IMPORT RISK ANALYSIS FOR THE IMPORTATION OF BULK MAIZE (*Zea mays* L.) FROM THE UNITED STATES OF AMERICA

REVISED DRAFT

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AUSTRALIA

Stakeholders may access the revised draft on the AQIS website at
http://www.aqis.gov.au/docs/plpolicy/plhome1.htm.
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The Australian Quarantine and Inspection Service (AQIS) is an agency within the Commonwealth Department of Agriculture, Fisheries and Forestry – Australia.

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Disclaimer

This Import Risk Analysis was prepared on the basis of the best information available at the time of writing on the pest and disease status of the commodity in question. Information relating to the identity of the respondent and the substance of the comments received in response to the earlier draft of this document may be released to other respondents and to third parties unless a request for confidentiality was included in the response. Where a request for confidentiality was not made, a respondent will be taken to have consented to the release of information including the respondent’s identity and the substance of the response for the purposes of the Information Privacy Principle 11 in section 14 of the *Privacy Act 1988*.

1. GLOSSARY OF TERMS AND ABBREVIATIONS

The phytosanitary terms used in this document conform with those officially recognised under the International Plant Protection Convention (IPPC, FAO 1999). The taxonomic terms and naming conventions used follow the International Code on Zoological Nomenclature, the International Code of Botanical Nomenclature and the Bacterial Code.

AFFA	Agriculture, Fisheries and Forestry - Australia
APHIS	Animal and Plant Health Inspection Service (USA)
AQIS	Australian Quarantine and Inspection Service
Area	An officially defined country, part of a country or all or parts of several countries
CSIRO	Commonwealth Scientific and Industrial Research Organisation
Endangered area	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled
Entry potential	Likelihood of the entry of a pest
Establishment	The perpetuation, for the foreseeable future, of a pest within an area after entry
Establishment potential	Likelihood of the establishment of a pest
FAO	Food and Agriculture Organisation
FGIS	Federal Grain Inspection Service (USA)
Introduction	Entry of a pest resulting in its establishment
Introduction potential	Likelihood of the introduction of a pest
IPPC	International Plant Protection Convention, as deposited in 1951 with FAO in Rome and as subsequently amended
IRA	Import Risk Analysis
ISPM	International Standards for Phytosanitary Measures
Official	Established, authorised or performed by a National Plant Protection Organization
Pest free area	An area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained
Pest risk analysis (PRA)	Pest risk assessment and pest risk management.
Pest risk assessment	Determination of whether a pest is a quarantine pest and evaluation of its introduction potential
Pest risk management	The decision-making process of reducing the risk of introduction of a quarantine pest
Pest	Any species, strain or biotype of plant or animal, or any pathogenic agent, injurious to plants or plant products. (Definition subject to formal amendment of the IPPC.)
Phytosanitary measure	Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests
Phytosanitary regulation	Official rule to prevent the introduction and/or spread of quarantine pests, by regulating the production, movement or existence of commodities or other articles, or the normal activity

	of persons, and by establishing schemes for phytosanitary certification
PRA	Pest risk analysis
PRA area	Area in relation to which a pest risk analysis is conducted
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled
RAP	Risk Assessment Panel
SPS Agreement	Agreement on the Application of Sanitary and Phytosanitary Measures
Spread potential	Likelihood of the spread of a pest
Spread	Expansion of the geographical distribution of a pest within an area
TWG	Technical Working Group
USA	United States of America
USDA	United States Department of Agriculture
WTO	World Trade Organization
WRA	Weed Risk Assessment

2. SUMMARY

An Import Risk Analysis (IRA) was conducted in response to an application to import bulk maize grain (*Zea mays* L.) from the United States of America (USA) for processing and use as animal feed in feedlots in Australia. This analysis was in accordance with International Standards, in particular the standard for Pest Risk Analysis (FAO 1996).

A number of pathogens, arthropod pests and weeds likely to be associated with bulk maize from the USA were identified. Of these, 17 pathogens, 14 arthropod pests and 80 weeds were determined to be capable of establishment in Australia via trade in bulk maize and have the potential to cause significant economic damage.

Phytosanitary measures to meet Australia's appropriate level of protection against pests associated with maize from the USA were examined.

