very low, may be abundantly clear (say, a nematologist considers low a few meters per year and very low less than 2-3 m per year), it is likely that the categorization is applicable and relative to spread characteristics within the group (Nematoda) and it is likely that an expert (or an expert source) that expresses low spreadability was considering a given nematode within the group and not comparing to the ability of spread for the armyworm noctuid moths (for example). It would appear by inspection that the differences between the categories (low, very low, etc) tend also towards the sui generis. The result of this is that ranking schemes based on pre-assigned numerical values which are then combined into a relativistic index should be taken with a grain of salt, because the ability to compare between the pests (the whole purpose of a relativistic ranking scheme) may be limited to the kind of pests included in the overall list."

The Australian Apple and Pear Industry has similar concerns and this has been previously been expressed to BA but obviously to no avail. More importantly, members of the industry technical panel have raised this issue and as a result it is referenced throughout this document.

Further within the correspondence Ron A Sequeira says *"another concern regards the assumptions about the model. The way that the model is put together (assuming independence of the components and thus the ability to multiply the components together to obtain a final index) may be a concern. I note that the way the pathway is constructed includes a level of detail in some of the components that suggests some of the components are actually sub-components of a whole. The problem here is that the way the model is articulated does affect the outcome. I use the analogy from linear regressions in statistics. A professor usually warns students about the contrived effects of including additional dependent variables. As more variables are added, the "representativity" (eg., the R^2) increases independent of the nature of the variable. The more variables, the "better" the model is a false impression against which students are warned. In a similar way, the more components we can add to a pathway, the lower the risk. This contrivance results from the fact that the model is multiplicative. No matter how we articulate a model, if we add a new component the result will always be lower risk (and vice versa). Even if we have the highest estimators (eg., 0.95) for each individual component, the risk will always tend to low if we multiply 0.95 by itself enough times…the impact of the "many components" effect of course is even greater if some of the components are not "high" but are moderate or low…The use of a multiplicative model is an argument for a careful discussion of how each of the pathway components is independent. Otherwise, the findings (final outcomes) will be biased towards "low" ".*

Again, the Australian Apple and Pear Industry would indicate it has similar concerns by supporting the premise that inappropriate 'sub-components' of a whole pathway

have been included within the model. Also, the process of 'Double Dipping', whereby a component is used more than once within the model eg., good management, chlorine, by using it within two importation steps or two subsets of a step. Throughout the APAL technical report, the areas in which 'Double Dipping' has occurred have been highlighted, and the effect on the outcomes indicated.
We would support the notion that the IRA Model has been utilised within the Apple RDIRA to contrive a result which places the ratings of all pests and diseases at 'VERY LOW' which is within Australia's ALOP.

The reviewer did "*find several specific items that might constitute biases. These items included the translation or mapping of qualitative descriptions to probability estimates. The reviewer also reported that low pest prevalence as a risk management component was considered for some pests of concern, but not others*".

A second scientist, Robert C Griffin (Director, Plant Epidemiology and Risk Analysis Laboratory) made the following assessments.

"The discussion on the Probability of entry, establishment and spread (pg 49) adds the concepts of distribution and transfer to a suitable host to the concept of entry. This may not be incorrect, but goes beyond the IPPC definition of entry. It is far more common for distribution and transfer to be associated with establishment and spread (i.e., entry only involves "crossing the border"). However, the document refers to the "probability of importation" which does not correlate directly with IPPC terms and definitions and can therefore be more flexibly characterized (as it is here)."

Industry would question why BA has gone further than required under the IPPC terms and definitions.

Robert Griffin further indicates *"that the lower end (low to negligible) has greater precision than the upper end (high and moderate). Without understanding the technical justification for the divisions, I would consider combining very low and extremely low, or at least question the rationale for this bias".*

Industry has continually questioned the reasoning for the greater precision at the lower level of the scale (Table 11. Page 48) compared to the upper end. One can only assume it is to establish a bias and achieve a contrived result.

Robert Griffin further states that *"I understand perfectly the rationale behind the table on pg 51 (not numbered?) which assigns quantitative values to the qualitative factors described in Table 9. While this is useful for consistency and to focus any technical dialogue, it may also be dangerous and impractical because it is not linked to evidence and uncertainty. Some caveats exist in the text, but the most serious weaknesses are not discussed. For instance, .001 may not be considered very low depending on the evidence. Likewise, the uncertainty associated with the estimate may be so great as to overlap with the ranges above and below".*
Industry has also within this document questioned the problem with regards the over lapping of ranges above and below.

Given the comments of both the technical experts utilised by the Australian Apple and Pear Industry and independent International experts, BA has no other option but to undertake a complete and immediate review of the Import Risk Analysis Model and associated Methodology.
The Apple RDIRA should be immediately withdrawn and a new document prepared once a new and more appropriate Import Risk Analysis Model is prepared.

REFERENCE:

Dunkle, R L. (2004) Letter and attachment to Biosecurity Australia regarding the Banana IRA. USDA – APHIS: 1 - 12.

SECTION 8: PATHWAYS

8. Pathways

8.1 ENTRY PATHWAY SCENARIO

Pages 51 to 57 of the RDIRA consider the steps in the importation scenario of more particularly the 'biological pathway'. The document indicates that

"Calculation of number of infected or infested apples might be imported during 12 months, No imported (infested) is tabulated in Table 13. This table shows the probability of importation was derived form probabilities attributed to ten individual pathways and that lead to the importation of infected or infested fruit. The pathways, numbered 1 to 10, were obtained from the analysis of the importation scenario in Figure 8."

A more detailed assessment of Figure 8 would indicate that there are more likely 20 to 24 pathways that lead to the importation of infected or infested fruit. This would highlight that the assessment process by the RAP, of the 'biological pathways', has been incomplete and that the pathway scenario is far more complex than detailed within the RDIRA.

One pathway scenario which could result in a high percentage of infected and/or infested fruit reaching Australia and a pathway that is not unrealistic at certain times of the harvest period could be where fruit is harvested and packed as 'off-tree' fruit and is not placed into any form of storage. This is a form of Path 1 being Imp1 x Imp 2 x Imp 4 x Imp 6 x Imp 8.

<u>Scenario</u>

- 'Off-tree' Apples harvested,
- Transported directly to the packing shed,
- hydro-cooled to take out the heat within the fruit,
- within the same day or one or two days after being harvested, be put across the grading equipment and packed, and
- Exported via air freight.

This would mean that the apples could be in the Australian market within a week of being harvested.

Another aspect that could be added to the scenario is that the orchard is an obvious 'hot spot'.

In an unrestricted risk situation the fruit would be 'almost certain' to be infected and/or infested fruit given that *"Fire Blight is endemic in New Zealand's North and South Islands"*.

"This shows that Erwinia Amylovora is present in orchards throughout the major production areas in New Zealand."
(Page 88, RDIRA)

"Fire Blight caused by E. Amylovora is present in all pome fruit production areas in New Zealand, all commercial varieties are susceptible, environmental conditions are

conducive for disease development, and the disease management measures are not fully effective."
(Page 89, RDIRA).

With a likelihood of 'almost certain' the probability becomes 1.

Fruit harvested from orchards will normally be treated with either cold storage and/or chlorine. The RDIRA highlights the Unrestricted Risk with regards cold storage and chlorine practices undertaken in New Zealand.

<u>Cold Storage.</u>
Page 92 of the RDIRA indicates that *"fruits would be kept in cold storage for a short time before they are put through the packing house procedures. The short period of cold storage would not reduce the bacterial population in or on fruit."*

<u>Chlorine Disinfestation.</u>
Page 95 of the RDIRA indicates that *"disinfestation of fruit with chlorine is carried out in most packing houses. Chlorine is used at 15 – 20 ppm in the water dump and 75 – 100 ppm as spray rinse (MAFNZ, 2004)".*

With fruit being treated and packed 'off-tree' the use of chlorine would be the standard pack house procedure and the fruit would not be subject to any cold storage.
Such a scenario will present a very likely and real situation resulting in a large quantity of fruit, infected/infested with one or more of the quarantine pests and/or diseases, entering Australia having received minimal treatment.

8.2 DISTRIBUTION PATHWAY SCENARIO

Pages 58 to 61 of the RDIRA consider the steps in the importation scenario with regards the distribution pattern relating to imported fruit.
Figure 9 (Page 59) endeavours to detail the *"utilization of apple fruit in Australia and generating waste".*
Industry would believe the assumptions made particularly with regards the first two pathways P1 and P2 and misleading and incorrect.

The RDIRA does not define what is considered an urban pack house nor does it delineate between the urban pack house and that of an orchard pack house.
Packing of apples requires some very sophisticated and up-to-date equipment and as a result there would be no urban wholesaler that would have such equipment.
Packing of bulk fruit imported into Australia will be packed by those businesses with the appropriate packing equipment ie., specific apple packing houses like Lenswood Co-operative or the Batlow Co-operative or Orchard based packing houses.
In reality, any packing and/or repacking of New Zealand apples is going to be undertaken in packing facilities within one or more of the Australian apple growing regions.

With regards Figure 9, reference to Urban pack houses should be removed form the right hand side box, as part of Pathway 2 (P2) and transferred to the left hand side box as part of Pathway 1 (P1). This would give a distinct division better reflecting the actual situation of Market Agents/Wholesalers versus Apple Growers/Packers/ Distributors/Category Managers.

Within Australia, between 60% and 70% of apples are sold to the two major retail supermarket chains – Coles and Woolworths. The majority of the apples are supplied

by specific industry based category manager and/or approved growers/packers/ distributors.
If New Zealand was to gain access to the Australian market, it is logical that they would look to target the major retailers particularly on the eastern seaboard markets. To access such markets would be best achieved through the current industry based category managers or approved suppliers.

Given the above mentioned scenarios, it is logical to assume that the higher volumes will enter via Pathway 1 (P1) and the lower volumes via Pathway 2 (P2). Therefore, in Table 14 the proportion of imported apple fruit utilised in urban/orchard based packers and re-packers would be HIGH.

8.3 WASTE STATIONS

With regards waste stations and their proximity to commercial orchards, orchard pack houses, retailers and food processors the IRAT has failed to adequately investigate the situation in the many specific growing regions.
For example:

a) In the Adelaide Hills there are waste stations in relative proximity to one or more of the utility points.
   - Major waste transfer station at Mount Barker (SA) within 5 kilometres of Commercial Orchards, major retail supermarkets and residential areas (Map 159/160, UBD Adelaide, 1997).

b) In Melbourne the following are examples
   - Melbourne Wholesale Market
     Transfer waste station and metropolitan housing within 2 km (Page 2t, Melways 2002, Greater Melbourne).
   - Major Commercial Packing Shed and Category Manager for a retail supermarket chain within 3 kilometres of a waste station (Map 83, Melways 2002, Greater Melbourne).
   - Packing shed and orchard within 2 kilometres of residential housing (Map 214).
   - Packing shed and orchard within 4 kilometres of waste transfer station

   All these facilities would be likely to receive New Zealand fruit and all are major suppliers to one or more of the retail supermarket chains.

SECTION 9: INTEGRATED FRUIT PRODUCTION

9. INTEGRATED FRUIT PRODUCTION

9.1 IFP WITHIN NEW ZEALAND

The IRA and the New Zealand apple industry place a great emphasis on the widespread adoption of Integrated Fruit Production **("IFP")** in New Zealand apple orchards and that only those growers implementing IFP would be registered to export to Australia.

Integrated Fruit Production aims to produce fruit in the most environmentally friendly manner and includes as a centrepiece Integrated Pest Management **("IPM")** principles for control of pests, diseases and weeds. In general, IPM aims to reduce the use of broad spectrum insecticides by employing a variety of strategies which may include:

1. Specific insecticides with low toxicity to other life forms, particularly vertebrates, e.g. insect growth regulators **("IGR").**
2. Population reduction using specific insect sex pheromones for mating disruption.
3. Reduction in the number of sprays used by optimised spray timing based on population monitoring systems and detailed knowledge of the insect's population dynamics. These systems may include trapping of insects in sex pheromone or other traps, direct population estimates on foliage, monitoring of damage levels in developing fruit or day degree accumulation to monitor development of insect life cycle stages.
4. The use of 'economic thresholds'. These are pest levels below which spraying is not cost-effective, i.e. the cost of applying the spray exceeds the cost of the damage prevented.
5. The use of biological control agents such as predators and parasites.

Of these, methods 1, 3, 4 and 5 are widely practised in New Zealand (Shaw *et al.*, 1997). The IFP programme is largely based around the use of an IGR chemical, tebufenozide, for control of the key leafroller pests and Codling Moth (Walker *et al.*, 1997, 1998). Predatory mites are instrumental in control of European Red Mite and Twospotted Mite (Wearing, 1996), and spray thresholds based on various population monitoring systems are implemented for most other pests (Walker *et al.*, 1997, 1998).

IFP has several important implications for quarantine. Compared with the traditional use of broad spectrum pesticides, orchards in which IFP is practised are likely to:

- Have higher and more variable population levels of key pests
- Include a higher diversity of pests

9.2 HIGHER KEY PEST POPULATIONS

There are several reasons why higher pest populations would occur in IFP orchards:

- For biological control to be effective there must always be a host population to support the specific predator or parasite population.
- The economic threshold philosophy virtually ensures there are low (subthreshold) populations of the pest in the orchard.

- Systems based on mating disruption are less effective for reducing pest population levels than broad spectrum sprays and usually result in higher levels of pest damage to apple crops.
- Similarly, specific chemicals such as IGRs may be less effective than broad spectrum chemicals such as organophosphates. However, tebufenozide is a particularly efficacious IGR.

9.3 HIGHER DIVERSITY OF PESTS

The use of pest control strategies targeted specifically to particular key pests, often leads to the emergence of new pests that were formerly suppressed, often unknowingly, by broad spectrum chemicals. These insects were usually recognised only as occasional or minor pests when broad spectrum sprays were in wide use. When these pests are released from broad spectrum control and become significant under IFP programmes, new control strategies need to be developed specifically for them. Such strategies must be compatible with the IFP strategies for all other pests. The result is that IFP becomes increasingly complex and fragile, often with a range of measures that result in suboptimal control of one or more of the pests because of the constraints on the system. Such systems require intensive maintenance and are prone to collapse if one of the key control measures fails due to a perturbation such as the development of resistance to a key chemical in one of the main pests. Often, there are few, if any, alternatives available.

The current pest complex on New Zealand apples features a number of pests that have risen to greater prominence under IFP (Shaw *et al.* 1997, Walker *et al*., 1997, 1998). The most notable of these is Apple Leaf Curling Midge, *Dasineura mali*, which is now one of the main apple pests in New Zealand (Smith and Chapman, 1997.) A similar phenomenon has occurred in organic blocks in New York State (Agnello *et al.* 2000), where *Dasineura mali* developed 'serious infestations'.

However, the New Zealand apple industry is aware of the quarantine risks associated with the implementation of IFP. IFP has been introduced to minimise environmental damage in orchards and surrounding areas, and to meet the demands of consumers worldwide for produce grown in an environmentally acceptable manner. The IFP programme attempts to balance the need to meet strict quarantine regulations on its export fruit with environmental responsibility. To avoid the potential quarantine issues arising from IFP, quite conservative spray thresholds are used to minimise the likelihood of quarantine breaches (Walker *et al*., 1997, 1998).

The foregoing considerations of the potential quarantine significance of IFP in New Zealand apples have been taken into account in evaluating the risks of entry for each pest in this review. This was done wherever possible by using published results of IFP monitoring studies as the base data for this analysis.

9.4 IFP MANUAL

While the IFP Manual has been referenced throughout the RDIRA the industry has not been able to formally access the document to adequately consider the document and the importance of the document in the RDIRA.

A request for access to the IFP Manual has been made to BA (letter to Bill Roberts, 31st May 2004). In a response from Dr Brian Stynes (16th June 2004) BA indicated that *"the IFP manual is the property of the New Zealand Pipfruit Ltd (PNZ).Biosecurity Australia has been informed by New Zealand Ministry of Agriculture and Fisheries that PNZ do not wish to release the document in its* *entirety. They have suggested that the most effective way to handle enquiries would be to direct them to Paul Browne, General Manager of PNZ".*

Based on personal communications, industry is aware that the IFP Manual covers the following pests/diseases:

- Leafroller
- Codling Moth
- Mealybug
- Scale
- Apple Leaf Curling Midge
- Pear Leaf Curling Midge
- Woolly Apple Aphid
- European Red Mite
- Two Spotted Mite
- Froggatt's Apple Leaf Hopper
- Noctuid Moths
- Fuller's Rose Weevil
- Pear Sawfly (Pear Slug or Cherry Slug)
- Lemon Tree Borer
- Pear Leaf Blister Mite
- Black Spot
- Powdery Mildew
- Phytophthora
- Fire Blight
- Summer Rots
- European Canker

In addition the manual has a section which covers insect control for USA market access. As part of the section industry understands that there is a 'zero tolerance for leaf roller in USDA inspection procedures' which requires a high level of leaf roller control within blocks of fruit that will be submitted for inspection.
In addition we understand that including the utilization of the IFP program New Zealand growers are required to use additional treatments for apples submitted for USDA inspection.

Industry also understands that for many pests / diseases there is a requirement to destroy plants that are host sources for pest and diseases either within or outside the orchard.

With regards Fire Blight the IFP Manual requires the removal of alternative hosts and infected plant material from the orchard and in the vicinity of the orchard. Removal of alternative hosts should be within 100 metres of an orchard block.

Unfortunately without access to the complete document industry has been denied the opportunity to offer a full and comprehensive review and report on a document that is considered an integral part of RDIRA.

SECTION 10: METHODOLOGY FOR IMPORT PEST RISK ANALYSIS

10. METHODOLOGY FOR IMPORT PEST RISK ANALYSIS

{Review of the Methodological Aspects of Importation of Apples from New Zealand: Revised Draft IRA Report – February 2004}

10.1 INTRODUCTION

The methodology is described in the RDIRA on pages 37 to 77, "Method for Import Pest Risk Assessment", and consists of three stages. These are Stage 1, "Initiation of this PRA", Stage 2, "Pest Risk Assessment", and Stage 3, "Pest Risk Management". Stages 2 and 3 rely on a risk modelling approach which can be described as Monte Carlo simulation, as implemented in the software package "@RISK", together with inputs elicited from scientific and industry experts. In this report we examine methodological, modelling and implementation issues which are pertinent to both Stage 2 and Stage 3 of the process. We find that the uncertainty in estimates of modelling input have been inadequately and misleadingly modelled, inappropriate assumptions have been made in the modelling, and that conditional probability has been incorrectly applied in a number of important respects. For these reasons, and several other methodological shortcomings which we fully explain in the following sections, the **outcome of the Pest Risk Assessment and Pest Risk Management steps is not scientifically defensible** as it currently stands in the RDIRA.

10.2 DESCRIPTION OF THE RISK ANALYSIS PROCESS

The Pest Risk Assessment, Stage 2 of the Import Risk Analysis, consists of four broad categories. These are (see page 37 of the RDIRA)

- pest categorisation,
- assessment of the probability of entry, establishment or spread,
- assessment of consequences, and
- combining the probability of entry, establishment or spread with consequences to estimate the risk.

10.2.1 General Comments on the Overall Process

Each pest or disease is considered independently, without regard to the number of significant potential threats. Basic probability implies that the risk of a serious disease or pest outbreak increases with the number of significant potential pests or diseases. **The increased risk to the industry due to the combined effect of a number of significant potential pests is not considered.** This is discussed further in Section 10.4.1.

When likelihoods and probabilities are elicited from expert opinion, no account is taken of the fact that people's judgement of unlikely events is generally poor, and quite uncertain[i]. The qualitative likelihood framework used (see Table 11, page 48) instead implies that people are much more certain about negligible, extremely low and very low probabilities than they are about low, moderate or high probabilities, and that as probabilities get smaller, people get more certain about them. **This does not reflect what is known**

about people's ability to judge the probability of unlikely events, and so imputes a precision to these categorical likelihood assessments that is questionable.

We note also that the modelling is conducted on the basis of a unit of one single apple, and the probabilities which constitute model inputs are consequently very low. As pointed out above, people are not able to accurately judge the probability of very unlikely events. In addition, the processes of contamination during importation, exposure to the disease or pest and subsequent establishment of the disease or pest are likely to involve clusters of infested/infected fruit resulting from hot spots of infestation/infection. Probabilities associated with such clusters as cartons or pallets are proportionately larger than that for a single apple, and therefore more easily and precisely estimated, as well as having a more direct relationship to the actual circumstances about which experts are making their judgements. This is further discussed in Section 10.4.8.

10.2.2 Pest Categorisation

Pest categorisation is described on pages 39 to 44, and consists of a process of six steps by which candidate pests or diseases are assessed. At the end of the process, a list of pests or diseases which are thought to require a pest risk assessment are obtained. A critical step, Step 3, (pages 41 & 42), is to assess the likelihood that a pest or disease has the potential to be on the importation pathway for apples coming to Australia from New Zealand. Table 8 on page 42 gives a set of rules for determining whether this is likely or not likely. **However the rules as given are inconsistent, and may result in a single pest being placed in either category under some conditions**. Details are given in Section 10.4.2.

10.2.3 Assessment of the Probability of Entry, Establishment or Spread

For each of the pests or diseases identified in the pest categorisation step, the probability of entry, establishment or spread is assessed, in relation to the importation of New Zealand apples. A general mathematical model is developed for this probability. In this model input variables are related to output quantities by mathematical equations, based on the situation being modelled. The input variables to the model are

(i) the likelihoods or proportions which can be assigned to various scenarios in the chains of events (pathways) which result in either infested/infected or clean fruit entering Australia, and subsequently allowing an exotic disease or pest to become established; and

(ii) The number of apples that will be imported to Australia from New Zealand in each year.

The analysis is repeated for all the pests identified in the pest categorisation step. In each instance, the input likelihoods of the model are adjusted to reflect the particular nature, behaviour and biology of the pest/disease being considered.

The output quantity is a probability of entry, establishment and spread for a pest/disease associated with the importation of apples from New Zealand. The model is broken down into three sections (See pages 45 & 46), the probability of importation, the probability of distribution, and the probability of establishment or spread. Input likelihoods and proportions for this model are based around six qualitative categories (seven if 'certain' is included) detailed in Table 11 on page 48. Although these input likelihoods are derived from expert opinion after reviewing the available scientific literature, **there is no**

attempt to gauge the uncertainty implicit in each input. Inputs are given arbitrary uniform distributions that do not reflect the uncertainty of expert opinion in each case, nor acknowledge that likelihood estimates of the same category may differ in their precision due to varying availability of scientific data. **The output distribution for the probability of entry, establishment or spread is therefore quite arbitrary,** giving a false impression of the variability in the model output. Hence characterising the output probability through **the use of percentiles such as the 50th or 95th, which are dependent on the form of the output distribution, is misleading.** In particular, we show that the **50th percentile significantly underestimates the risk**. These points are explained in detail in Sections 10.4.11.2 and 10.4.12.

10.2.3.1 Probability of Importation

The probability of importation is modelled as a series of importation pathways (See Table 13, page 57) describing the various pathways that an imported apple travels to reach Australia. These pathways are represented implicitly on Figure 8 on page 52. Each pathway is modelled as a series of events, to which a probability is assigned. These events are referred to as importation steps, and numbered from 1 to 8. The likelihoods associated with each importation step are referred to as Imp1 to Imp8. The probability of a pathway is computed by multiplying the probabilities associated with each importation step on the pathway (See Table 13, page 57). The summation of the probabilities associated with the ten pathways associated with infested/infected apples arriving in Australia, gives the overall probability of importing an infested/infected apple. For each pest, each importation step must be assigned a likelihood through expert review of the available scientific evidence.

There is no clear acknowledgement in the documentation (pages 51 to 57) that the probabilities attached to each importation step must be conditional probabilities in order for the multiplications of Table 13, page 57, to be valid. That is each likelihood from Imp2 to Imp8 must be specified conditionally upon the previous importation events in its pathway. For example, the Imp3 of Path2 is conditional on the pest being absent from the source orchard, while the Imp3 of Path6 is conditional on the pest being present in the source orchard. Since importation step 3 is the event that clean fruit is contaminated by the pest during harvesting and transport to the packing house, this must depend on whether the pest is present in the source orchard. This point is taken up in Section 10.4.6.
Additionally, this lack of appreciation of the conditional nature of the probabilities may lead some experts to underestimate the likelihoods.

The calculation of the probability of importation is made under the assumption of independence (see page 56, including footnote 17). However many infestation and disease processes occur in clusters, or hot spots. While it is possibly true that this will have little impact on the average proportion of diseased or infested apples, **the occurrence of clusters of diseased apples will significantly increase the variability in this proportion.** The risk associated with importation must therefore be increased as a consequence. This is further discussed in Section 10.4.5.

10.2.3.2 Probability of Distribution

The model for probability of distribution is outlined on pages 58 to 66. The distribution network is divided into utility points, namely urban and orchard packing houses, fruit processors, retailers, the food service industry and consumers, as shown in Figure 9 on page 59. Proportions P1 to P13 represent the proportions of imported apples that follow the pathways defined in Figure 9. The proportion of imported apples discarded as waste at each utility point are computed as in Table 14 on page 61, once again representing the multiplication of conditional probabilities (referred to as proportions) along each pathway leading to waste. This aspect of the model depends on the sound choice of input parameters, P1, P3, P6, P7, P9 and P10, the ability of the model to truly reflect the actual distribution network, the correctness of assumptions that allow some pathways to be designated low risk and so ignored in the analysis, and the assumption that only waste apples are implicated in the distribution of pests or disease. This last assumption is clearly incorrect in the case of flying insects. The input parameters (P1, P3, P6, P7, P9 & P10) should be determined by industry experts, supported by actual sales figures, if available. **The document gives no detailed justification for assigning these proportions**, saying only that they were discussed at an industry stakeholder meeting, and this discussion was considered. The discussion in Section 10.4.11.1 about **uncertainty being incorrectly handled in the input proportions and likelihoods** is also applicable to this part of the model.

10.2.3.2.1 Assumption of Independence

On pages 62 to 64, four steps in the calculation of the probability of distribution for each exposure group are explained by way of a hypothetical example. These steps are summarised in Tables 15 and 16, on pages 64 and 65. In step 4 on page 63, the probability of exposure resulting from a number of infected apples is computed as if each infected apple acted independently. **The assumption of independence here is questionable**, as infested/infected apples may often occur in clusters, and **the impact of discarding a cluster of infested/infected apples has not been considered**. In many cases, this may greatly increase the probability of the pest or disease being transferred to a susceptible host. As the RDIRA itself states on page 66, “It is important that establishment or spread begins with the assumption that a sufficient or sustainable number of pests have been transferred to a suitable site on a susceptible host plant (as described in the Probability of Distribution)”. This is further discussed in Section 10.4.5.

10.2.3.2.2 Single Apple Modelling is Problematic

The fact that the RDIRA bases its modelling on a single apple is also problematic. As the RDIRA states on page 68, “Minimum population needed for establishment-if possible, the threshold population that is required for establishment should be estimated.” It is unlikely that this threshold population will be reached, for many pests, by the discard of a single apple. This may be why the value “negligible” (in most cases) is given to the input likelihood for the probability that exposure of susceptible hosts within the exposure group would result from the utility point discarding a single infected apple. It is quite conceivable that were experts asked to consider the likelihood of exposure in the context of a cluster of waste apples, or indeed an entire shipment for the case of flying insects, these likelihoods would be considerably higher. This is further discussed in Section 10.4.8.

10.2.3.2.3 Inappropriate Model for Insect Pests

The model for distribution and generation of waste apples is given on pages 58 to 61, and summarised in Figure 9 on page 59 and Table 14 on page 61. This model is inappropriate for gauging the exposure of susceptible plants to pests such as flying insects which may escape from a consignment of apples at any stage of the distribution network, without requiring infested apples to be discarded as waste. The RDIRA acknowledges this saying, “… the possibility of an insect flying out early in the distribution pathway has been accommodated in the waste calculation”. However no specific details of the accommodation have been given, other than to say it involves “allocating likelihoods to determine the number of waste units that come near susceptible host plants”. Examination of the Unrestricted Risk Input Tables[ii], shows no evidence that this has been done. This is fully discussed in Section 10.4.9.

10.2.3.3 Probability of Establishment or Spread

The probability of establishment and the probability of spread were assessed separately, then combined with the rules given in Table 12, page 50. Each probability is assessed through expert opinion and supported by the available scientific evidence, and is detailed in the Pest Risk Assessment for each pest considered. There are several methodological factors that are problematic in this step.

- The use of Table 12 **incorrectly reduces the uncertainty** inherent in the result (See Section 10.4.13).
- The use of Table 12 implies that the likelihoods are multiplied. This in turn implies that spread is conditional on establishment of the pest in an exposure group**. This does not seem to have been taken into account**, for example, in the assessment of the partial probability of spread for wild and amenity plants for Fire blight. This is judged to be low (p115), without any clear discussion of why wild and amenity plants should be considered differently to the other classes of plants, ***once the pest has become established***.
- The probability actually computed is the probability of establishment ***and*** spread, not the probability of establishment ***or*** spread (See p7, quote from Quarantine Act 1908). **The probability of establishment AND spread must be less than, or at most equal to, the probability that a pest will be established OR spread**, which is simply equal to the probability of establishment.

10.2.3.4 Annual Probability of Entry Establishment or Spread

The annual probability of entry, establishment or spread is calculated from the probabilities for each exposure group of establishment or spread, multiplied by the partial probability of distribution for that exposure group, according to Table 17 on page 69. Implicit in this computation is that the probability of establishment or spread is conditional on the probability of distribution to each exposure group. The comments in Section 10.4.6 concerning experts' estimation of conditional probabilities also apply here.

10.2.4 Assessment of consequences

Consequences are assessed against a number of criteria by giving them an impact score from A to G, after assessment of consequences at either a local, district, regional or national level. Consequences for each criterion are combined using a set of rules (pages 73 & 74) to give the overall impact, ranging from extreme, through high, moderate, low and very low, to negligible. While such a scheme may be open to argument upon the grounds of political or economic value judgements and whether those reflected in the proposed method are appropriate, this is beyond the scope of this methodological analysis. Standard economic modelling of utility could be adapted to give a more rigorous treatment of the consequences which would allow integration with economic modelling on industry impacts (See for example Aven[i], 2003, p30).

10.2.5 Combining the probability of entry, establishment or spread with consequences to estimate the risk.

The annual probability of entry establishment or spread is combined with the consequences determined for the introduction of a pest or disease using Table 19 on page 76. The construction of Table 19 reflects political and economic value judgements which are beyond the scope of this methodological analysis. The approach presented is unsophisticated. There is a large body of risk modelling literature which establishes how utility and probability combine within a more rigorous mathematical framework[i].

A major methodological problem with the approach of the RDIRA is that the uncertainty in the probability of entry, establishment, or spread generated through Monte Carlo simulation is effectively discarded without proper consideration. The probability of entry, establishment, or spread is computed by the Monte Carlo simulation as a probability distribution. This distribution, if input likelihoods and their uncertainties have been correctly elicited, embodies the uncertainty associated with a point estimate of the probability of entry, establishment or spread. This uncertainty is not considered in Table 19, and **the percentage probability that the risk could be substantially greater or less than the overall risk reported is not given**. This is further discussed in Section 10.4.13.

10.3 PEST RISK MANAGEMENT

If the overall risk category for a particular pest or disease is higher than Australia's Appropriate Level of Protection (ALOP) (defined as very low risk in Table 1 on page 10), then various measures are introduced to lower the input likelihoods, and the modelling is repeated incorporating these restrictive measures, until Australia's ALOP can be satisfied with minimally restrictive measures. This is summarised on page 77 of the RDIRA. For each pest or disease whose overall risk was judged to be low or higher, the RDIRA seeks to justify in reference to the scientific literature and expert opinion, the lowering of specific input likelihoods in response to particular management measures. This is documented in the section “Risk Management for Quarantine Pests”, beginning on page 467. In the risk management discussion for Fire Blight (Erwinia amylovora), on pages 468 to 476, **there are two methodological problems that both result in significantly underestimating the restricted risk.** An error has been made which consists of failing to acknowledge that probabilities associated with importation steps four and five (Imp4 & Imp5) are conditional on prior steps in the importation pathway. **They will not be reduced by sourcing apples from symptom free orchards, as claimed**. This is discussed fully in Section 10.4.4. Secondly, the value for Imp4 given in Table 122 has itself been under reported. This is due to a misunderstanding of the fact that the reduction in likelihood due to dropping from moderate to low in two multiplied likelihoods, does not necessarily imply a drop from moderate to very low in the result. **This results in underestimating the value for Imp4** in Table 122, and is discussed in detail in Section 10.4.3.

10.3.1 Restricted Likelihood for Verification Inspection.

In the section of the RDIRA referring to “Risk management for Quarantine Pests” (pages 467 to 492), the verification inspection is introduced for the pests Apple Leafcurling Midge (pages 482 to 483), Leafrollers (page 484) and Wheat Bug (pages 486 to 489). Inspections take place either in New Zealand (importation step 6) or Australia (importation step 8). A rejected consignment will contain both infected/infested apples and clean apples. Thus the effects of verification inspection apply to both infested/infected and clean fruit, not just the former. For simplicity in the modelling, inspection is assumed to be at the final step applying to both infested/infected and clean fruit. The probability of acceptance of a consignment will depend on the proportion of infested/infected apples in the consignment, their distribution through boxes and pallets, and the sampling scheme. According to the RDIRA, the introduction of verification inspections justifies changes to likelihoods for importation steps 6 or 8 (see pages 482, 484, 486 and 488). **However the effect of inspection is substantially overestimated in the RDIRA**. This is due both to a methodological misunderstanding concerning the effect of inspection on the proportion of infested/infected apples which are imported, and to a failure to consider clustering in the occurrence of infected/infested apples. Section 10.4.10 discusses both of these points in more detail.

10.4 DETAILS OF METHODOLOGICAL, MODELLING, AND IMPLEMENTATION PROBLEMS

10.4.1 Separate Treatment of Pests and Diseases

The risk assessment strategy treats each disease or pest of importance separately. But if we look at the risk of an adverse effect on the industry, the number of significant pests or diseases is an important consideration. One may argue that if there are more significant pests or diseases that must be protected against, the allowable risk associated with each individual pest or disease must be lower in order to maintain Australia’s ALOP for an industry sector. For example if there are five significant disease threats for industry A, and 20 significant disease threats for industry B, and assuming a probability of 0.001 (high end of very low) for each of them, the probability of a significant disease event in industry A is $1 – (0.999)^5 = 0.005$. However, for industry B it is $1 – (0.999)^{20} = 0.02$. Assuming the same economic consequence for the introduction of any of the pests or diseases, the risk for industry B is approximately four times as great. **The allowable level of risk for each pest**

or disease must be adjusted according to the number of significant potential pests or diseases in order to maintain an appropriate level of protection for an industry as a whole.

10.4.2 Pest Categorisation

Table 8 on page 43 defines the potential of a pest for being on the pathway. The criteria for this to be 'not likely' are not consistent. For example, if a pest is not found on mature apple fruit, but has been intercepted on fresh fruit exported from New Zealand, then the rules given place that pest in both categories. Common sense here indicates that such a pest should go in the 'likely' category, however this inconsistency opens the possibility that some pests may have been incorrectly assigned to 'not likely' instead of 'likely', and so may have been omitted from the risk assessment in error. At the very least, **the criteria in Table 8 should be made consistent (e.g. by substituting 'and' for 'or' in the criteria for 'not likely'), and the pest categorisation process reviewed for pests that may have been missed** due to this inconsistency. The rules of logic also imply that criteria (ii) for 'not likely', "no life stage associated with apple transportation including packaging and pallet materials", should have a corresponding criterion in the 'likely' category. That is, if a pest has a life stage associated with apple transportation including packaging and pallet materials, it should be considered in the 'likely' category. This is simply a consequence of there being two categories, and each case must be in one or the other category.

10.4.3 Likelihood Category Reductions in Risk Management for Fire Blight

The impact of a risk reducing method, such as the introduction of chlorine baths, certification of symptom-free areas, or cold storage are assessed individually, and the relevant input likelihood is reduced. For example, in the restricted risk analysis of Fire Blight (see pages 468 to 476), the introduction of chlorine treatment is judged to reduce the input likelihood 'Imp4' from moderate to low. The introduction of cold storage measures is judged to reduce the input likelihood of 'Imp4' from moderate to low also. If we take the mid points of the ranges associated with these likelihood categories, this represents a reduction of the likelihood by 2.86 times. Looking at the extremes of the range, the possible reduction is no reduction to 14 times reduction. The logic of the RDIRA seems to be that if each measure reduces the likelihood by a qualitative category, then two such measures combined will decrease the resultant likelihood by two categories. However this does not necessarily follow. If the first measure implies a reduction of 2.68 times, and the second measure implies a reduction of 2.68 times, then their combined effect, assuming they act independently, is a reduction of 7.2 times. If we take into account the extreme possibilities of the ranges, then the reduction may be from no reduction to 14*14= 196 times. However the implied reduction in likelihood in going from moderate to very low is, based on the midpoints of the ranges, 0.5/0.0255 = 19.6 times, with a possible range of 0.3/0.05 = 6 to 0.7/0.001 = 700 times. In other words, the reduction in likelihood in going from moderate to very low is almost three times greater than would be expected based on two independent likelihoods being reduced from moderate to low, and then combined independently, and may be up to six times greater if one considers the extremes of the ranges. Therefore it is an error to reduce the input likelihood by two categories of qualitative likelihood because acting separately two measures each reduce it by one category. In the example considered, after the appropriate reduction, based on the midpoints, the likelihood will be 0.5/7.2 =0.07. This is in the low range of Table 11 on page 48, rather than the very low range as stated in the RDIRA in Table 122 on page 474.