It was determined that any treatment, for which it was demonstrated to a high degree of certainty that maize was devitalised and pests destroyed could achieve Australia's appropriate level of protection. At this time, steam heat treatment is a feasible option; however irradiation and infrared heat treatment are examples of other treatments that should be capable of achieving the desired level of phytosanitary protection for Australia. Offshore treatment of bulk maize would be acceptable provided effective measures were taken to prevent post-treatment re-infection, re-infestation or contamination of the shipment.

This document provides the findings of the IRA and includes consideration of comments received from stakeholders on an earlier draft of this document.

3. INTRODUCTION

The Australian Quarantine and Inspection Service (AQIS) received an application in June 1997 for permission to import bulk maize from "low risk areas of the USA" to Australia. The application specified that the imported maize was for direct delivery through conventional transport systems, without further AQIS intervention, to feedlots located inland for processing and use as animal feed.

Australia's current legislation prohibits the importation of maize seed and grain except in the circumstances where AQIS issues import permits that may specify phytosanitary measures to effectively manage quarantine risks (Quarantine Proclamation 1998 made under the Quarantine Act 1908). Imports of maize seed for sowing include the requirement to grow imported seed in quarantine for one generation with release of progeny after disease screening. Bulk maize imports are currently permitted for processing in metropolitan areas at approved premises under quarantine supervision.

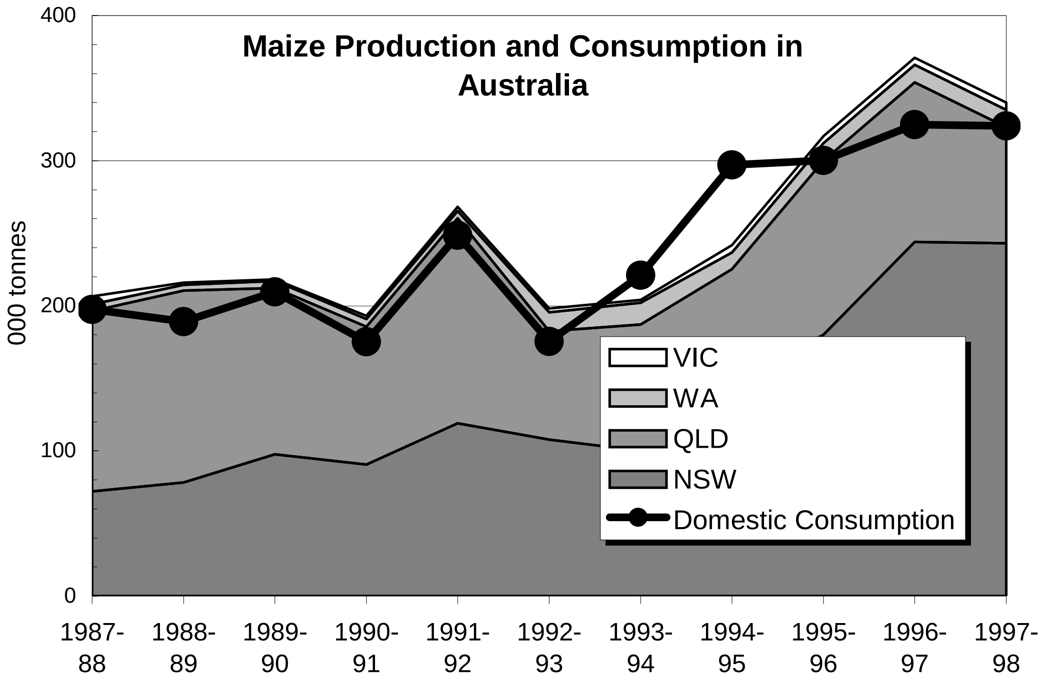
Previous pest risk analyses (Section 11.1) have identified a number of diseases/arthropod pests and weeds of quarantine concern to Australia, and have considered risk management options.

This IRA draws on previous work and new analysis to assess the risks to Australia of the proposal to import bulk maize from the USA. An evaluation of possible risk management measures is provided with recommendations on managing the phytosanitary risks to meet Australia's appropriate level of quarantine protection.

3.1 Australian maize industry

Maize is the second most important crop in the world in terms of total food production. It is the most widely distributed cereal crop in the tropics and is important in the Americas, Africa and Asia. Most of the maize produced in temperate areas is used for livestock feed and industrial products.

Maize production in Australia is concentrated in New South Wales and Queensland, with smaller amounts produced in Western Australia and Victoria. Most of the maize produced in Australia is consumed domestically. In some years, production has not been sufficient to meet consumption demands. Details of production and consumption are shown in the following figure.