10.4.4 Conditional Probability Error – Risk Management for Fire Blight

On page 475, in the restricted risk analysis for Fire Blight, the RDIRA makes the statement "These likelihoods would be further reduced if apples for export were sourced from an area free from disease symptoms". The statement is in reference to likelihoods Imp4 and Imp5, and justifies changing the restricted risk from very low to extremely low for Imp4, and from extremely low to negligible for Imp5. However the statement is incorrect, as the likelihoods Imp4 and Imp5 are conditional on the prior steps of the importation pathway. Thus Imp4, the probability that a pest survives routine processing in the packing house, is conditional on the fact that the pest has arrived at the packing house. The pest free status of the orchard may affect the number of infected apples reaching the packing house, but it can have no influence on the likelihood of the pest/disease surviving the packing house procedures, once a diseased apple arrives there. The impact of sourcing apples from symptom free areas is already taken into account by reductions to likelihoods earlier in the pathway (Imp2 and Imp3). Imp5 is already conditional on the fact that fruit is uncontaminated at the start of processing. For it to be reduced further because of a reduction in Imp2, would be to imply that environmental contamination in the packing house would be reduced. If packing houses were restricted to processing only apples from symptom free areas, this could be true. However this measure is not considered in the restricted risk analysis.

10.4.5 Assumption of Independence in Probability Model

On page 56, the RDIRA describes how the probability of importation is used to calculate the proportion of imported fruit that may be infected or infested with a particular pest. The modelling used assumes that the infection status of an individual apple is independent of other apples. It is noted in footnote 17 on page 56 that the assumption of independence is not always appropriate, but that this can be over looked because the volume of imported apples is likely to be large. While footnote 17 is correct with respect to proportions, it over looks the fact that the assumption of independence may seriously over estimate the precision to be attached to the estimate of the proportion of infected fruit imported.

For example, if infections occur in batches of M apples, such that either all the apples in a batch are infected or not infected, then the variance in the number of infected apples under a binomial infection model is multiplied by M. A beta-binomial model is typically used to account for the inflation of variance due to clustering of infection/infestation (see for example Hughes & Madden, 2002[iii]) The consequence for the model is that greater uncertainty is introduced. The probability of establishment or spread may therefore be significantly greater than that estimated.

The same issue arises again in step 4, page 63, in reference to the probability of a host plant becoming exposed to a pest. It is almost certainly not the case that the probability of exposure from *n* infected apples in the one place at the same time is equal to the probability of exposure from *n* infected apples at *n* different times and places. The approach taken in the RDIRA overlooks this distinction, which is related to the problem of the infection "hot spot" which may significantly increase the probability of establishment and spread.

10.4.6 Conditional Probabilities in Pathways

In general, for likelihoods to be multiplied together as in Table 13 on page 57, and Table 14 on page 61, they must be conditional probabilities (see for example Grimmet &Welsh, 1986[iv], or Vose, 2000, pages 36-37[v]). That is, they must be calculated assuming that each prior step on the pathway has already occurred. This important distinction has not been adequately explained in the RDIRA. It is particularly important that experts who are assessing input likelihoods are clear on the implication of this, as the tendency may be to underestimate a conditional probability of an already unlikely event, simply because it is unlikely. This is, however 'double counting', a mistake already discussed in Section 10.4.4, in reference to the restricted risk analysis of Fire Blight.
The conditional probabilities along each pathway imply that **many of the importation steps may have not one, but several different values, depending on which pathway is being considered.** This is not recognised in the RDIRA, and is a **serious methodological error**. In estimating the likelihoods of the importation steps, experts should be considering each different pathway, and firstly deciding whether the probability is the same or different for the different pathways, before estimating the likelihood associated. For example, Imp3 for paths 2, 3, 4 and 5, assumes that the pest is present in the source orchard, while Imp3 for paths 6, 7, 8 and 9 must assume that the pest is not present in the source orchard. Similarly, Imp5 and Imp7 are likely to be path dependent. Since Imp3 represents the probability that a clean apple will be infested or infected during harvesting and transport to the packing house, this probability will be affected by whether the pest is present in the source orchard or not. Imp3 in the restricted analysis will also depend on whether fruit is sourced from a symptom free orchard, or from a designated symptom free block within an otherwise infested orchard. (See page 469 of the RDIRA). This may also affect Imp5, and Imp7.

10.4.7 Conditional Probability of Exposure

The probability of exposure should be conditional on the pest arriving at the utility point. (Table 27 on page 102, Table 33 on page 135, Table 39 on page160, Table 45 on page 183, Table 51 on page 205, Table 57 on page 229, Table 63 on page 254, Table 69 on page 275, Table 75, page 303, Table 81, page 328, Table 87, page 350, Table 93, page 372, Table 99, page 396, Table 105, page 418, Table 112, page 452). Probabilities of exposure are given as negligible in most cases, and it appears that they may have been estimated on an overall basis, rather than on the correct conditional basis. That is, one must assume that a diseased apple is discarded at the utility point, and assess the probability of exposure assuming that this is the case.

10.4.8 Modelling Based on a Single Apple

The assessment is based throughout on probabilities and likelihoods related to a single apple. However this obscures and misrepresents some of the major processes relating to the establishment and spread of a pest or disease. For example, it is most unlikely that infested or diseased apples will occur evenly distributed among the apples which are imported as is assumed in the RDIRA (see, for example, Hughes & Madden, 2002[iii], and also Section 10.4.10). They are most likely to occur in a cluster, as a carton, a number of cartons, or a pallet load of fruit originating from the same orchard and packing house.

Disease processes are likely to be strongly influenced by such clusters of infested/infected fruit, and these influences should be taken into account in the modelling. It may also be argued that it is much more realistic to ask an expert to judge the likelihood of disease or pest establishment given that such a cluster of diseased or infested apples arrives at a utility point. Such an approach would lead to more accurate assessment of likelihoods for two reasons. Firstly, modelling based on aggregations such as cartons or pallets better reflects the actual mechanism of disease or pest occurrence and spread. Secondly, likelihoods associated with cartons or pallets will be larger, and so more easily and accurately assessed[i].

10.4.9 Flying Insects Not Correctly Modelled

The model for distribution and generation of waste fruit given on pages 58 to 61, and summarised in Figure 9 on page 59 and Table 14 on page 61 is inappropriate for gauging the exposure of susceptible plants to pests such as flying insects. These pests may escape from a consignment of apples at any stage of the distribution network, without requiring infested apples to be discarded as waste. Infested apples from all streams, whether waste or not, can potentially harbour flying pests that can be released upon unpacking given suitable conditions. For example a container of apples can release insects when opened at a dock or freight depot. Cartons and pallets may also discharge flying insects at packing houses and retailers, and individual apples may allow discharge of insects after purchase by the consumer, again regardless of whether the apple has been diverted into a waste stream. A more appropriate model here (assuming modelling based on a single apple – but see criticisms in Section 0) is to consider, for an infested apple, the likelihood that adults will emerge and fly away at each stage of the distribution network. The waste streams are still required in the model, for they determine the number of apples that reach each point in the distribution network. The number of adults that emerge and fly off at each utility point could then be calculated from the number of infested apples arriving at each utility point or utility point waste stream, multiplied by the likelihood of the adults emerging at each utility point or utility point waste stream given the arrival of an infected apple. Note that likelihoods of adults emerging from the waste streams and non waste streams at each utility point may well differ. The modelling could then continue with this number multiplied by the "$\text{Proximity}_{\text{Utility point near exposure group}}$" to replace "$\text{Waste units}_{\text{from utility point near exposure group}}$" in Table 16 on page 65. While these adjustments to the model would appear to be trivial to implement, their lack may have a profound influence on the accuracy of the modelling.

The RDIRA acknowledges on page 65 that "…an insect may fly out during transport of apples, or when pallets or boxes are opened at wholesalers or retailers, and find a susceptible host." It then adds, "…that fact, where relevant, was taken into consideration in allocating likelihoods to determine the number of waste units that come near susceptible host plants. That is the possibility of an insect flying out early in the distribution pathway has been accommodated in the waste calculation".

However the details of this accommodation have not been given. Making such adjustments to the likelihoods of waste streams, in fact, would alter the accuracy of the rest of the model, which would then no longer accurately reflect the proportions of apples arriving at the different utility points. In any case, eliciting the appropriate correction from entomological experts would be problematic, as the correction they would be asked to estimate has no connection to the reality of the situation. Likelihoods of adults emerging at the different utility points and their waste streams, on the other hand, could much more reliably and accurately be elicited (especially if cartons or pallets are considered), because this model more closely corresponds to the actual situation.

According to Table 15, page 64, the quantity of imported apples that are discarded is given by the number of imported apples which are infected multiplied by the proportion of imported apples that are channelled to a utility point and subsequently discarded. Therefore, if the approach of the RDIRA is followed, the proportions P3, P7, P10, and P12 (see pages 59 to 61, and Table 14, page 61) should be adjusted to reflect that all fruit reaching the utility point, not just that which is discarded, is a potential source of flying insect pests. However examination of the Unrestricted Risk Input tables, "Importation of Apples from New Zealand (Revised Draft IRA Report February 2004): Unrestricted Risk Input Tables" shows these input proportions are exactly the same for all pests. It appears that no adjustment has been made for flying insects. **Without such an adjustment, the probability of distribution of these pests will be significantly under-estimated.**

10.4.10 Effects of Inspection

Verification inspection as a risk management measure is discussed on pages 482 to 484 and pages 486 to 489 of the RDIRA. **The effects of inspection are overestimated because of (i) methodological errors and (ii) the likely clustering of infested/infected apples which has not been taken into account. As a result, restricted likelihoods have been underestimated in the RDIRA.**

The RDIRA assesses the effect of verification inspections for the pests Apple Leafcurling Midge (pages 482 to 483), Leafrollers (page 484) and Wheat Bug (pages 486 to 489). For Wheat Bug the likelihood for importation steps 6 or 8 (but not both) is reduced from the unrestricted likelihood estimate of high to the restricted likelihood of very low (Table 129, page 483). Using midpoints of likelihoods (Table 11, page 48), 0.85 for high, 0.0255 for very low, the implied effect of inspection is to reduce the likelihood for step 6 or 8 by a factor equal to 0.0255/0.85 or 0.03. We will show below that this is a substantial overestimate of the effect of inspection.

The effect of inspection can be found using various assumptions. One assumption is that the inspection is 100% effective with no error and this depends on the nature of what is being inspected and how. No inspection error is assumed for Leafcurling Midge and Wheat Bug but not for Leafrollers (see pages 482 and 483, 484, 486 respectively). Another assumption depends on the distribution of the infested items throughout the consignment and whether this is random (homogeneous) or clustered. The report assumes (page 482) that "Verification inspection of fruit is to inspect 600 units of randomly selected apples from a *homogeneous* consignment (or lot)."

The report assesses the effect of inspection (pages 482 & 483) as follows, "This would provide a confidence level of 95% that not more than 0.5% of the units in the consignment are infested/infected by the pest." This statement does not imply that values of the restricted likelihoods should be reduced, as the RDIRA states they should be, compared with the unrestricted likelihoods. We provide an argument below.

The confidence level statement in the paragraph above is associated with the following argument. Let t be the probability that an apple is infested by the pest or the proportion of infested apples in a consignment. If 600 apples are selected from a consignment then the consignment is accepted if there are no infested apples in the sample of 600. Assuming apples are independently infested with probability equal to *t*, an assumption equivalent to the homogeneous consignments assumed by the RDIRA, then the probability of accepting the consignment is $(1-t)^{600}$, an approximation which holds provided the consignment size is sufficiently large relative to 600. When *t* = 0.005 the probability of accepting the consignment is 0.05 and when *t* is greater than 0.005 this probability is less than 0.05. However, acceptance of the consignment implies infested/infected apples are present in the consignment. If the consignment size is large compared with 600, and this would generally be the case and we assume this, then **knowledge that no infested/infected apples are to be found in a sample of 600 does not change the proportion or probability of the apples in the remaining part of the consignment being infested/infected from *t*.** (See for example Vose, 2000, pages 361 to 364 for a discussion on sampling to assess disease prevalence[v])

What is changed by inspection is the distribution of *t* over consignments which are accepted. If every consignment had the same value of *t* then the value of *t* would not be changed by inspection. Accepted consignments would satisfy the condition that no infested/infected apples were found in the sample of 600.

The effect of inspection can be applied at importation step 8 or step 6 (page 54). We will assume it is step 8 but similar results hold if inspection is applied at step 6. Suppose *t* is the probability that an individual apple is infested/infected prior to step 8 (this can be found by adding all the probabilities for the 10 pathways on page 57 except that Imp 8 is omitted from all calculations) then we can take this probability as the proportion of infested/infected apples in a consignment. Suppose *t* varies over consignments with distribution p(*t*) then the effect of inspection is to change this distribution to

$$\mathrm{p}(t)(1-t)^{600} \Big/ \int_0^1 \mathrm{p}(t)(1-t)^{600}\,dt$$

This follows by applying conditional probability (see for example Lindley, 1997[vi]) as follows.

The expression above is p(*t* | acceptance), that is the distribution of *t* assuming the consignment has been accepted. We have

$$\mathrm{p}(t\,|\,\text{acceptance}) = \mathrm{p}(\text{acceptance}\,|\,t)\mathrm{p}(t) \div \mathrm{p}(\text{acceptance})$$

and

$$\mathrm{p}(\text{acceptance}\,|\,t) = (1-t)^{600}$$

and

$$\mathrm{p}(\text{acceptance}) = \int \mathrm{p}(\text{acceptance}\,|\,t)\mathrm{p}(t)\,dt$$

giving the result above.

The effect of inspection is to be found by comparing p(*t*), which is the distribution before inspection, with p(*t* | acceptance), the distribution after inspection. A possible way is to compare the mean of these two distributions and consider the ratio of the latter to the former as the effect of inspection and then to multiply the unrestricted likelihood by this ratio to obtain the restricted likelihood for step 8. We illustrate this below.

For Wheat Bug, using the midpoint values for the qualitative likelihoods in Figure 43, page 446, we obtain t = 0.0038 and the following analysis shows the possible effect of inspection at importation step 8. We assume a distribution for t which takes the values 0.0025 and 0.005 with equal probability, giving a mean of 0.00375.

When the value of t is 0.0025 then the probability of accepting the consignment is 0.22, and, as above, when the value of t is 0.005 then the probability of accepting the consignment is 0.05.

The effect of inspection is found by the above result for p(*t* | acceptance) but using summation instead of integration. Then we find that p(*t*=0.005| acceptance) is equal to 0.05/(0.05+0.22) or 0.19, and p(*t*=0.0025| acceptance) is equal to 0.22/(0.05+0.22) or 0.81 with mean value of t after acceptance equal to 0.00290. Thus the effect of inspection is to change the mean value of t , the proportion of infected apples in the consignment, from 0.00375 to 0.00290, giving the effect of inspection as the ratio 290/375 or 0.77.

The estimated effect here of inspection is to multiply High (midpoint 0.85) by 0.77 to give a likelihood value of 0.65, in the moderate range, not very low as in the RDIRA.
This result therefore suggests that in Table 133 for Wheat Bug the effect of inspection to change the unrestricted likelihood for step 8, Imp 8, from high to the restricted likelihood value very low is incorrect and moderate is a more appropriate value.

For Apple Leafcurling Midge using likelihoods from Figure 17, page 153, and the midpoint likelihood analysis for the ten paths leading to importation step 8 as above, we obtain t = 0.072. Then the probability of accepting the consignment using the formula $(1-t)^{600}$ implied by the RDIRA is 3.4e-20, so that no apples would be imported if inspection were applied at importation step 8 as all would be rejected at the inspection stage. For Leafrollers using likelihoods from Figure 23, page 221, and the midpoint likelihood analysis for the paths leading to importation step 8 as above, we obtain t = 0.034. Then the probability of accepting the consignment using the formula implied by the RDIRA is $(1-t)^{600}$ and it is estimated as 9.7e-10, so that no apples would be imported if inspection were applied at importation step 8, as all would be rejected at the inspection stage. However, in this example the RDIRA states (page 484) that inspection does not lead necessarily to 100% detection but the RDIRA gives no evidence for the size of the likely inspection error. What is required is the probability that an apple is infested and when inspected it is detected correctly but this is not given. Thus it would appear that if a consignment were to be accepted it would be on the basis of inspection error and consequently the effect of inspection is impossible to determine for this case. There is no evidence in the RDIRA to provide a value for the restricted likelihood for importation at step 8 and therefore should take the same value as the unrestricted likelihood, high, and not low as in the RDIRA (Table 130, page 484).

The combined effect of inspection can be considered for the pests mentioned here. If apples are infested independently and we ignore Leafrollers because of unknown inspection error, then using midpoint values of the qualitative likelihood categories implies that the probability that an apple is not free of both Wheat Bug and Apple Leafcurling Midge is equal to 1- (1- 0.00375)x(1- 0.072) or 0.0755. This gives the probability of acceptance equal to 3.5e-21. **This implies that no consignments of apples would be accepted under the RDIRA's inspection scheme.**

The assumptions of the RdIRA can be questioned further with respect to whether the consignment is homogeneous with respect to the distribution of infested apples (see last line, page 482, for example). For pests it is reasonable that infested apples will be clustered within cartons, which results from apples picked from the same tree or hot spots of infestation/disease in the orchard or packed at the same time and place. If one assumes that 600 apples are sampled by sampling 6 cartons of apples, each with 100 apples, and that apples are infested or not uniformly within cartons then the sample of 600 apples becomes a sample of 6 cartons. The value of *t* remains the same but the effect of Inspection is now given by the probability of acceptance as $(1 - t)^6$ which has the value 0.970 for t=0.005 and 0.985 for t=0.0025. As the value $(1 - t)^6$ is very similar for both values of *t* the effect of inspection is negligible and consequently the restricted likelihood is little changed from the unrestricted likelihood value, High. This will be true for a wide range of small values of *t* as well so this result will hold generally under these assumptions.

The sampling scheme could be to sample 600 boxes and one apple from each box, with boxes randomly selected from the consignment, and then the original formula $(1- t)^{600}$ would be obtained and the theory above would apply.

The analyses above represent cases depending either on the assumption of homogeneity in the distribution of infested/infected apples within a consignment, or its lack thereof. Generally, the sampling scheme for inspection would reflect what is actually known about the heterogeneity of the distribution of infested apples and be carried out in a stratified manner, sampling pallets, cartons and apples. The RDIRA indicates that only the homogeneous case has been considered which is in error as there is likely to be heterogeneity.

A similar argument could be constructed for inspection in New Zealand before transportation with similar conclusions for importation step 6.

Thus the RDIRA has not considered the effect of verification inspection appropriately in two respects as described above. In the first, the correct theory has not been explained and seen to be applied correctly and in the second, no account of possible clustering or heterogeneity of infested apples has been considered.

In conclusion, the RDIRA overestimates the effect of inspection on the likelihoods for importation steps 6 and 8. In Tables 129 (page 483), 130 (page 484), 132 (page 486), 133 (page 487), 134 (page 134) the restricted likelihoods for importation step 6 or 8 should be no smaller than moderate whereas the RDIRA gives these values as low or very low. These likelihoods are based on the assumption that apples are imported and using the RDIRA's sampling scheme appropriately it is suggested that no consignments would be accepted for importation.

10.4.11 Handling Uncertainty

A major criticism of the model, and one that severely diminishes its usefulness, is the failure to correctly and consistently handle the uncertainty that should be attached to the model input likelihoods and proportions. This inadequacy is carried through the simulation, and results in an arbitrary output distribution which does not adequately reflect the underlying science, or the certainty about model inputs in judgments elicited from experts.

For example, suppose it is known that in a given region a pest is ubiquitous so that all orchards are infested/infected and this region contributes 25% of apples exports to Australia. The pest is absent from the rest of the country. On this basis the likelihood for importation step 1 is taken to be equal to 0.25 and given a qualitative value of low. On the other hand an analysis could be carried out which only considers the exports from this region and then the number of apples exported is 25% of the total. On this basis the likelihood for importation step 1 is taken to be equal to 1.00 and given a qualitative value of certain. The RDIRA's procedures and use of @Risk would consider these two cases differently. In the first case the low value of imp1 would be given a uniform distribution (Table 11, page 48) ranging from 0.05 to 0.3. This has two effects; introduces spurious uncertainty and, on average, reduces the known value of 0.25 to the midpoint value 0.175. In the second case, imp1 would be equal to 1.00 always and the errors of the first case avoided. The RDIRA follows the first case.

10.4.11.1 Uncertainty in Model Inputs Based on Expert Opinion

A key feature of Monte Carlo simulation is that it allows uncertainty in the input variables to be modelled. The usefulness of the output for decision making purposes depends directly on how realistically this uncertainty is modelled. This involves both the range of possible values, and the likelihood of occurrence of each value within the range. Uncertainty can be due to either natural variability in a quantity, or lack of specific knowledge about a quantity. Both types of uncertainty should be represented by appropriate probability distributions (see for example Vose, 2000 pages 18 to 20[v]).

The modelling strategy adopted by the RDIRA assigns uncertainty in qualitative likelihood estimates inappropriately. (See Table 11, page 48). For example, all events judged to have a high likelihood are given exactly the same probability distribution. This does not take into account that the probability of some events which may be described as having a high likelihood is known much more precisely than the probability of other events assigned a likelihood of high. It also assumes that likelihoods estimated to be high, moderate and low are estimated with much the same precision, while the likelihoods characterised as very low, extremely low and negligible are known which a much greater precision. In addition these uncertainties are modelled by mutually exclusive uniform distributions. There is no reason why this should be the case.

To correctly model the uncertainty in individual likelihoods, the level of uncertainty must be decoupled from the likelihood category.
It is standard statistical practice when eliciting likelihoods from experts to also elicit an indication of the uncertainty to be attached to each figure, typically as a probability distribution. (See, for example Garthwaite & O'Hagan, 2000[vii]; Vose, 2000[v], O'Hagan, 1998[viii], Kadane & Wolfson, 1998[ix], Van Der Fels-Klerx *et al*., 2002[x]). This is not done in the RDIRA. The @RISK software package is specifically designed for use with inputs which are assigned an uncertainty through a probability distribution. This uncertainty should be meaningful, expressing as appropriate natural variability and/or lack of precise knowledge. It should be based on the state of scientific and expert knowledge and opinion, rather than arbitrarily assigned according to the category of the estimated likelihood, as is, in fact acknowledged on page 47 of the RDIRA, "One of the requirements of an assessment in which elements are quantified is that any uncertainty or natural variation in individual estimates should be incorporated. This is important because quantitative assessments may otherwise appear to convey a degree of 'precision' that is not present in the underlying science, or in the model parameter being estimated." Quite clearly, the RDIRA does not follow its own good advice.
The consequence for the model is that there will be an incorrect spread of results over the simulation, which will not correctly represent the state of scientific and expert knowledge. Characterisations made on percentiles of this incorrect distribution will be invalid, as explained in Section 10.4.11.2.

10.4.11.2 Uncertainty in the Output
The output distribution of a Monte Carlo simulation for risk analysis should express the uncertainty due to both natural variability in the phenomena under analysis, and expert uncertainty about the exact behaviour of certain of the phenomena (see for example Pouillot *et al*., 2004[xi]). In order to correctly assess the risk, the spread of this output distribution must be assessed (using, for example, 5th, 25th, 75th and 95th percentiles), as well as its mean value, or some other measure of central tendency. This is because of the different approaches to risk management which are required if, for example, it is known that an undesirable event has exactly a 20% likelihood of occurring, compared to knowing the same event has on average a 20% likelihood of occurring, but that this likelihood may have a 5% chance of exceeding a value of 60%. In the latter case, one may wish to be a good deal more prudent, even though the average chance in both cases is the same. **The methodology of the RDIRA errs in treating both such cases as if they represented the same risk.**
It is rightly recognised in page 68 and 69 of the RDIRA that the risk modelling software reports a distribution rather than a single value for the annual probability of entry establishment or spread of a disease. However the methodology errs in specifying that the 50th percentile should define the qualitative likelihood category when the distribution spans more than one qualitative likelihood category. In choosing to base the analysis on the 50th percentile, one is acknowledging that there is a 50/50 chance that the probability of entry, establishment or spread will be higher than the 50th percentile. However, because the uncertainties in qualitative likelihoods have not been assigned appropriately (see Section 10.4.11.1 above), there is no sound

indication of how much greater than, say, twice or ten times the 50th percentile the probability of entry, establishment or spread could be. If the uncertainties in qualitative likelihoods had been assigned soundly, then the 95th percentile would give a degree of reassurance that the probability of entry, establishment or spread of a disease was equal to or less than the category of the 95th percentile. However as it stands, the 95th percentile is a more or less arbitrary figure which cannot be relied upon because of the unsound assessment of the uncertainty of expert judgement. This does not mean that it is better to use the 50th percentile, however, because the 50th percentile is also quite arbitrary, depending as it does on the shape of the arbitrary output distribution (See Section 10.4.12). The only adequate solution is to correctly characterise the uncertainty in each and every estimation of qualitative likelihood. Then the 95th percentile may be used, on the understanding that this entails a small probability (5%) that the actual probability of entry establishment or spread may be greater than that indicated by the 95th percentile.

10.4.12 Error in the 50th Percentile

Pages 68 and 69 of the RDIRA discuss the computation of the annual probability of entry establishment or spread, which is represented as a probability distribution as a result of Monte Carlo simulations.

If the midpoints of the uniform distributions used for quantitative assessment were assumed to correctly represent the most probable values of expert judgement for likelihoods then the use of the single pre-specified 50th percentile to characterize this uncertainty leads to underestimates of risk compared with that based on the midpoints.

On page 69 it is stated that, “The 50th percentile was chosen as the likelihood to be used because it provides a more robust measure of central tendency for skewed (asymmetrical) distributions”.

Although this statement is true in general for distributions, this statement is not applicable to the case of the “@RISK” simulations of the RDIRA. In the following discussion, we show that use of the 50th percentile in the RDIRA’s @Risk Monte Carlo simulation estimates of probabilities leads to underestimates of risk compared with a deterministic method that assumes that the midpoints of the uniform distributions used for quantitative assessment correctly represent the most probable values of expert judgement for the likelihoods. It should be noted that it is generally not the case that these midpoints do actually represent the most probable values of expert judgement for the likelihoods as these midpoints unnecessarily reduce the choice of most probable values to six distinct values excluding 0 and 1, see Table 11, page 48.

The arbitrary use of uniform distributions with the RDIRA’s “@RISK” simulations and the use of the 50th percentile generally produces probability estimates less than the corresponding midpoint analysis by an amount which varies considerably from case to case. We investigated this by simulation and give some results below.

For example, we consider the probability of importation of apples according to pathway 1 (page 57, Table 13, prob(path 1)=Imp1 x Imp2 x Imp4 x Imp6 x

Imp8), for Fire Blight (*Erwinia amylovora*) with likelihoods given on page 87, Figure 13, and interpreted as uniform distributions as in Table 11, page 48. Pathway 1 has by far the largest probability for this pest. We divide prob(path1) by its value computed using midpoints of quantitative likelihoods corresponding to the qualitative descriptions (Table 11, page 48). We obtain a variable which has mean equal to 1, and compare percentiles of the resulting distribution to the mean of 1. Based on 100000 simulations, we obtain

50^{th} percentile is 0.920

75^{th} percentile is 1.42.

The histogram of simulation values is shown in figure 10.1, which has a distribution skewed to the right. We note that the 50^{th} percentile is 0.920 and so the 50^{th} percentile is 92.0% of the midpoint estimate of prob(path1), that is, smaller than the midpoint estimate.

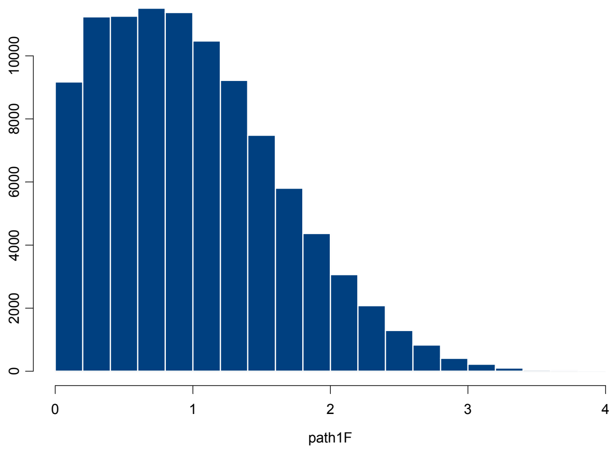

Figure 10.1. Simulations of the probability of importation pathway 1 for Fire Blight

When the likelihood distribution for the volume of trade (pert (100m, 200m, 400m), page 56) is incorporated into the calculation and the resulting distribution divided by 200m, the 50^{th} percentile is 0.925 compared with the midpoint value of 1.00. This shows that the "@RISK" simulation approach used with the 50^{th} percentile tends to underestimate the volume of infested/infected apples imported in a year.

We repeated this analysis of the probability of path 1 for European Canker (*Nectria galligena*) using the likelihood estimates in Figure 15, page 127. We obtained simulation based percentile estimates of prob (path1) divided by the midpoint estimate based on 100000 simulations as follows.

50^{th} percentile is 0.644

75^{th} percentile is 1.39

The histogram of these values is given in Figure 10.2, and shows a distribution which is very skewed to the right.

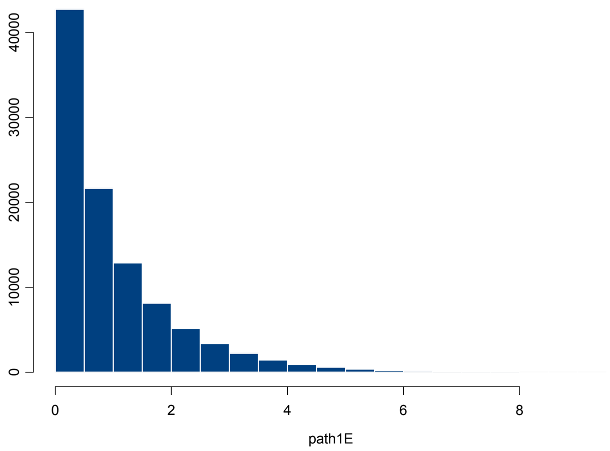

Figure 10. 2. Simulations of the probability of importation pathway 1 for European Canker.

For this case we note that the 50th percentile is 0.644 and so the 50th percentile is 64.4% of the midpoint estimate of prob(path1), that is substantially smaller than the midpoint estimate.

When the likelihood distribution for the volume of trade (pert(100m, 200m, 400m), page 56) is incorporated into the calculation and the resulting distribution divided by 200m, the 50th percentile is 0.643 compared with the midpoint value of 1.00. This shows that the "@RISK" simulation approach used with the 50th percentile tends to underestimate the volume of infested/infected apples imported in a year.

Here we note that the midpoint of the uniform is also its mean. So that if the uniform distributions were replaced by any distributions, not necessarily restricted to the range of the uniform distribution but of course restricted to the interval (0,1), with mean equal to the corresponding midpoint of the uniform distribution, then the @Risk simulations using these distributions for probabilities of pathways would produce distributions for probabilities of pathways having means equal to the probability values based on the midpoint analysis as described above. Without knowing these distributions, the value of the 50th percentile of the @Risk simulation distribution for a probability of a pathway could be greater, smaller or equal to that obtained from the midpoint analysis.

These examples illustrate that the RDIRA's "@RISK" Monte Carlo simulation approach produces 50th percentile likelihood estimates of probabilities of pathways and volumes of infested/infected apples which can be substantially less than those obtained by using the midpoints of the uniform distributions and that these amounts vary considerably from case to case. Such an approach leads systematically to an underestimate of risk in the RDIRA compared with an estimate which uses the midpoints of intervals.

10.4.13 Combining Descriptive Likelihoods

The rules for combining descriptive likelihoods given in Table 12 on page 50 imply that a probability of high multiplied by a probability of high remains high. Thus multiplying a likelihood of high by successive likelihoods of high always results in a likelihood of high. In quantitative terms, this implies that a likelihood of high is 1 or very close to it. This is inconsistent with the definition of the qualitative likelihood high given in Table 11, page 48.

In fact, there is no need for qualitative likelihoods to be combined using rules such as those of Table 12. **Using such rules prevents the propagation of uncertainty through the model.** Instead of these arbitrary rules, one should, at the input stage, assign the appropriate distribution to describe the likelihood and its uncertainty (see Section 10.4.11.1), and carry this through the modelling process, combining probabilities using the appropriate mathematical expressions at each stage.

The effect of Table 12 is to replace whatever distributions occur legitimately at the input with the arbitrary uncertainty of the linear distribution associated with the resulting output category. At the very least, such a combination of the type described in Table 12, equivalent to the multiplication of random variables, should increase the spread of the result. Table 12 ignores this effect, with the spread of the output category arbitrarily assigned in the same way as the spread of the input categories.

10.4.14 Uncertainty in Risk Estimation

Uncertainty should be carried through the model, from the beginning right through to the final assessment of the risk (pages 75 to 76, Table 19). The risk modelling software actually produces a probability distribution for the annual probability of entry establishment or spread. This entire distribution, assuming appropriate handling of uncertainty, is the appropriate input for the risk estimation stage, not a single categorical estimate based on a measure of central tendency. If it was felt necessary to persist with categories of qualitative likelihood, weightings should be assigned to each category, according to the distribution for the annual probability of entry, establishment or spread. These weightings would then carry over to the risk estimation category of Table 19.

For example, if the distribution for the annual probability of entry, establishment or spread implied 10% probability of being very low, a 50% probability of being low, and a 40% probability of being moderate, then assuming consequences are evaluated to be low, the risk would have a 10% chance of being negligible, a 50% chance of being very low, and a 40% chance of being low. In the current methodology, this would be judged an acceptable level of risk, as the 50th percentile would indicate a very low probability, which when combined with low consequences, gives a very low risk. However, there would be a 40% chance that the actual risk would exceed the ‘very low risk’ level. **This principle has not been taken into account in the RDIRA.**

10.5. CONCLUSIONS

There are significant methodological problems with the procedures and approach adopted by the RDIRA. These make the outcomes of the Pest Risk Assessment and Pest Risk Management Steps scientifically indefensible as they currently stand.

Conclusions drawn in the document about risks before and after risk management procedures are not likely to adequately reflect either the nature of current scientific understanding or expert opinion. The main reasons are that

- The uncertainty in expert opinion is not adequately assessed for model inputs, and is not satisfactorily carried through the model. As a result, the output distribution for the probability of entry, establishment or spread is quite arbitrary, and measures based on 50th or 95th percentiles have no sound basis.
- Conditional probabilities are not adequately explained or acknowledged. In particular, probabilities associated with importation steps are conditional on the particular pathway being considered. This has not been taken into account, leading to errors in estimating the likelihood of some importation steps. It is necessary to elicit values for each importation step for each different pathway, unless it is demonstrated that the value is the same for each pathway. Expert opinion must be elicited after clear instruction about the nature of conditional probabilities, that prior points in the pathway must be assumed to have already taken place. There is some evidence that this has not been observed, for instance in the Pest Risk Management for Fire Blight (See Section 10.4.4).
- The assumption of independence in many aspects of the modelling is inadequate to capture the actual way that fruit might be contaminated, the clustering that may occur in harvesting, processing, distribution, and subsequent discard of waste fruit, or escape of flying insects. This leads to overestimation of inspection efficacy, an over estimate of the precision of final estimates, and is likely to under estimate the probability of exposure and subsequent disease establishment.
- Modelling based on a unit of one apple forces experts to judge likelihoods that are very low. It is known that people are poor at accurately estimating such likelihoods. It also forces them to judge likelihoods out of the context in which they are familiar. For example it would seem more reliable to judge the likelihood of insects escaping from a pallet or consignment of apples, rather than from a single apple.

Until the points above, including those of Section 10.4, are satisfactorily addressed, the conclusions of the RDIRA must remain questionable.

10.6 REFERENCES

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SECTION 11: FIRE BLIGHT - PEST RISK ASSESSMENT

11. FIRE BLIGHT - PEST RISK ASSESSMENT

{RESPONSE TO THE REVISED DRAFT IMPORT RISK ANALYSIS ON THE IMPORTATION OF NEW ZEALAND APPLES - 2004, WITH SPECIAL REFERENCE TO FIRE BLIGHT}

11.1 INTRODUCTION:

The concept of the Disease Triangle (Figure 11.1), depicting the interaction between the host, pathogen and the environment, which is fundamental to the discipline of plant pathology, will form the basis for the response. For disease to occur all the components of the triangle must be present, with the environment being favourable for infection and development of disease.

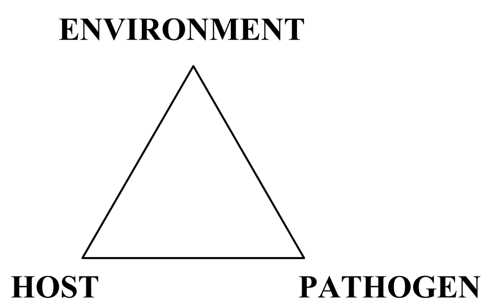

Figure 11.1 Disease triangle showing the interacting components of host, pathogen and the environment

In the case of fire blight the host component principally includes apple, pear, hawthorn, firethorn, cotoneaster, quince and sorbus; 129 other species of plants belonging to the family *Rosaceae* have also been found to be susceptible to a lesser degree. The pathogen component is the bacterium *Erwinia amylovora*. The environment component comprises both meteorological and edaphic factors. Temperatures between 21-26 °C and high humidity are optimal for disease development. In regard to edaphic factors, rich soils which promote vigorous succulent growth of trees are particularly favourable for disease development.

Basically, the purpose of this response is to show that if New Zealand apples were to be imported the three risk management measures (plus consignments free of trash) proposed in the RDIRA do not lower the risk of introducing fire blight into Australia. This would mean that the level of risk that Australia would accept, if the import of apples is allowed, will be above the Appropriate Level of Protection (ALOP) stipulated in the

RDIRA. Consequently, the fire blight pathogen (*Erwinia amylovora*) will become available to susceptible host plants in sufficiently large numbers, under environmental conditions favourable for the disease, to complete the Disease Triangle leading to the establishment and spread of the disease in Australia.