Source: Australian Commodity Statistics, 1998. Australian Bureau of Agricultural and Resource Economics, Canberra. 346 pp.

Production has exceeded domestic consumption by an average of 10,000 tonnes per year over the ten years to 1997/98. However, maize is a preferred feed grain for some intensive livestock industries and there has been significant interest in the importation of bulk maize from overseas, particularly in years when local supplies have been restricted by drought.

3.2 Scope of Analysis

The scope of this analysis, as requested by the proponent, is to assess the phytosanitary risks associated with the importation of bulk maize originating from the USA and to examine means to manage all significant phytosanitary risks by measures applied (as necessary) outside Australia. The imported grain would be transported on arrival in Australia to rural areas for processing and use as animal feed with no further controls by AQIS once it leaves the port area. The hazards considered include spillage during transport into rural areas and during storage and handling at feedlots prior to processing.

In the USA, corn is defined as “Grain that consists of 50 percent or more of whole kernels of shelled dent corn and/or shelled flint corn (*Zea mays* L.) and may contain not more than 10.0 percent of other grains under Federal Grain Inspection Service (FGIS) standards, established under the United States Grain Standards Act". This definition establishes a minimum specification but there are a range of specific grades defined by FGIS. For example, the maximum percentage foreign matter that can be present ranges from 2% in US Grade 1 to 7% in US Grade 5. The grade standards also specify the allowable limits of damaged kernels. The foreign material content has clear implications for the presence of other seed-borne pathogens on grain admixture and makes the overall assessment of risk difficult. Damaged grain may also be of quarantine relevance depending on the reason for damage, which can include disease and other pest damage with implications for the phytosanitary risk.

The potential volume of imports is not known, but for the purposes of the IRA it was assumed to be at least tens of thousands of tonnes, in contrast to imports of maize seed for sowing that would normally be less than 100 tonnes per year. In the light of experience gained from importations of maize in 1995, other factors that require consideration include soil, trash, weed seeds and admixtures of other grains (eg. barley, oats, millet, sorghum, soybean, wheat, rice, beans, sunflower, peanut, linseed and chickpea) that could be present in substantial quantities in bulk maize imports.

There are existing arrangements for the importation of bulk grain for processing at the port of entry, or at approved premises in metropolitan areas. Approvals have included:

- steam heat treatment of whole grain at the port of entry to devitalise grain and any associated pests prior to transport to rural feedlots for use as animal feed,
- steam pelleting at approved premises in metropolitan areas for stockfeed manufacture,
- destructive processing for extraction of amylopectin starch for industrial purposes,
- processing for manufacture into products such as corn chips.

Subject to the existence of approved facilities and the ability to meet general quarantine conditions, AQIS will continue to approve applications to import maize for metropolitan processing on a case by case basis.

Although relevant information relating to these arrangements has been considered in this risk analysis the information has not considered in detail in this report as it is outside the scope of the request submitted to AQIS.

A number of non-phytosanitary issues relevant to the importation of maize fall outside the scope of the risk analysis and have not been addressed. Examples include pesticide residues or the potential economic impact of competition for the domestic producers from the importation of bulk maize grain. These issues are not directly relevant to the quarantine decision-making process but may be addressed, if necessary, by other areas of the Department of Agriculture, Fisheries and Forestry -Australia (AFFA).

3.3 IRA Process

For any application to import a new commodity from a new source, AQIS conducts an import risk analysis[1] (IRA) on the phytosanitary risk to Australia posed by a proposed importation in accordance with the International Standards for Phytosanitary Measures (ISPM) - Principles of Plant Quarantine as related to International Trade ISPM No.1 FAO, 1995; Guidelines for Pest Risk Analysis ISPM No.2 FAO, 1996 and other standards developed by the Secretariat of the International Plant Protection Convention (IPPC) of the Food and Agriculture Organization (FAO).

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1 In this document the term import risk analysis includes the process of pest risk analysis as defined in the FAO Glossary of Phytosanitary Terms (FAO, 1999) and the consultation process as described in the AQIS Import Risk Analysis Process Handbook (1998).

The primary purpose of an IRA is to identify quarantine pests (Section 1, FAO 1999) potentially associated with the commodity, to analyse the risk of their introduction and establishment in Australia, and to evaluate candidate management options to mitigate such risks.

After consultation with stakeholders, it was determined that the IRA would follow the non-routine process outlined in *The AQIS Import Risk Analysis Process Handbook* (1998). In a non-routine process, the IRA is undertaken by a Risk Analysis Panel (RAP) that typically includes non-AQIS members.

In accordance with the non-routine process, a draft IRA was circulated to stakeholders on 19 March 1999 for comment within 60 days. This document covered technical issues related to pest risk, risk management options and a preliminary view on which option would achieve Australia's appropriate level of protection. The World Trade Organisation (WTO) was also notified of the release of this document. After considering all technical issues and other comments received, the RAP has released this revised draft in order that those stakeholders who provided comments can confirm that the issues raised have been addressed. The RAP will then finalise its recommendations to the Executive Director of AQIS.

Following consideration of the RAP's recommendations and a determination by the Executive Director of AQIS, AQIS will advise the applicant and other stakeholders and arrange for notification in the AQIS Bulletin and on the AQIS Internet homepage. Any stakeholder of the opinion that the process outlined in the Handbook has not been properly followed, including that the risk analysis failed to consider a significant body of relevant scientific or technical information, may appeal to the Director of Quarantine (Secretary of AFFA) within 30 days of the date on which advice is sent to stakeholders. If there are no appeals the policy will be adopted.

3.4 Risk Analysis Panel

The members of the RAP were:

Dr Bill Roberts (Chair)	Chief Plant Protection Officer AFFA
Dr Bob Ikin	Senior Manager Plant Quarantine Policy Branch, Policy and International Division AQIS
Mr Bill Magee	Senior Manager Plant Quarantine Policy Branch, Policy and International Division AQIS
Mr Mev Connell	Private Consultant (formerly member of the Advisory Committee to the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Division of Entomology; Chief Executive Officer, Grain Elevators Board of Victoria; Director, Australian Wheat Board; Assistant General Manager, Australian Wheat Board)
Professor John Irwin	Professor and CEO, Cooperative Research Centre for Tropical Plant Protection The University of Queensland

3.5 Technical Working Groups

The RAP established four Technical Working Groups (TWGs) to examine issues relevant to the risk analysis. A RAP member chaired each TWG. The TWGs considered specific aspects of the IRA as described below.

1. **Pathogen TWG**: Analysis of quarantine pathogens and nematodes likely to be associated with imports of bulk maize grain and assessment of the key disease risks associated with contamination of bulk maize shipments with seeds of other agricultural plant species such as barley, oat, millet, sorghum, soybean and wheat.
2. **Arthropod TWG**: Analysis of insect and mite pests potentially present in the bulk grain pathway (principally stored maize grain) in North America (Canada, USA and Mexico). This TWG also considered molluscs that might be associated with maize from the USA.
3. **Weeds TWG**: Analysis of quarantine weeds associated with proposed imports of bulk maize grain and consideration of different genotypes within species of common weeds already present in Australia. Herbicide resistant strains of weed species were included as potential quarantine pests.
4. **Operations TWG**: Analysis of operational issues relevant to the importation of bulk maize grain from the USA, including risk management options consistent with Australian Government policy, the SPS Agreement and relevant International Standards, and operational procedures for implementation of management options recommended by the other TWGs.

Each TWG was given terms of reference outlined by the RAP and was asked to submit findings in the form of a technical report. The RAP drew upon these reports and discussions with the TWG in producing this draft IRA.

Details of the membership and terms of reference of TWGs are given in Appendix 3.

The TWG technical reports contain specific details of pests and diseases, both quarantine and non-regulated (non-quarantine), associated with the proposed importation of bulk maize sourced from the USA.

The TWGs were asked to draw upon all available information including international scientific literature and technical abstracts. The United States Department of Agriculture Animal and Plant Health Inspection Service (USDA/APHIS) was asked to comment on a number of issues identified by the TWGs. Although the USDA response was received after the TWG reports were finalised the RAP, in consultation with relevant TWG members, considered the response. The RAP considered that the information provided by USDA was consistent with, and did not substantially alter, the findings of the TWG reports. Information provided by USDA is discussed, where appropriate, in this report. TWG members were also given an opportunity to consider stakeholder comment on the draft IRA. The RAP members who chaired each of the TWGs coordinated this discussion and reported back to the RAP.