The RDIRA, contains, among other measures, cold storage treatment as a risk mitigation measure for fire blight. This is a new measure which was not included in the Draft Import Risk Analysis (DIRA) of 2000, or in the proposals put forward earlier by New Zealand to export apples to Australia. When used in combination with two other risk mitigation measures given in the RDIRA (page 475), it concludes that the cold storage treatment has the ability to reduce the risk of introducing the disease to an (ALOP). Apart from the incorporation of this new measure it is apparent that the protocol designed for risk mitigation in the RDIRA is less stringent than those in the New Zealand proposals of 1986, 1989 and the DIRA of 2000.

11.2 Probability Of Entry – Unrestricted Risk

11.2.1 Probability of Importation

<u>Importation Step 1</u>: Likelihood that *E. amylovora* is present in the source orchards. RDIRA has rated this likelihood as High. This rating is considered appropriate. Likelihood **High (0.85).**

Importation Step 2: Likelihood that picked fruit is infected/infested with *E. amylovora.* RDIRA has rated this likelihood as Very Low. The assessment being done here is to determine the **annual unrestricted risk** where extra risk management measures (eg. inspection of orchards to establish that they are free of symptoms) for the purpose of export to Australia are not applied. If the likelihood of *E. amylovora* being present in the source orchards is high as assessed for **Imp 1,** then the rating of **Very Low for Imp 2** is considered inadequate.

It is assumed here that the source orchards are not inspected at harvest for disease symptoms; as such, the likelihood that the picked fruit is infected/infested would be **Moderate (= 0.5)** for unrestricted risk.

Mature apples infection

Infection/Infestation of mature fruit

The infection/infestation of mature fruit by *E. amylovora* is reported by (Hale *et al.* 1987; van der Zwet *et al.*1990). There is evidence that *E. amylovora* is able to survive on mature fruits in a symptomless orchard in a season when fire blight was active (van der Zwet *et al.* 1990; Clark *et al.* 1993).

- The absence of fireblight symptoms is not an indicator of the absence of *E. amylovora* infection/infestation. Mature apples from a blight-free orchard in West Virginia were infected with *E. amylovora* (sampling in September 1985) (van der Zwet *et al.* 1990).

Table 11.1 Summary of Importation steps in the RDIRA, the assessment of their likelihoods by APAL compared with those by BA, and justification for change of BA's assessments by APAL for FIRE BLIGHT

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		High (0.85)	High (0.85)	Risk rating is the same as in the RDIRA
Imp 2		Very low (0.0255)	Moderate (0.5)	As the orchard is infected the fruit will be infected/infested by endophytic and epiphytic (surface and calyx) *E. amylovora.* As this assessment is for unrestricted risk orchards that may be both infected and infested. Therefore, fruit harvested will have a substantial level of infection. Low levels of *E. Amylovora* populations reported in the literature cited in the RDIRA is due to indirect techniques being used to isolate the bacteria from fruit calyxes and surfaces. These methods detect only planktonic bacteria and not embedded and attached bacteria
Imp 3		Very low (0.0255)	Low (0.175)	As the fruit in the orchard is already infected to some degree cross contamination will occur during picking and handling of fruit. During picking the pickers' hands will come in contact with leaves carrying epiphytic bacteria; these may be transferred to some of the clean fruit. Contamination can also occur from pickers' bags and from bins.
Imp 4		Moderate (0.5)	High (0.85)	RDIRA refers to reduction of bacterial numbers by long term cold storage. Cold storage should not be considered here as the assessment is for unrestricted risk. In any case, cold storage would only prolong survival. Washing in water dump will spread the bacteria from surface infestations and contaminations (not calyx infections/infestations) to clean apples. Low levels of chlorine used in packing houses (unrestricted risk) may have very little or no effect in killing the bacteria.
Imp 5		Very low (0.0255)	Moderate (0.5)	Washing in water dump will spread the planktonic bacteria from surface infestations and contaminations (not calyx infections/infestations) to clean apples. Bacterial numbers will progressively build up in the dump water. Chlorine is not routinely used in some packing houses. Chlorine is used at a rate too low to be effective. Grime built up will bind the chlorine reducing the concentrations further.
Imp 6		High (0.85)	Certain (1)	The bacteria are certain to survive as palletisation, quality inspection, containerisation and transportation have no effect at all on the bacteria
Imp 7		Negligible (0.0000005)	Negligible (0.0000005)	Some cross contamination is unavoidable, but with due care taken this will be minimal.
Imp 8		High (0.85)	Certain (1)	The minimum border procedures do not have any steps or measures that would reduce or otherwise affect the bacteria, and, therefore, the bacteria are CERTAIN to survive.
Probability of Importation		Very low (0.0255)	Moderate (0.684)	

Of the 8 steps the only step where a reduction in the likelihood could occur is Imp 2. This is not because of any particular procedure in this step, but because of the fact that not all fruit even from an orchard with severe symptoms is likely to be infected. For assessment of unrestricted risk orchards cannot be selected based on absence of symptoms. Imps 3, 5 and 7 only ADD further bacteria. Imps 4, 6 and 8 have no effect at all on the bacterial levels already there on or in the fruit.

- The lack of symptoms on trees is not correlated with infection/infestation. In Sweden, *E. amylovor*a was isolated from symptomless *Crateagus* or *Cotoneaster* leaves two years after the expression of clear and obvious host symptoms (Persson 1999). In that case there was no infection "nearby at the time", suggesting that the only source of inoculum was the presence of epiphytic populations of *E. amylovora*. Similar findings were reported in Belgium where part of the country free of fire blight symptoms was tested for the presence of epiphytic populations of *E. amylovora* (Geenen *et al*. 1981). In the following two years epiphytic populations of *E. amylovora* increased from 3.8% to 18.7% of the host tree tested without reports of fire blight symptoms.

- It is a function of maturation in apples that sugar content rises. Fluctuations in the physical and nutritional conditions of plants influence variation in bacterial populations (Lindow and Brandl 2003). It therefore could be argued that at the crucial time of apple maturation, shortly prior to harvesting as observed by Hale *et al.* 1987) the level of *E. amylovora* infection will rise due to a rapid increase in the availability of nutrients for bacterial growth.

- Qualitative evaluation of detection techniques revealed that amongst the bacterial recovery techniques the more sensitive recovery technique is capable of detecting only 7.25×10^{3} CFU/ 100 buds (Mazzuchi *et al.* 1984). Most of the techniques used in apple infection studies use a single calyx as sample. Calyx is of very small weight and size. Depending on the volume of water or medium used to wash off *E. amylovor*a and the plating technique used, the performed tests may only detect very high populations of *E. amylovora* in the calyx. There are significant deficiencies in the details of experimental methods reported in papers cited in the RDIRA.

- To gain a more accurate understanding of the risks associated with *E. amylovora,* mature apple infection studies should be undertaken to test apples collected from lightly and heavily infected orchards, using direct examination techniques and indirect methods to evaluate the real sensitivity of those methods. All of the techniques which examine the ability of *E. amylovora* to infect apple use only indirect examination techniques. It is recommended that direct techniques be employed in such investigations. Additionally, indirect methods, such as washing are capable of detecting the epiphytic bacteria from the apple surface in planktonic form. There is a growing body of research reporting that bacteria on plant surfaces exist not only in planktonic form but may also exist as small attached bacterial clusters on leaves (Lindow and Brandl 2003) and on the apple surface (Burnett *et al.* 2000, and Burnet and Beuchat*.* 2002).

- The mechanism of pathogen survival on fruits between flowering and fruit maturation has been established for many plant pathogens. Recently the subject of internal and external pathogen internalization has gained significant attention. *Salmonella* was reported to survive on and in tomato plants from the time of inoculation at flowering and early stages of fruit development through to fruit ripening (Guo *et al.* 2001). A study with *E.*

coli O157: H (Burnett *et al.* 2000) showed "bacterial ability to penetrate the inner core of Red Delicious apples, dispersing and attaching to the cartilaginous pericap of the ventral cavity and seed locules, and to seed integument. The internal trichomes within the floral tube entrapped the pathogen, which may contribute to observations made by other researchers (Buchanan *et al.*1999) that greater numbers of *E. coli* O157: H7 inoculated onto intact apples were recovered from the outer core regions compared to the apple skin" (Burnett *et al.* 2000). There is no reason to believe that a similar survival strategy may not be adopted by *E. amylovora* and this requires investigation.

- In an experiment conducted over 4 seasons, 3/9 symptomless orchards (as established by 2 inspections, the first at bloom and the second at the immature apple stage) Clark *et al.* (1993) yielded a high level of fruit contamination (up to 14.6%). The efficacy of buffer zones was tested in 2/3 orchards but not in the most infected orchard. It is not clear why the experimental design varied so much, and why the most infested orchard was not followed up after the initial testing. A conclusion which may be drawn from the work is that apple infestation is not always accompanied by disease symptoms in the orchard.

- The results of some testing of *E. amylovora* apple contamination reported in the RDIRA are highly irregular, suggesting some problems with detection techniques. In Hale and Clark (1990) two techniques were used to detect the presence of *E. amylovora* on apples; DNA hybridization and direct plating. It is not clear why *E. amylovora* was not detected by direct plating. One explanation would be the inefficiency of the extraction method of bacteria from calyxes at the time the experiment was conducted. Additionally there is no validation of the sensitivity of the test. The method of detection employed by Hale *et al.* (1996) was capable of detecting *E. amylovora* after artificial inoculation on apple blossom at 10^7 CFU/ml, which is an enormous load of bacterial inoculum considering the size of the sample. Hale *et al* (1987) does not reveal any data on assay sensitivity and sensitivity of the recovery technique. Inexplicably, Clark *et al.* (1993) did not follow any clearly identified rules of experimental design following the detection of infected/infested apples in symptomless orchards.

Endophytic infections

Endophytic infections in fruit cannot be detected by visual inspections. The RDIRA states (page 469) that endophytic fruit infections are unlikely to occur on symptomless trees, and that *E. amylovora* has been isolated from internal fruit tissues only in rare instances RDIRA page 86). However, there is now increasing evidence that endophytic infections in apple trees, which remained symptomless for a few years, suddenly cause symptoms on their rootstocks (Paulin 1997).

According to Paulin (1997) "in some cases *E. amylovora* may be trapped in xylem vessels, where it stays alive for a long period, without provoking any local symptoms. This can allow the bacteria to move fast and far into the plant, and induce symptoms far from the point of infection".

Hickey *et al.* (1999) reported isolating the pathogen from shoot tips located 100-300 cm away from active cankers during summer. In fact, according to these authors shoot blighting in eastern fruit growing regions of the USA is due to endophytic *E. amylovora* in the tree, which they call “latent canker blight”.

If endophytic infections could result in the movement of *E. amylovora* into the rootstock of the tree (Paulin 1997) and shoot tips (Hickey *et al* 1999) how could one be certain that it would not move into its fruit?

Systemic upward and downward movement of *E. amylovora* in symptomless plants, involving the xylem, phloem and cortical parenchyma has been well documented (Eden-Green 1972; Rosen 1929; Shaw 1934; Thomson 2000).

In the light of such evidence it is difficult to rule out the possibility that endophytic infection of fruit could occur from trees that do not show any symptoms of fire blight.

The following passage from the Monograph on “Fire Blight” by van der Zwet and Keil (1979) is cited to point out the possibility of endophytic fruit infections even when bacterial numbers are low in the tree and may not have symptoms:

> “We believe that there is sufficient evidence today that *E. amylovora* can enter its host through nectaries, hydathodes, lenticels, and other avenues and spread through the trees systemically as resident bacteria in or on shoots, flowers, fruit, and other tissues.
>
> According to the laws of nature under which the healthy rather than the diseased state predominates, numbers of bacteria apparently remain low. Increased numbers of bacterial cells and the subsequent infection process depend on and are determined by many factors, such as degree of innate resistance, percent intercellular humidity, tree nutrition, environmental conditions, and injury caused by wind, hail, farm equipment, and so forth.”

Summary

We agree with RDIRA that mature apples can be infected by *E. amylovora*. Extrapolating the results of Hale *et al.* (1987), van der Zwet *et al.* (1990) and Clark *et al.* (1993), it is anticipated that one million to 2.6 million infected/infested apples are likely to be imported annually if the New Zealand proposal is approved. This is based on the assumption that the volume of trade (importation) will be about 200 million apple fruit per year.

We do not agree with the RDIRA assessment that the level of infestation is very low since the majority of recovery techniques used in assessment of *E. amylovora* infection of mature apple were indirect methods. Most of the reported techniques are capable of recovering planktonic bacterium but not attached or internalized bacteria. The assertion by RDIRA that internal infection of fruits is rare is based on a lack of evidence rather then scrupulous testing of naturally infected apples. On that basis the assessment by RDIRA of the likelihood that picked fruit is infected/infested with *E. amylovora* as very low is inadequate and **Moderate =0.5** level of risk is proposed.

<u>Importation Step 3:</u> Likelihood that clean fruit is contaminated by *E. amylovora* during harvesting and transport of apples to the packing house.

RDIRA has rated this likelihood as very low. Although the contamination here is largely superficial this rating is still considered inadequate. As such, the likelihood is rated as **Low (=0.175)** in the present response for unrestricted risk. Reasons for raising the likelihood for this step from very low to low are considered below in detail.

A Contamination at picking

Plant pathogenic bacteria are at advantage when they enter a resident phase on leaf surfaces of a host plant. Residence is the first step leading to the invasion of the host. Epiphytic populations of bacterial pathogens need to be considered not only as potential inoculum (Hirano and Upper 1983), but also as a part of the infection process. Leaves infected with *E. amylovora* on contact will transfer inoculum to surface of a clean apple. The rate of inoculum transfer between surfaces is determined in Ceroni *et al*. (2004).

A substantial body of research supports epiphytic survival of *E. amylovora* (Calzolari *et al.* 1982; van der Zwet *et al.* 1988; Crepel *et al.* 1996 and Steiner, 2001).

RDIRA makes the point on p 91 "*That bacteria on leaves and fruit surfaces may cause infection. Therefore, fruit and leaves have the potential to contaminate clean fruit if they are harvested during or shortly after hail storm or thunderstorm."* This statement implies that a source of inoculum can be generated when the plant is infected/infested expressing disease symptoms. That statement is true with regard to inducing fire blight in planktonic form. There is a growing body of research reporting that bacteria on plant surfaces may also exist as attached bacterial clusters on leaves. However, there is no morphological or physiological reason that would prevent epiphytic bacterial populations being a source of inoculum. Such infection pathways have previously been recognised (Keil *et al*. 1964; Persson 1999; Geenen *et al*. 1981). More importantly, the survival of *E. amylovora* epiphytic populations in nutrient poor conditions (Wei *et al.* 1992; Wei *et al.* 1995 and Wei *et al.* 2000) suggest survival responses triggered by stress in environmental circumstances which may be replicated on apple surfaces. It is well established that *hrp* genes activate under conditions of nutrient deficiency triggering the infection process. The nutrient conditions of the apple surface or leaf surface resemble nutrient conditions sufficient to trigger *hrp* gene response and induce infection without high bacterial numbers.

B Contamination in bins

- *E. amylovora* is more than capable of surviving from season to season on wooden bins (Ceroni *et al.* 2004). In these circumstances, contamination of clean fruit *via* contact with a contaminated bin cannot be discounted and requires thorough investigation. The endemic nature of the disease in other countries has understandably obliged focus on more obvious sources of contamination. In fact, in the absence of reliable research findings, the RDIRA risk assessment is speculative. A safe general rule would be that clean apple that comes into contact with a contaminated surface will become contaminated. The point made in the RDIRA that *E. amylovora* will survive on packaging material but that it will rapidly perish on the apple surface is, in the absence of scientific evidence to support it, simply an argument which is contrary to general principle in produce handling (Barlass *et al.* 1998) and contrary to research which affirms *E. amylovora* transfer from contaminated surfaces to fruits (Ceroni *et al.* 2004)

- In New Zealand, where bins are recycled, there is a significant risk of cross contamination. A contaminated bin provides an infection pathway to clean apples with which it is in direct contact, and *vice versa* (Ceroni *et al*. 2004).

Summary

Emerging direct examination results which illustrate a ready pathway for epiphytic infection of apples (Kenney *et al.* 2001; Burnet *et al.* 2000) obliges caution in evaluating risk and the effectiveness of risk management processes and further challenges the scientific foundation of this part of the RDIRA.

The RDIRA acknowledges that *E. amylovora* can survive in soil, on leaves and wood and be present when apples are harvested (RDIRA page 91). The RDIRA acknowledges research which establishes infection pathways between such sites and clean fruit. However, it does not acknowledge that mature uninjured fruit can become significantly infested from these sources and assesses the risk as “very low”. We agree with the RDIRA that a source of inoculum is available at the time of harvesting in the restricted and unrestricted scenario. The RDIRA conclusion that the acknowledged risks are very low is not sustained (and is in fact contradicted) by the research upon which it premises its acknowledgement of risk. That research points to **Moderate (0.5)** risk and in our opinion that level of risk ought not be underestimated.

Importation Step 4: Likelihood that *E. amylovora* survives routine processing procedure in the packing house. RDIRA has rated this likelihood as Moderate. However, for reasons given below the likelihood is considered **High (=0.85)** in the present response.

A Washing

- Washing will be ineffective where bacteria are present in internal tissues or protected sites such as the calyx cavity. Some bacteria may be washed off; however, “there is no evidence that numbers of bacteria infecting/infesting the fruit will be reduced by washing the fruits with high-volume, high pressure water” (RDIRA Report 2004)

- In most packing houses the concentration of chlorine is well below effective concentrations (RDIRA 2004).

- Failure to maintain adequate chlorine levels in washing water may result in the cross-contamination of produce (Nguyen-the and Carlin 1994).

- Biofilm formation on fresh produce has been observed with confocal microscopy (Carmichael *et al*. 1999) and has ramifications in terms of surface disinfection treatments applied to fruits and vegetables because of diffusion or the protection from penetration of active disinfectants into biofilm matrices (Stewart *et al*.1995) (Burnett *et al*. 2000).

- Emerging new techniques using confocal microscopy have revealed that bacterial inoculum tends to internalise the discontinuity of the waxy cuticle, lenticels and the floral tube. Such internalisation occurs especially where there is a temperature differential between the apple and the external environment, as is the fact during post harvest processing (Burnett *et al.* 2000; Beuchat 2001; Kenney *et al.* 2001).

Waxing

- High survival as stated in the RDIRA.

- Rubbing of apples leads to the sealing of pathogens like *E. coli* within the waxy cutin platelets (Beuchat 2001). Other bacteria on the apple surface are likely to be protected from similar processes. Sealed bacteria may later be released when the seal is breached, whether by subsequent abrasion or injury or surface deterioration (Kenney *et al.* 2001)

Cold storage

- Several inoculation studies are cited in the RDIRA (page 93) as evidence of the efficacy of cold storage in the control of *E. amylovora* on the surfaces of mature apples (Hale and Taylor 1999; Sholberg *et al.* 1988 and Taylor and Hale 2003). The studies quoted in the RDIRA concern artificially inoculated apples. Sholberg (1988) recognizes that naturally infected apples are a more realistic measure of the efficacy of treatments. Sholberg's inoculation studies report that an inoculum concentration of 10^7 CFU/ml of *E. amylovora* declined gradually in cold storage over 6 months, the decline mainly occurring between 4-6 months. In the first 3 months there is no statistical difference in the reported inoculum level between apple stored for 3 months in cold storage and freshly inoculated apple. The inoculum decline can be attributed to natural discrepancy occurring during sampling.

- Hale and Taylor (1999) and Taylor and Hale (2003) tested the survival of *E. amylovora* by harvesting inoculum in PBS. Inoculum prepared in such a way would wash away the EPS protective coating and leave the bacteria exposed. Exposure of unprotected bacterial cells to cold temperatures will lead to gradual death. The stability of the *E. amylovora* bacterial cell is associated with the cell envelope and in particular the bacterial capsule and fatty acids. The bacterial capsule and fatty acids are known as ultra structures. The age of the culture and the composition of the growth medium influence cell envelope ultra structures (Cassano *et al.* 1988). The process of harvesting *E. amylovora* into a nutrient poor medium would inhibit bacterial motility and, therefore, survival (Raymundo and Ries 1981). Naturally occurring bacteria are not affected by these deficiencies and are protected by EPS, and are capable of surviving the storage temperatures (van der Zwet *at al.* 1990). The claim that a naturally occurring *E. amylovora* population would decline in cold storage is a claim which is not sustained by the reported studies upon which the RDIRA assessment is based.

- Naturally contaminated apples were not affected by cold storage or the combination of cold storage at 1°C and sanitation in 0.65% of sodium hypochlorite (van der Zwet *et al.* 1990).

- A factor not considered in the RDIRA risk assessment is bacterial population infiltration of the surfaces of harvested apples such as identified by Buchannan *et al*. (1999) and Burnett *et al.* (2000). A factor influencing infiltration is temperature. Pathogenic bacteria infiltrate the surface at the temperature differential of 20°C (Beuchat 2001). It may be inferred that *E. amylovora* too would be capable of infiltration like the other pathogens.

- *E. coli* O157:H7 can infiltrate the external surface and internalise the core area (Burnett *et al.* 2000).

- Cold storage in vegetable and fruit processing is recognised as a process which delays bacterial growth, through slowing the metabolism, but does not as such reduce bacterial populations of non temperature sensitive micro-organisms.

Summary
We agree with RDIRA that current packing house operations reported in the RDIRA (pages 92-94) do not reduce bacterial infestation/infection as stated by RDIRA on p.92 and p.94. We do not agree that "cold storage appears to significantly lower the number of bacteria present as infestations on the fruit surface and in the calyx". The RDIRA fails to distinguish and address the implications of research which points to the difference of impact of cold storage on artificially inoculated and naturally occurring bacteria. RDIRA states (page 94) "not all fruit is cold stored for long periods". While some fruit may be cold stored other fruit may be placed in controlled atmosphere storage. RDIRA states, p. 92 that "…Only some packing houses use chlorine in the dump tank…….and in most it is well below the effective concentration (MAFNZ, 2004)". The likelihood of *E. amylovora* survival is **High (0.85)** rather than Moderate (0.5) as stated by RDIRA.

<u>Importation Step 5:</u> Likelihood that clean fruit is contaminated by *E. amylovora* during processing in the packing house.

RDIRA has rated this likelihood as very low. This rating is considered inadequate as, according to the RDIRA (page 92), chlorine is not used routinely in all packing houses. Furthermore, in those packing houses where chlorine is used the rates of 15-20 ppm in the water dump is certainly too low to have any effect. It is important to bear in mind that it is in the water dump that some of the bacteria on the surface of the fruit would get washed out. **In any case as chlorine treatment is a risk mitigation measure it cannot be considered here under unrestricted risk**. For this reason as well as for reasons listed below, the likelihood of this importation step needs to be increased to **Moderate (=0.5).**

- The RDIRA concludes that *E. amylovora* is unlikely to be released into water in the dump tank due to air pocket formation. Bacteria however may release from any part of the apple surface. Bacteria introduced during harvest are likely at least in the initial period to be randomly distributed across the surface. Air pocket formation inhibits the effectiveness of washing processes.

- It is well documented that *E. amylovora* is found not only on apple fruit but also on plant material in the late season during harvesting (van der Zwet *et al.* 1990; Thomson and Gouk 1999; van der Zwet and Walter 1999; Blachinsky *et. al.* 2003; Dueck and Morland 1975). Bacteria introduced to washing tanks, whether from apples or from contaminated plant material are unlikely to be inactivated due to the insufficient level of sanitizing agent, therefore contributing to cross contamination (Nguyen-the and Carlin 1994).

- It is clear that if fruits or leaves are placed in water and agitated for a short while a portion of inoculum will be released to the washing water (Sutton and Jones 1975; Dueck and Morland 1975; Miller and Schroth 1972; van der Zwet and Buskirk 1984). The level of *E. amylovora* released during washing will depend on the level of infection/infestation of the washed material. The range of inoculum of *E. amylovora* that was reported to be released to water during washing of fruits was $10^{3..3}$ CFU/ml (Sholberg 1988); washed shoots were reported to release up to 2.3 x 10^{4}CFU/ml after 1 min wash (Özakman and Maden 1999).

- Grime (as referred in the RDIRA p 95) does build up in the packing lines. Some debris inevitably enters the processing lines and it is for these reasons that the brushing of the fruits is introduced to eliminate any remaining debris after washing. As described on page 22-24 of the RDIRA, the water in dump tanks is changed every 600 bins or at the end of a working week. An adequate level of free chlorine is unlikely to be maintained by current washing procedures.

- The observed operational failure to maintain adequate chlorine in wash water, can lead to increased microbial populations on produce whether in apples or vegetables (Beuchat 1992).

- The apple surface is capable of absorbing bacterial inoculum on immersion. A proportion of that inoculum will internalise the apple surface (see the discussion Imp 4). During packing house processes any bacteria on the apple surface would be waxed and sealed. Sealed bacteria may be released upon abrasion or injury or when the apple is eaten or discarded or at any stage when the skin surface deteriorates (Kenney *et al.* 2001).

- An increase from 4 % to 14% of *E. amylovora* contamination on apples was observed after sanitation and cold storage (1^{o}C for 4 months)(van der Zwet 1990). The increase in the level of infection can be attributed to the reduced competition from some of the saprophytic bacteria that may be more affected by sanitation, therefore enabling *E. amylovora* stronger growth.

Packing lines and some equipment in packing houses are washed only in the off season. Contaminated trash grime or fruit is a likely source of transfer of bacteria to equipment with which it is in contact. Such equipment provides an additional pathway for the contamination of clean fruit passing along packing lines.

Summary

We agree that bacteria in calyxes infection may not be released in washing tanks. However, *E. amylovora* entering the dump water would largely originate from any trash material and any infected fruit surfaces other than the calyx. Infected plant material entering the washing process would introduce *E. amylovora* to the washing tank. Critically, unrestricted risk does not assume that orchards are free from fire blight symptoms.

RDIRA states, p. 92 that "…Only some packing houses use chlorine in the dump tank…….and in most it is well below the effective concentration (MAFNZ, 2004)". It is known that failure to adequately maintain chlorine levels may result in contamination of non infected produce (Nguyen-the and Carlin 1994).

The effectiveness of washing to kill bacteria is conditioned by the physical, functional and quality control process. The likelihood for Imp 5 was assessed as **Moderate (0.5).**

<u>Importation Step 6:</u> Likelihood that *E. amylovora* survives palletisation, quality inspection, containerisation and transportation, and remains undetected.

RDIRA has rated this likelihood as High. The bacteria are **Certain (=1)** to survive as palletisation, quality inspection, containerization and transportation have no effect at all on the bacteria.

<u>Importation Step 7:</u> Likelihood that clean fruit is contaminated by *E. amylovora* during palletisation, quality inspection and transportation to Australia.

RDIRA has rated this likelihood as Negligible. This rating is considered appropriate. Likelihood **Negligible (=0.0000005)**. It is important to recognise that this is an additional introduction of *E. amylovora* onto the fruit, although negligible, and, as such, cannot be used in any model to lower the combined likelihood (high) of steps 1 and 2. That assessed level of risk is correct only if palletised apples are stored in air sealed packing houses and if pallets are not exposed at any stage to rain and wind, each being natural elements known to be vectors of *E. amylovora* in New Zealand. If these conditions are not met then the assessed risk would be higher.

<u>Importation Step 8:</u> Likelihood that *E. amylovora* survives and remains with fruit after on-arrival minimum border procedures.

RDIRA has rated this likelihood as High. However, the minimum border procedures do not have any steps or measures that would reduce or otherwise affect the bacterial survival, and therefore, the bacteria are **Certain= (1)** to survive.

Of the 8 importation steps listed above step 1 is the most critically important step because it is at this stage that calyx infection/infestation by *E. amylovora* is initiated and established. This is the first step in the estimation of the **unrestricted risk** and has been rated in the RDIRA as High. Of the subsequent steps the only step that could lower this risk to any appreciable degree is step 2. Although the RDIRA has discussed orchard inspections under importation steps, especially under step 2, such discussion is not relevant at all in dealing with **unrestricted risk**.

Conclusions – Probability of importation: On the basis of the likelihoods the RDIRA concludes (page 97) that the probability of importation of *E. amylovora* from one year of trade as Very Low by inserting the likelihoods to a simulation model. It is difficult to understand as to how the simulation model came up with a probability of Very Low when a calculation using information given in Table 11 shows the RDIRA probability of importation should work out as Low. However, in the response the likelihoods picture indicated a Moderate (0.684) probability.

11.3 PROBABILITY OF DISTRIBUTION

11.3.1 Sequence of events for successful exposure

11.3.1.1 Cold Storage

In the RDIRA although **cold storage treatment** was earlier considered in detail under Importation step 4, it is being considered again under this heading. The comments made in the response later under Risk Management (see paragraph 7.5 below) will apply here too.

11.3.1.2 Number of bacteria required to initiate an infection

In the literature the **number of *E. amylovora* cells required to initiate an infection** has been reported to range from one cell (Hildebrand 1939), 5 cells (van der Zwet 1994) to several thousand cells (van der Zwet 1994; Hale *et al* 1996). Under this topic the RDIRA (page 99) is referring to apples from symptomless orchards or lightly infected orchards unaware of the fact that it is dealing with unrestricted risk. In relation to the number of cells required for infection RDIRA concludes (page 99) that it is highly unlikely that the minimum dose to initiate infection will be found in apple waste. This is pure speculation as there is no firm evidence as to the exact number of cells for this; naturally it would depend on both the host and environmental factors.

Also, no proper studies have been done as yet to find out whether or not the bacteria in decaying fruit, carrying epiphytic (calyx or surface) or endophytic infections, undergo slow or rapid multiplication. Large quantities of nutrients released during the breakdown of tissues (physiological) in decaying fruit would support the growth of *E. amylovora* as well as saprophytic organisms that subsequently invade the rotting fruit.

Among the substances released during the process of decay would be certain chemicals called kairomones (Whittaker and Feeny, 1971) that would attract all kinds of insects. Kairomones are volatile chemicals that have several functions; one of them is that they would attract all kinds of insects. The insects attracted by kairomones may carry the bacteria to susceptible plants to initiate an infection prior to colonization by other microorganisms that would result in complete decay of the fruit.

The RDIRA states (page 98) that any *E. amylovora* present in the decaying fruit will be overrun by saporphytic microrganisms and, therefore, will not be available for transfer. This argument, which is not logical, assumes that the insects are unlikely to visit the waste fruit until after all *E. amylovora* bacteria have been eliminated by the saprophytes due to competition.

However, the reality would be that with the increased availability of nutrients due to decay the *E. amylovora* already resident in the fruit will start utilizing the nutrients first resulting in increased numbers which may be picked up by visiting insects. With the subsequent invasion by saprophytic organisms the *E. amylovora* numbers are most likely to go down as a result of increased competition.

11.3.1.3 Transfer to a susceptible host

The transfer of the pathogen to a susceptible host should not be considered under probability of entry, which in the RDIRA includes probability of importation and probability of distribution. The reason for this is that transfer of the bacterium from infested/infected apples is an **on-shore event and** would occur after the fruit has been imported and distributed to the various utility points. This matter is discussed in detail in paragraph 9 below.

The transfer of E. amylovora to a susceptible host is a low probability event even in countries where fire blight incidence is particularly high. In plant pathology, as well as in human and veterinary medicine, it is an accepted principle that in nature the transfer of a pathogen to its host, leading to infection, is always a low probability event.

Nevertheless, the pathogen must find some means to transfer itself to a host for its own survival and perpetuation; this is a fundamental biological norm.

In the case of fire blight the transfer would predominantly be by flying insects other than bees.

If transfer occurs during blossom time then large numbers of bacteria are not needed as the stigmatic surface of flowers provide an excellent medium for their rapid multiplication. Only low numbers of E. amylovora are known to be transferred to host plants by rain splash or insects (Thomson 2000).

RDIRA (page 98) appears to be generalising from the work of Taylor *et al.* (2003) that bacteria are not transferred from contaminated calyxes by insects, wind or rain. This is the only paper in the literature where experiments on this aspect have been reported; its principal weakness is that the fruit used were artificially inoculated and the work has not been repeated.

As for the manner and means by which *E. amylovora* is transferred to its host, there are **still gaps in the understanding of this process.** This is evident from the statements by the following researchers:

(a) "Fire blight is one of the most erratic and unpredictable diseases of pear and apple. Our perplexity is due mainly to our lack of fundamental knowledge of the bacterium and its mode of infection, especially just before and during bloom" (van der Zwet et al. 1988)**.**

(b) "Great progress has been made in the knowledge of the epidemiology of fire blight in the last 30 years but, despite the advances, fire blight still causes major losses of fruit and trees and creates economic losses amounting to millions of dollars" (Thomson, 2000).

(c) "Fire blight continues to be one of the most intensively studied bacterial diseases of plants. …. In spite of this effort, the disease is still not satisfactorily controlled; it continues to spread throughout continental Europe and remains a major concern in most countries where pome fruits are grown". " Twenty four-years later, this summation (by Schroth et al. 1974) of the status of fire blight is unchanged" (Johnson and Stockwell, 1998).

This story is still being repeated by researchers at every International Fire Blight Workshop held once every two years.

Basically, as mentioned earlier, the perplexity is due mainly to our lack of fundamental knowledge of the bacterium and its mode of infection (van der Zwet et al. 1988)**.**

11.3.1.4 Available nutrition

The RDIRA states (page 98) that the *E. amylovora* cells present in the calyxes do not have access to carbon sources and may explain the rapid decline of bacteria in that site and the rapid decline in numbers due to lack of growth and multiplication. This is speculative on two counts. Firstly, the source for the statement about the bacteria not having access to carbon sources comes from the paper by Taylor *et al.* (2003). These authors are not saying that on the basis of any experimental evidence; nor have they cited any references to support that statement. It is only a discussion point in the Discussion section of their paper. On the other hand Gross *et al.* (1992) state that endopolysaccharides formed by *E. amylovora* release easily metabolizable glucose for their survival. Secondly, as stated before, rapid decline of cell numbers in the calyxes have been observed predominantly in experiments where artificially inoculated apples have been used.

Large quantities of nutrients released during the breakdown of tissues (physiological) in decaying fruit would support the growth of *E. amylovora* as well as saprophytic organisms that subsequently invade the rotting fruit. With this increased availability of nutrients the *E. amylovora* already resident in the fruit will start utilizing the nutrients first resulting in increased numbers which may be picked up by visiting insects and transferred to a susceptible host. Following subsequent invasion by saprophytic organisms nutrient supply would decrease and the *E. amylovora* numbers are most likely to go down due to competition.

11.3.1.5 Survival in soil

Although *E. amylovora* populations having transient survival in the soil may not be a potent source of inoculum, Thomson (2000) has concluded, on the basis of his own results, that soil cannot be totally discounted as a source, especially in nurseries. Thus, there is a low probability of *E. amylovora* being carried in soil moved from an orchard with a heavy fire blight infection to an export orchard and acting as a source of inoculum to infect the export orchard.

In the conclusion to this section (Sequence of events for successful exposure) the RDIRA states that the probability of transfer of *E. amylovora* from waste discarded at any utility point to susceptible host was assessed as negligible. This conclusion is considered unrealistic as it has been based largely on results of experiments done with artificially inoculated fruit (Taylor *et al.* 2003), and on speculations about availability of nutrients in the calyx and rapid decline of bacterial cell numbers. With a plentiful supply of nutrients in decaying fruit *E. amylovora* would multiply rapidly in the initial stages producing ooze. Following colonization of the decaying fruit later by saprophytic organisms the ooze would be consumed by these organism and a decline in numbers would occur.

However, if the ooze dries up under low humid conditions the bacteria may remain viable for a longer period. Thus, according to Hildebrand (1939), *E. amylovora* cells remain viable in dried natural ooze for 15-25 months, and in bacterial strands for 12 months.

11.3.2 Partial probability of distribution

The table showing the proportions of utility points near host plants susceptible to *E. amylovora* in the four exposure groups (Table 26 in the RDIRA), and the pictorial representation of infested/infected apples discarded by utility points near exposure groups of *E. amylovora* (Figure 14) generally appear to be factual. However, the table showing the probability of exposure of susceptible host plants to *E. amylovora* by utility points discarding a single infested/infected apple near exposure groups (Table 27), underestimates some of the probabilities (rated as Negligible). This has resulted largely from the way scientific evidence has been used to assess the probabilities for the following:

11.3.2.1 The probability that the exposure of commercial fruit crops would result from a single infested/infected apple from orchard wholesalers:

This constitutes one of the important paths for the transfer of *E. amylovora* to a susceptible host where infected/infested fruit is the only source of inoculum. While most orchard wholesalers may have their waste disposal sites well away from packing sheds, they may not necessarily be outside their orchard property. In any case flying insects that are attracted to decaying fruit may pick up bacteria and fly to a susceptible host (commercial fruit crop) or be carried by wind and may land on a susceptible host plant. Janisiewicz *et al* (1999) conducted experiments to study the transmission of *Escherichia coli* from infested apple tissue to fresh fruit by fruit flies. They found that the fruit flies were easily contaminated both externally and internally after contact with the bacterium source. The flies transmitted the bacteria to uncontaminated apple wounds resulting in a high incidence of contaminated wounds. Although there are no reports in the literature on the transmission of *E. amylovora* from discarded apple fruit to blossoms or succulent vegetative tissue, this study demonstrates that such transmission is a possibility. For the aforementioned reasons the probability for this path is increased from Negligible in the RDIRA to **Low (0.175).**

11.3.2.2 The probability that the exposure of commercial fruit crops would result from a single infested/infected apple from consumers:

Apart from the possibilities listed in the RDIRA (page 103) for this utility point there is also the possibility that some consumers may discard cores of apples they may eat in the vicinity of commercial fruit crops. Flying insects that are attracted to decaying fruit may pick up bacteria and fly directly to a susceptible host (commercial fruit crop) or be carried by wind and may land on a susceptible host plant. Also, the assumptions made in the RDIRA (page 103) about the disposal of waste from consumers are strictly not correct. In country towns consumers are allowed to dispose of their waste *via* garbage disposal which may end up in the open air near susceptible hosts. Therefore, the probability here should be changed to **Extremely Very Low (0.0005005).**

11.3.2.3 The probability that the exposure of nursery plants would result from a single infested/infected apple from orchard wholesalers:

The first three dot points discussed under this utility point in the RDIRA indicate (page 104) that the probability of this event occurring is at least very low, if not above. Thomson (2000) has stated that the transient E. amylovora populations in the soil could act as sources of inoculum to infect susceptible nursery plants. Another point in regard to this path is that the proportion of succulent tissue in young plants growing in nurseries would be higher than in mature plants in orchards. Succulent tissues in fire blight host plants are particularly prone to infection. Hence the probability here needs to be increased to at least Very Low (0.0255).