3.6 Stakeholder comment on draft IRA

AQIS sent the draft IRA to 393 stakeholders and received 21 sets of written comments (Appendix 1). Nine stakeholders (three State Government departments, five industry groups and one private consultant) supported the position taken in the draft IRA. Eleven stakeholders (all industry groups) did not support the position taken. The USDA provided technical comment and indicated that the proposed conditions for import may be impractical and uneconomic.

Specialist technical reports commissioned by some stakeholders were included in their submissions. Professor Denis McGee and Dr Barry Jacobsen, based in the USA, provided technical comment on the quarantine pathogens identified in the draft IRA. ACIL Consulting provided a detailed analysis of the report from a procedural and economic standpoint. A technical report, prepared for the Meat Research Corporation in 1997, was referred to in comments by a number of stakeholders. After a request by AQIS this report was provided to the RAP on a Commercial in Confidence basis, and relevant issues raised were considered by the RAP and addressed in the IRA.

Three stakeholders who supported the position taken in the draft nevertheless emphasised that the efficacy of any devitalising treatment would need to be clearly demonstrated before imports were permitted.

The view of a number of stakeholders disagreeing with the position taken in the draft IRA was that "the draft IRA did not adequately identify, measure and evaluate the quarantine risks associated with bulk maize imports from the USA". Substantive issues raised included: that the pathogen risks were not correctly assessed; a complete economic analysis of costs and benefits was not undertaken; and the analysis was not sufficiently quantitative.

Stakeholders disagreeing with the draft IRA based their technical concerns largely on an assessment of the magnitude of the risk posed by the quarantine pathogens provided by two USA technical experts they had consulted, Professor Denis McGee and Dr. Barry Jacobson. To further clarify the quarantine pathogens issues raised by these experts, the RAP held a direct discussion with Professor Denis McGee.

There was little comment on the significant weed and possible arthropod risks identified in the draft IRA, except that one stakeholder identified an extra 6 weeds considered to be of quarantine concern. The RAP accepted the quarantine significance of these weeds and they have been dealt with in the appropriate sections of this report.

Some stakeholders commented that the draft IRA was not sufficiently quantitative. Although the RAP agrees that quantitative risk analysis is a desirable aim it considered that it is not technically feasible to undertake a quantitative analysis of the risk of establishment and spread of all relevant pests at the present time: there are gaps in understanding of the biology of these pests, and in many cases there is little quantitative data on the likelihood of key events that would be essential if a pest were to establish.

Nevertheless in response to stakeholder comments the RAP did explore the usefulness of a quantitative approach using weeds as a case study (Appendix 4). Although this analysis supports the original draft conclusion that weed risks are significant and would require management, the RAP considers that given the lack of data caution should be used in relying on this analysis.

Some stakeholders provided specific technical comments about the risks of various pests, and in a number of these cases the RAP has accepted the view of stakeholders and modified appropriate sections of this report. However, this has not altered the overall conclusion of the IRA that treatment is required to manage the risks posed by pests of quarantine concern.

Some stakeholders appear to have misunderstood the scope within which AQIS can make an economic assessment. The SPS Agreement (Article 5.3) makes no allowance for consideration of the benefits of trade, as this is not a phytosanitary issue that can be considered in pest risk analysis. Managed risk is not about balancing costs against benefits. It is about using phytosanitary measures that are consistent with the analysis of risk that indicates a country's appropriate level of protection. However, the potential economic impacts of pests are a legitimate issue for risk analysis and this has been taken into account in the IRA.

Specific RAP responses to all significant issues raised by stakeholders are in Appendix 1. Where relevant, specific stakeholders' comments are discussed throughout the text of this

IRA.

3.7 Publications

An *Issues Paper*, outlining the technical issues considered during the risk analysis, was circulated for comment on 6 July 1998 and a draft version of this IRA was circulated for comment on 19 March 1999. These documents are available on the AQIS Internet homepage at http://www.aqis.gov.au/docs/plpolicy/plhome1.htm.

A public file, containing the draft IRA, non-confidential stakeholder comments and technical documentation, was established. The public file is held at AQIS headquarters in Canberra and is available to stakeholders during business hours for perusal and copying. Contact information for making appointments to gain access to this public file is at page 2 of this document.

The full reports of the TWGs, including data sheets for quarantine pests detailing their biological properties, extent of host range, potential impact and difficulty of detection, are available on the AQIS Public File. The pathogen TWG report includes a world list of maize pathogens, the preliminary assessment of the risk from these pathogens, and other important quarantine pathogens that may be introduced in admixtures. These TWG reports were considered by the RAP in producing the draft IRA and have not been updated to reflect stakeholder comment provided in response to the draft. Therefore there may be minor technical differences between the TWG reports and the subsequent IRA documents.

4. PATHOGEN RISK ANALYSIS

4.1 RISK IDENTIFICATION

The assessment found at least 428 pathogens and nematodes associated with maize. These pests were assessed for their presence in the USA and Australia, their ability to be transported with bulk maize, and their ability to cause significant losses. The assessments for the 373 pests that have been reported in the USA are in Appendix 2, Table 14.1. The full lists are in Appendix 1 and Appendix 2 of the Pathogen TWG Report.

Of the 428 pests identified, 55 were excluded as they have not been recorded in the USA. A further 202 were excluded because they either occur in Australia, or are unlikely to enter Australia in bulk maize, while 106 were not examined in detail due to the lack of detailed information. The RAP considered that the lack of information indicated that these pests were unlikely to be of significance.

A stakeholder was concerned that a decision to grant or refuse import cannot be made until the analysis on all pathogens is complete. Risk analyses have not been done on the 106 pathogens with insufficient data for judgement or quarantine pathogens of other crops potentially present in admixtures. However, the RAP considered that risks associated with these pathogens would be managed by treatments to control the major maize pathogens already considered.

Of the 65 pathogens that occur in the USA and not in Australia and can occur in the pathway, 48 were excluded as they are not reported to cause significant economic losses. Seventeen pathogens were identified that are present in the USA, could potentially occur in the pathway, are not present in Australia, and are capable of causing significant economic damage, and therefore meet the criteria for a quarantine pest.

There are many quarantine pathogens of other crops potentially present in admixtures likely to be in bulk maize. The RAP considered that there is significant risk that these other pathogens could be introduced if untreated bulk maize of USA origin, containing significant admixture of other crops, were moved into agricultural areas of Australia.

Table 4.1 shows the seventeen organisms identified as potential quarantine pests, ranked on their likelihood of entering and causing loss in Australia. Ten of these pests have a greater overall risk. Some have the capacity to cause serious losses on commodities of substantially higher economic value in Australia than maize. For example, *Peronosclerospora sorghi* can attack sorghum while High Plains virus and wheat streak mosaic virus can damage wheat. Some of these high risk pathogens have relatively wide host ranges, extending to sorghum, wheat and naturalised grasses such as Johnson grass. In Australia there are many situations where feedlots and crops of maize, sorghum and wheat are in close proximity to each other. These issues need to be considered when developing possible management options.

Nematodes are included as quarantine pests in table 4.1 at a lower risk rating because they are not seed-borne. Nevertheless, the nematodes can be present in soil and trash associated with bulk maize and one stakeholder has emphasised this point. The stakeholder also noted that the root knot nematode, *Meloidogyne chitwoodi* should be given at least equal ranking to *Heterodera zeae* because of the economic damage caused in the USA and Europe. In consultation with members of the pathogen TWG, the RAP has reassessed this nematode as at least of equivalent concern to the others in table 4.1 and amended the table accordingly.

Phymatotrichopsis omnivora, a minor pathogen of maize but serious on cotton and many other dicotyledons, was regarded as having a lower potential for establishment because it would be soil or trash-borne only. If an incursion did occur, however, and it became established, this pathogen would be extremely difficult to manage. Comments provided by Professor Denis McGee (a cereal pathologist based in the USA) indicated that maize is not grown with cotton in the USA midwest. However, the RAP considered contamination remains a problem because of difficulties with identity preservation through the grain transport and consolidation systems in the USA. Feedlots in Australia are present in cotton growing areas so there is the potential for the disease to establish on cotton if it were to be introduced in imports of bulk maize.

Cercospora zeae-maydis is a serious disease on maize in humid areas. However, it is regarded as less of an overall risk than some other fungal, bacterial and viral pathogens because it is likely to be only trash-borne and to be pathogenic only on maize. Professor McGee confirmed that this is a serious problem in the USA and is getting worse with the increasing adoption of stubble retention systems.

It is useful to compare the 10 highest risk pathogens in Table 4.1 with the work of Phillips (1994). This study lists six of these pathogens as quarantine pathogens but Phillips did not include High Plains virus, *Sclerospora graminicola* and *P. omnivora*. Since this study, High Plains virus has been shown to be seed-borne, which justifies its present inclusion. The scope of the Phillips (1994) study did not cover pathogens that are not seed-borne. *S. graminicola* and *P. omnivora* are trash and soil-borne, and therefore could be present as contaminants in bulk maize.