11.3.2.4 The probability that the exposure of <u>household and garden plants</u> would result from a single infested/infected apple from consumer waste:

The probability of transfer of E. amylovora by this path would be as high as by the orchard wholesalers – commercial crops path. Among the household and garden plants would be cotoneasters and hawthorn that are particularly susceptible to fire blight. A further danger that lies with this path is that disease symptoms would go unnoticed until the disease had established itself on the infected host plant and it had spread to susceptible plants in the vicinity. Another point that needs to be considered is compost heaps wherein apple cores and peels may be placed. Therefore, the probability here needs to be increased to Low (0.175)

11.3.2.5 The probability that the exposure of <u>wild and amenity plants</u> would result from a single infested/infected apple from (a) orchard wholesalers, (b) urban wholesalers, (c) retailer waste (d) food service waste and (e) consumer waste:

While (a), (b),(c) and (c) would have probabilities ranging from negligible to extremely low, (e) is likely to be at least Low (0.175). The reason for the latter is that a significant proportion of consumers tend to have their mid-day meals during the week as well as weekends away from home. Many would consume their meals in nature reserves, parks and gardens (including botanic gardens) where susceptible wild and amenity plants would be found in abundance. In such environments most people would not bother about finding bins to throw their apple cores; they would be discarded just anywhere in those places. As the density of wild and amenity plants in nature reserves, parks and gardens is relatively high such cores, if infested/infected, would act as a potent source of inoculum to infect susceptible hosts in the area.

The subject of infection of the **core tissues** of the apple fruit by *E. amylovora* has received only very little attention in the RDIRA. In studying the correlation among developing apple fruit, blight source, and *E. amylovora* populations van der Zwet *et al.* (1990) examined the core tissues of Rome Beauty apples picked at points of 0, 15, 60 and 200 cm from blighted shoots. Endophytic populations of *E. amylovora* were isolated in 21% of core sections of the fruits picked from a distance within 15 cm of blighted shoots.

In the field of food microbiology the path followed by *E. coli* in contaminating the apple core has been studied in detail in the USA by Burnett *et al* (2000) using confocal scanning laser microscopy (CSLM). In their studies inoculation of Red Delicious apples were effected by taking advantage of infiltration of inoculum suspension resulting from temperature differentials (inoculum at 2°C and fruit at 25°C). Their studies revealed the following:

(i) bacterial cells attach to intact apple skin at discontinuities in the waxy cuticle; lenticels and russet areas also attracted cells but in lower numbers.

(ii) Cells enter through the calyx end and after passing through the floral tube infiltrate into the **core of the fruit**. Although the wall of the floral tube did not harbour high numbers of cells the bacterium attached readily in high numbers to the **apple flower remnants** and internal trichomes just within the floral tube. Within the **core,** *E. coli* cells were found in the ventral cavity and seed locules. Discolouration of the parenchymatous cortex (flesh of the fruit) surrounding the core was also observed, suggesting infiltration into these tissues. **The authors conclude that on the basis of their own results as well as evidence presented by other workers, the calyx end of the apple is an area of great concern with regard to the infiltration of bacteria.**

If *E. amylovora* was to cause the discolouration of the parenchymatous tissue surrounding the infected core will be discarded by the consumers.

Thus, the probability that the exposure of wild and amenity plants would result from a single infested/infected apple from consumer waste would be **Low (0.175)**

11.4 PROBABILITY OF ESTABLISHMENT OR SPREAD

11.4.1 .Partial probability of establishment:

The following comments are made in connection with some of the information given in the RDIRA (pages 109-113):

11.4.1.1 The potential for adaptation of the pest: Resistance to streptomycin

Resistance of *E amylovora* to streptomycin is becoming increasingly widespread in countries having fire blight (Thomson *et al*., 1993; Jones and Schnabel., 2000; Sholberg *et al,,* 2001; Norelli *et al.,* 2003).

The occurrence of streptomycin resistant strains of *E amylovora* in New Zealand has been reported by Thomson *et al.* (1993) and by Vanneste and Voyle (2000).

"The existence of streptomycin-resistant strains makes fire blight control difficult, if not impossible, because streptomycin is the only effective plant safe pesticide available in many countries for the control of fire blight" (Jones and Schnabel., 2000).

Therefore, the extreme consequences to the Australian pome fruit industry, if a streptomycin-resistant strain was to be introduced with any New Zealand apples, must be very seriously examined by Biosecurity Australia (BA).

Resistance to streptomycin in *E amylovora* is of two types based on the mechanisms on which they operate. One is a result of a mutation of a specific chromosomal gene in the bacterium. The other is a result of a gene, which code for enzymes that modify streptomycin; this gene is acquired by the bacterium into its plasmid from another bacterium (Jones and Schnabel, 2000).

Chromosomal gene resistance strains can withstand higher doses of streptomycin than the plasmid gene (acquired) resistance strains.

While the genes in the acquired (plasmid) resistance strains are easily transmissible to other bacteria crossing species barriers, the genes in the chromosomal resistance type are not transmissible.

The easy transmissibility of resistance genes (acquired resistance) can result in the "rapid widespread of streptomycin resistance" (Vanneste and Voyle, 1999).

Even a more serious effect than the inability to control fire blight would be the transmissibility of the resistance genes from *E. amylovora* to human and animal bacterial pathogens. Once that happens it will not be possible to prescribe streptomycin for the management of human and animal diseases caused by bacterial pathogens that are normally streptomycin sensitive.

11.4.1.2 Minimum population needed for establishment:
The information given in the RDIRA (from the literature cited) (pages 98-99) shows that the threshold number of *E. amylovora* cells required to initiate an infection could be anywhere between 1, 5 and 10,000. Clearly, if only 1 or 5 bacteria are required to initiate an infection the risk to Australia from imported fruit is much higher and the likelihoods estimates may need to be adjusted upward. In the light of this discrepancy in research Australia should assume the "worst case scenario" and work on the assumption that a few as 1-5 viable bacteria lodged in a single apple calyx could be sufficient to establish the disease in Australia.

11.4.1.3 The method of pest survival:
The method of pest survival is detailed in the section titled New science. Under that heading, three factors understood as fundamental to the survival of pathogenic bacteria are explained in detail. The factors are epiphytic survival, aggregation/biofilm formation and the σ factor (sigma factor). The RDIRA does not address any of the three factors.

The implications of an epiphytic survival mechanism is illustrated by *E. coli* and its highly successful transfer by fruit flies to wounded apples (Janisiewicz *et al.* 1999). Other flies are known to successfully transfer inoculum. With *E. amylovora* such transfer does not need to occur to another wounded apple. Inoculum growth occurs much faster when *E. amylovora* is transferred to nutrient rich sites such as the stigma or wounded leaf. However, epiphytic survival and infection can occur on intact shoots and leaves or even wooden boxes (Crepel *et al.* 1996; Ceroni *et al.* 2004).

The above comments on the methods of pest survival point to the obvious conclusion that an orchard free of symptoms is not necessarily free or even low in bacterial infestation/infection. Visual inspection alone is, therefore, not enough to ensure that the harvested fruit would carry only minimal populations of *E. amylovora*. It would be necessary for statistically representative samples to be tested using a sensitive detection technique to ensure that the apple exported to Australia would not carry more than minimal numbers of bacteria that would be able to comply with BA's ALOP.

11.4.1.4 Conclusion - Partial probability of establishment:
The high partial probabilities stated in the RDIRA for commercial crops and for nursery plants, are considered fair.

However, for the same reasons, as given for the latter exposure groups, and for the following reason, the partial probabilities for household and garden plants, and for wild and amenity plants need to be raised. While the spread of the pathogen would be high in commercial fruit crops and in nursery plants, establishment would be higher than moderate in household and garden plants and in wild and amenity plants. The principal reason for this is that in the latter groups the disease will remain unnoticed even after *E. amylovora*, and consequently fire blight, is well established in the plants. Thus, the rating for partial probability of establishment in the response for all four groups would be High (0.85).

11.4.2 Partial probability of spread: The following comments are made in connection with some of the information given in the RDIRA (pages 113-115):

11.4.2.1 <u>Potential movement of pest with commodities or conveyances:</u>
As to the question of apple fruit being a pathway for transmission of *E. amylovora*, in countries already having fire blight there are more potent sources of inoculum and more efficient means of spread to be concerned with than determining whether fruit is a vector. An answer to this question is important only to countries like Australia proposing to import fruit from countries with fire blight. Thus, comparatively, infected/infested fruit would not naturally fall into the same category as cankers in countries having fire blight.

11.4.2.2 Conclusion – partial probability of spread:
In the RDIRA (page 115) the partial probabilities of spread for commercial crops, nursery plants, and household and garden plants have been stated as high. The rating of High for these is considered appropriate. Similarly, the partial probability of spread of Low for wild and amenity plants is also considered appropriate. The ratings in the response are the same as in the RDIRA.

11.4.3 Combined partial probability of establishment or spread

11.4.3.1 <u>Household and garden plants</u>:
Establishment and spread of fire blight in this exposure group would be as high as in commercial fruit crops or nursery plants. The principal reason is that these plants are normally not subjected to any kind of inspection. Thus, the disease could get established and would easily remain unnoticed for quite some time. In that time it could easily spread to surrounding susceptible plants. When this is

considered together with the information in the RDIRA (page 116) the combined partial probability of establishment or spread here would be **High.**

11.4.3.2 Wild and amenity plants:

The comments made with respect to household and garden plants apply equally well here too. Thus, when taken together with the information in the RDIRA (page 116) the combined partial probability of establishment or spread here would be **Moderate.**

The combined partial probabilities of establishment or spread of *E. amylovora* as rated in the response are shown in Table 11.2 (equivalent of Table 29 of RDIRA).

Table 11.2. Combined partial probabilities of establishment or spread of *E. amylovora*

	Commercial fruit crops	Nursery plants	Household and garden plants	Wild and amenity plants
Establishment	High	High	High	High
Spread	High	High	High	High
PPES	High	High	High	High

11.5 ASSESMENT OF CONSEQUENCES:

11.5.1 Consequences rating

In general the supporting evidence presented in the RDIRA (page 117) for direct impact (on plant life, human life and health, and other aspects of environment), and indirect impact on control/eradication, domestic trade or industry, international trade and environment of *E. amylovora*, and the impact scores assigned to them are considered appropriate. However, there would be a more serious impact on the communities, than indicated in the RDIRA, as a result of the introduction *E. amylovora* strains having resistance to streptomycin being introduced with apples from New Zealand. Streptomycin resistance in *E. amylovora* is known to occur in New Zealand, with the resistance being both chromosome and plasmid based (see paragraphs 4.1.1). Therefore, an impact score of “E” is given to this indirect impact

11.5.2 Conclusion – consequences:

The overall assessment made in the RDIRA (page 123) of the consequences as High (0.85) is considered appropriate.

11.6 UNRESTRICTED ANNUAL RISK:

In the light of what has been discussed above in this response on probability of entry, establishment or spread, the overall probability for the combined effect would be High (0.85) (unrestricted annual risk) (Table 11.3). Table 11.3 is equivalent of Table 31 in the RDIRA). In the RDIRA the unrestricted annual risk has been estimated to be Moderate.

Table 11.3. Risk estimation for *E. amylovora*

Overall probability of entry, establishment or spread	**High**
Consequences	**High**
Unrestricted annual risk	**High (0.9999)**

11.7 RISK MANAGEMENT FOR *E. amylovora* (FIRE BLIGHT)

11.7.1 Impact of proposed protocols

Protocols for risk management considered in the RDIRA (page 469) are those that BA believes would reduce the unrestricted risk resulting from Imp2, Imp 3, Imp 4 and Imp 5.

Using the protocols it would be possible to lower to a somewhat appreciable level the risks related to Imp 3, Imp 4 and Imp 5. However, they will have no effect at all either alone or in combination (systems approach) on the calyx infestations/infections and endophytic fruit infections related to Imp 2.

Calyx infestations/infections are natural events that originate in the source orchard, and the reasons why the protocols proposed will not be effective are discussed below under each risk mitigation method.

11.7.2 Areas free from disease symptoms as a risk mitigation measure

The RDIRA (page 469) states that, according to ISPM 4 and ISPM 10, an area free from disease symptoms could be a place of production or a site of production. However, ISPM 10 states that "A place of production or production site can be declared free from a given pest to an adequate degree of security if the characteristics of the pest are suitable for this." The ISPM 10 then lists the following 7 characteristics that would make the pest being considered suitable:

i) The natural spread of the pest (or its vectors, if appropriate) is slow and overshort distance.
ii) The possibilities for artificial spread of the pest are limited.
iii) The pest has a limited host range.
iv) The pest has a relatively low probability of survival from previous seasons.
v) The pest has a moderate or low rate of reproduction.
vi) Sufficiently sensitive methods for detection of the pest are available either by visual inspection or by tests applied in the field or in the laboratory, at the appropriate season.
vii) As far as possible, factors in the biology of the pest (e.g. latency) and in the management of the place of production do not interfere with detection.

Of the 7 characteristics stated *E. amylovora* strictly meets only (vi). Thus, according to ISPM 10, areas or orchards free from fire blight symptoms do NOT constitute pest free place of production or pest free site of production. The definition is clear and unambiguous.

However, even if one were stretch the argument beyond limit, to imply that orchards free of symptoms can be considered as a pest free place of production or pest free site of production, with fire blight it would be practically impossible to achieve this for the following reasons:

11.7.2.1 Endophytic infections

As discussed in detail under Imp 2 endophytic infections of fruit is not a rare occurrence, and there is now increasing evidence that endophytic infections in apple trees, which remained symptomless for a few years, suddenly cause symptoms on their rootstocks (Paulin 1997). The endophytic bacteria could likewise move into the fruit and would remain undetected during visual inspections of orchards for symptoms.

11.7.2.2 Visual inspection

Ensuring that apple orchards are free of symptoms is an enormous task and the impracticability of determining whether a given orchard is free of symptoms with any degree of confidence cannot be overemphasised, provided of course, that the source orchards are inspected at full bloom and at harvest and found to be 'totally free' of symptoms. Then there is the question of whether fruit sourced from orchards free of symptoms are necessarily free of infection. This can only be verified with some degree of certainty by testing fruit at both the immature and mature stages using a highly sensitive detection technique.

As for ensuring apple orchards are free of symptoms, how would New Zealand inspectors do this? How would an inspector detect small cankers on twigs and small branches at the top of the tree? It is generally known that about 30% of the tree biomass is invisible to the examiner (see attached report by Associate Prof M. Coote, 2004).

Although some of the larger holdover (indeterminate) cankers on the trunks and lower branches are easily detected and may be active, the smaller cankers developing on twigs which are difficult to detect are also known to be active. Thus, according to Brooks (1926), and Ritchie and Klos (1975) bacteria are often present in cankers that are formed in twigs as small as 4 mm in diameter. Furthermore, the of size cankers where *E. amylovora* overwinters varied considerably, with some twigs as small as 2-5 mm in diameter, but the majority averaging 6 mm (Brooks, 1926; Miller, 1929).

In preparing orchards for registration to export apples, registered growers, in accordance with good orchard practice, would be expected to remove all visible cankers and cut out any strikes in the previous season. However, Johnson and Stockwell (1998) maintain that once disease has become established in an orchard it is not feasible to locate and remove every holdover canker.

11.7.2.3 Presence of *E. amylovora* in orchards free of symptoms

Clark *et al.* (1993) isolated *E. amylovora* from 8.7%, 6.7% and 14.7% of the immature fruit picked from orchards with no fire blight symptoms at all. Thus, in addition to the fact that orchards free of disease symptoms cannot be equated to area freedom, apples from these orchards could carry *E. amylovora* infestations/infections in the calyx (apart from surface infestations and endophytic infections see 7.2.1).

Experiments conducted in New Zealand (Hale *et al.,* 1987) have demonstrated that *E. amylovora* populations detected in the calyxes of immature fruit do survive till maturity (harvest) with the levels falling from 50% (immature) to 3% (mature).

Many signs of the disease are inconspicuous and hard to detect. Infectious cankers may be as small as 0.25 cm (Steiner 2000).

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Active cankers are often missed in controlled experiments carried out by experienced plant pathologists; in these cases it is only after positive experimental analysis and repeated inspection were disease symptoms found (van der Zwet *et al.* 1990; Hale and Clark 1990; Clark *et. al* 1993).

It is known that fire blight disease is endemic in New Zealand (Cunningham, 1920; Reid 1930 and Wilson 1970) and would not be detected by visual inspection.

11.7.2.4 Conclusions on symptom freedom as a risk mitigation measure

Inconsistencies pointed out in the previous section (7.2.3) clearly indicate the unreliability of determining whether or not mature fruit is infested/infected based on the presence or absence of fire blight symptoms in the source orchards.

Some orchards, designated as export orchards, may develop fire blight symptoms (strikes) and growers as part of their orchard management practices will prune out these affected shoots or even cankers prior to inspection at harvest. If prior to pruning, these cankers and shoots had been in close proximity to fruit then, based on the work by van der Zwet *et al.* (1990), the fruit harvested would be infected. Such fruit would still be exported.

We do not agree that inspection of orchards can lower the likelihood for Imp 3 and Imp 5 in the restricted risk scenario.

11.7.3 Estimate of restricted risk of fruit sourced from symptomless orchards

Although RDIRA states (page 470) that the restricted risk, as a result of combining ‘source orchards free from symptoms’ with the estimate of consequences, is low, it is apparent from the above comments that it is **High** (Table 11.4). Table 11.4 is the equivalent of Table 117 in the RDIRA. As stated earlier under paragraph 2.1.3- A, steps Imp 3 and Imp 5 involve **further addition** of *E. amylovora* populations (contamination) to the apples which already carry the bacteria from the source orchards. Therefore, these steps do not contribute to a further reduction of the overall restricted likelihood even if they are reduced to negligible.

Table 11.4 Effect of orchards free from fire blight symptoms

Step	Unrestricted likelihood	Restricted likelihood
Imp 2	Moderate (0.5)	Low (0.175)
Imp 3	Low (0.175)	Low (0.175)
Imp 5	Moderate	Moderate
PEES	High (0.85)	High (0.85)
Risk estimate	High (0.85)	High (0.85)

11.7.4 Chlorine treatment as a risk mitigation measure:

The limitation of chlorine treatment in relation to post harvest handling of fruit and vegetables is well recognized. Traditionally, chlorine based solutions have been used for surface sanitation, with hypochlorus acid being the active agent affecting bacterial cell metabolism.

The current move away from the use of chlorine based systems in vegetable and fruit processing to other sanitizing agents recognizes the instability of hypochlorus acid instability in the washing environment and health safety concerns due to the prolonged exposure of factory processing staff to high levels of chlorine vapor (Hery *et al.* 1998).

Studies with lettuce show that the amount of produce that can be effectively washed in a chlorine based system rapidly decreases with cumulative produce weight (Simons and Carmichael 2001). Any failure to maintain adequate chlorine levels in washing water may result in the cross-contamination of produce (Nguyen-the and Carlin 1994). Failure to maintain adequate chlorine in wash water, can lead to increased microbial populations on produce (Beuchat *et al.* 1992). Break down of chlorine in contact with organic matter is well known (Nguyen-the and Carlin 1994).

In studies on the control of bacterial soft rot of celery (*Erwinia carotovora* ssp *carotovora*) Wimalajeewa (1976a; 1976b) found that it was necessary to monitor the chlorine concentration in the hydrocooling *cum* wash water daily and replenish the chlorine at least twice a day especially during summer.

Chlorinated washing water was observed to contain 10^3 CFU of microbial flora (Nguyen-the and Carlin1994), and produce washed with 114 ppm chlorine resulted in an increased total microbial population (Nguyen-the and Carlin 1994), while Senter *et al.* (1985) found that the *Enterobacteriaceae* level was only reduced in 226 ppm of chlorine. More recently, the response of microorganisms to antimicrobial agents including chlorine in processing environments has been investigated (Zottola 1994; Sheo and Frank 1999) and has brought into question much of the previous data on the efficiency of sanitizing wash agents.

In the context of the recent findings reported above, the IRA reliance on 100 ppm chlorine treatment as an effective sanitation procedure is misplaced. Further, the report is based on results of artificial inoculation as published in Hale and Clark (1992). This report was not published and therefore the data and experimental procedure could not be scrutinized. In a peer reviewed paper van der Zwet *et al.* (1990) documents that apples naturally contaminated with *E. amylovora,* were after washing in 650 ppm chlorine and cold storage of 1 month, more contaminated (15%) than apples that were not disinfected (3%). Sholberg (1988) found that chlorinated wash of particularly contaminated apples for up to 30 min had limited efficacy and was no more effective than 20 min exposure to water as a control.

Internalization of bacteria in apples is not a rare occurrence. *E. coli* O157:H7, another enteriobacteriace was also found to infiltrate the external surface and internalise to the core area (Burnett *et al.* 2000; Beuchat *et al.* 2001).

Challenge testing of washing agents must be performed on naturally infected apples as part of a thorough scientific examination of the RDIRA proposal. For example *E. coli* adapts to starvation conditions by developing a chlorine resistant phenotype (Lisle *et al.* 1998).

The RDIRA proposition that chlorine treatment would reduce the likelihood of contamination of clean fruits in the packing house is not supported by recent science. The RDIRA does not report studies which test and validate its proposal or which report upon the effectiveness of the proposal on a large scale.

As far as fruit is concerned chlorine treatment (100 ppm for 1 min) is likely to be effective only against the *E. amylovora* present on the fruit surface, on the stem end and those epiphytic on the fruit stalk. Even here it will not be 100% effective (Sholberg *et al,* 1988). Its effect will be negligible or nil in reducing or eliminating the bacteria in the calyx sinus, because of air pockets preventing access into that space. Also, it will not be effective against endophytic infections present in the flesh of the fruit or in the lenticels.

As for the concentration of chlorine, in the light of findings by Janisiewicz and van der Zwet (1988) a higher concentration may have to be used. Sholberg *et* al. (1988) found chlorine to be ineffective in eliminating *E. amylovora* present on apple fruit surfaces or in the calyxes.

However, even if chlorine treatment may reduce the surface bacteria on trash it will not have any effect on the bacteria in the calyx or within the tissues. Thus, in terms of importation steps, it may effect a low level of reduction in bacterial numbers in Imp 3 and Imp 5, but will only very marginally reduce numbers in Imp 4.

As such, the overall reduction of the unrestricted risk originating from the source orchards, due to chlorine treatment, will be very marginal. Table 118 in the RDIRA (page 471) indicates a 50-fold reduction Imp 5 (from very low to extremely low) as a result of chlorine treatment. However, the literature cited in the RDIRA does not provide support for such a conclusion; nor does it really support a 3-fold reduction in Imp 4 for naturally contaminated fruit. Although RDIRA states (page 471) that the restricted risk, as a result of combining chlorine treatment with the estimate of consequences, is low, it is apparent from the above comments that it is **High** (Table 11.5). Table 11.5 is the equivalent of Table 118 in the RDIRA.

Table 11.5. Effect of chlorine treatment on *E. amylovora*

Step	Unrestricted likelihood	Restricted likelihood
Imp 4	High (0.85)	Moderate (0.5)
Imp 5	Moderate (0.5)	Low (0.175)
PEES	High (0.85)	High (0.85)
Risk estimate	High (0.85)	High (0.85)

11.7.5 Cold storage as a risk mitigation measure

The claim that cold storage is effective in bringing about a decline of *E. amylovora* populations is based on experiments conducted with artificially inoculated fruit. (Sholberg *et al.* 1988; Hale and Taylor, 1999; Roberts 2002; Taylor and Hale, 2003, Ceroni *et al.* 2004). The cited reports vary in their observations as to inoculum decline in artificially inoculated apples. Sholberg *et al.* (1988) reported no difference between the survival of *E. amylovora* prior to storage and after 2 mo of storage; a significant decrease occurred only after 6 months of storage. Ceroni *et al.* (2004) reported *E. amylovora* survival in calyx end after 1-3 months. The survival of *E. amylovora* depended on the level of protection it gained from external environment. The sensitivity of the method by which *E. amylovora* is recovered from any plant material is essential to the understanding of the results. Most of the papers to which the RDIRA refers do not test the sensitivity of the isolation technique. All of the papers rely on indirect *E. amylovora* recovery of inoculum by gentle washing in medium. Therefore, most of the tests have no ability or limited ability to isolate infiltrated inoculum (c/f the discussion Imp 4).

The intricacy of artificial inoculation in cold storage experiments is explained in detail in Imp 4. In isolation these experiments tell us nothing about the survival of *E. amylovora* in naturally occurring populations. What can be said is that artificially inoculated *E. amylovora* can survive in calyxes or packaging materials in cold storage up to 3 months (Ceroni *et al.* 2004). In naturally contaminated apples *E. amylovora* has been observed to survive in calyxes or packaging material for up to 5 months (Sholberg *et al.* 1988).

In the RDIRA the effect of cold storage was already considered in detail earlier under probability of importation in rating Imp 4 as Moderate (pages 94-96). It was considered as both a short term precooling as well as a long term cold storage adopted in some packing houses. The rating of a Moderate likelihood for Imp 4 was given in the RDIRA on the basis of these considerations. Therefore, either it should not have been considered earlier or should not considered again now.

Leaving that point aside, RDIRA states (page 472) that with cold storage alone in place, the likelihood that bacteria would survive routine packing house operations would become low. This inference has been based largely on the work done by Hale and Taylor (1999) and by Taylor and Hale (2003).

However, Nachtigall *et al* (1985) found that under similar cold storage conditions *E. amylovora* populations in the fruit survived for 34 weeks. Nachtigall (1985) used both artificially inoculated and naturally infected fruit in his experiments.

The basic weakness with most of these experiments is that they have been done largely using fruit that were artificially inoculated. In the case of naturally infected or infested fruit the bacteria would be more intimately associated with the host tissue; furthermore, the physiological status of the two are likely to be different.

AQIS received a letter from NZMAF on 8 September 1999, outlining the cold storage experiments that New Zealand scientists were conducting at the time. AQIS asked a panel of scientists comprising Peter Merriman, Les Penrose and Satish Wimalajeewa, to comment on these experiments.

Precisely for the aforementioned reasons the panel suggested that a series of parallel experiments need to be done with naturally infested/infected fruit to obtain meaningful and conclusive results on the effect of cold storage on calyx infections/infestations.

Sholberg *et al.* (1988) working on the effect of various chemical treatments in eliminating *E. amylovora* contaminations in apple fruit, have indicated the merits of doing experiments of this nature using naturally infected/infested fruit.

Except for results of just one experiment reported by Hale and Taylor (Hale and Taylor 1999), and also by Nachtigall *et* al. (1985), so far there has been no evidence in the literature of experiments having been conducted with naturally infected fruit. Even with experiments using artificially inoculated fruit, results have not been consistent.

Thus, cold storage cannot be considered as a reliable method to reduce *E. amylovora* infections/infestations in the calyx that originate in the source orchards. From a biological point of view cold storage would slow down the metabolic processes of the bacterial cells and, thereby, prolonging their survival.

A further point to consider in this regard is what happens in field situations in pome fruit growing areas that experience temperatures well below freezing in winter and still have severe fire blight. If temperatures of 0°C - 2° C are likely to eliminate or considerably reduce *E. amylovora* populations from plant tissues then there may be very little or no inoculum left in overwintering cankers to initiate primary fire blight infections in spring in these areas.

Under 'Probability of distribution' the RDIRA states (page 98) that the "population numbers are <u>probably</u> reduced because of low levels of nutrients in the calyxes, rather than exposure to low temperatures". **This claim is obviously speculative and there is no experimental evidence in the literature to support it.** The inoculum studies cited by RDIRA involve methods and procedures which compromise the physiology of bacterial cells and elevate the effect of exposure to cold temperature. Naturally occurring bacteria are not so compromised. A detailed explanation as to the differing stress performance of artificially inoculated and naturally occurring bacterial infection is presented under the title: Artificial **contamination and challenge testing of *E. amylovora*.** Results drawn from artificial inoculation studies cannot be extrapolated to imply that a similar effect would occur in naturally occurring bacterial populations.

Table 119 in the RDIRA (page 472) indicates a 3-fold reduction in Imp 4 following cold storage. However, the literature cited does not support such a reduction over 6 weeks period of cold storage. In the present response cold storage is not considered to have any effect. Thus, when cold storage treatment is combined with the estimate of consequences of high for fire blight, the restricted risk would work out to be **High** (Table 11.6) rather than moderate as stated in the RDIRA. Table 11.6 is the equivalent of Table 119 in the RDIRA.

Table 11.6 Effect of cold storage on *E. amylovora*

Step	Unrestricted likelihood	Restricted likelihood
Imp 4	**High (0.85)**	**High (0.85)**
PEES	**High (0.85)**	**High (0.85)**
Risk estimate	**High (0.85)**	**High (0.85)**

11.8. Systems approaches:

As described in the RDIRA (page 472) “systems approaches comprise the integration of different risk management measures, at least two of which act independently, and which cumulatively achieve the appropriate level of protection (ISPM 14).”

11.8.1 Areas free from disease symptoms and chlorine treatment

On the basis of analysis done above with respect to Imp 2, Imp 3, Imp 4 and Imp 5 the restricted risk estimate would be **High (**Table 11.7). Table 11.7 is the equivalent of Table 120 in the RDIRA.

Table 11.7. Effect of areas free from disease symptoms/chlorine treatment on *E.amylovora*

Step	Unrestricted likelihood	Restricted likelihood
Imp 2	Moderate (0.5)	Low (0.175)
Imp 3	Low (0.175)	Very Low (0.0255)
Imp 4	High (0.85)	Moderate (0.5)
Imp 5	Moderate (0.5)	Low (0.175)
PEES	High (0.85)	High (0. 85)
Risk estimate	High (0.85)	High (0.85)

11.8.2 Areas free from disease symptoms and cold storage

On the basis of analysis done above with respect to Imp 2, Imp 3, Imp 4 and Imp 5 the restricted risk estimate would be **High** (Table 11.8). Table 11.8 is the equivalent of Table 121 in the RDIRA.

Table 11.8 Effect of areas free from disease symptoms and cold storage on *E. amylovora*

Step	Unrestricted likelihood	Restricted likelihood
Imp 2	Moderate (0.5)	Low (0.5)
Imp 3	Low (0.175)	Low (0.175)
Imp 4	High (0.85)	High (0.85)
Imp 5	Moderate (0.5)	Moderate (0.5)
PEES	High (0.85)	High (0.85)
Risk estimate	High (0.85)	High (0.85)

11.8.3 Chlorine treatment and cold storage

On the basis of analysis done above with respect to Imp 2, Imp 3, Imp 4 and Imp 5 the restricted risk estimate would be **High** (Table11.9)**. It is important to bear in mind that any reduction in *E.amylovora*** numbers here is very marginal, and that only some of the bacteria (not 100%) contaminating the external surface of the fruit would be killed. Table 11.9 is the equivalent of Table 122 in the RDIRA.

Table 11.9. Effect of chlorine treatment and cold storage on *E. amylovora*

Step	Unrestricted likelihood	Restricted likelihood
Imp 4	High (0.85)	Moderate (0.5)
Imp 5	Moderate (0.5)	Low (0.175)
PEES	High (0.85)	High (0.85)
Risk estimate	High (0.85)	High (0.85)

11.8.4 Areas free from disease symptoms and chlorine treatment and cold storage

On the basis of the overall analyses done above with respect to all the imps (Imp 1 - Imp 8) the restricted risk estimate would be **High** (Table 11.10). Although the risk associated with trash is highly significant, and is discussed below in detail in paragraph 10, it was not taken as a factor in the equation in estimating the restricted risk. Table 11.10 is the equivalent of Table 123 in the RDIRA

Table 11.10 Effect of areas free from disease symptoms and chlorine treatment and cold storage on *E. amylovora*

Step	Unrestricted likelihood	Restricted likelihood
Imp 2	Moderate (0.5)	Low (0.175)
Imp 3	Low (0.175)	Very low (0.0255)
Imp 4	High (0.85)	Moderate (0.5)
Imp 5	Moderate (0.5)	Low (0.175)
PEES	High (0.85)	High (0.85)
Risk estimate	High (0.85)	High (0.85)

Conclusions: risk management for fire blight
It is apparent from the above analyses, summarised in Table 11.10, that the risk management measures listed do NOT lower the risk either when applied individually or in combination of all the measures together (systems approach) to a level within Australia's appropriate level of protection (ALOP). The overall High Restricted Likelihood, shown in Table 11.10, would not meet Australia's ALOP. In fact, if the overall risk was determined **purely qualitatively**, using a commonsense approach, the outcome would have turned out to be Moderate rather than **High**.

Thus, in Australia, with the availability of susceptible hosts in abundance, and areas with weather conditions particularly favourable for fire blight, sufficient levels of inoculum (of *E. amylovora*) will become available, even with a Low risk estimate, let alone a high to complete the Disease Triangle, leading to establishment and spread of the disease, if apples from New Zealand were to be imported.

11.9 General discussion of issues in the RDIRA relating to unrestricted and restricted risk

Pathways of entry of E. amylovora with imported apples.

The more recently issued ISPMs (ISPM No. 11 of May 2001; ISPM 11 Rev. of April 2003 and ISPM 14 of March 2002) and the RDIRA glossary of terms define ‘entry’ as the “Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled”. In the case of Australia the whole country is PRA area according to this definition. Therefore, realistically the steps comprising ‘entry’ should end with the release of the imported apples following on-arrival inspection by the quarantine authorities in Australia. The section on “Steps in the importation scenario”, and Figure 8 (Importation scenario for apple fruit from New Zealand) in the RDIRA (pages 51-52) bring out this point clearly when it states at the end of the direct pathway “imported apples infected or infested” following importatation step 8 (Imp 8). When infected or infested apples have been imported and entered Australia (PRA area) the pathogen has also entered Australia (PRA area) along with these apples. It is not possible to consider the entry of apples as separate from the entry of the pathogen which is associated with the fruit. Thus, steps in the distribution of the imported apples should not be included as a component of ‘entry’, **especially the transfer of the pathogen to a susceptible host** as given in the RDIRA (page 97) under ‘Sequence of events for successful exposure’.

The ISPMs (ISPM No. 11 of May 2001; ISPM 11 Rev. of April 2003 and ISPM 14 of March 2002) refer to the entry of the pest into the PRA area, whereas the RDIRA (page 45) is extending the entry to the **endangered area**. The latter area is defined in these ISPMs as an area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss. Thus, they are areas either within the PRA area or the entire PRA area itself. For fire blight, an example would be the Goulburn Valley in Victoria.

Transfer of E. amylovora to a susceptible host is a low probability event even in countries where fire blight incidence is particularly high.

In plant pathology, as well as in human and veterinary medicine, it is an accepted principle that in nature the transfer of a pathogen to its host, leading to infection, is always a low probability event.

Therefore, by combining entry with a low probability event in the distribution of the pathogen BA is unrealistically lowering the probability of entry.

The possible entry of the fire blight bacterium, E. amylovora, into Australia with New Zealand apples is primarily the most important single event occurring in the pathway associated with the importation.

Once the pathogen has entered the country in sufficiently large numbers it will find some natural means to invade a susceptible host and establish itself, **thus completing the disease triangle**. Therefore, the other events that follow entry of the pathogen will become only secondary to ‘entry’.

11.10 Importation of trash:

Although the RDIRA has identified the importation of trash (page 468) as a potential pathway for the introduction of *E. amylovora* into the country it has not considered this pathway in the analysis on the grounds that the exports from New Zealand are limited to those free from trash. The latter is to be based on an inspection of a statistical sample of the consignment at the border. However, as pointed out in responses to previous IRAs all fruit packers admit that the elimination of trash is an impossible task.

According to Dr Broc Zoller of Pear Doctor Inc, California, and Adobe Creek Packaging, California (a plant pathologist, fruit grower and a fruit packer), it is only accidentally that one may find a box without trash. The trash may come from the same orchard as the fruit or may come from an unregistered orchard and may be infected.

So, despite inspection at the border, there is at least a **low likelihood** of infected trash being imported with the apples.

Infected trash would pose a serious risk if it accompanies fruit; this is the reason why in the New Zealand application in 1995, requesting access for their apples, it was specifically mentioned that " …mature apple free of trash are not a vector for fire blight".

It is important to bear in mind trash does not mean entire leaves or easily visible pieces of leaves and pieces of twigs. Tiny pieces of leaves lodged in the calyx end or the stem end of the fruit also constitute trash. They would also pose a risk if they get lodged in the stem-end space or in the calyx sinus.