The Phillips (1994) study included *Ustilago zeae*, *Sporisorium holci-sorghi* and *Claviceps gigantea*. The first two pathogens are present in Australia and the present risk analysis has not found sufficient data to justify their inclusion as quarantine pests on the basis of possible differences in strains between the USA and Australia. However, further work may show that strains in Australia differ from those in the USA, which would change the risk potential classification of *U. zeae* and *S. holci-sorghi*, and justify Phillips' (1994) conclusion. Although *C. gigantea* has not been recorded in the USA it has been recorded in parts of Mexico. Risk management measures would need to ensure that shipments of bulk maize from the USA are not contaminated by maize from Mexico.

Stakeholders commenting on the draft IRA presented technical advice that the prevalence in the USA of some of the diseases in Table 4.1 is very low and that seed transmission is exceedingly unlikely. While accepting that the probability of transmission by maize seed of some of the pathogens identified was very low, risk of transmission by soil, trash and admixture remained a major concern for some pathogens such as *P. sorghi* and *C. zeae-maydis*. Given the potential volume of bulk shipments and the likely level of soil and trash present (Section 3.2), the view of the RAP on the pathogen risks expressed in the draft IRA remains essentially unchanged.

Table 4.1. A qualitative analysis of the relative[2] risk to Australia of 17 quarantine pathogens associated with maize grain from the USA

Pathogen (hosts)	*Disease Introduction Risks*	*Economic Damage Risks*	*Disease Management costs*	**Overall Risk**
Peronosclerospora sorghi (downy mildew of maize, sorghum)	*high*	*high*	*high*	**high**
Maize dwarf mosaic potyvirus (maize)	*high*	*medium*	*medium to high*	**medium to high**
High Plains virus (maize, wheat)	*medium*	*high*	*low to medium*	**medium to high**
Wheat streak mosaic rymovirus (WSMV) (maize, wheat)	*medium*	*high*	*low to medium*	**medium to high**
Sclerospora graminicola (maize, sorghum, pearl millet and many grasses)	*medium*	*high*	*medium*	**medium to high**
Phymatotrichopsis omnivora (Texas root rot of cotton and other dicotyledonous plants)	*medium*	*high*	*medium*	**medium**
Maize chlorotic mottle machlomovirus (maize)	*very high*	*low to medium*	*low*	**medium**
Cercospora zeae-maydis (gray leaf spot of maize)	*high*	*low to medium*	*low to medium*	**medium**
Pantoea stewartii subsp. *stewartii* (Stewart's wilt of sweet corn)	*low to medium*	*medium*	*low to medium*	**medium**
Clavibacter michiganensis subsp. *nebraskensis* (Goss's bacterial wilt of maize)	*medium*	*low*	*low to medium*	**medium**
Heterodera zeae (maize cyst nematode)	*low to medium*	*low*	*low*	**low**
Ustilaginoidea virens (false smut of maize)	*low to medium*	*low*	*low*	**low**
Dolichodorus heterocephalus (Awl nematode)	*low*	*low*	*low*	**low**
Hoplolaimus columbus (lance nematode)	*low*	*low*	*low*	**low**
Longidorus breviannulatus (needle nematode)	*low*	*low*	*low*	**low**
Pratylenchus scribneri (root	*low*	*low*	*low*	**low**

[2] The risk estimates are relative to other pathogens in this table and are based on the collective judgement of the TWG members

lesion nematode)				
Meloidogyne chitwoodi (root knot nematode)	*low*	*low*	*low*	**low**

A summary of the important features of three of the high risk pathogens (*Peronosclerospora sorghi*, High Plains virus and Wheat streak mosaic rymovirus) follows, to illustrate the range of issues that arise in relation to quarantine pests.

4.1.1 Peronosclerospora sorghi

Peronosclerospora sorghi, the cause of sorghum downy mildew, presents one of the greatest quarantine risks to the Australian grains industry from the importation of bulk maize from the USA. The disease was first reported in the USA in Texas in 1961 (Keyes *et al*., 1964). By the early 1970s it had reached the corn belt in the Ohio River Valley in Indiana and Illinios (Frederiksen, 1980).