Although some researchers have reported that *E. amylovora* populations on leaves are either rare or are very transient, Sholberg *et* al (1988) recovered the bacterium from 100% of the leaves **sampled at harvest** from apple trees free of fire blight symptoms. Furthermore, they found that this high level of **leaf contamination** (100%) **continued for a further one month after harvest**. McManus and Jones (1995) also detected *E. amylovora* in 61 %, 84% and 100% of leaves, sampled from a scion orchard of apples free of fire blight symptoms, using first round PCR, PCR-dot-blot hybridization, and nested PCR respectively. There are two points in relation to this paper (McManus and Jones, 1995) that are particularly important from the point of view of the RDIRA. The authors state that the shoots collected for the tests were from an orchard that did not have any symptoms of fire blight at the time of collection. **However, symptoms have been found in previous years, but they have been pruned out in those years.** This point itself questions the validity of orchard inspections for areas free from disease symptoms referred to in the RDIRA (pages 469-470). Even if the detection technique may have picked some dead cells it is unlikely that all the cells picked up would have been dead. The second point about the paper concerns a statement made by a BA scientist at a meeting held in Donnybrook in May 2004. It has been said that the high incidence of epiphytic *E. amylovora* detected by McManus and Jones (1995) in the scion orchard was a result of hail damage to this orchard. Even if this was true the **main point is that the orchards were symptomless, yet had a very high level of epiphytic bacteria**. The same thing could happen with an export orchard in New Zealand; the orchard could be damaged by hail and may not show any symptoms but will have a heavy epiphytic population, and, consequently, will be used to source apples for export to Australia.

The effect of various risk management measures on the level of risk associated with trash is shown below in Table 11.11.

Trash originating from orchards free from fire blight is likely to carry less *E. amylovora* populations.

Similarly, chlorine treatment would reduce some of the surface *E. amylovora* populations on trash but would not affect those within the tissues. Cold storage would not affect either.

Table 11.11. Effect of the various risk mitigation measures on the level of risk associated with trash.

Treatment (risk mitigation measure)	***Unrestricted risk (without mitigation measures)***	***Restricted risk (with mitigation measures)***
Orchards free from fire blight symptoms	High (0.85)	Moderate (0.5)
Chlorine	High (0.85)	Moderate (0.5)
Cold storage	High (0.85)	High (0.85)
Risk estimate	High (0.85)	Moderate (0.5)

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SECTION 12: EUROPEAN CANKER - PEST RISK ASSESSMENT

12. EUROPEAN CANKER – PEST RISK ASSESSMENT

{A REVIEW OF THE REVISED DRAFT IRA REPORT ON IMPORTATION OF APPLES FROM NEW ZEALAND WITH REFERENCE TO EUROPEAN CANKER (*NECTRIA GALLIGENA*)}

12.1 INTRODUCTION

Biosecurity Australia (BA) has carried out a detailed analysis of the unrestricted annual risk of importing apples from New Zealand and the results are published in the Draft IRA Report (February 2004). It is evident from the Report that the unrestricted annual risk for apples intended for export to Australia exceeds ALOP for European Canker. Consequently, BA is proposing risk mitigation measures which are considered to reduce risk to a very low or negligible level and this would satisfy ALOP.

A combination of risk mitigation measures are proposed that include registration of source orchards, inspection to ensure freedom from pests and diseases and application of phytosanitary measures.

The terms of reference are to critically examine the analysis for European Canker caused by the fungus *N. galligena* and to comment on the assessment of risk and the risk mitigation measures proposed by BA. Comments on the BA report are below.

12.2 PEST CATEGORISATION

As can be expected, BA has determined that *N. galligena,* the causal organism of European Canker, is a quarantine pest because it satisfies all of the primary elements in the categorisation of a pest as a quarantine pest. This is in accordance with the International Plant Protection Conference (IPPC 2003) definition. *N. galligena* has been recorded on more than 60 tree and shrub species in diverse orders of plants. Although economic damage attributed to *N. galligena* is most severe on apple and pear, losses to forest tree species have also been observed in many genera. European Canker is one of the most economically damaging diseases of apple and pear in Europe, North America and South America. Heavy losses occur at all stages of production, from the tree nursery to the fruit stored.

The disease occurs in all apple-growing areas in New Zealand but not in Australia. The climate in most production areas in Australia is favourable for the disease and the varieties grown are also susceptible. No other country, with the exception of Tasmania, has been able to eradicate it once it has established and the annual cost of control can be high. **Hence the decision by BA to declare *N. galligena* a quarantine pest is fully justified.**

12.3 UNRESTRICTED RISK SCENARIO

The main concerns in the importation of apples from New Zealand as regards European Canker (*N. galligena*) are latent infections of fruit that would not have been expressed at harvesting or during processing in the packing house and infestation of fruit in the field by conidia. Other less serious concerns include contamination of clean fruit with spores in the routine processing procedures in the packing house and the likelihood that *N. galligena* survives palletisation, containerisation and transportation and remains on the fruit on arrival in Australia.

The risks associated with these concerns are discussed below under two headings as reported in the RDIRA Report (February 2004).

12.3.1 Probability of importation

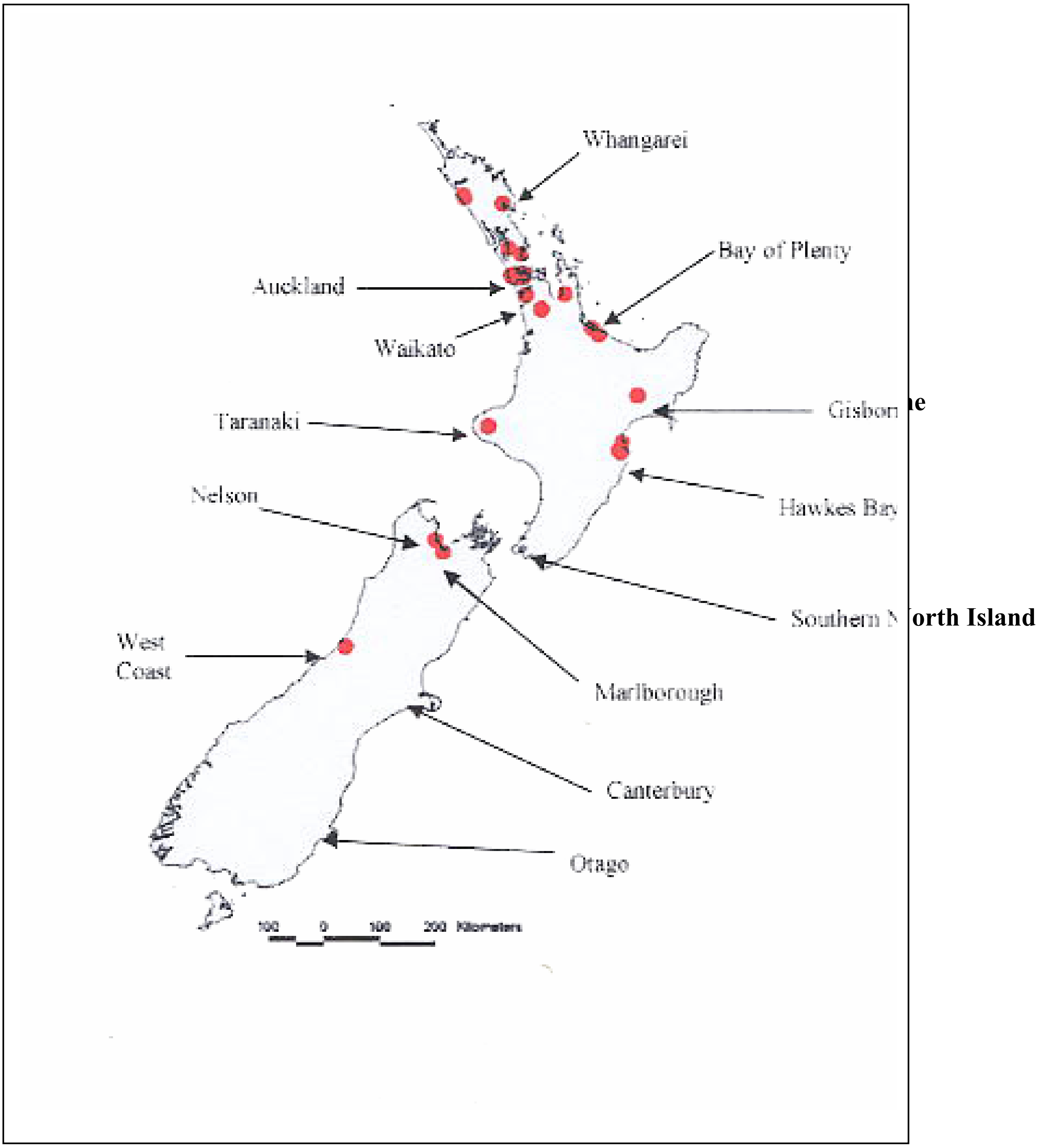
The initial step in the importation chain is the sourcing of apples from orchards in New Zealand and the end-point is the release of fruit from the port of entry in Australia.
The importation scenario has been divided into eight steps in the RDIRA report by BA (p.127) and the likelihood of the presence of *N. galligena* is estimated for each step. The eight steps and the estimates are as follows.

Step 1	Source orchards	Low
Step 2	Harvesting of fruit for Export	Very Low
Step 3	Contamination of clean fruit during picking or transport	Negligible
Step 4	Processing in packing house	Very Low
Step 5	Contamination of clean fruit in 4 above	Extremely Low
Step 6	Pre-export and transport to Australia	Moderate
Step 7	Contamination of clean fruit in packing house during, quality inspection, containerisation and transport	Negligible
Step 8	On-arrival procedures	High

12.4 COMMENTS ON EACH STEP

Importation Step 1 - Published reports indicate the disease occurs in Whangarei, Auckland, Gisborne, Hawke's Bay, Waikato, Bay of Plenty and Nelson. These are major areas of apple production from which apples are exported. Hawke's Bay and Nelson alone accounted for about 85 % of all apple exported from New Zealand in 1999 and European Canker is reported to occur in both of these regions recently. Figure 12.1 shows the distribution of the disease in New Zealand.

Figure 12.1 Distribution of European Canker (red dots) in New Zealand



Source: http://nzfungi.landcareresearch.co.nz/images/maps/12911.gif 26 April 2004

The RDIRA estimate for the presence of *N. galligena* for this step is low because the disease is considered to be under control and it only occurs in a few orchards in areas previously reported to have had the disease. As evidence presented in the supporting text indicates the disease is present in all areas selected for export, varieties grown are susceptible and environmental conditions are favourable for disease development, the assessment low for likelihood is an underestimate. High reliance appears to have been placed on reports and records based on one survey, random inspections and observations.
A more appropriate rating for this step would be MODERATE.

Importation Step 2 - The likelihood for this step is estimated as very low, largely on the assumption that fruit harvested from source orchards will be free from infection/infestation. Supporting arguments include use of regular apple scab sprays, varieties exported will express disease at or before harvest when infected fruit will be discarded and European Canker is mostly a disease of branches and twigs.
Infection of fruit with *N. galligena* results in either restricted lesions called eye rot or the fruit may remain symptomless until it matures. Fruit rot is rarely observed before harvest although in some cultivars a dry necrotic rot has been seen around the calyx. Latent infections on fruit often develop in storage and this may sometimes take 7-8 months.
Fruit harvested from infected orchards can therefore be infected or infested. Conidia are most prevalent in early summer to late autumn and are dispersed in rain run-off and also by rain splash (Swinburne 1971; Munson 1939). As conidia are abundant in summer and autumn, the likelihood of fruit being infected/infested is high if wet periods occur at this time. Infection of fruit can take place on the tree through the open calyx, lenticels, apple scab lesions and injuries caused by insects. Fruit from trees with active cankers is liable to develop rot in store. Losses of 10-60% of stored fruit have been recorded from various parts of the world (CABI 2003a).
Although scab spraying can be effective, its inadequacy for the control of European Canker is discussed in detail in the section on risk mitigation. It should be mentioned that scab sprays have to be thorough because scab lesions on fruit can serve as entry points for *N. galligena*.

In view of the above, the very low assessment for this step is questionable and it should be raised to LOW.

Importation Step 3 – The likelihood of clean fruit becoming infected by *N. galligena* during picking and transportation to the packing house is assessed as negligible. Again, evidence presented in the text does not support this assessment. As pointed out in Step 2, because of high conidial production under favourable weather conditions, especially in high rainfall areas such as Auckland, Gisborne and Nelson, contamination of clean fruit at harvest through dispersal by water and handling can be significant. Although it is stated that the disease appears in these areas in wet springs, the fungus can still be active throughout the growing season and produce sufficient conidia to contaminate fruit at harvest time. Detailed studies on conidial production during the growing season are necessary to confirm this point.
The assessment negligible therefore seems to be an underestimate and a more appropriate rating for this step is LOW.

Importation Step 4 – The likelihood that *N. galligena* survives routine packing house procedures is considered stepwise.

Precooling - As the pre-cooling is of a short duration, it would not have any significant effect. It would neither help reduce infection/infestation nor allow expression of latent infection.

Washing - High-pressure washing would remove most infestations, viz. conidia on the surface, but is unlikely to have any effect on incipient or dormant infections. Also, one cannot be certain that high-pressure washing would remove spores from the calyx and calycine and stem-end sinuses. On the contrary, it could move spores into these cavities. Experiments should be conducted to verify if this is a possibility because spores trapped in the sinuses can survive all of the remaining importation steps.

Waxing – Not likely to have any effect on survival.

Sorting and grading – This procedure would remove most fruit with visible infection but latent infections on varieties like Fuji and Granny Smith would go undetected

Cold storage – This procedure would not be of much use in eliminating infected/infested fruit because duration of storage is short. Some varieties such as Granny Smith could take up to seven months to express symptoms. No precise data are available to be able to express a firm opinion.

Although high-pressure washing would have removed most surface contamination, there is no evidence to show it would remove spores trapped in the calyx and the calycine and stem-end sinuses. Moreover, none of the above treatments would have any effect on latent fruit infection.

Therefore, the assessment of very low likelihood seems unjustified and more appropriate ratings would be:

a) **latent infection – CERTAIN; and**
b) **infestation – LOW.**

Importation Step 5 - Any possible contamination at this stage would be extremely low, and we agree with the stated estimation.

Importation Step 6 – **The assessment moderate for this step should be raised to CERTAIN/CERTAIN as it would have no effect on latent infection or infestation as nothing in the process outlined in the RDIRA would have any effect.**

Importation Step 7 – Agree with IRA assessment.

Importation Step 8 - The estimate for latent infection would be certain as most latent infections would not express symptoms as transit time would be short. For infestation, the estimate would be low as some infestation would remain on fruit and a few latent infections could develop rot and produce conidia. The viability of conidia would be reduced by high humidity and desiccation but as shipping conditions are not known, it is difficult to consider this point.
The estimate for this step should also be CERTAIN/LOW as for steps 4 and 6.
Conclusion – We recommend re-insertion into the simulation model of the revised likelihoods as shown below and a new estimation made.

Step	IRA Assessment	Revised Assessment
1	Low	Moderate
2	Very Low	*Low/Low
3	Negligible	*Low/Low
4	Very low	*Certain/Low
5	Extremely low	*Extremely low
6	Moderate	*Certain/Certain
7	Negligible	Negligible
8	High	*Certain/Low

*Latent infection/infestation

12.5 PROBABILITY OF DISTRIBUTION

This section (pp. 132-141) deals with the distribution of imported apples and the likelihood of *N. galligena* being transferred to a suitable host as a viable propagule. It is covered under three sub-headings as described below.

12.5.1 Sequence of events for a successful exposure

An infection on a discarded apple could be one developing from a latent infection or a surface infection/infestation undetected earlier. Such infections/infestations can produce conidia under ambient conditions during the distribution process and serve as inoculum for infection.
Host plants with wounds, leaf scars and other avenues would be available throughout the year. It is evident that conidia can be dispersed up to a distance of 10m by rain splash and much further in stormy weather. Dispersal by birds and insects is also possible.

12.5.2 Partial probability of distribution

Five utility points have been identified and the probability of exposure of these points to four groups of host plants was estimated separately for each. These are shown in Table 32 of the RDIRA Report.
The only comment I have in regard to these partial probabilities is the low to very low rating given to wild and amenity plants. Wild and amenity plants are widely distributed and are in close proximity to all utility points, except perhaps for orchard wholesalers, and even for them they would not be far away. There is a clear need for a detailed survey of the proximity of wild plants susceptible to European canker to utility points.
Therefore a rating of LOW for all utility points to wild and amenity plants appears more appropriate.

The probability of exposure of susceptible host plants to *N. galligena* by utility points discarding a single infested/infected apple near exposure groups is shown in Table 33. The likely risk of a discarded apple in wholesaler waste to commercial crops is regarded as extremely low and negligible to the other exposure groups, viz. nursery plants, household and garden plants, and wild and amenity plants.
Orchardist wholesalers would naturally be more careful in dealing with their waste because they would not like to introduce disease into their own

orchards. The ratings given to commercial fruit crops, nursery plants and household and garden plants are acceptable.
The rating negligible for wild and amenity plants for the reason mentioned in the previous paragraph should be raised to LOW.

Retailer waste will mostly end up in a landfill and is likely that an infected fruit dumped there could be exposed to wild and amenity plants. The rating extremely low therefore appears to be an underestimate as little is known about the proximity and distribution of host species near landfills.
A rating of LOW is more appropriate.

Since more than 90% of the fruit would eventually go to the consumer, it is likely that more infected fruit would be present in their waste than in waste from the other utility points. As they are last in the distribution chain latent infections would have had more time to express and they would also be holding fruit at ambient temperature both of which could result in conidia production and release. **Furthermore, in view of their close proximity to household and garden plants and amenity plants, their waste poses a greater risk to household and garden plants and amenity plants and hence the rating extremely low assigned to them should be raised to LOW.**

12.5.3 Conclusion

The partial probabilities of distribution from each utility point to each exposure group calculated by the simulation model, taking into account the volume of trade are given in Table 34. The high scores for household and garden plants and wild and amenity plants validate the comments in regard to these groups.

12.6 PROBABILITY OF ESTABLISHMENT OR SPREAD

12.6.1 Probability of establishment

The information provided under this heading on pages 142-143 indicates *N. galligena* is a high risk pathogen with great potential to establish and spread in commercial orchards, forests and many garden, amenity and wild plants. Average annual rainfall of about 1000mm favours the establishment of the disease. The fungus has a high rate of production of spores and inoculum is available throughout the year. Annual rainfall close to or more than 1000mm occurs in apple growing areas in Australia, e.g. Orange (949mm), Batlow (949mm) and Adelaide Hills (1118mm), Perth Hills and Manjimup. An estimate of the partial probability of establishment of *N. galligena* for the four exposure groups is high for commercial fruit orchards and nursery plants, low for household and garden plants and moderate for wild for amenity plants (p.143). **The last group should also be given a rating HIGH for reasons already stated.**

12.6.2 Probability of spread

European Canker can occur both in the natural and managed environments. In addition to the fruit industry, timber and nursery industries have the potential to be involved if an incursion of *N. galligena* occurred in Australia. Based on available information, the partial probability of spread for each exposure group has been assessed as moderate for commercial fruit crops, high for nursery plants, low for household and garden plants and moderate for wild and amenity plants.
Again, a rating of HIGH for wild and amenity plants would be more appropriate.

The combined partial probabilities of establishment or spread of *N. galligena* for the four exposure groups have been assessed as moderate for commercial fruit crops, high for nursery crops, very low for household and garden plants, and low for wild and amenity plants. **If the ratings for wild and amenity plants that have been suggested are used, the rating for the last group will also be HIGH as for nursery plants.**
A great deal of data has been provided to justify the above ratings. The low rating for wild and amenity plants appears to be based on the fact that the distribution of wild species is scattered which is arguable and it is not the case with amenity plants. Another reason given is that the outbreak in Tasmania did not spread to trees in the wild. The reason why European Canker spread to only a few orchards and not to wild trees in Tasmania. A possible reason might be the absence of the perfect stage of *N. galligena*; although perithecial initials were detected but mature asci were never found. The absence of air-borne ascospores which are better suited to long-distance dispersal than conidia probably restricted the spread of the pathogen (Ranson, 1997). Details regarding the differences between conidia and ascospores and their formation are outlined in Part B of the RDIRA (Page 93).

12.6.3 Combined partial probability of establishment or spread

A rating of HIGH for wild and amenity plants is more appropriate

12.7 ASSESSMENT OF CONSEQUENCES

The direct consequences to some aspects of the environment have been assigned a score of E although it is significant at the regional level and highly significant at the district level. The overall impact is considered minor nationally when the supporting text clearly suggests a higher rating**.**
The Australian community values very highly its garden and forest environments, therefore the consequences for this criterion should be considered significant at the national level and the impact score raised to F.

In regard to indirect consequences, the score allocated to control or eradication of D is considered to be an underestimation. European Canker is an insidious disease as symptoms are not striking and easily seen and therefore difficult to control. With the exception of Tasmania, no other country where the disease is serious has been able to eradicate it. In the long term living with a disease is more expensive than eradication. Canker diseases are generally difficult to control, eg bacterial canker of stone fruit and phytophthora-induced cankers on citrus cultivars. Apple scab sprays alone are not sufficient for effective control of European Canker and in a State like Western Australia where apple scab does not occur control would entail considerable additional expenditure. In this context, one wonders whether factors such as the consequences of the incursion of the pathogen into the Goulburn Valley in Victoria

and the impact it would have on the canning pear industry there have been considered. Although the annual rainfall is low in the Valley, the number of wet days in a year may be comparable to those in apple growing areas in New Zealand. Another factor probably not considered in this assessment is the likelihood of the disease entering more than one State simultaneously.
For these reasons, the score of D for this criterion is low and it should be raised to E.
A re-assessment of the overall consequences is suggested using the revised scores for the two criteria as shown below.

	IRA Score	Revised Score
Aspects of the Environment	**E**	**F**
Control or eradication	**D**	**E**

12.8 RISK MANAGEMENT

The unrestricted annual risk has been assessed by BA as low when the overall probability of entry, establishment or spread was combined with consequences. As this score exceeds ALOP, risk mitigation measures are proposed to bring down the score to very low.
In addition to the requirement for registration of orchards, inspection for disease freedom, audit, certification and verification, other measures are proposed to lower the risk to negligible level so that fruit can be safely exported from New Zealand. This section analyses whether the measures proposed by the RDIRA will be effective in reducing risk and also recommends other measures that are considered essential to meet an ALOP of very low (pp. 476-479).
After a sensitivity analysis of the unrestricted scenario for European Canker, it is concluded that the best way to reduce risk is to:

1. Source apples for export from orchards free from *N. galligena* (pest free areas); and
2. Source apples for export from orchards free from European canker symptoms (disease free areas).

12.8.1 Pest free areas

Area freedom would require, inter alia, systems by which MAFNZ would establish, maintain and verify freedom including assurance that the pest was absent at the time of harvest and that it had not been reported within a specified period before harvest. Freedom from European Canker could be established by regular inspections during the growing season and would be subject to audit. It is not clear whether such areas would be officially declared as “disease free areas”. It is claimed that under this area-freedom arrangement, the likelihood of *N. galligena* being present in source orchards (Importation Step 1), the likelihood of picked fruit being infected/infested (Importation Step 2) and the likelihood of clean fruit being contaminated in the packing house (Importation Step 5) would be negligible. This would reduce the likelihood of entry, establishment or spread of European Canker to a very low level. When this was combined with the estimate for consequences, i.e. moderate, the restricted risk for European Canker was found to be negligible and it satisfies Australia’s ALOP. Apples can therefore be safely imported from pest free areas. Article 10 of the SPS Agreement states that an importing country shall accept the measures of other countries as equivalent (article 9), if it is objectively demonstrated, that the measures meet the importing member's ALOP. In this context, in the absence of a detailed work plan for visual inspections, the only conclusion that can be made is that New Zealand has not yet demonstrated, objectively, that apples exported from supposedly pest free areas would meet Australia's ALOP. This applies to areas free from disease symptoms as well as New Zealand has not detailed inspection procedures and control measures for European Canker.

12.8.2 Areas free from disease symptoms

These areas refer to production and associated sites which would be kept free from symptoms of European Canker. It is the responsibility of MAFNZ to establish, maintain and verify freedom from canker of such areas. Measures that are proposed to ensure freedom include fungicidal treatments and cultural practices. MAFNZ would be required to produce assurances that disease symptoms have not been reported in the growing season and the fruit produced are also similarly free. Regular inspections and audit would be carried out to ensure freedom.

In the unrestricted scenario, the likelihood of canker infection of fruit was considered to be very low in New Zealand orchards. Therefore, apples produced in areas free of disease symptoms would be even less likely to be infested/infected, compared with the unrestricted scenario. Hence fruit harvested from these areas can be considered to be extremely low for infestation/infection. Based on this assumption, it is estimated that fruit from these areas would meet an ALOP of very low.

It appears that the so-called pest free areas refer to localities where the disease/pest has not been seen to occur during a specified period in the past and areas free from disease symptoms refer to production areas where, as far as practical, all disease symptoms have been removed and regular fungicidal treatments and cultural practices are in place to prevent reappearance of symptoms.

12.8.3 Inspection of orchards for freedom from European Canker

BA has advised that no work plan has yet been developed for visual inspections but this would occur shortly after the final IRA has been accepted. The term "free" presents considerable difficulties in its interpretation, especially when it refers to absence of disease. It is practically impossible to declare a block of trees or plants as free from a particular disease by any known method, let alone by visual inspection. This applies to European Canker as well. One can only say that a particular lot of trees is disease-inspected after a given number of inspections by trained staff and can be assumed to be reasonably free.

The number of inspections per year and the best times for inspection would be determined by the resources available to MAFNZ and the apple industry. It is believed that orchards would be inspected during the growing season with at least one of the inspections being at harvest time but how many inspections would be carried out annually is not stated. Apparently, growers would carry out all inspections under the supervision of MAFNZ officers. The question arises whether all growers in designated areas would be competent enough to conduct inspections in a consistent manner and MAFNZ has adequate resources and the administrative infrastructure to ensure inspections are efficient, efficacious and consistent.

There are no indications of a joint inspection by MAFNZ and AQIS at any time. It is my view that a joint inspection at least in the early years, preferably at harvest time, would help assuage any apprehension the Australian apple industry might have in regard to inspection procedures and boost its confidence in the system. We note that a joint inspection for export of apples from New Zealand to Japan has been mooted.

As there is little in the literature on the epidemiology of European canker in New Zealand, it is difficult to suggest specific times for inspection of trees. The infection pattern would be similar to Northern Ireland, at least in areas with high rainfall in New Zealand. In Northern Island it has been observed that about 75% of cankers resulted from infections in spring and summer and about 25% from autumn infections (Swinburne *et al*., 1975)). Cankers arising from spring and summer infections were apparent in autumn but were recorded in early winter because they were easily seen at that time. Infections which occurred at leaf fall were recorded in spring. It is therefore suggested that at least one inspection for European Canker should be carried out in winter before pruning. Inspection of twigs which can also be infected and in which the fungus can survive adverse environmental conditions would be impossible. The same difficulty applies to inspection of the canopy for small lesions.

Fruit lesions even when visible can hardly be examined because of the sheer number and the best time to check is during grading and sorting in the packing house. In dessert varieties if rot develops before harvest such fruit would invariably drop off or be discarded during picking.

12.8.4 Effect of apple scabs sprays on European Canker

In areas with frequent rain during the growing season some fungicides used for the control of apple scab would also be effective against European Canker. The spray calendar for apple scab in Victoria recommends spraying at green tip, pink bud, 10% blossom, full bloom and four cover sprays at 10-14 days intervals from October to December. Further sprays are also suggested at three-week intervals until end of March to control secondary infections if rain periods occur.

A variety of fungicides are available for scab control that, include both protectant and systemic fungicides. In the selection of fungicides effectiveness against sporulation by *N. galligena* should be taken into consideration. Results in Northern Ireland have shown carbendazim to be highly effective in reducing sporulation as well as providing good control of canker.

Protective fungicides such as Bordeaux mixture and fixed copper and demethylation inhibitors such as myclobutanil and penconazole have been to found to be effective against both diseases but not as effective as a program which included benzimidazoles.

Whilst scab sprays would effectively control European Canker in spring and summer, additional spraying would be necessary especially in autumn to prevent latent fruit infection as well as control fruit infestation by conidia. Pre-harvest application of fungicides to prevent fruit infections may appear impractical due to difficulties in providing adequate cover under commercial conditions. Therefore to reduce such applications in orchards at most risk it may be necessary to use predictive models to determine infection periods and spray only when it is considered necessary. One can also foresee some problems here as it may be difficult to integrate additional spray applications into the existing IFP and IPM programs.

As leaf scars are a major avenue for infection by *N. galligena*, application of Bordeaux mixture or fixed copper at the commencement and 50% leaf fall should be added to the spray program.

In California the main rainy period and infection is in winter. It is not known if this is the case in New Zealand but it is likely that the climate in Auckland and Waikato in the North Island would be similar to California and dormant sprays in winter may also be necessary there. Also, because *N. galligena* is prolific in spore production and sporulation occurs almost throughout the year in wet areas, spraying is necessary in autumn and winter to reduce sporulation. For these reasons, apple scab sprays alone will not be adequate for the effective control of European Canker.

12.8.6 Post arrival inspection

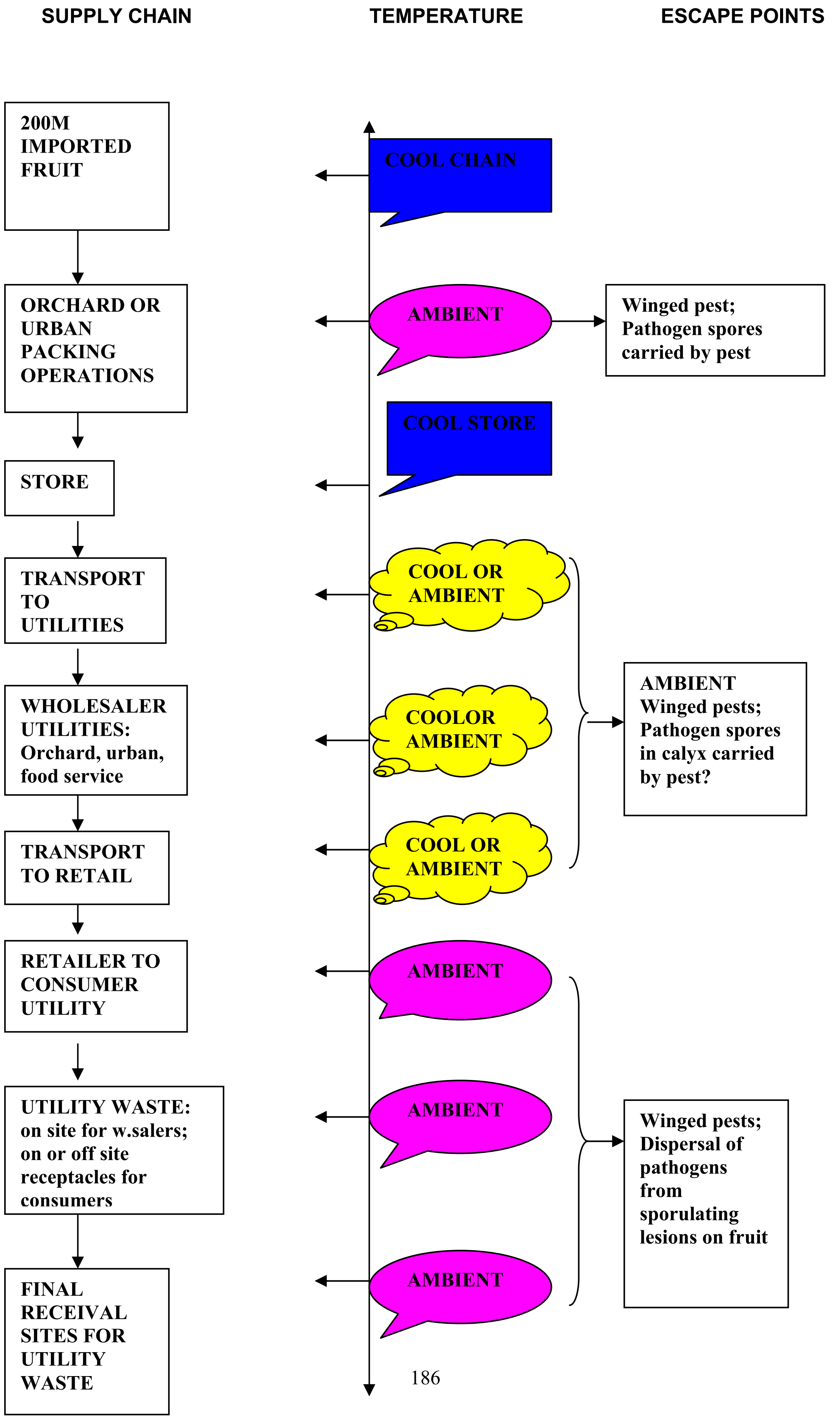
It is stated that latent infection on fruit and some surface infestation could remain when fruit arrived in Australia. Some rots resulting from infestation/infection may express symptoms during transportation to Australia. On-arrival inspections may detect a few of these infections at random sampling but the bulk of them would be detected at the various utility points during the distribution process. As fruit will be exposed to ambient temperatures at various times in the supply chain, some diseased fruit could sporulate and release conidia. It is therefore important that imported fruit should be held under cool conditions wherever possible in the supply chain and all rotten fruit encountered should be placed in closed bins until disposal (Figure 2).

12.8.7 Disposal of waste

The disposal of waste from the different utility points in the supply chain has been considered in great detail in the RDIRA. Waste collected at these points will in addition to trash contain rotting fruit. As pointed out earlier, fruit will be exposed to ambient temperatures at many points (Figure 12.2) where the chances of sporulation from infected fruit are a distinct possibility. To avoid dispersal of spores from such fruit, it is recommended that receptacles used to hold waste should be kept closed always, both in the shed and during transport to the dumping site.

Furthermore, waste placed in landfill and other dumping grounds should be regularly turned over and covered with soil if feasible to prevent release of spores into the air and possible dispersal by birds and insects. The relevance to the disposal of waste must be questioned given that Biosecurity Australia or Australian Quarantine Inspection Services officials have no control over how landfills and other dumping facilities are managed.

Figure 12.2. IDENTIFICATION OF PEST ESCAPE POINTS IN RELATION TO SUPPLY CHAIN, WASTE STREAM AND ASSOCIATED TEMPERATURES



12.9 DISCUSSION

Having examined carefully the various steps in the risk analysis pathway and identified a few steps for which the qualitative estimates of risk do not seem justified, the RDIRA estimates have been adjusted for these steps. The revised steps are shown in the accompanying Table, together with the reasons for the change.
In some cases it has been difficult to make an objective assessment of the risk associated with each step due to gaps in the available information. These are outlined below.

- More robust evidence is required on the incidence of the disease in export areas. Current evidence seems to be based on random inspections, one survey and field observations.
- Evidence on the incidence of the disease in Hawke's Bay in particular, which is a major export area, is scanty. Two references are cited regarding the presence of European Canker in Hawke's Bay. One cites a survey in Nelson and Hawke's Bay and it concludes that the disease was not observed in Hawke's Bay (MAFNZ, 2000c- Correspondence with AQIS). The other reference that talks about recognising European Canker symptoms (Wilton, 2002b), is not available. Clearly a more comprehensive survey of this important area is needed.
- Detailed studies on the epidemiology of European Canker have not been carried out in New Zealand and most of the information used in risk analysis is based on work done overseas. Data on seasonal changes in spore production and the pattern of infection and disease development, for example, would be useful in suggesting effective risk mitigation measures. Also, information on incidence on latent infection of fruit and its correlation with canker incidence would be useful. Too much emphasis appears to be placed on total annual rainfall and a figure of 1000mm is considered to be highly significant. One would think that the distribution of rainfall and the number and duration of wet periods and leaf wetness would be far more critical for infection than total rainfall and these should be determined at least for the major areas producing apples for export so that control measures can be timed more effectively. With regard to European Canker Swinburne (1971) states that spore discharge is closely related to the number of hours of leaf wetness than the total volume of rainfall.
- The spray calendar for apple scab, and information on the materials used, is not available so the effectiveness of apple scab sprays against European Canker cannot be properly assessed.
- With regard to the exposure group Wild and Amenity Plants, a detailed survey of their proximity to waste dumping sites, their distribution and the host species involved is necessary to make a rational assessment of their susceptibility to European Canker.
- Precise evidence is also required on the survival or not of conidia of *N. galligena* in the calyx and calycine and stem-end sinuses after high-pressure washing.

A simple method by which export fruit can be checked for the presence of latent infections/infestations would be to collect random samples of fruit from packing houses and store them in cool store for the required length of time for symptoms to express. In this way, a good estimate of the likelihood of *N. galligena* surviving on export fruit can be obtained.
It is suggested that the Unrestricted Annual Risk be recalculated using the revised estimates for the steps shown in the attached Table. The method of calculation of

overall probability of entry, establishment or spread is unclear. It is stated that this calculation was made using @ Risk.
However, if the revised estimates are used the overall probability would work out to be MODERATE.

The revisions suggested for consequences are not likely to alter the estimate moderate assigned to this factor. Therefore, it is estimated that the Unrestricted Annual Risk after recalculation would be MODERATE and the revisions suggested for consequences would change the estimate of moderate to HIGH (page 74, set 4). Therefore, the Unrestricted Annual Risk for European Canker would be HIGH.

As this would widen the gap between the estimated risk and the acceptable risk (ALOP), there is a need for reinforcing the risk mitigation measures already in place. In these circumstances, the establishment of disease free areas for sourcing export fruit, to the satisfaction of the Australian fruit industry, seems to be the best option for the export of apples to Australia.
Additional risk mitigation measures have been suggested and further refinements can be made only after the gaps outlined are filled. In this context, the establishment of buffer zones around export blocks to avoid contamination of export fruit from neighbouring blocks before and during harvest could be considered. Other host species of *N. galligena* in the neighbourhood should also be taken into account.

Table 12.1 Summary of the Review of the Estimate of Unrestricted Risk for European Canker

Pathway components	**Risk in 2004 IRA**	**Recommended Risk**	**Justification**
Importation step			
Imp 1	Low	Moderate	Disease occurs in all districts; robust evidence needed on incidence and severity; rainfall in more than 40% of export area favourable for disease; all varieties grown susceptible; high levels inoculum can occur at low disease incidence.
Imp 2	Very Low	Low/Low*	Heavy reliance on apple scab sprays for control; more information needed on seasonal changes in sporulation and quantitative estimate of latent fruit infection.
Imp 3	Negligible	Low/Low*	Detailed studies on conidia production required; inoculum level at harvest critical.
Imp 4	Very Low	Certain/Low*	None of the treatments will have any effect on latent infection; effect of high-pressure washing on spores trapped in calyx and calycine and stem-end sinuses not known
Imp 5	Extremely Low	Extremely Low	
Imp 6	Moderate	Certain/Certain*	Same as in 4 above
Imp 7	Negligible	Negligible	
Imp 8	High	Certain/Low*	Same as in 4 above
Distribution Proximity to Exposure groups- Wild and amenity plants (Table 32)	Very low	Low	Amenity plants widely distributed and close to all utility points; wild plants though scattered not far away; both groups contain many host species
Establishment Amenity and wild plants (Page 143)	Moderate	High	Amenity and wild plants widely distributed; rainfall in some areas of apple production close to or more than 1000mm; fungus prolific in spore production and inoculum available throughout the year
Spread Amenity and wild plants (Page 144)	Moderate	High	Same as above
Establishment or spread (PPES) (Table 35)	Low	High	Same as above
Consequences Human life or health	Omit	---	No known record of *N. galligena* causing any injury to human life. This criterion should apply to animal diseases only.
Environmental effects	E	F	Community values highly its environment; as *N. galligena* has a wide host range its effect on the Australian ecosystem can be very significant
Control or eradication	D	E	Insidious disease; difficult to eradicate; control expensive; possible impact on other industries eg canning fruit in Victoria

* Latent Infection/Infestation

12.10 CONCLUSION

A critical examination of the evidence presented to justify the estimated risk for the various steps in the importation and distribution pathways has led to the revision of some of the IRA estimates and these are shown in the Table provided in the text. The reasons for the changes are indicated briefly in that Table and are also discussed in more detail in the text.
In some instances it has not been possible to make an objective assessment of the risk due to lack of precise information on the epidemiology of European Canker in New Zealand. In such cases, a more conservative approach should be adopted in revising the IRA estimate in those areas that the RDIRA has failed to adopt a conservative approach that is not in accordance with Australia's accepted level of protection.
Gaps in the available information on European Canker in relation to its epidemiology and control in New Zealand have been highlighted and discussed in detail in the text.

It is evident from the literature that European Canker caused by the fungus *Nectria galligena* **("*N. galligena")*** is one of the most economically damaging diseases of apple. In Europe there are reports that the severity of epidemics is increasing (Huberdeau, 1996; Schmitz *et al.*, 1996). With the exception of Australia, where it has been eradicated, *N. galligena* is present in almost all regions of apple production (CABIa, 2003). The disease has been recorded in many tree and shrub species and all apple cultivars are susceptible. Both young and old trees can be affected. In young orchards loss of trees due to canker may exceed 10%, and in some instances requiring replanting of the whole plantation. Also losses of 10-60% of fruit due to storage rot have also been recorded (Swinburne, 1970; McCartney, 1967).
The disease has been reported to occur in all of the major apple growing regions of New Zealand but more comprehensive surveys are necessary to determine the incidence and severity of the disease in these areas. The absence of the disease in orchards/ blocks claimed to be disease free needs more compelling evidence to satisfy the Australian fruit growers.
The view that the disease is not important in areas below 1000mm rainfall is too simplistic (MAFNZ, 2004) as the distribution of rainfall and the number and duration of wet periods, prior to harvest in particular, are critical factors that need investigation. Also, data on the seasonal pattern of spore dissemination would assist in determining the level of fruit infection/infestation, if any, and formulate effective control measures.
It is important to remember that that the disease does not occur in Australia and there are apple-growing areas in the country with favourable climate for disease establishment and spread. Furthermore, besides Tasmania, no other country has been able to eradicate the disease and the additional cost of control could be substantial, especially for growers in Western Australia where apple scab does not occur. Even in the other States apple scab sprays alone would not be sufficient to control European Canker effectively.
The impact on wild and amenity plants of an incursion of *N. galligena* into Australia needs to be more carefully considered following a detailed survey of their distribution and proximity to utility points and waste disposal sites in view of the high value the Australian community places on its forest and garden environments. The manner in which waste is disposed at the various utility points and dumping sites also requires investigation.
If the revised estimates for overall probability of entry, establishment and spread and consequences are used and the unrestricted annual risk recalculated, it would be HIGH, which means more rigorous risk mitigation measures are required to reduce risk to an acceptable level for the export of fruit. The principal reason for the HIGH estimate for risk is the likely threat to

aspects of the environment if an incursion of *N. galligena* occurred. In these circumstances, the establishment of pest free areas for sourcing export fruit, to the satisfaction of the Australian fruit industry, appears to be the best option.

12.11 REFERENCES

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SECTION 13: INSECTS - PEST RISK ASSESSMENT

13. INSECTS – PEST RISK ASSESSMENT

{REVIEW OF THE ENTOMOLOGICAL COMPONENTS OF *IMPORTATION OF APPLES FROM NEW ZEALAND: REVISED DRAFT IRA REPORT – FEBRUARY 2004}*

13.1 INTRODUCTION

This review was conducted at the request of Apple and Pear Australia Limited. It provides an independent appraisal of the scientific and logical basis for the conclusions reached in the RDIRA for the proposed importation of apples from New Zealand. In particular, the aims of this review are:

1. to evaluate the scientific basis for estimates of risks of entry for quarantine pests used in the risk analysis equations
2. to determine whether the risk analysis methodology has been applied consistently within and between analyses
3. recommend any changes needed to the risk values for entry, establishment, spread and consequences
4. recommend any additional risk mitigation measures required to reduce the risk levels to meet the ALOP of very low

Each pest of quarantine concern will be considered in detail following the process adopted in the 2004 RDIRA. At the same time differences between the conclusions reached in the earlier 2000 DIRA and the current 2004 RDIRA will be evaluated.

13.2 GENERAL COMMENTS

13.2.1 Integrated Fruit Production

The RDIRA and the New Zealand apple industry place a great emphasis on the widespread adoption of Integrated Fruit Production (IFP) in New Zealand apple orchards and that only those growers implementing IFP would be registered to export to Australia.

Integrated Fruit Production aims to produce fruit in the most environmentally friendly manner and includes as a centrepiece Integrated Pest Management (IPM) principles for control of pests, diseases and weeds. In general, IPM aims to reduce the use of broad spectrum insecticides by employing a variety of strategies which may include:

1. Specific insecticides with low toxicity to other life forms, particularly vertebrates, e.g. insect growth regulators (IGRs).
2. Population reduction using specific insect sex pheromones for mating disruption.
3. Reduction in the number of sprays used by optimised spray timing based on population monitoring systems and detailed knowledge of the insect's population dynamics. These systems may include trapping of insects in sex pheromone or other traps, direct population estimates on foliage,

monitoring of damage levels in developing fruit or day degree accumulation to monitor development of insect life cycle stages.
4. The use of 'economic thresholds'. These are pest levels below which spraying is not cost-effective, i.e. the cost of applying the spray exceeds the cost of the damage prevented.
5. The use of biological control agents such as predators and parasites.

Of these, methods 1, 3, 4 and 5 are widely practised in New Zealand (Shaw *et al.*, 1997). The IFP programme is largely based around the use of an IGR chemical, tebufenozide, for control of the key Leafroller pests and Codling Moth (Walker *et al.*, 1997, 1998). Predatory mites are instrumental in control of European Red Mite and Twospotted Mite (Wearing, 1996), and spray thresholds based on various population monitoring systems are implemented for most other pests (Walker *et al.*, 1997, 1998).

IFP has several important implications for quarantine. Compared with the traditional use of broad spectrum pesticides, orchards in which IFP is practised are likely to:

- Have higher and more variable population levels of key pests
- Include a higher diversity of pests

13.2.1.1 Higher Key Pest Populations

There are several reasons why higher pest populations would occur in IFP orchards:

- For biological control to be effective, there must always be a host population to support the specific predator or parasite population.
- The economic threshold philosophy virtually ensures there are low (subthreshold) populations of the pest in the orchard.
- Systems based on mating disruption are less effective for reducing pest population levels than broad spectrum sprays and usually result in higher levels of pest damage to apple crops.
- Similarly, specific chemicals such as IGRs may be less effective than broad spectrum chemicals such as organophosphates. However, tebufenozide is a particularly efficacious IGR.

13.2.1.2 Higher Diversity of Pests

The use of pest control strategies targeted specifically to particular key pests, often leads to the emergence of new pests that were formerly suppressed, often unknowingly, by broad spectrum chemicals. These insects were usually recognised only as occasional or minor pests when broad spectrum sprays were in wide use. When these pests are released from broad spectrum chemical control and become significant under IFP programmes, new control strategies need to be developed specifically for them. Such strategies must be compatible with the IFP strategies for all other pests. The result is that IFP becomes increasingly complex and fragile, often with a range of measures that result in suboptimal control of one or more of the pests because of the constraints on the system. Such systems require intensive maintenance and are prone to collapse if one of the key control measures fails due to a perturbation such as the development of resistance to a key chemical in one of the main pests. Often, there are few, if any, alternatives available.

The current pest complex on New Zealand apples features a number of pests that have risen to greater prominence under IFP (Shaw *et al.* 1997, Walker *et al*., 1997, 1998). The most notable of these is Apple Leaf Curling Midge, *Dasineura mali*, which is now one of the main apple pests in New Zealand (Smith and Chapman, 1997;). A similar phenomenon has occurred in organic blocks in New York State (Agnello *et al.* 2000), where *Dasineura mali* developed 'serious infestations'.

However, the New Zealand apple industry is aware of the quarantine risks associated with the implementation of IFP. IFP has been introduced to minimise environmental damage in orchards and surrounding areas, and to meet the demands of consumers worldwide for produce grown in an environmentally acceptable manner. The IFP programme attempts to balance the need to meet strict quarantine regulations on its export fruit with environmental responsibility. To avoid the potential quarantine issues arising from IFP, quite conservative spray thresholds are used to minimise the likelihood of quarantine breaches (Walker *et al*., 1997, 1998).

The foregoing considerations of the potential quarantine significance of IFP in New Zealand apples have been taken into account in evaluating the risks of entry for each pest in this review. This was done wherever possible by using published results of IFP monitoring studies as the base data for this analysis.

13.2.2 Distribution in New Zealand

Most of the insects of quarantine concern are native New Zealand species that have adopted apples as a host. Most of these insects are widespread in New Zealand, or belong to groups of similar species that are common throughout New Zealand, e.g. the Green-headed and Brown-headed Leafrollers. Where the literature states that a species or group of species occurs throughout New Zealand, it is reasonable to conclude they are certain to occur in every New Zealand orchard, even if in very low numbers. This logic has not been applied in the RDIRA, rather it has been considered that the probability of occurrence of such pests is 'high', and for some even 'low' or 'very low'. In the RDIRA 'high' ranges from 0.7 to 1 with a midpoint of 0.85, which is here considered far too low for widespread, common pests.

13.2.3 Host Range

Many of the pests of quarantine concern are also polyphagous, i.e. they are capable of utilising many host plants and this lack of host specificity is one of the reasons they have been able to utilise apples as a host. Such insects have a high probability of finding a suitable host if transferred to a new environment such as Australia. Therefore, all species known to be polyphagous should be regarded as having a reasonably high probability of finding host plants no matter where they may escape in Australia. Many garden plants and broad-leaved weeds are likely alternative hosts that could allow establishment to occur. There is little consideration in the RDIRA of the host potential of broad-leaved weeds, which are ubiquitous in Australia. In this review, broadly polyphagous species will be considered as likely to establish and spread irrespective of the utility point to which they are distributed.

13.2.4 Factors Contributing to High Quarantine Risk

The RDIRA is primarily structured around the Risk Analysis Model, which in turn is based on the fate of a theoretical single piece of infested fruit. This framework, while appearing to be rigorous and all-encompassing, does not facilitate the incorporation of pest and disease biology and population dynamics into the risk analysis. It is very difficult to think about pest biology in the context of a single piece of fruit. In other words, biological reality has been sacrificed for statistical convenience. Pests function as populations, not as single individuals, as would often be associated with a single piece of infested fruit. Nowhere does the RDIRA discuss in overall terms the factors that constitute high risk from a biological viewpoint, although some are mentioned under the discussion for individual pests. The following attempts to identify the key characteristics of pests that contribute to high quarantine risk.

The risk factors vary for different steps along the importation and distribution pathways and are summarised below for two quite distinct groups; those that usually infest fruit as single individuals, and those that may have multiple individuals per fruit.

13.2.4.1 Single Individuals per Fruit

The following characteristics represent the highest quarantine risks for insects that inhabit the fruit singly:

- They spend their larval stages inside the fruit where they feed and grow. The infestation may not be obvious without cutting the fruit open.
- They enter the fruit through the calyx so that the entry hole is difficult to detect on the sorting line in the pack house, allowing them to pass through.
- They are capable of active flight. This is necessary for them to find mates and host plants after arrival in Australia.
- They are polyphagous and hence have a wide range of potential host plants available for establishment.

Insects with these characteristics are typically moths, and include the Greenheaded and Brownheaded Leafrollers (*Planotortrix* ssp. and *Ctenopseustis* ssp., respectively), Oriental Fruit Moth (*Grapholita molesta*) and Codling Moth (*Cydia pomonella*). Such insects will only establish if at least two moths, a male and a female, escape at the same place at about the same time, and there are host plants in the vicinity. Pests that inhabit fruit singly and need to mate in order to reproduce are less likely to establish as a result of being discarded as a single fruit by a consumer, than pests that can have multiple individuals per fruit.
The main risk scenario for these pests is escape from points where bulk fruit is being stored, repackaged or processed. Only under these circumstances is it likely that several insects may escape at similar times. Another necessary requirement is for the cool chain to be broken, such that insect development and activity can occur. This will be a major constraint in well managed operations since maintenance of the cool chain is essential for preserving fruit quality.

13.2.4.2 Multiple Individuals per Fruit

The following characteristics represent the highest quarantine risks for insects that may have multiple individuals on the fruit:

- They are very small and hence many individuals can inhabit sheltered places like the stalk and calyx cavities. Being lodged deep in the stalk or calyx cavities at least partially protects them from pack house processes such as high pressure washing and brushing.
- They are hard to see (cryptic), which makes them difficult for sorters to detect on the packing line, allowing them to pass through.
- They may or may not be capable of flying.
- They are polyphagous and hence have a wide range of potential host plants available for establishment.
- Infestation of fruit by multiple individuals in the stem end or calyx regions, increases the likelihood that fruit will remain infested after routine pack house procedures. This is because while high pressure washing and brushing may remove a moderate proportion of individuals, a high proportion of infested fruit will remain infested, albeit with lower pest numbers. There does not appear to be any readily available data with which to test this.

Such insects include the eggs of European Red Mite (*Panonychus ulmi*) and Grey-brown Cutworm (*Graphania mutans*), all life-cycle stages of sedentary species such as Oystershell Scale (*Diaspidiotus ostreaeformis*) and Mealybugs (*Pseudococcus calceolariae* and *Planococcus mali*), and Apple Leafcurling Midge (*Dasineura mali*). All but the last of these are flightless and will require placement of infested fruit very close to a host plant. The scenario of highest risk for these species is discarding of an apple core into a patch of hosts by a consumer, or possibly dumping of bulk waste fruit in or near an orchard.

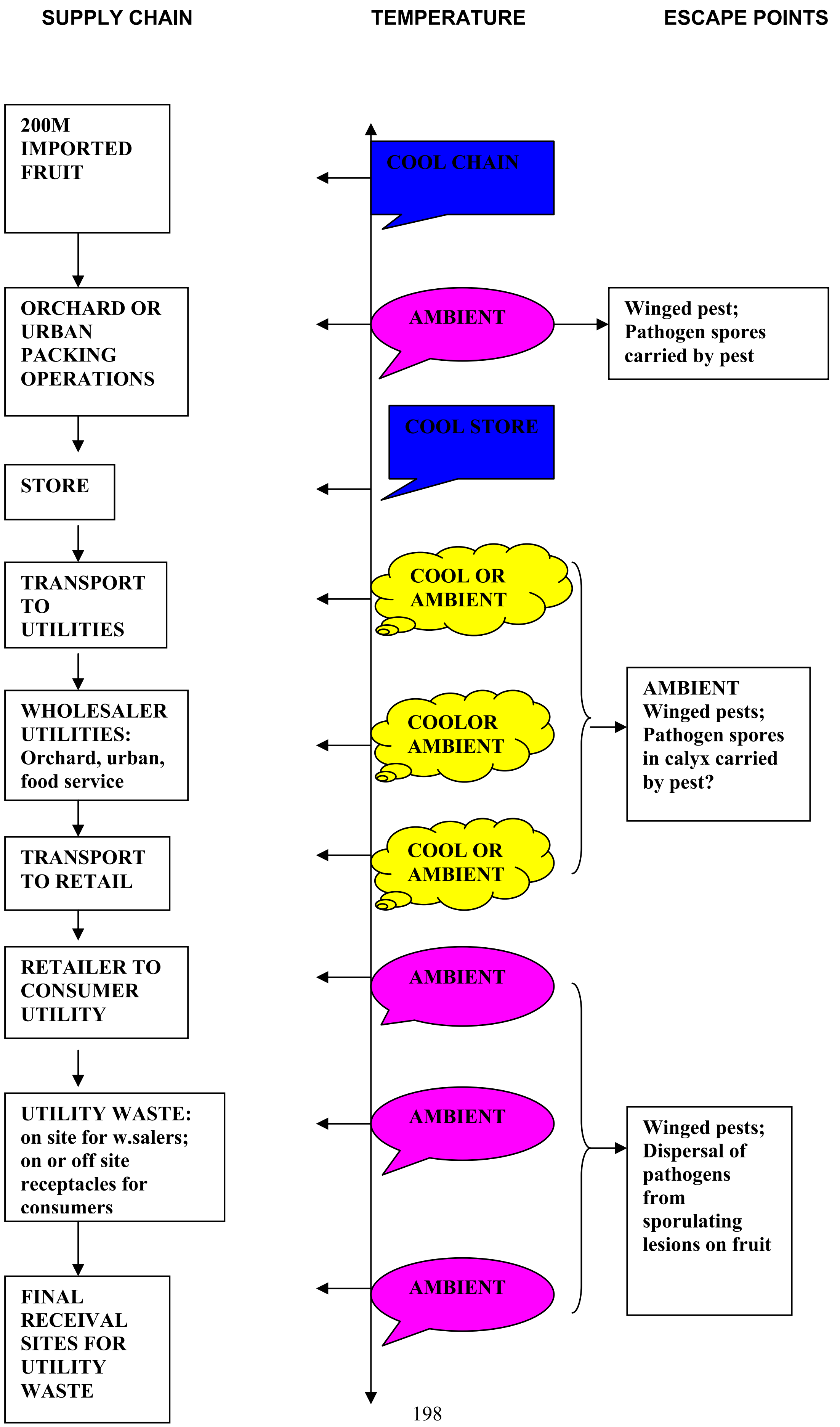
Apple Leafcurling Midge represents a particularly high risk in that it not only has the potential to occur as multiple individuals on a single fruit, but is also winged. Hence, it is possible for a single discarded piece of infested fruit to initiate an infestation, and that fruit does not have to be as close to apples as for the wingless pests. On the other hand, Apple Leafcurling Midge is not polyphagous, being host specific on apples, so that establishment can only occur if there are apple or crabapple trees in the vicinity of an infested discarded fruit or waste dump.

The above scenarios have been considered and applied to the risk analysis model in the RDIRA in this review.

13.2.5 Cool Chain

There is little, if any, consideration in the RDIRA about the potential effects of breaking the cool chain on the likelihood of escape by winged insects. It appears to be assumed that the cool chain will always be maintained, but this is not necessarily so. Figure 13.1 indicates the points along the distribution pathways where the cool chain may be broken allowing pests to resume development, escape from the fruit or emerge from pupae. This risk has been very much downplayed in the RDIRA, with the escape of winged insects from non waste fruit being regarded as ‘extremely rare’. Figure 13.1 indicates there may be many opportunities along the distribution pathway for insect development to continue and for winged insects to escape. Some of these escape points are missing from the Import Risk Analysis model altogether, particularly the transport steps.

Figure 13.1 IDENTIFICATION OF PEST ESCAPE POINTS IN RELATION TO SUPPLY CHAIN, WASTE STREAM AND ASSOCIATED TEMPERATURES



13.3 REVIEW OF INDIVIDUAL PEST SPECIES

13.3.1 Apple Leafcurling Midge, *Dasineura mali*

Apple Leafcurling Midge **("ALCM")** is now regarded as a serious pest in most apple growing regions of New Zealand (Tomkins *et al*., 1994; Smith and Chapman, 1995, 1997). Introduced into New Zealand from the Netherlands in 1950, it was generally regarded as a minor pest controlled by the pesticides applied for other insects (Walker *et al*., 1997; Tomkins *et al.*, 2000; Shaw *et al*., 2003). From the mid 1980s it increased its pest status (Shaw *et al*., 2003). Tomkins *et al*. (1994) reported up to 11.5 percent of fruit was infested with cocoons in Waikato, while Burnip *et al.* (1998) found that up to 20 percent of harvested fruit was infested in some Waikato and Hawkes Bay orchards. The reason for the increase in pest status of ALCM most likely relates to reductions in the use of broad spectrum insecticides (Tomkins *et al.* 1994, Agnello *et al*., 2000, Walker *et al*., 1997) coincident with the development of IPM programmes for key apple pests such as the Codling Moth, *Cydia pomonella* and Leafrollers, *Epiphyas*, *Planotortrix* and *Ctenopseustis* species. ALCM 'is now a serious pest in most apple growing regions of New Zealand. The high incidence of ALCM infestations in many commercial orchards clearly indicates the importance of this insect and has raised concern in the apple industry' (Smith and Chapman, 1997).

Obtaining adequate control of ALCM in the framework of IFP is proving difficult in New Zealand (Burnip *et al*., 1998; Shaw *et al*., 2003). Selective control measures such as monitoring of egg masses on shoot tips to determine the need for spraying have not given satisfactory suppression (Smith and Chapman, 1997), and the application of diazinon to the soil surface in spring to control emerging first generation adults has given variable results between districts (Burnip *et al*., 1998). Control of ALCM on the foliage is often ineffective because the larvae are protected by the curled leaves and, in any event, foliar applications of broad spectrum organophosphates severely disrupt the biocontrol of other pests (Burnip *et al*., 1998, Shaw *et al*., 2003). Data from IFP trials in 1997 (Walker *et al*., 1997) showed that ALCM was the second most important pest, after mealybugs, in 13 orchards where the MAF maximum pest limit of 0.5% for export was exceeded. In trials at Nelson, ALCM was present on 0.7% and 0.9% of Cox and Gala fruit as graded out in the packhouse (Walker *et al*., 1997).

The current difficulties being experienced in control of ALCM in New Zealand are reflected in the high level of quarantine interceptions for this pest on fruit going into the USA. According to a Trade Councillor, Dennis Hannapel, at the United States Embassy in Canberra, some sixty percent (60%) of inspections of New Zealand export apples for the US market have revealed the presence of ALCM. These sorts of infestation levels prompted the immediate implementation of a Special Procedure for ALCM by the United States Department of Agriculture in 2002 (www.aphis.usda.gov/ppq/manuals/PPQ_BB/NZ%20Inspection%20Apples%20Pears.pdf). Under this procedure, the preclearance officer in New Zealand is required to write a specific "midge' statement on the USDA PPQ Form 203. If shipments arrive in the US with a Form 203 stating that 'Midges are present', the shipment may **not** enter the State of California. If the shipment is consigned to California, the importer has the following options:

- To destroy the shipment
- To re-export the shipment

- To fumigate the shipment for midges
- To ship to another State

The implications of the current situation regarding ALCM in New Zealand are clear for Australian growers and are summarised here:

- ALCM is a difficult pest to control in the context of IPM/IFP and hence will jeopardise Australian IPM/IFP programmes developed at great cost by industry and government.
- ALCM has significant quarantine implications in some overseas markets.
- If it became established in Australia there would be significant additional costs for growers to control it, and for industry to develop long term control strategies.

The life history of ALCM makes it a particularly poor candidate for analysis by the approach used in the RDIRA. ALCM does not feed on the fruit after the flowering period, it only pupates there if it lands on the fruit after leaving the leaf roll to seek a pupation site on the ground. Mature adults develop within a small cocoon and leave it when they mature. Over wintering generation pupae take longer to leave the cocoon than those from summer generations (http://www.hortnet.co.nz/publications/hortfacts/hf401055.htm). However, a period of 7 days in cold storage may induce emergence in ALCM (Tomkins *et al.*, 2000), which may also be accomplished by cold storage of harvested fruit. It is therefore likely that cold stored fruit arriving in Australia would have provided sufficient chill for ALCM larvae to emerge when the cool chain is broken. This may occur at any of the points indicated in Figure 13.1 and such emergence will not be confined to waste fruit. Rather, it will be associated with any point at which fruit is warmed, whether it is sound or not, and the likelihood of midges escaping will be dependent on the total number of infested fruit, not the number of infested waste fruit. It is likely that fruit will be warmed for short periods at distribution centres such as wholesalers, and for long periods at retailers, or during transport. This likely mode of distribution of ALCM is not considered by the RDIRA, which is based entirely on the fate of waste fruit. It is considered that the RDIRA approach to risk analysis is inappropriate for ALCM.

In light of the above information and despite the above reservations about the adequacy of the risk assessment model for this species, the probability of entry for ALCM has been reassessed as in Table 13.1. It is considered that the risks identified in the RDIRA have understated the true likelihood of entry of ALCM into Australia associated with the importation of New Zealand apples. The reasons are detailed in Table 13.1. It is also considered that the 'pest specific estimates' for probabilities of distribution and establishment of ALCM in Tables 38 (p.158) and 39 (p.160) of the RDIRA underestimate the capacity of this pest to find host plants. Since the adults can fly and are very host specific, it is highly likely they will be able to detect and home in on apple and crabapple plants via their specific chemical signature from a distance. More realistic likelihoods for Table 38 are:

Utility Points	**Exposure Groups**			
Proximity	**Commercial fruit crops**	**Nursery plants**	**Household and garden plants**	**Wild and amenity plants**
Orchard wholesalers	Certain	Very low	Very low	High
Urban wholesalers	Extremely low	Extremely low	Extremely low	Extremely low
Retailers	Very low	Very low	Extremely low	Extremely low
Food Services	Extremely low	Extremely low	Extremely low	Extremely low
Consumers	Very low	Very low	High	Very low

Similarly for Table 39, it is not credible that an ALCM on a waste piece of fruit would have a negligible likelihood of reaching a nearby host plant. ALCM are active flyers, whose pupae are likely to be in the calyx or stem ends of the fruit, where they are not likely to be adversely affected by fruit decay. A likelihood of **'MODERATE'** is more appropriate.

Utility Points	**Exposure Groups**			
Exposure	**Commercial fruit crops**	**Nursery plants**	**Household and garden plants**	**Wild and amenity plants**
Orchard wholesalers	Moderate	Moderate	Moderate	Moderate
Urban wholesalers	Moderate	Moderate	Moderate	Moderate
Retailers	Moderate	Moderate	Moderate	Moderate
Food Services	Moderate	Moderate	Moderate	Moderate
Consumers	Moderate	Moderate	Moderate	Moderate

However, when applied to the model the amended likelihoods had no influence on the final unrestricted risk of 'LOW'.

Table 13.1 Reassessment +-----------of Risk of Entry for Apple Leafcurling Midge, *Dasineura mali*

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		High	Certain	The New Zealand literature indicates that all surveys for ALCM have found it in all orchards surveyed (Tomkins *et al*., 1994; Smith and Chapman, 1995). The probability of occurrence is therefore 1.
Imp 2		Low	Low	Up to 20 percent of fruit may be infested with ALCM at harvest (Burnip *et al*., 1998). This is a 'high' level of infestation in entomological and industry terms, but must be classified as low according to Table 11 of the 2004 IRA for the purposes of the risk calculations.
Imp 3		Very Low	Very Low	This estimate is considered reasonable, but is not based on any data.
Imp 4		Moderate	High	The estimate of moderate in the 2004 IRA is not based on any data. It is assumed that the fruit sorting staff would remove about half the infested fruit. However, ALCM pupae are small, hidden in the calyx, or at the stem base, and would be nearly impossible to see as the fruit moves quickly along the grading line. It is more likely that a high proportion of infested apples would escape detection. This is supported by the high proportions of infested samples (60%) found by detailed USDA inspections of New Zealand apples.
Imp 5		Negligible	Very low	High levels of leaf infestations by ALCM regularly occur in New Zealand orchards, of the order of 50 to 93 percent (Tomkins *et al*., 1994), 26 to 62 percent (Smith and Chapman, 1995) and 18 to 69 percent of shoots (Smith and Chapman, 1997). This indicates that leaf material introduced to the pack house with picked fruit has at least a moderate chance of containing ALCM. Mature larvae dislodged from these leaves, in say the dip tank, may attach themselves to an apple stem or calyx and pupate. The chance of this happening is considered to be much greater than negligible and a rating of very low is recommended.
Imp 6		High	Certain	Nothing has been identified in the IRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce ALCM infestation levels. On the contrary, it is likely that all but a very few pupae would survive, so that the likelihood is close to certain. This is supported by the relatively high levels of ALCM detected in USDA inspections of packed New Zealand fruit (see above).
Imp 7		Negligible	Negligible	This estimate is considered reasonable, but is not based on any data.
Imp 8		High	Certain	The likelihood of survival of ALCM through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the IRA that would reduce survival through this step.
Probability of Entry	Moderate	Low	(High) (Low)	The recommended risk of high for the overall probability of entry is not based on putting the recommended risks for steps 1 to 8 through the risk analysis calculations. (By multiplying the midpoints of the likelihoods, a Probability of Entry of low is obtained). It is based on the inescapable logic that sixty percent of Lots of New Zealand apples inspected by USDA procedures were found to be infested by ALCM (see above). Clearly, the moderate rating of risk of entry given in the 2000 IRA is closer to reality than the 2004 rating, but is still too low.

Implications of the Analysis.

The unrestricted risk of **'LOW'** calculated by the model is not considered to represent the true risk of entry for ALCM. Consideration of the high levels of interception of this species in USDA preclearance inspections, sixty percent of lots, leads to the inescapable conclusion that this species represents a **'HIGH'** unrestricted risk, as suggested in Table 13.1. This is a very serious failure rate, is of great concern and plainly represents a high risk to the Australian industry. Clearly, the 'MODERATE' rating of risk of entry given in the 2000 DIRA is closer to reality than the 2004 rating, but is still too low. This is a problem for the risk analysis approach in the RDIRA, i.e. the method of estimating likelihoods and calculating probabilities does not relate well to the outcomes of quarantine inspections in this case.

Given the high risk of entry, it is clear that current risk management procedures for this pest in New Zealand are inadequate. It is recommended that the United States Department of Agriculture risk mitigation measures for New Zealand apples into California (USDA – NZMAF, 2004) be implemented for Australia in accordance with ISPM2 (FAO, 1996):

- AQIS inspectors be based in New Zealand to supervise preclearance inspections by accredited independent inspection staff with costs paid by the New Zealand industry.
- Inspection protocols used by USDA be implemented for fruit to Australia. This requires a higher level of inspection than the 600 fruit sample proposed in the RDIRA.
  Sensibly, the USDA protocols have a sliding scale of inspection levels based on the size of the Lot (USDA – NZMAF, 2004).
- Any New Zealand apples for export to Australia found to contain ALCM be fumigated before leaving New Zealand.
- Any non-precleared New Zealand apples found to contain ALCM upon arrival in Australia by AQIS inspections be fumigated prior to distribution. (It is of concern that the AQIS inspection levels give only a 95 percent confidence that not more than 0.5% of units in the consignment are infested. For quarantine, this is too low a level of assurance).

13.3.2 Garden Featherfoot, *Stathmopoda horticola*

There appears to be very little literature available on the Garden Featherfoot **("GFF")**. It is not listed as a significant pest in any recent New Zealand publications on pest management in apples. It would appear to be a minor or occasional pest in the north of the country only.

GFF is reported to be widespread in New Zealand (2004 RdIRA). It is known to attack Kiwifruit as well as apples, but its degree of polyphagy could not be determined.

The larvae are reported to feed in the calyx and stem end of apples below a silken covering.

Implications of the Analysis

Probability of Entry

The analysis presented in Table 13.2 disagrees at some steps with that in the 2004 RDIRA:

- GFF is a widespread polyphagous species and is highly likely to occur within, or in close proximity to apple orchards. Hence at importation step 1 it has been regarded as having a **'HIGH'** likelihood of occurring in orchards by contrast to the 'VERY LOW' rating in the RDIRA.
- The RDIRA rating of 'VERY LOW' at imp 3 is too high. Transfer of larvae between fruit will not result in an increase in infestation levels.
- It is considered the likelihood in the RDIRA of very low at this point greatly overestimates the loss of infested fruit at this step. A rating of **'LOW'** is recommended.

These adjustments alter the probability of entry from 'EXTREMELY LOW' in the RDIRA to '**VERY LOW'**.

Probability of Distribution and Spread

Because GFF is a highly polyphagous species like the leafrollers, it will have ready access to hosts in Australia. This has not been recognised in the RDIRA to the extent that it should have been. The utility points x exposure groups tables for proximity and exposure (Tables 44 and 45, pages 181 and 183, respectively) when adjusted in the same way as for leafrollers, give an unrestricted annual risk of **'LOW'**, by contrast with 'NEGLIGABLE' in the RDIRA. **'LOW'** is above Australia's ALOP of 'VERY LOW'. In view of this, risk mitigation procedures will be required for this species.

Table 13. 2 Reassessment of Risk of Entry for the Garden Featherfoot, *Stathmopoda horticola*.

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		Very low	High	The lack of information on the polyphagy of this species makes it very difficult to assess this importation step with any certainty. The nominated likelihood of ‘Very low’ is at best subjective. The Garden Featherfoot (GFF) is a widespread species, with a high likelihood of being present in all orcharding districts. On this basis a likelihood of High is recommended.
Imp 2		Extremely low	Very low	The lack of references to this species in the New Zealand apple pest management literature strongly suggests it is never a serious pest and has not been intercepted by quarantine inspections of export fruit. However, it has been recorded as feeding on apples on the North Island. On this basis, a rating of ‘Very low’ is most appropriate.
Imp 3		Very low	Negligible	The rating of ’Very low’ in the IRA is hard to understand. The supporting statements indicate transfer of larvae between fruit would virtually never occur. Such transfers, if they occurred, would not result in a net increase in the number of infested fruit. The most appropriate rating is ‘Negligible’.
Imp 4		Very low	Low	The feeding location of larvae of GFF in the stem or calyx end of fruit suggests it may not always be removed by brushing or washing. However, the relatively large size of its cocoon or silken feeding shelter indicates the majority would be removed by sorters on the packing line. Nevertheless, a likelihood of very low is probably too great a reduction in the population for this step.
Imp 5		Negligible	Negligible	The reasoning in the IRA for the rating of ‘Negligible’ is accepted.
Imp 6		High	Certain	Nothing has been identified in the IRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce GFF infestation levels. On the contrary, it is likely that all but a very few eggs would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	Since larvae are highly unlikely to move between fruit, and would not cause an increase in infestation levels if they did, this likelihood is considered reasonable.
Imp 8		High	Certain	The likelihood of survival of GFF through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the IRA that would reduce survival through this step.
Probability of Entry	Low	Extremely low	Very low	The above assessment, when entered into the risk analysis model using the midpoint probabilities, gives a Probability of Entry for GFF of ‘very low’.

13.3.3 Grey-brown Cutworm, *Graphania mutans*

Grey brown Cutworm **("GBC")** is a polyphagous species that occurs throughout New Zealand. As such its distribution includes all apple growing areas and it is reasonable therefore, to regard it as potentially present in all orchards.

The limited literature on GBC indicates it has similar behaviour to noctuid moths, such as *Heliothis* species, in Australian apple orchards. GBC has a peak of activity in New Zealand apple orchards in spring. This is probably related to flowering; adult moths feed avidly on the nectar of apple flowers at night and lay eggs at the same time, leading to a peak of larval feeding damage to the developing fruit in the ensuing weeks. Up to 16 percent damage has been recorded on individual cultivars unprotected by pesticides in organic blocks (Wearing *et al*., 1994), but typical damage levels are of the order of 3 to 6 percent.

In GBC most larvae drop to the orchard floor to feed on weeds as they grow. Any larvae remaining on the trees or in the ground cover will be killed by the spring program of sprays for the first generation of leafrollers and codling moth (Wearing, 1995b). Under IFP programs, spraying may cease by late January and as pesticide residues in the orchard decline, opportunities are available for GBC to reinvade orchards from surrounding areas, especially pastures (Burnip *et al*., 1995). These moths may lay eggs on the trees including around the calyx of fruit. These eggs may be present at harvest and go through the pack house to become a potential quarantine issue in overseas markets (Burnip *et al*., 1995).

<u>Implications of the Analysis.</u>

<u>Probability of Entry</u>

The analysis for risk of entry of GBC in the RDIRA contains a number of serious logical errors as follows (Table 13.3):

- GBC is regarded in the RDIRA as having a 'LOW' likelihood of occurrence in NZ apple orchards, despite the first dot point (p.199) indicating it is present in all NZ apple growing areas. The evidence presented under the other dot points which shows low infestation levels in fruit relates to importation step 2 not 1. The correct likelihood for importation step 1 is certain, since all orchards or their immediate surrounds are likely to have populations of GBC.
- The likelihood of 'VERY LOW' at importation step 4 in the RDIRA is far too low. While any fruit with larvae are likely to be removed in the pack house, eggs are very likely to pass through unscathed since they are laid in batches in the calyx where they are unlikely to be removed by washing or brushing.
- As with all other pests in this review it is considered that the likelihood of infested fruit passing through importation steps 6 and 8 is certain, rather than high as in the RDIRA, since nothing occurs at these steps that would reduce infestation levels for unrestricted risk.

The adjustments to likelihoods in Table 13.3 result in a Probability of Entry for GBC from 'EXTREMELY LOW' as in the RDIRA to **'VERY LOW'**. This is more consistent with the finding of GBC eggs in quarantine inspections.

These adjustments feed through the analysis to give an unrestricted risk of entry of **'LOW'** instead of 'NEGLIGIBLE' as in the RDIRA.

Probability of Distribution and Spread

Because GBC is a highly polyphagous species like the leafrollers, it will have ready access to hosts in Australia. This has not been recognised in the RDIRA to the extent that it should have been. The utility points x exposure groups tables for proximity and exposure (Tables 50 and 51, pages 203 and 205, respectively) when adjusted in the same way as for leafrollers generate an unrestricted annual risk of **'LOW'**, by contrast to the result of 'NEGLIGIBLE' in the RDIRA. The level of **'LOW'** is above Australia's ALOP of very low indicating risk mitigation procedures will be required for this species.

Table 13.3 Reassessment of Risk of Entry for Grey-brown Cutworm, *Graphania mutans*.

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		Low	Certain	GBC is polyphagous, occurs throughout New Zealand and is present in all apple growing regions. There is no data to indicate it is absent from any orchards. The supporting data for a low rating in the IRA is not relevant to Importation Step 1; rather it relates indirectly to Step 2.
Imp 2		Very low	Very Low	The data in the IRA under Importation Step 1 indicates damage levels due to GBC varies from about 2 to 10 percent (Wearing *et al*., 1994; Burnip *et al*., 1995; Wearing, 1996). However, damage does not equate to the presence of larvae at harvest, most larvae will have left the fruit long before harvest. The critical issue is the presence of eggs on fruit laid by moths late in the season. There is no data with which to evaluate egg loads on fruit, except the anecdotal contention of Wearing *et al*., (1994) that 'the presence of eggs on fruit is a potential quarantine problem for export organic apples, although the incidence appears to be rare'. The only data on incidence of Noctuid eggs on New Zealand fruit appears to be through quarantine interceptions (Burnip *et al*., 1995), which demonstrate that detectable levels of egg laying occur.
Imp 3		Extremely low	Negligible	Since eggs are highly unlikely to move between fruit, and few larvae are likely to be present, this likelihood is considered too high. There is only likely to be one larva per fruit, so that any larvae moving between fruit will not increase the percentage of fruit infested.
Imp 4		Very low	Moderate	While any larvae on the fruit are likely to be removed by washing and brushing, there are unlikely to be many larvae on the picked fruit. The most likely scenario is for eggs to be laid around the calyx of the fruit pre-harvest (Wearing *et al.*, 1994, Burnip *et al.*, 1995). Photos of GBC eggs in the NZ Hortnet Bugkey (Hortnet) show the eggs laid against the calyx. Most, if not all, eggs laid in this location will survive pack house procedures.
Imp 5		Negligible	Negligible	Since eggs are highly unlikely to move between fruit, and few larvae are likely to be present, this likelihood is considered reasonable.
Imp 6		High	Certain	Nothing has been identified in the IRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce GBC infestation levels. On the contrary, it is likely that all but a very few eggs would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	Since eggs are highly unlikely to move between fruit, and few larvae are likely to be present, this likelihood is considered reasonable.
Imp 8		High	Certain	The likelihood of survival of GBC through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the IRA that would reduce survival through this step.
Probability of Entry	Low	Extremely low	Very Low	The Probability of Entry of GBC in the 2004 IRA of 'Extremely low' is considered unreasonable. The assessment presented here agrees with that in the 2000 IRA, and is more consistent with the findings of GBC eggs in New Zealand export fruit by quarantine inspections.

13.3.4 Leafrollers

Brown-headed Leafrollers, *Ctenopseustis herana* and *C. obliquana*

Green-headed Leafrollers, *Planotortrix excessana* and *P. octo*

The native New Zealand Brownheaded (*Ctenopseustis herana* and *C. obliquana*) and Greenheaded (*Planotortrix excessana* and *P. octo*) leafrollers are pests in apples and a number of other horticultural crops. The main pests of apples are *C. obliquana* in the North Island and northern South Island (www.hortnet.co.nz/key/keys/info/bhl-info.htm), *C. herana* is prominent near Nelson in the north of the South Island (Shaw *et al*., 1994) and *P. octo* in the Otago area in the south of the South Island (Wearing, 1995a,b). However, the major leafroller pest in New Zealand is the Australian species, Light Brown Apple Moth **("LBAM")**, *Epiphyas postvittana* (Bradley *et al*., 1998). The native New Zealand leafrollers have been treated as a group in the RDIRA because of their similar life histories and physical damage to apples. The larvae of these four species are difficult to distinguish from each other and from LBAM. However, the four species are distributed differently between and within apple growing areas as indicated above (Shaw *et al*., 1994; www.hortnet.co.nz). From a quarantine perspective, the most threatening life cycle stages are the eggs, which may be on the surface of fruit, but are usually laid on leaves, and the larvae, which may burrow through the calyx into the flesh of the fruit where they can be difficult to detect.

The IFP programme for New Zealand apples depends on the use of Insect Growth Regulator pesticides, primarily tebufenozide, to control leafrollers (Walker *et al*., 1997; Walker *et al*., 1998), although broad spectrum chemicals may be used if monitoring suggests excessive damage is likely. An additional tactic being explored is mating disruption with sex pheromones (Wearing, 1995). A concerning issue for IFP of leafrollers is the development of resistance to tebufenozide and organophosphates in some populations of *Planotortrix octo* (Wearing, 1995a; 1999; Lo *et al*., 1997), *Ctenopseustis obliquana* and LBAM (Lo *et al*., 2000). Clearly, Australian growers would be doubly disadvantaged if insecticide resistant leafrollers were introduced from New Zealand; not only would there be an additional pest causing damage and requiring control, but control would be much more difficult due to the resistance.

Because of the similarity in the damage caused by the five species of leafrollers in New Zealand, it has not been possible to directly apportion damage among species. This can be done indirectly by correlating pheromone trap catches with damage because each species has a specific pheromone (Wearing, 1995b). However, few studies appear to have attempted to determine the relative contributions to damage of the five species. This makes it impossible to assess which of the species would constitute the greatest threat to Australian growers if introduced. This is complicated further by the fact that LBAM is regarded as the dominant pest species in New Zealand and is already present in Australia. Gross levels of leafroller damage to fruit in New Zealand vary from less than 0.1 percent in some Otago orchards (Wearing 1995a) to almost 8 percent in various research blocks (Bradley *et al*., 1998); however, pheromone trap catches showed the latter was mostly due to LBAM, while the former was due mainly to *Planotortrix octo*.

Overall damage due to leafrollers in regional IFP trials (Walker *et al*. 1997, 1998) showed generally good leafroller control, however in 1997, fruit damage levels in the range of 0.6 to 2.0 percent occurred relatively frequently on some varieties, particularly late season cultivars, and in all districts. Damage levels in excess of one percent would be of concern to Australian growers. Damage levels higher than 2 percent occurred in 1997 in 25 and 30 percent of Braeburn and Cox blocks at Nelson, respectively, and this was attributed to pesticide resistance. This highlights the higher likelihood of resistant moths being present on exported fruit than susceptible ones. The trials in 1998 had only four percent of orchards on average with greater than one percent damage due to leafrollers. However, 14 percent of Nelson orchards had between one and two percent of harvested fruit with leafroller damage. The regional level of infestation at harvest at Nelson averaged 1.5 larvae per 10,000 fruit, while a level of 0.3 larvae per 10,000 occurred in Hawkes Bay (Walker *et al*., 1998). Although these regional averages are very low, there are clearly much higher levels in individual orchards which would translate to some export lots having considerably higher infestation probabilities than others.

Table 13.4 Reassessment of Risk of Entry for Leafrollers, *Planotortrix* and *Ctenopseustis* species.

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		High	Certain	This group of insects is widespread throughout New Zealand. Survey and monitoring data from numerous IFP and other trials in apples indicates one or other of these species is nearly always detectable in all orchards in New Zealand (Wearing, 1995; Shaw *et al.*, 1994; Walker *et al.*, 1997, 1998).
Imp 2		Very low	Very low	Reported average rates of larval infestation at harvest support the likelihood of very low at this step (Walker *et al.*, 1998). The likelihood of 'Very low' is considered reasonable.
Imp 3		Very low	Negligible	There is no quantitative information upon which to base an estimate at this step. However, the rating in the IRA is considered to be much too high, since there is only likely to be one larva per infested fruit, the transfer of larvae between fruit will not increase the overall percentage of fruit infested.
Imp 4		High	High	This rating is also considered reasonable, although data is lacking. Contrary to the supporting statements on p. 224 in the IRA, it is unlikely that fruit sorters on the packing line would see leafroller entry holes in fruit because a), entry is through the calyx and the hole would not be visible, and b), the washing and brushing processes would remove most of the silk and frass making detection difficult.
Imp 5		Extremely low	Negligible	There is no quantitative information upon which to base an estimate at this step. However, the rating in the IRA is considered to be too high, since there is only likely to be one larva per infested fruit, the transfer of larvae between fruit will not increase the overall percentage of fruit infested.
Imp 6		High	Certain	Nothing has been identified in the IRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce leafroller infestation levels. On the contrary, it is likely that all but a very few larvae would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	This estimate is considered reasonable, but is not based on any data.
Imp 8		High	Certain	The likelihood of survival of leafrollers through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the IRA that would reduce survival through this step.
Probability of Entry	High	Very low	Very low	The Probability of Entry assessed here agrees with that in the IRA, and is much lower than that assessed in the 2000 IRA. This assessment depends entirely on one report by Walker *et al.*, (1998) that larval levels at harvest in fruit from IFP blocks are very low. In addition there do not appear to have been many quarantine interceptions of leafrollers, but this is unverified.

Implications of the Analysis

Probability of Entry

The analysis presented in Table 13.4 agrees with that in the RDIRA for the Probability of Entry of leafrollers. However, this outcome is based entirely on one report (Walker *et al*., 1998) that indicates very low numbers of leafroller larvae are present in fruit at harvest in IFP orchards. There are a number of factors that could change this probability dramatically, particularly the increasing incidence of pesticide resistant leafroller populations in New Zealand apple orchards.

Distribution, Establishment and Spread

The RDIRA greatly underestimates the potential for establishment and spread of Brownheaded and Greenheaded Leafrollers in Australia. Both pairs of species are highly polyphagous being known from in excess of 100 host species each in New Zealand. These hosts comprise over 60 plant families including many common and widespread ornamental and weed species in Australia (http://www.hortnet.co.nz), for example the ubiquitous weeds, *Hypochaeris* spp. and *Plantago lanceolata*. There is no doubt that hosts suitable for both groups of leafroller species occur virtually everywhere in the more heavily populated parts of Australia and that any escaping moth would be within easy flying distance of a suitable host. This means that many of the probabilities in Table 56, page 227 of the RDIRA (Proportions of utility points near host plants susceptible to leafrollers in the four exposure groups) are gross underestimates. Table 56 would be more realistic, if amended as follows:

Utility Points	**Exposure Groups**			
Proximity	**Commercial fruit crops**	**Nursery plants**	**Household and garden plants**	**Wild and amenity plants**
Orchard wholesalers	Certain	Very low	High	Certain
Urban wholesalers	Extremely low	Extremely low	Low	Certain
Retailers	Very low	Low	High	Certain
Food Services	Extremely low	Extremely low	Low	Certain
Consumers	Very low	Very low	Certain	Certain

The likelihood of 'NEGLIGIBLE' given for the probability of exposure of susceptible host plants of leafrollers from discharge or discard of a single infested/infected apple (Table 57, page 229) is probably realistic, since at least two moths, a male and a female, need to escape at the same location for mating and egg laying to occur.

However, establishment of any of the New Zealand leafrollers in Australia will depend on multiple insects escaping from utility points where significant volumes of New Zealand fruit are aggregated. These places will be urban or orchard wholesalers, and retailers, and not consumers. It will also depend on the cool chain being broken to allow mature larvae to leave fruit and pupate in the box or pallet, or elsewhere in the premises or display area (Fig. 1). Once the pupa has matured, the adult will emerge and fly away. While many may not succeed in escaping, sites with large volumes of fruit, will provide a relatively high likelihood of sufficient numbers for mating, egg laying and establishment. Note: this scenario does not depend on waste for release and establishment of a population and hence is not specifically covered by the analysis in the RDIRA. To accommodate this scenario, Table 57 of the RDIRA should be modified as follows to take account of the likelihood of other insects escaping at about the same time from relevant utility points:

Utility Points	**Exposure Groups**			
Exposure	**Commercial fruit crops**	**Nursery plants**	**Household and garden plants**	**Wild and amenity plants**
Orchard wholesalers	Very low	Negligible	Very low	Very low
Urban wholesalers	Negligible	Very low	Very low	Very low
Retailers	Extremely low	Extremely low	Extremely low	Extremely low
Food Services	Negligible	Extremely low	Extremely low	Extremely low
Consumers	Negligible	Extremely low	Extremely low	Extremely low

Despite the above considerable revision of likelihoods on the distribution and establishment pathways in the risk analysis model, the final unrestricted risk remained unchanged at **'LOW'**. This is also in spite of the overall likelihood of entry, establishment and spread (PEES) increasing from 0.7645 to 0.9932. The latter probability is classed in the model as 'HIGH', but is close enough to 1 to be regarded as certain. Even so, the rules governing the model, would still give an unrestricted risk of **'LOW'**. The unrestricted risk of '**LOW'** is above Australia's ALOP of 'VERY LOW' and risk mitigation is required to bring the risk down to acceptable levels.

Due to the enhanced quarantine risks posed by pesticide resistant leafrollers, the resistance status of leafroller populations in New Zealand should be reported by MAFNZ to AQIS and risk management adjusted accordingly, as a condition of any export approval. Should leafrollers be detected in pre-clearance or on-arrival quarantine inspections, the affected lot should be fumigated before distribution.

13.3.5 Native Leafroller, *Pyrgotis plagiatana*

There is very little published information on this species apart from host records on native shrub and tree species that suggest it is widespread in New Zealand and is polyphagous. It has been recorded as an occasional or minor pest on apples and pears (2004 RDIRA). It is not listed as a significant pest of apples in any of the recent New Zealand pest management literature. However, it has been found at very low rates on or in fruit during preclearance quarantine inspections of New Zealand apples for export to the USA (2004 RDIRA).

<u>Implications of the Analysis</u>

<u>Probability of Entry</u>

The analysis presented in Table 13.5 gives a different result from that in both the 2000 DIRA and the 2004 RDIRA. A Probability of Entry of **'VERY LOW'** is concluded, by contrast with 'LOW' for the 2000 DIRA and 'EXTREMELY LOW' for the 2004 RDIRA. These differences reflect the lack of any real data on this species and different interpretations of subjective likelihoods at key steps in the importation pathway. This species does not appear to have been a quarantine issue for New Zealand apples previously, so a Probability of Entry of **'VERY LOW'** is reasonable.

<u>Probability of Distribution and Spread</u>

Because NLR is a highly polyphagous species like the leafrollers and Garden Featherfoot, it will have ready access to hosts in Australia. This has not been recognised in the IRA to the extent that it should have been. The utility points x exposure groups tables for proximity and exposure (Tables 62 and 63, pages 252 and 254, respectively) when adjusted in the same way as for leafrollers, generate an unrestricted annual risk of **'LOW'**, by contrast to 'VERY LOW' in the RDIRA. '**LOW'** is above Australia's ALOP of 'VERY LOW', so that risk mitigation procedures will be required for this species.

Table 13.5 Reassessment of Risk of Entry for the Native Leafroller, *Pyrgotis plagiatana*

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		Very low	High	The lack of detailed information on the distribution and biology of this species makes it very difficult to assess this importation step with any certainty. The nominated likelihood of 'Very low' is at best subjective. The Native Leafroller (NLR) appears to be a widespread polyphagous species, with a high likelihood of being present in all orcharding districts. On this basis a likelihood of High is recommended.
Imp 2		Very low	Very low	The lack of references to this species in the New Zealand apple pest management literature strongly suggests it is never a serious pest. However, the fact that it has been found in quarantine inspections of export fruit indicates it is present below economic levels, say consistently less than 0.1 percent. On this basis, a rating of 'Very low' is most appropriate.
Imp 3		Extremely low	Negligible	The rating of 'Extremely low' in the IRA is possibly an overestimate. Transfers of larvae between fruit, if they occurred, would not result in a net increase in the number of infested fruit. The most appropriate rating is 'Negligible'.
Imp 4		High	Moderate	The finding of NLR in preclearance checks in New Zealand (IRA, 2004) indicates it can pass undetected through the pack house. If the larvae feed on the outside of fruit, the likelihood of them surviving washing, brushing and grading is low to very low. If, on the other hand, they feed internally, the likelihood is more appropriately low to moderate. To be conservative, a likelihood of moderate is recommended.
Imp 5		Negligible	Negligible	The reasoning in the IRA for the rating of 'Negligible' is accepted.
Imp 6		High	Certain	Nothing has been identified in the IRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce NLR infestation levels. On the contrary, it is likely that all but a very few eggs would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	Since larvae are highly unlikely to move between fruit, and would not cause an increase in infestation levels if they did, this likelihood is considered reasonable.
Imp 8		High	Certain	The likelihood of survival of NLR through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the IRA that would reduce survival through this step.
Probability of Entry	Low	Extremely low	Very low	The above assessment differs from the finding in the IRA finding that the Probability of Entry for NLR is 'Extremely low'.

13.3.6 New Zealand Flower Thrips, *Thrips obscuratus*

New Zealand Flower Thrips **("NZFT")** is a serious pest of stonefruit, but is not regarded as a pest of apples in New Zealand. NZFT occurs on apple blossom without apparently doing significant damage, by contrast to the Australian Plague Thrips. It also occurs on apple foliage (Hortnet, 2004), probably as a result of eggs laid during flowering. It is not regarded as a pest in any of the recent New Zealand literature on apple pest management. Numbers of NZFT on apples decline after blossoming and it is not attracted to apple fruit. By contrast it is highly attracted to the fruit of nectarines, peaches, apricots and cherries. It is also a quarantine pest of cutflowers and asparagus (McLaren and Fraser, 1998).

NZFT is highly polyphagous with over 200 recorded hosts (RDIRA, 2004), and is distributed throughout New Zealand. NZFT has been frequently detected on New Zealand stonefruit arriving in Australia (DIRA, 2000).

<u>Implications of the Analysis</u>

<u>Probability of Entry</u>

The analysis presented here for a probability of entry of **'VERY LOW'** (Table 13.6) is higher than that in the 2004 RDIRA of 'EXTREMELY LOW'. The 'HIGH' rating in the 2000 DIRA was based on the erroneous assumption that the high quarantine interception rate for this species on stonefruit would be the same for apples. However, this pest is not attracted to apple fruit.

<u>Probability of Distribution and Spread</u>

NZFT is a highly polyphagous species that would have no difficulty finding suitable hosts in Australia, no matter where it escaped. It is even more likely to be able to find suitable hosts and establish than polyphagous moth species such as the Greenheaded and Brownheaded Leafrollers and Grey-brown Cutworm. Hence, the likelihoods in Tables 68 and 69, pages 273 and 275 respectively, in the RDIRA, should reflect this. All utility points will be close to suitable hosts for this species. The following tables give more realistic likelihoods for proximity and exposure to hosts.

Utility Points	**Exposure Groups**			
Proximity	**Commercial fruit crops**	**Nursery plants**	**Household and garden plants**	**Wild and amenity plants**
Orchard wholesalers	Certain	Very low	High	Certain
Urban wholesalers	Extremely low	Low	Moderate	Certain
Retailers	Very low	Moderate	High	Certain
Food Services	Extremely low	Low	Moderate	Certain
Consumers	Very low	Moderate	Certain	Certain

Table 69, page 275 in the RDIRA indicates that the probability of exposure of host plants to NZFT on a single piece of waste fruit is 'EXTREMELY LOW'. Given the mobility of thrips, it is very likely they will be able to move to the host, such that 'EXTREMELY LOW' is a gross underestimate. In addition if the insect is a gravid female, egg laying will occur. A likelihood of **'MODERATE'** is considered appropriate.

Utility Points	Exposure Groups			
Exposure	**Commercial fruit crops**	**Nursery plants**	**Household and garden plants**	**Wild and amenity plants**
Orchard wholesalers	Moderate	Moderate	Moderate	Moderate
Urban wholesalers	Moderate	Moderate	Moderate	Moderate
Retailers	Moderate	Moderate	Moderate	Moderate
Food Services	Moderate	Moderate	Moderate	Moderate
Consumers	Moderate	Moderate	Moderate	Moderate

However, because this species is capable of active flight and is essentially a hitch hiker on undamaged apples, escape from waste fruit is not the only feasible, or even most likely, establishment scenario. Accordingly, as for Wheat Bug, the risk analysis model in the RDIRA is particularly inappropriate for this species. The most likely points from which multiple individuals could escape to allow rapid population establishment to occur are from locations where relatively large quantities of apples are stored, such as warehouses and packing sheds, and to a lesser extent, supermarkets. The notion of a healthy NZFT still being on an apple by the time it gets to a consumer is ludicrous, yet the RDIRA indicates this is the most likely mode of establishment for this species.

When the above adjustments to the entry, distribution, establishment and spread pathways are fed into the risk analysis model, the unrestricted annual risk rises from ‘VERY LOW’ in the RDIRA to **‘LOW’**, which is above Australia’s ALOP, indicating that additional risk mitigation measures are required.

Table 13.6 Reassessment of Risk of Entry for New Zealand Flower Thrips, *Thrips obscuratus*

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		High	Certain	New Zealand Flower Thrips (NZFT) is a widespread, abundant polyphagous insect that would certainly occur in all New Zealand apple orchards. It is principally a pest of stonefruit, citrus, cutflowers and asparagus (McLaren and Fraser, 1998).
Imp 2		Negligible	Extremely low	NZFT is not considered to be a pest of New Zealand apples. It occurs on flowers in spring, but disappears from the trees after a spring generation, the adults preferring other plants when apple flowering is over. The presence of NZFT on fruit is likely to be incidental, more a result of insects resting in transit. The occurrence of NZFT on apples is likely to be higher where apple blocks adjoin other hosts such cutflowers or stonefruit. Given that NZFT may be present on fruit as a contaminant, a likelihood of ‘Extremely low’ is recommended.
Imp 3		Very low	Very low	There are records of NZFT on apples and these are considered to represent accidental contamination of fruit from adjacent hosts such as stonefruit. This may occur on fruit in bins in transit from the orchard to the packing shed. Such contamination might result from insects flushed from hosts on the orchard floor, windrows or other plants, and would result in only a very low likelihood of an individual fruit being infested.
Imp 4		Extremely low	Extremely low	The arguments presented in the IRA in support of an ‘extremely low’ rating at this step are accepted.
Imp 5		Negligible	Extremely low	
Imp 6		High	Certain	Nothing has been identified in the IRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce NZFT infestation levels. On the contrary, it is likely that all but a very few insects would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Very low	The adults of NZFT are quite mobile and there is more than a negligible likelihood of redistribution among fruit if they are a) present and b) disturbed. An increase in the numbers of fruit infested could occur if some fruit had more than one thrips on them. A likelihood of ‘very low’ is recommended.
Imp 8		High	Certain	The likelihood of survival of NZFT through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the IRA that would reduce survival through this step.
Probability of Entry	High	Extremely low	Very low	The Probability of Entry presented here is higher than that in the 2004 IRA, based on a midpoint analysis. The 2000 IRA Probability of Entry was based on false assumptions that apple fruit was attractive to NZFT, as stonefruit is.

13.3.7 Codling Moth, *Cydia pomonella*

Codling Moth **("CM")** is a key pest of apples in New Zealand (Walker *et al*., 1997, 1998) and eastern Australia. It is absent from Western Australia. CM is present in every apple growing area in New Zealand and would certainly be present in every apple orchard.

The larvae of CM burrow into the apple through the skin and feed on the internal tissues. They are very hard to control once inside the fruit, so control strategies aim to kill adults, eggs and newly hatched larvae before they burrow into the fruit. The main quarantine risk for CM is the failure to detect fruit infested internally with a larva, both on the grading line in the pack house and at quarantine inspections.

CM is generally well controlled in most orchards in New Zealand and Australia, the exceptions being those where resistance to pesticides has developed, or where organic fruit is being grown for specialist organic markets. Generally, CM damage levels in New Zealand are very low, less than 0.02 percent at Dumbarton from 1990 to 1994 (Wearing, 1994) and averaging less than 0.06 percent in IFP orchards in 1998 (Walker *et al*., 1998). Leafrollers are a more serious problem, with CM generally controlled by sprays for leafrollers supplemented by additional sprays for CM based on pheromone trap catches, if necessary (Walker *et al*., 1998).

CM is a major quarantine issue into countries such as Taiwan and Japan, and the State of Western Australia.

<u>Implications of the Analysis</u>

<u>Probability of Entry</u>

The analysis for Probability of Entry of CM (Table 13.7) returned a probability of very **'LOW'**, which was at first glance a surprising result given that it is:

a. Below the level of 'LOW' assessed in the 2004 RDIRA
b. A major quarantine pest internationally and within Australia

This result is based on recognition of the true commercial situation of good control of codling moth in New Zealand apple orchards and the likelihood that most infested fruit would be removed by sorters in the pack house. It is considered the likelihoods used in the 2004 RDIRA are too high at the critical importation steps of 2 and 4.

Probability of Distribution and Spread

Consideration of Table 80, page 236 for the proximity of utility points to exposure groups resulted in only two minor recommended changes for the proximity of nursery plants, and wild and amenity plants to orchard wholesalers form 'VERY LOW' to **'LOW'**. This is because fruit tree nurseries often occur within orcharding districts and there are usually many wild fruit trees along roadsides and on waste ground in orchard areas.

Utility Points	**Exposure Groups**			
Proximity	**Commercial fruit crops**	**Nursery plants**	**Household and garden plants**	**Wild and amenity plants**
Orchard wholesalers	Certain	Low	Very low	Low
Urban wholesalers	Extremely low	Extremely low	Extremely low	Extremely low
Retailers	Very low	Moderate	Extremely low	Extremely low
Food Services	Extremely low	Extremely low	Extremely low	Extremely low
Consumers	Very low	Very low	Low	Low

Table 13.7 Reassessment of Risk of Entry for Codling Moth, *Cydia pomonella*

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		High	Certain	Codling moth (CM) occurs in all New Zealand apple growing districts, is a major pest of apples and would certainly be present in all orchards.
Imp 2		Low	Very low	The supporting statements presented in the IRA for a 'low' rating are uncritically stated and the last dot point in particular vastly overestimates the likelihood of CM infestations in picked fruit in New Zealand commercial orchards. A rating of 'Very low' is more realistic. (Note also that damage levels were used for these likelihoods and that damage does not equal infestation; much damage at harvest is old and the larva has either been killed, or left the fruit).
Imp 3		Negligible	Negligible	The arguments presented in the IRA for a 'negligible' rating are accepted.
Imp 4		High	Moderate	The 'high' likelihood given in the 2004 IRA for CM infested fruit passing through the packing house processes is an overestimate. CM infested fruit has obvious external damage that would generally not be overlooked on the grading line. A significant proportion of infested fruit would be graded out. Only those fruit where CM entered through the calyx would be likely to be missed.
Imp 5		Negligible	Negligible	The arguments presented in the IRA for a 'negligible' rating are accepted.
Imp 6		High	Certain	Nothing has been identified in the IRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce CM infestation levels. On the contrary, it is likely that all but a very few larvae would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	The arguments presented in the IRA for a 'negligible' rating are accepted.
Imp 8		High	Certain	The likelihood of survival of CM through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the IRA that would reduce survival through this step.
Probability of Entry	Not assessed	Low	Very low	The assessment for Probability of Entry presented here is below that in the 2004 IRA. The likelihood adjustments made above reflect the true commercial situation, and are very different to those in the IRA, two critical ones of which are quite unrealistic.

The use of the likelihood 'NEGLIGIBLE' for the probability of exposure of a host plant to a single infested waste fruit (Table 81, page 328) is considered reasonable, given that at least two adult CM, one male and one female, would be required for mating and egg laying to occur.

The likelihoods derived in this review produce an unrestricted annual risk of **'LOW'** for CM in the risk analysis model, in agreement with the RDIRA. This will require risk mitigation to meet Australia's ALOP of 'VERY LOW' for New Zealand apples going into Western Australia.

However, as pointed out above for other moth pests, the scenario of infestation arising from a single waste apple is unrealistic. While the probability of establishment is clearly increased for larger lots of waste fruit, it is not the probability obtained by simply multiplying the midpoint of the negligible probability range by the number of fruit. This oversimplification ignores the greatly heightened chance of establishment resulting from having a population versus an individual. Therefore, the 'NEGLIGIBLE' likelihoods resulting from consideration of a single waste fruit as in Table 81 greatly underestimate establishment potential for those situations where multiple moths may escape at the same place. These include scenarios that do not involve waste fruit. Codling Moth is most likely to escape and establish a viable population wherever large lots of fruit are stored together at distribution centres, warehouses and to a much lesser extent at retailers. Moths are likely to escape from infested fruit long before it is regarded as waste, hence the modelling around waste fruit is grossly over simplistic. It is concluded that the risk analysis model is excessively simplistic and unrealistic, not only for CM, but all apple pests.

13.3.8 European Red Mite, *Panonychus ulmi*

European Red Mite **("ERM")** is the major mite pest of apples in New Zealand, and with Two-spotted Mite, *Tetranychus urticae*, is one of the two most important mite pests of apples in Australia. However, ERM is absent from Western Australia. In New Zealand, ERM occurs in all apple growing areas and would be present in all orchards.

During late spring, summer and early autumn, ERM feed and lay eggs on apple foliage. When temperatures begin to decline in autumn, adult females begin to lay 'winter eggs' on the twigs and branches of the tree, but also to a lesser extent on the fruit, especially around the calyx. These winter eggs do not hatch until the following spring. Laying of winter eggs may occur as early as January, if heavy infestations of mites have damaged the foliage to the point that it is no longer a good source of food.

In New Zealand ERM is successfully controlled in Integrated Mite Control programmes utilising predatory mites in combination with supplementary miticide sprays if needed (Wearing, 1996). The need to spray is determined by monitoring population levels on leaves and can be done by the grower or professional pest scouts. In general ERM mites are not a widespread problem in IFP orchards (Walker *et al*., 1997, 1998), but may occasionally escape control if a grower has to apply a chemical detrimental to predatory mites to correct some other pest problem. Walker *et al*. (1997) reported one IFP orchard in the Hawkes Bay area where 4.3% of fruit were infested with mite eggs at harvest. It can be expected that low levels ERM may occur on fruit, due to the winter egg laying activities of late season females.

<u>Implications of the Analysis</u>

<u>Probability of Entry</u>

The analysis presented here (Table 13.8) has yielded the same Probability of Entry, **'VERY LOW'**, as in the 2004 RDIRA. However, the treatment in this review differs from that in the RDIRA. The likelihood of picked fruit being infested with ERM (Imp 2) is too high in the RDIRA and has been reduced here to **'VERY LOW'** from 'LOW'. On the other hand, the RDIRA overestimates the chances of infested fruit being removed during grading and packing (Imp 4); the two changes effectively cancel each other out (Table 8).

<u>Probability of Distribution and Spread</u>

ERM is polyphagous on a wide range of common, perennial, deciduous shrubs and trees. From this point of view the proximity of utility points to hosts is likely to be relatively higher than indicated in the RDIRA in Table 86, page 348, which is amended as follows:

Utility Points	**Exposure Groups**			
Proximity	**Commercial fruit crops**	**Nursery plants**	**Household and garden plants**	**Wild and amenity plants**
Orchard wholesalers	Certain	Very low	Low	Moderate
Urban wholesalers	Extremely low	Extremely low	Very low	Very low
Retailers	Very low	Low	Low	Low
Food Services	Extremely low	Extremely low	Very low	Very low
Consumers	Very low	Very low	Moderate	Moderate

In addition, the life history characteristics of ERM suggest it may have more than a negligible chance of infecting a potential host plant if an infested apple is placed near it (Table 87, page 350 of the RDIRA). ERM is likely to have multiple overwintering eggs per infested fruit, giving multiple chances for a larva to reach the host. In addition, ERM has an arrhenotokous lifecycle whereby females do not need to be fertilised in order to lay eggs, i.e. a population can be established by a single female. So, even though ERM is flightless, other aspects of its lifecycle favour its chances of establishment. On this basis a likelihood of **'EXTREMELY LOW'** is recommended for Table 87 rather than 'NEGLIGIBLE'.

Table 13.8 Reassessment of Risk of Entry for European Red Mite, *Panonychus ulmi*

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		High	Certain	European Red Mite (ERM) is the principle mite pest of New Zealand apples. It occurs in all apple growing areas and would certainly be present in all orchards.
Imp 2		Low	Very low	The likelihood of 'Low' in the IRA is considered to be an overestimate for well managed orchards. A likelihood of very low is considered more realistic.
Imp 3		Very low	Very Low	The likelihood of 'Very low' in the IRA is accepted as reasonable, but for an additional reason to that advanced in the IRA. Contamination of fruit by ERM is mainly by winter eggs. These are laid by females influenced by declining food resources, or the onset of lower temperatures in autumn. Some females may be present on fruit at picking and may transfer between fruit in the picking bags or field bins resulting in some egg laying on additional fruit
Imp 4		Low	High	ERM eggs are very small, and while they are easy to see on fruit when present in large numbers, the small numbers likely to be present on fruit in most orchards, or the more lightly infested fruit from problem orchards, would be very difficult to detect on the packing line. It is highly likely that most lightly infested fruit would pass through packing shed sorting without being detected. In addition, while packing house processes such as washing and brushing may remove some winter eggs, they are unlikely to greatly reduce the percentage of infested fruit, since multiple eggs will be present on most fruit.
Imp 5		Negligible	Negligible	The IRA likelihood for this step is accepted.
Imp 6		High	Certain	Nothing has been identified in the IRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce ERM infestation levels. On the contrary, it is likely that all but a very few eggs would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	The arguments presented in the IRA for a 'negligible' rating are accepted.
Imp 8		High	Certain	The likelihood of survival of ERM through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the IRA that would reduce survival through this step.
Probability of Entry	Not assessed	Very low	(Low)	The reassessment presented here does not agree with the outcome in the 2004 IRA. It is considered the Probability of Entry is 'Low', rather than 'Very low'.

These amendments give rise to an unrestricted annual risk of **‘LOW’**, by contrast to ‘NEGLIGIBLE’ in the RDIRA. Contrary to the conclusion in the RDIRA, additional risk management measures will be needed for ERM to meet Australia’s ALOP for New Zealand apples going into Western Australia.

13.3.9 Mealybugs, *Pseudococcus calceolariae* and *Planococcus mali*

Citrophilus mealybug, *Pseudococcus calceolariae* **("CMB")** is present throughout the apple growing regions of the North Island of New Zealand and the Nelson district in the north of the South Island, but is absent further south (Hortnet, 2004). Therefore its likelihood of being present in orchards is considered to be 'High' rather than 'Certain' as for most other pests. There is very little information on *Planococcus mali* on apples either from Australia, where it originated, or from New Zealand, and it will not be considered further here, since its pest status is negligible. CMB is common in Tasmania, is a pest of mainland citrus, but is absent from Western Australia.

Mealy bugs normally feed on plant sap which they access by piercing the veins of leaves with their sucking mouthparts. On apple fruit most mealybugs congregate in the calyx area, often deep within the cavity below the calyx segments (sepals) (see photographs in Hortnet, 2004). In this last location they are protected from packhouse processes such as washing and brushing, and are unlikely to be detected by sorters on the grading line.

Mealybugs were the most prevalent pests on harvested fruit in 13 IFP orchards which exceeded the MAF Maximum Pest Limit of 0.5% in New Zealand in 1997 (Walker *et al*., 1997). The mean incidence of mealybugs in these orchards was 2.07% with a maximum of 3.55%. Mealybugs were the second most prominent pest after leafrollers across all IFP orchards in 1998 (Walker *et al*., 1998). In North Island crops district averages for mealybug infested fruit varied from 0.31 to 0.4%, while between 7 and 11% of orchards exceeded fruit infestation levels of 1%. Maximum recorded levels of mealybugs ranged from 4.2 to 4.75% and some North Island crops exceeded the MAF tolerance for this pest on export apples (Walker *et al*., 1998). The species of mealybugs were not specified in these assessments and are likely to include species other than CMB.

Implications of the Analysis

Probability of Entry

The analysis presented here (Table 13.9) determined the Probability of Entry to be **'LOW'** by contrast with the 2004 RDIRA in which it was determined to be 'VERY LOW'. The reasons for this are very similar to those for European Red Mite and Oystershell Scale, and relate to three factors in the infestation of fruit by both pests, viz:

- Small size
- Infestation by multiple individuals per fruit
- Aggregation in the calyx area

These characteristics are high risk for the transmission of apple pests on fruit, because pack house procedures are unlikely to significantly reduce the percentage of infested fruit, even though brushing and washing will reduce the total population. The small size and hidden locations of the pests mean that many will not be detected by sorters on the packing line.

Probability of Distribution and Spread

CMB is a polyphagous species with herb, shrub and tree hosts in over 40 plant families, including some common weeds. This suggests it will be in close proximity to potential hosts wherever it may escape from infested fruit. Accordingly, Table 92, page 370 has been amended to more realistically reflect the proximity of potential hosts of CMB to utility points:

Table 13.9 Reassessment of Risk of Entry for Mealybugs, *Pseudococcus calceolariae* and *Planococcus mali*

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		High	High	Since Citrophilus Mealybug (CMB) is a much more significant pest species than *Planococcus mali*, it is the most likely to be present on export apples. CMB is absent from the southern parts of the South Island of New Zealand, so its likelihood of being present in an individual orchard is considered to be 'High', rather than 'Certain' which has been allocated to most other pests in this report.
Imp 2		Low	Low	The likelihood of 'Low' allocated in the 2004 IRA is considered reasonable.
Imp 3		Very low	Very low	While mealybugs are mobile insects and have the potential to move between fruit in the picking bags or bins, there is no data to indicate how great this movement may be. If mealybugs are sensitive to disturbance they may disperse widely and multiply the infestation. If, as seems more likely, they simply hang on more tightly, there will not be a great redistribution and the IRA rating of 'Very low' is reasonable.
Imp 4		Low	Moderate	A proportion of mealybugs in the calyx and stem ends of fruit, where most of them will be, will be removed by the washing and brushing processes in the pack house. However, while the numbers of CMB will be reduced, the percentage of infested fruit may not significantly decline, since many mealybugs on each fruit will be unaffected. Furthermore, it is likely most of the remaining mealybugs will not be detected as fruit pass quickly down the packing line. The likelihood of detection would be proportional to the number and size of the mealybugs present. Large infestations are likely to be removed by sorters, while the more numerous small infestations and individuals are likely to be overlooked. A rating of 'Moderate' is recommended. The rating of 'Low' in the IRA on the basis that CMB comprises only about one third of the mealybugs present is false logic, since the step refers only to CMB, not all mealybugs.
Imp 5		Extremely low	Extremely low	The likelihood in the IRA for this step is accepted.
Imp 6		High	Certain	Nothing has been identified in the IRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce CMB infestation levels. On the contrary, it is likely that all but a very few insects would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	The arguments presented in the IRA for a 'negligible' rating are accepted.
Imp 8		High	Certain	The likelihood of survival of CMB through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the IRA that would reduce survival through this step.
Probability of Entry	Moderate	Very low	Low	The reassessment presented here does not agree with the outcome in the 2004 IRA. It is considered the Probability of Entry is 'Low', rather than 'Very low'.

Utility Points	Exposure Groups			
Proximity	**Commercial fruit crops**	**Nursery plants**	**Household and garden plants**	**Wild and amenity plants**
Orchard wholesalers	Certain	Very low	Low	Moderate
Urban wholesalers	Extremely low	Extremely low	Very low	Very low
Retailers	Very low	Low	Low	Low
Food Services	Extremely low	Extremely low	Very low	Very low
Consumers	Very low	Very low	Moderate	Moderate

The likelihood of CMB being able to infest potential hosts from a waste apple discarded near them is better than negligible as indicated in Table 93, page 372 of the RDIRA. CMB is likely to have multiple individuals per infested fruit, such that females are likely to be fertilised. Although females are flightless, they are capable of crawling to hosts. These factors suggest a rating of **'EXTREMELY LOW'** rather than 'NEGLIGIBLE' in Table 93.

The analysis in this review gives an unrestricted annual risk of **'LOW'**, rather than 'VERY LOW' as in the RDIRA, indicating additional risk mitigation measures will need to be implemented for this pest for New Zealand apples going into Western Australia.

13.3.10 Oriental Fruit Moth, *Grapholita molesta*

Oriental Fruit Moth **("OFM")** is not a primary pest of apples, but is a major pest of stonefruit. Infestations on apples are only occasional and usually occur close to plantings of stonefruit. It feeds by burrowing into the shoot tips of stonefruit trees and other hosts, and into the flesh of fruit. On apples only the fruit is attacked, and it is reported only to attack ripe or over ripe apples in New Zealand, suggesting it is unlikely to be in fruit at harvest, which occurs some time before fruit is fully ripe (Hortnet, 2004).

Oriental Fruit Moth is a relatively recent arrival in New Zealand, dating from around 1976 and has not spread beyond the North Island (Murrell and Lo, 1998).

<u>Implications of the Analysis</u>

<u>Probability of Entry</u>

The analysis in this review has amended the likelihoods applied in the RDIRA, but the changes have acted to cancel each other out, so that the probability of entry of **'VERY LOW'** assessed in Table 13.10 agrees with that in the RDIRA.

<u>Probability of Distribution and Spread</u>

OFM has an extensive host range including stonefruit trees, apples, pears, quinces, members of the family Rosaceae and many woody ornamentals. On this basis potential hosts are highly likely to occur wherever it may escape and the likelihoods in Table 98, page 394 of the RDIRA should be amended to reflect this as follows:

Utility Points	**Exposure Groups**			
Proximity	**Commercial fruit crops**	**Nursery plants**	**Household and garden plants**	**Wild and amenity plants**
Orchard wholesalers	Certain	Very low	Low	Moderate
Urban wholesalers	Extremely low	Extremely low	Very low	Very low
Retailers	Very low	Low	Low	Low
Food Services	Extremely low	Extremely low	Very low	Very low
Consumers	Very low	Very low	Moderate	Moderate

The likelihood of a potential host being infested from a single waste apple discarded nearby is given in Table 99, page 396 of the RDIRA as 'NEGLIBILE'. Since a waste fruit is likely to support only a single OFM larva, and there are unlikely to be other larvae nearby for eventual mating, this probability is considered reasonable.

However, note the comments on the inappropriateness of the risk analysis model for moths under Leafrollers and Codling Moth. The risk analysis does not accommodate the most likely establishment scenarios for these species.

When the likelihoods recommended in this review are fed into the risk analysis model, an unrestricted annual risk of **'LOW'** is obtained, which is well above the level of 'NEGLIGIBLE' arrived at in the RDIRA. The risk of **'LOW'** is above Australia's ALOP of 'VERY LOW', indicating that additional risk management measures are required for New Zealand apples into Western Australia.

Table 13.10 Reassessment of Risk of Entry for Oriental Fruit Moth, *Grapholita molesta*

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		Low	Moderate	Oriental Fruit Moth (OFM) is confined to the North Island, where it occurs in the main orcharding districts, but may not be present in all orchards. It is likely to be present in a third to one half of New Zealand apple orchards. Therefore a rating of ‘Moderate’ is more appropriate.
Imp 2		Very low	Very low	The likelihood of ‘Very low’ in the RDIRA is considered reasonable at this step.
Imp 3		Negligible	Negligible	The likelihood of ‘Negligible’ in the RDIRA is considered reasonable at this step.
Imp 4		High	Moderate	The IRA suggests most infested fruit would pass undetected through the grading and packing step. This is unlikely to be the case, given that there is usually some external evidence of the presence of a larva in the fruit. This evidence includes frass and an entrance hole, and possibly some visible subsurface tunnelling. It is possible that the entrance hole could be difficult to see if near the calyx or stem end, or that a young larva may not yet have a large hole. On this basis the likelihood is assessed as ‘Moderate’.
Imp 5		Negligible	Negligible	The likelihood of ‘Negligible’ in the RDIRA is considered reasonable at this step.
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce OFM infestation levels. On the contrary, it is likely that all but a very few larvae would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	The arguments presented in the RDIRA for a ‘Negligible’ rating are accepted.
Imp 8		High	Certain	The likelihood of survival of OFM through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the IRA that would reduce survival through this step.
Probability of Entry	Not assessed	Very low	Very low	This assessment agrees with that in the RDIRA.

13.3.11 Oystershell Scale, *Diaspidiotus ostreaeformis*

Oystershell Scale **("OSS")** is the main scale pest on apples in the southern parts of the South Island of New Zealand (Hortnet, 2004). It is absent from the major apple growing area of Nelson in the north of the North Island, and is confined to Canterbury and areas south of it. It is therefore likely to be absent from 95 percent of New Zealand's production areas.

In the first years of IFP production in New Zealand, OSS levels on fruit at harvest were as high as 10 percent (Wearing, 1996). Scale infestations on fruit at harvest in Canterbury and Otago apple orchards in the IFP program averaged 0.44 and 0.56% in 1998 (Walker *et al.*, 1998). Overall, in the IFP program in 1998, 'scale insects were present in a significant proportion of IFP orchards in each district and a few crops were unacceptable for export certification'. OSS was the principle scale pest in Otago with 3% of blocks exceeding 1% scale infested fruit at harvest. In Canterbury 25% of blocks exceeded 1% of scale infested fruit, but the scale species is not stated. However, it is likely to have included a significant amount of OSS. Overall, Walker *et al*. (1998) indicated that scale insects were difficult to control under IFP recommendations for some growers in all districts.

<u>Implications of Analysis</u>

<u>Probability of Entry</u>

The analysis in Table 13.11 shows that OSS has a **'LOW'** probability of entry by contrast with the 2004 IRA which gives an 'EXTREMELY LOW' probability. The reasons for the higher risk relate to the analysis in this review being restricted to fruit from infested regions, some errors of logic in the Import Risk Analysis shown in Table 13.11 and a greater likelihood of infested fruit passing undetected down the packing line than considered likely in the RDIRA. The reason this analysis has been restricted to infested regions is that such fruit will pass through the marketing system together and will not be mixed with fruit from uninfested areas. The model assumes that all pests will be randomly distributed amongst the entire New Zealand crop, which is clearly not the case for OSS. Some 95 percent of the New Zealand crop presents no risk for OSS, while 5 percent presents a relatively high risk. This problem also occurs to a lesser extent for Oriental Fruit Moth, which should be treated in the same way.

<u>Probability of Distribution and Spread</u>

OSS has very similar characteristics to European Red Mite and Citrophilus Mealybug. Accordingly, this analysis has applied the same likelihoods for proximity to, and exposure of, hosts as to those pests. The likelihoods recommended in this review for proximity of utility points to potential hosts (Table 104, page 416 of the RDIRA) are:

Utility Points	**Exposure Groups**			
Proximity	**Commercial fruit crops**	**Nursery plants**	**Household and garden plants**	**Wild and amenity plants**
Orchard wholesalers	Certain	Very low	Low	Moderate
Urban wholesalers	Extremely low	Extremely low	Very low	Very low
Retailers	Very low	Low	Low	Low
Food Services	Extremely low	Extremely low	Very low	Very low
Consumers	Very low	Very low	Moderate	Moderate

As for European Red Mite and Citrophilus Mealybug, it is considered the likelihood of infestation of a host from a single infested apple discarded nearby is higher than ‘NEGLIGIBLE’. This is because there are likely to be multiple insects per infested apple and the first instar crawler can move to, or be blown onto, the host unlike the other lifecycle stages that are sedentary. An apple with a gravid female will give rise to multiple crawlers that may be sufficient to initiate a reproducing population.

When these amended likelihoods are fed into the risk analysis model an unrestricted annual risk of **‘LOW’** is generated, by contrast to the RDIRA result of ‘NEGLIGIBLE’. The **‘LOW’** risk is above Australia’s ALOP indicating that additional risk management measures are required for this pest for entry to Western Australia.

Table 13.11 Reassessment of Risk of Entry for Oystershell Scale, *Diaspidiotus ostreaeformis*

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		Very low	High	Oystershell Scale (OSS) is the main scale pest on apples in the southern parts of the South island of New Zealand. It is absent from the major apple growing area of Nelson in the north of the North Island, and is confined to Canterbury and areas south of it. It is therefore likely to be absent from 95 percent of New Zealand's production areas. This analysis considers only fruit from infested areas, where Imp 1 will have a 'high' likelihood.
Imp 2		Very low	Low	The rating appropriate here is for harvested fruit from orchards in the south of New Zealand where the scale occurs, not all orchards as in the RDIRA. A rating of 'Low' is considered more appropriate than 'Very low' (see discussion above).
Imp 3		Extremely low	Very low	The logic employed in the RDIRA to assign an 'Extremely low' rating at this step is faulty. It is irrelevant that the majority of the infestation is on the bark since Imp 3 considers only the fate of those that are on the fruit. Therefore, there is greater than an 'Extremely low' likelihood that some redistribution of crawlers will occur while the fruit is in the picking bag and field bin. This is considered more likely to be 'Very low'.
Imp 4		Moderate	High	The logic behind the allocation of 'Moderate' at this step in the RDIRA is also faulty. There is no doubt that the pack house processes of washing and brushing will reduce scale numbers on fruit. However, since fruit will be infested by multiple insects and that some scale are likely to remain on most fruit, the percentage of infested fruit will not greatly change. In addition, the small size of the scale insects means that low numbers of scales on fruit are less likely to be detected during grading, and lightly infested fruit, which are likely to be the majority, will not be removed. A rating of 'High' is more appropriate.
Imp 5		Negligible	Negligible	The RDIRA rating of 'Negligible' is accepted.
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce OSS infestation levels. On the contrary, it is likely that all but a very few scales would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Negligible	The arguments presented in the RDIRA for a 'negligible' rating are accepted.
Imp 8		High	Certain	The likelihood of survival of OSS through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the RDIRA that would reduce survival through this step.
Probability of Entry	Not assessed	Extremely low	Low	The reassessment presented here does not agree with the outcome in the 2004 RDIRA. It is considered the Probability of Entry is 'Very Low', rather than 'Extremely Low', however, this is based on multiplication of likelihood midpoints rather than use of the risk analysis model.

13.3.12 Wheat Bug, *Nysius huttoni*

Wheat Bug **("WB")** is a native New Zealand species that is not a significant pest of apples, but is a serious pest of Brassicaceae and Poaceae (Ferguson, 1994), which includes many important vegetable, crop and pasture species, grain crops, including wheat (Gurr, 1952, 1957; Bejakovich *et al*., 1998), barley, ryecorn and oats (Bejakovich *et al*., 1998) and pasture grasses including brome grass and ryegrass (Bejakovich *et al*., 1998). Densities of Wheat Bug can be very high; Ferguson (1994) reported densities of 1218/m^2 in a direct drilled swede crop. The wide host range of Wheat Bug, including weeds (Ferguson 1994; Sale, 2003), and its distribution throughout New Zealand indicates that it is very likely to be present in host orchards, by contrast to the conclusion at Importation Step 1 in the RDIRA. The RDIRA appears to have confused its likely presence in orchards with its possible presence on fruit.

Wheat Bug is known to be a 'hitchhiker' species from a quarantine perspective, i.e. it may inadvertently land or crawl onto picked fruit or bins in the field, or cartons or pallets in the packing shed. The hitchhiking capabilities of this species have been confirmed by its detection on shipments of New Zealand apples going into the USA (Sale, 2003; 2004 RDIRA). Because of this, the importation pathway outlined in the RDIRA is not appropriate and needs to be interpreted differently. For example, while Wheat Bug may not often be present in high numbers on fruit being picked, it is more likely to enter the pathway by crawling into or landing on fruit in the field bins. Also, because adults can fly, they may fly into the packing shed, or from field bins, to boxes being packed or pallets being stacked. Observations in New Zealand indicate Wheat Bug is likely to move into bins and pallets placed on open areas with low weeds around the packing shed, which may support high bug numbers (Sale, 2003). This indicates the recontamination steps of the importation pathway are likely to be far more important for this species than others. It also means that the notion of considering the infestation of a single piece of fruit in analyses is inappropriate. The unit that should be assessed is the pallet because Wheat Bugs may access these in some numbers rather than being on individual fruit. The bugs will travel with the pallet and numbers may leave it at various points along the distribution pathway. The risk is likely to be quite high for large consignments of fruit sent directly from New Zealand to large packhorses in horticultural areas, such as Montague's in Victoria or Plummers in South Australia.

For the United States Department of Agriculture (USDA – NZMAF, 2004), Wheat Bug is one of the two most concerning insects potentially present on New Zealand apples, due to its potential impact on the US grains industry. The other is Light Brown Apple Moth, *Epiphyas postvittana*. These two insects are termed 'primary pests of concern'.

Implications of the Analysis

Probability of Entry

For a hitchhiker species like Wheat Bug, the RDIRA analysis based on individual infested fruit is entirely inappropriate. For this reason the analysis in this review has been done in two ways in Table 13.11; one taking the fruit as the unit of analysis, and the other using the pallet of fruit, since Wheat Bug is more likely to be associated with the pallet than the fruit itself. The pallet analysis results in a much higher Probability of Entry for Wheat Bug, viz; **'LOW'** versus 'VERY LOW' for individual fruit.

Table 13.12 Reassessment of Risk of Entry for Wheat Bug, *Nysius huttoni*.

Importation Step	Risk in 2000 IRA	Risk in 2004 IRA	Recommended Risk	Justification
Imp 1		Very low	Certain	The distribution of *N. huttoni* throughout New Zealand, its wide host range, and often high abundance, indicate that it is likely to be present in every orchard.
Imp 2		Extremely low	Very low (fruit); Moderate (bins)	The RDIRA likelihood of 'Extremely low' is not based on any data, indicating this estimate is subjective and may be too low. However, the most likely route for infestation of fruit shipments is insect invasion of bins in the orchard, or when placed outside the packing shed (Sale, 2003). A likelihood of moderate, with the bin as the unit of infestation, is considered more appropriate (see discussion above).
Imp 3		Low	Low (fruit); Moderate (pallets)	High infestation levels of bugs on low weeds in the orchard may result in movement of bugs into bins where they would shelter between the slats or amongst the fruit. This could also happen for bins of freshly picked fruit left outside the pack house, if the pack house apron is weedy. The rating of moderate is based on the bin as the unit of infestation rather than an individual fruit (see discussion above).
Imp 4		Very low	Very low (fruit)	The likelihood of 'Very low' assigned at this step is subjective, since no quantitative supporting data is presented, however, is accepted as reasonable.
Imp 5		Negligible	Low (fruit); Moderate (pallets)	While it is reasonable to consider most bugs would be removed from fruit during washing, brushing or waxing in the pack house, it is likely that recontamination could occur during packing due to the mobility of this insect. Bugs that lodged in bins or among fruit would be disturbed during bin tipping and other processes, and would likely fly out into the pack house with some settling in or on cartons of fruit. At the carton level a rating of low is considered reasonable, which would become moderate for a pallet of cartons.
Imp 6		High	Certain	Nothing has been identified in the RDIRA in the palletisation, quality inspection, containerisation and transportation steps that would reduce Wheat Bug infestation levels. On the contrary, it is likely that all but a very few larvae would survive, so that the likelihood is close to certain.
Imp 7		Negligible	Low (fruit); Moderate (pallets)	The main routes of Wheat Bug contamination appear to be movement of bugs to shelter in the cracks and joints of bins and pallets in contact with infested weeds outside the pack house, or on the pack house floor. In the latter case disturbed bugs flying or crawling in the pack house will likely seek shelter in pallet stacks waiting to be transported or stored.
Imp 8		High	Certain	The likelihood of survival of Wheat Bug through on-arrival minimum border procedures is considered to be close to 100 percent, or certain. Nothing has been identified in the RDIRA that would reduce survival through this step.
Probability of Entry	Not assessed	Very low	Very low (fruit) Low (pallets)	

Probability of Distribution, Establishment and Spread

The inappropriateness of the risk analysis in the RDIRA is reinforced when it is realised that Wheat Bug does not damage the fruit and is unlikely to escape into the Australian environment from waste apples. Accordingly, as for Apple Leaf Curling Midge and New Zealand Flower Thrips, the risk analysis model in the RDIRA is particularly unsuitable for this species, and no change to the Import Risk Analysis has been attempted here. The most likely points from which multiple individuals could escape to allow population establishment to occur are from locations where relatively large quantities of apples are stored, such as warehouses and packing sheds, and to a lesser extent, supermarkets. The notion of a healthy Wheat Bug still being on an apple by the time it gets to a consumer is ludicrous, yet the RDIRA indicates this is the most likely way for this species to be established.

13.4 DISCUSSION

The results obtained in this review are summarised in Table 13.13. In general this review has assigned higher likelihoods of entry, distribution, establishment and spread than in the RIRA, except for Codling Moth for which the results are very similar. There is less disagreement between the two treatments for the probability of entry than for the probability of distribution, establishment and spread pathways. This is because there is at least some quantitative scientific data for the infestation levels of pests on fruit in New Zealand, but there is no data for any of the steps in the distribution, establishment and spread pathways. It is argued in this review that Biosecurity Australia has greatly underestimated the proximities of the various utility points to host plants, particularly of polyphagous pest species, and has often underestimated the likelihood of exposure of hosts to the pests. This has resulted in all the subject pests being given low unrestricted annual risks of entry in this review, which is above Australia's ALOP. This essentially happens as soon as the almost universally applied likelihood of negligible in the RDIRA for exposure of hosts is raised to more realistic levels.

Table 13.13 Summary of results of reassessment of likelihoods in the 2004 New Zealand Apple Import Risk Assessment.

Pest species	Probability of Entry		Unrestricted Annual Risk	
	IRA	This Review	IRA	This Review
Pests for all of Australia				
Apple Leafcurling Midge	Low	Low	Low	(High)*
Garden Featherfoot	Extremely low	Very low	Negligible	Low
Grey-brown Cutworm	Extremely low	Very low	Negligible	Low
Leafrollers	Very low	Very low	Very Low	Low
Native Leafroller	Extremely low	Very low	Very low	Low
New Zealand Flower Thrips	Extremely low	Very low	Very low	Low
Wheat Bug	Very low	(Low)*	Moderate	-*
Pests for Western Australia				
Codling Moth	Low	Very low	Low	Low
European Red Mite	Very low	Very low	Negligible	Low
Mealybugs	Very low	Low	Very low	Low
Oriental Fruit Moth	Very low	Very low	Negligible	Low
Oystershell Scale	Extremely low	Low	Negligible	Low

* See text

It is clear from Table 13.13 that New Zealand apples potentially carry a large number of significant pests absent from parts or all of Australia and that there is an unacceptable risk of entry for these pests via unrestricted trade. While the RDIRA considers the risks of entry of each of these pests on an individual basis, it is obvious that the risks of entry of any pest at all is increased the more pests there are. From this point of view New Zealand apples present a particularly high risk, especially for Wester Australia, which enjoys a high degree of pest freedom on apples.

Given the high diversity of New Zealand apple pests and the unacceptable risks of entry, it is recommended that:

- Preclearance inspections be implemented in New Zealand for export apples to Australia using the USDA-MAF (2004) model.

- The protocols adopted for Apple Leafcurling Midge on apples into California be mandated for entry into Australia for all New Zealand pests absent from eastern Australia.

- In view of the larger number of pest species potentially on New Zealand apples that are absent from Western Australia, and the cryptic nature of many of these, it is recommended that all fruit for Western Australia be disinfested in New Zealand before export, and that no fruit from Canterbury or Otago be shipped to Western Australia on account of Oystershell Scale.

The recommended risk mitigation of inspection of 600 apples per lot on arrival in Australia is insufficient in the face of the overall risks posed to the Australian industry by New Zealand fruit. Preclearance inspection in New Zealand supervised by an AQIS inspector and with sample sizes proportional to the size of the lot is highly recommended. The USDA-New Zealand MAF model (USDA-MAF 2004) would give more assurance of risk minimisation commensurate with the risks posed by New Zealand fruit. The particular problem of Western Australia, which lacks all 11 pests in Table 13.13, demands a higher level of risk mitigation in accordance with the recommendation above.

13.5 CONCLUSIONS

(1) Integrated Fruit Production (IFP) as practised in New Zealand results in increased quarantine risks because it allows previously suppressed secondary pests, such as Apple Leaf Curling Midge, to increase.

(2) Risk Analysis Model.

The risk analysis model used in the RDIRA is a statistically convenient tool, but has many inherent shortcomings, and there are problems in the way it has been applied in the RDIRA:

- The focus of the model on a single infested fruit and what happens to it is biologically unrealistic. This abstraction ignores the reality that pests function as populations, not as individuals. Population scenarios likely to result in establishment of new pests in Australia are ignored. (This issue is discussed in detail in this review for the Greenheaded and Brownheaded Leafrollers, and Codling Moth).

- The model is built around the unrealistic assumption that establishment of new apple pests will only come from waste fruit generated at each step on the distribution pathway. While waste is important, there are other similarly important, and in some cases, more important pathways that are dismissed.

- The risk analysis in the RDIRA generally uses a 'high' probability as the highest level (midpoint 0.85) when, in many cases, the actual probability is close to 1, or 'certain'. This use of 'high' forces population reductions along pathways that do not occur in reality.

- The model also creates anomalies for pests with restricted distributions in New Zealand, such as Oystershell Scale, which occurs only in the Otago and Canterbury regions. The analysis should be run only for fruit from affected areas, as it will move through the system together, while the model implies it will be diluted among all New Zealand apples.

- Real data is missing from most of the analysis of the distribution and establishment pathways. This part of the analysis is largely conjectural and lacks credibility. Detailed examination of the 'pest specific estimates' on these pathways indicates many are very unrealistic.

(3) Host Plants

The RDIRA generally underestimates the availability of host plants in Australia for polyphagous pests such as the Greenheaded and Brownheaded Leafrollers, Grey-brown Cutworm, Native Leafroller, New Zealand Flower Thrips, European Red Mite, Mealybugs and Oystershell Scale.

(4) The RDIRA makes surprisingly little use of United States Department of Agriculture data derived from preclearance inspections of New Zealand apples. This data would allow more rigorous assessment of the risks of entry for pests, and would provide a check on the IRA methodology.

(5) This review reassessed the probabilities of entry, distribution, and establishment and spread for eleven pest species considered in the RDIRA. All had revised unrestricted annual risks of entry above Very Low, Australia's Appropriate Level Of Protection (ALOP).

(6) Review of the risk analysis for pests in the RDIRA found:

- Apple Leaf Curling Midge (ALCM)
  It is concluded that the RDIRA risk analysis is inappropriate for this pest. The high level of quarantine interceptions by USDA on New Zealand apples shows the unrestricted risk for this pest should be much higher than the 'LOW' rating given in the RDIRA. This indicates the risk analysis methodology has given an unrealistic outcome in this case. Standard fruit inspection will not provide adequate risk mitigation for this species. Higher levels of inspection and/or fumigation of shipments is required.

- Garden Featherfoot (GFF)
  The analysis for probability of entry in this review was assessed as **'VERY LOW'**, by contrast to 'EXTREMELY LOW' in the RDIRA. The revised unrestricted annual risk of entry of **'LOW'** is also above the level of 'EXTREMELY LOW' assessed by the RDIRA

- Grey-brown Cutworm (GBC)
  This review considers the probability of entry for GBC to be **'VERY LOW'** rather than 'EXTREMELY LOW' as in the RDIRA. The RDIRA also greatly underestimates the probabilities of establishment and spread for this polyphagous species, such that the revised unrestricted annual risk of entry is **'LOW'** rather than 'NEGLIGIBLE'.

- Greenheaded (GHL) and Brownheaded Leafrollers (BHL)
  This review found that the probability of entry for GHL and BHL was 'VERY LOW', in agreement with the RDIRA. However, this scenario could change rapidly in these species if resistance to pesticides becomes more

widespread. Also, the probabilities of establishment and spread derived in the RDIRA are greatly understated, such that the revised unrestricted annual risk of entry is **'LOW'** rather than 'VERY LOW'.

- Native Leafroller (NLR)
  The RDIRA has handled the analysis of NLR very poorly, with several logical inconsistencies. It is considered that the probability of entry for NLR is **'VERY LOW'** by contrast with 'EXTREMELY LOW' in the RDIRA. It is also considered that the likelihood of establishment and spread for this species has been underestimated. The revised annual risk of entry is **'LOW'** rather than 'VERY LOW'.

- New Zealand Flower Thrips (NZFT)
  The analysis in this review gave a probability of entry of **'VERY LOW'**, by contrast to 'EXTREMELY LOW' in the RDIRA. In addition, the probabilities of establishment and spread for this species are grossly underestimated, such that the revised unrestricted annual risk of entry is **'LOW'** rather than 'VERY LOW' as in the RDIRA.

- Codling Moth (CM)
  This is the only insect for which the RDIRA has given a higher probability of entry, 'LOW', than this review, **'VERY LOW'**, showing a major inconsistency in the way this pest has been treated in the RDIRA. Also by contrast to the other pests, the unrestricted annual risks calculated in this review and the RDIRA are both 'LOW'.

- European Red Mite (ERM)
  ERM has given the same probability of entry in this review as in the RDIRA. However, the likelihoods of distribution, establishment and spread are higher in this review giving a much higher unrestricted annual risk of entry of **'LOW'** versus 'NEGLIGIBLE' in the RDIRA.

- Citrophilus Mealybug (CMB)
  CMB represents a higher quarantine risk than most pests considered in the RDIRA. This review considers the probability of entry to be **'LOW'** by contrast to 'VERY LOW' in the RDIRA. The unrestricted annual risks of entry are also **'LOW'** and 'VERY LOW' in the RDIRA.

- Oriental Fruit Moth (OFM)
  This review agrees with the RDIRA for probability of entry of this pest, but gives a higher unrestricted annual risk of entry, **'LOW'**, than the RDRA, 'NEGLIGIBLE'.

- Oystershell Scale (OSS)
  It is considered that the risk analysis methodology is inappropriate for Oystershell Scale, which only occurs in the south of the South Island of New Zealand, representing about five percent of the New Zealand apple crop. When the appropriate sub sample of fruit is analysed, a much higher probability of entry, **'LOW'**, is generated than that in the RDIRA, 'EXTREMELY LOW'. The revised unrestricted annual risk of entry is **'LOW'**, by contrast to 'NEGLIGIBLE' in the RDIRA.

- Wheat Bug (WB)
  The Import Risk Analysis methodology is totally inappropriate for this pest which does not attack apple fruit at all. It would have been better to

analyse by pallet units, rather than by fruit. On the basis of pallets, a probability of entry of **'LOW'** is generated, rather than 'VERY LOW' as in the RDIRA. The analysis of establishment and spread for WB is also highly flawed.

13.6 RECOMMENDATIONS

It is recommended that:

1. Biosecurity Australia develops a more appropriate risk analysis model that realistically takes account of the population dynamics of pests and diseases.

2. Biosecurity Australia establishes an expert panel to reanalyse the risks associated with the importation of New Zealand apples in the light of the many inadequacies in the RDIRA revealed by this and other reviews.

3. Biosecurity Australia obtains from New Zealand MAF, the results of all USDA preclearance inspections of export apples for the last three years in order to validate the probabilities of entry in the RDIRA, and makes the data available to the Australian industry.

4. Preclearance inspections be implemented in New Zealand for export apples to Australia using the USDA-MAF (2004) model.

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SECTION 14. APPLE SCAB – PEST RISK ASSESEMENT

14. APPLE SCAB – PEST RISK ASSESSMENT

14.1 INTRODUCTION.

While Apple Scab or black spot, caused by the fungus *Venturia inaequalis* is considered in the RDIRA the National Apple and Pear technical panel has not undertaken a full and detailed review of this disease or the information detailed within the RDIRA.

Both the western Australian Fruit Growers Association and the Western Australian Department of Agriculture have considered Apple Scab in detail within their technical submissions.

14.2 CONSEQUENCE TO WESTERN AUSTRALIA

There appears to be inconsistency in the RDIRA in relation to economic consequence of disease outbreaks. Apple Scab is the most economically damaging disease of apples worldwide and this fact is supported by numerous scientific references. According to CAB International's Crop Protection Compendium (2003 Edition) *"losses from scab over a period of years far exceed those from any other disease or pest of apples. The major economic loss to the grower is the reduction in fruit quality of scabbed apples. Severe attack of the leaves will cause mid-season defoliation and a reduction of tree vigour which, in turn may lead to failure of fruit bud formation and to stunted and reduced growth. In regions and years with favourable weather conditions for scab infection with a high PAD (potential ascospore dose), nearly all the fruits may be infected. In such regions, about 70% of the pesticides applied are used in relation to scab control".*

It therefore should follow that the economic consequence to apple growers in Western Australia should be rated higher than Fire Blight to other Australian growers. **The RDIRA has an overall consequence of Fire Blight as 'HIGH' and Apple Scab as 'MODERATE'. This rating is most unfair and unacceptable for apple growers within Western Australia.**

Further, the consequence for Western Australian growers are further exacerbated by the fact that they and the State Agricultural Department will have to meet any costs associated with eradication without any assistance from the Commonwealth or other State Agricultural Departments and/or growers.

14.3 MISCALCULATION IN IMPORTATION STEP 4 IN RELATION TO APPLE SCAB

The RDIRA states (page 296) that the likelihood for Imp4 is very low because there would be a low level because there would be a low level of fruit infection in the orchard as a consequence of good management. However the impact of good management has already been taken into account in Importation steps 1 and 2 (source orchards and harvesting of fruit for export) and should not be a factor in Imp4. Importation step 4 should only deal with the likelihood of Apple Scab surviving routine processing procedures in the packing house. The RDIRA document admits that the conidia survive all of the routine processes and the likelihood assigned to Imp4 should reflect this fact and be amended to a 'HIGH' likelihood. The impact of a 'HIGH' likelihood needs to be assessed.

Restricted Risk.

The RDIRA states that *"in the unrestricted risk assessment for Apple Scab Imp4 (processing of fruit in packing house) was assessed considering all the procedures that take place in New Zealand's packing houses. This includes the use of sanitizers and short-term cold storage by some packing houses. There is no evidence in the literature showing any ability of these procedures to mitigate symptomless infection. Therefore, it is not feasible to seek measures to reduce the likelihood allocated to Imp4".*

This contradicts the assessment made by Imp4 where *" the likelihood for Imp4 was assessed as very low because there would be a low level of fruit infection in the orchard as a consequence of good management" (Pages 296 -297).* In the first instance BA appears to suggest that nothing can be done to reduce the likelihood associated with Imp4, yet in the second instance BA states that the likelihood of Imp4 can be brought down to a low rating as a consequence of good management.

Inconsistencies in the RDIRA such as this identify the serious need for the RDIRA to be rejected and a further assessment undertaken.

SECTION 15. OTHER ISSUES

15. OTHER ISSUES

The RDIRA, while a comprehensive document has failed to adequately consider a wide range of issues that are considered by Industry as integral to the process of undertaking the Apple Import Risk Analysis.
Some of these issues, which have not been covered in detail by this Technical Submission, but require further consideration by the Import Risk Analysis Team (IRAT) include:-

a) Pest/disease outbreaks in close proximity to registered export blocks.
b) Symptom removal prior to inspection.
c) Historical incidence/outbreaks of Quarantine pests/diseases within New Zealand and other Countries.
d) Movement of pests/diseases during harvesting, transport and cold storage.
e) Movement of pests/diseases during packing and transporting
f) Inspection of 600 pieces of fruit at the point of entry.
g) The issue of trash has not been considered in sufficient depth in the RDIRA with particular consideration to its significance as a vector for pests and/or diseases.
h) The issue of handling errors and illegal acts have not been taken into account despite the fact that WTO has specifically ruled that both may be taken into account.
i) Visual inspection of orchards is given as a risk mitigation factor when it is clear that visual inspections will not detect small Fire Blight cankers or European Canker lesions
j) Biosecurity issues within New Zealand which highlight potential problems with inspection procedures. (Feutrill and Kelly. 2003)

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SECTION 16. CONCLUSIONS

16. CONCLUSION

The 2004 Revised Draft Import Risk Analysis document is a very large document and as indicated by Biosecurity Australia representatives, during the national roadshow, it is a 'warts and all' document.

The RDIRA is based on an application from New Zealand to export mature apples that are free of trash to Australia.
Through Apple and Pear Australia Limited, the Australian Apple and Pear Industry has endeavoured to focus Biosecurity Australia on the many issues relating to the importation of apples from New Zealand, particularly with reference to the introduction of a wide variety of pests and/or diseases.

While the process over the past two and a half years has offered a new level of transparency and improved communications, the process has still been far from perfect. The result has been a high level of frustration particularly for the 'grass roots' apple and pear grower.

The result of over two years work by the Risk Analysis Panel and the Import Risk Analysis Team was the 'warts and all' 800 page document that was released to stakeholders on the 23rd February 2004. Originally, stakeholders were given 60 days to respond but after requests from stakeholders and other interested parties, the time frame was extended to 120 days.
During this period the Australian Apple and Pear Industry, through APAL, assembled a team of scientific and technical experts to undertake a comprehensive review of the RDIRA. Substantial time and resources were committed to this process and this Technical Report is the culmination of that work.
The aims of the review were to:-

1. Evaluate the scientific basis for estimates of risks of entry for quarantine pests/diseases used in the risk analysis equations.

2. Determine whether the risk analysis methodology has been applied consistently within and between analyses.

3. Recommend any changes needed to the risk values for entry, establishment, spread and consequence.

4. Recommend any additional risk mitigation measures required to reduce the risk levels to meet the ALOP of very low.

Specific consideration was given to:-

1. The Import Risk Analysis Model and Methodology.

2. Pest Risk Assessment of Fire Blight.

3. Pest Risk Assessment of European Canker.

4. Pest risk Assessment of Apple Scab.

5. Pest Risk Assessment of 12 specific Insects.

Comparisons of the RDIRA with a detailed analysis by experts have revealed flaws in the mathematical model used to estimate risk. This critique of the mathematical model begs the question of whether, in its current form, the RDIRA can know be accepted as an accurate method of risk assessment for this and further IRA's.
The analysis by technical experts has already exposed significant differences in the quantitative estimates of risk for specific pests and diseases in the importation pathway. In most instances risk estimates published in the RDIRA are consistently LOWER than those assigned by the industry's technical experts.
This means that the unrestricted risk calculated for each of the pests and diseases is, in most cases, HIGHER than reported in the RDIRA. The implication is that more rigorous mitigation measures will be required if Biosecurity Australia is going to meet Australia's ALOP.

In view of these deficiencies it is considered by the Australian Apple and Pear Industry that the Revised Draft Import Risk Analysis document should not be approved in its current form as the reference document for the Importation of Apples from New Zealand.

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17. BIBLIOGRAPHY

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