There is recent evidence that *P. sorghi* consists of more than one species with some strains that occur on maize now recognised as a separate species, *P. zeae*. Further work is needed to determine the distribution of this species (Jeger *et al*., 1998). Until the situation in the USA is better defined, the strains have been considered as one species.

In response to a request for information from the RAP, APHIS cited a paper by Shivas (1989) in which this pathogen was recorded in Australia. This was based on a single doubtful record (Tweedie 1970) that Ramsey and Jones (1988), after examining a herbarium specimen (Herb IMI 147292), considered to be *P. maydis* not *P. sorghi*. In view of this, the RAP determined that it was valid to consider *P. sorghi* absent from Australia in accordance with ISPM No.8 (FAO 1998), Determination of Pest Status in an Area.

The risks of introducing *Peronosclerospora sorghi* into Australia through bulk maize grain imports are summarised as follows:

- *P. sorghi* is in the pathway (maize seed, sorghum admixtures, trash or soil). It is likely to cause serious economic losses if introduced into Australia, particularly in grain sorghum, other *Sorghum* spp., sweet corn, maize, *Panicum* spp. and *Pennisetum* spp. The gross value of sorghum and maize produced in Australia in 1996/97 was $225 million and $75 million, respectively. Information from a USA expert supported the view that the disease was a serious problem in sorghum.
- *P. sorghi* is seed-borne and can also be carried in trash and soil.
- *P. sorghi* is widely distributed in the USA from southern Texas to central Illinios, where it was reported on sweet corn in 1990 (Pataky and Pataky, 1990). It can infect wild sorghums and it would be expected to produce oospores in systemically infected maize (Bigeriwa *et al*., 1998) that could form a pathway for seed transmission. Thus it would be difficult to source from maize-producing areas in the USA that are free of *P. sorghi*. Information from the USA indicated that the prevalence of *Peronosclerospora sorghi* in USA maize was low but the pathogen is prevalent on other grasses that can be amongst the trash in bulk maize.
- Many feedlots in Australia are in agricultural areas where maize and sorghum are grown. If untreated imported grain is transported to such feedlots, *P. sorghi* could be introduced through spillage of grain, soil or trash present in the bulk import. If spillage occurred, oospores of *P. sorghi* could be dispersed by wind. The wide distribution of Johnson grass in northern Australia would provide a perennial source of susceptible host material. A USA expert agreed that oospores in trash or soil associated with a maize consignment was a potential pathway for introducing the pathogen to Australia although he felt the degree of

risk was low.

- The systemic nature of *P. sorghi* could mean that it would remain undetected for a considerable period of time, particularly in an uneconomic and widespread host such as Johnson grass. Thus the pathogen could spread widely before being detected reducing the likelihood of successful eradication. For this reason, a USA expert indicated that USA pathologists would be reluctant to give area freedom assurances.

4.1.2 High Plains virus (HPV)

HPV was first recognised in 1993 in the western plains of the USA in maize. The virus is transmitted between plants by the eriophyid mite *Aceria tosichella*, and can be lethal to maize, wheat, barley and other grasses.

The disease is known to be seed-transmitted, and can be recognised by the presence of a protein that is specific to HPV infection. A USA expert pointed out that the experimental evidence for seed transmission does not clearly demonstrate that seed transmission can occur under field conditions. He did accept that infected volunteer plants arising from spilt grain would present a risk if seed transmission does occur.

HPV has been positively identified in 10 States of the USA, from eastern Nebraska to western Idaho, and from Montana and South Dakota to the Texas panhandle. It has also been identified from sweet corn samples from Florida. Genetic variability exists in maize reactions to HPV but this variability has not yet been characterised (Marcon *et al*. 1997). The USA expert indicated that the disease, while widespread, had little economic consequence in the USA although it was a more serious problem in other countries.

Because HPV is only a relatively recently discovered virus (1993), there is still much to learn about its aetiology, distribution and management. Importantly, diagnostic tools have now been developed which will allow determination of its distribution and further clarification of its economic significance. This pathogen is regarded as a high risk to the Australian grains industry because:

- HPV could be seed-borne and seed-transmitted in maize.
- Yield losses of up to 75% have been reported in some parts of the USA in some seasons.
- The disease also significantly affects wheat and barley and thus must be regarded as a major threat to the $5 billion Australian wheat industry.

Devitalisation of the seed by grinding or other means should be an effective management strategy for this pathogen, since there is no evidence it is capable of being mechanically transmitted.

4.1.3 Wheat streak mosaic rymovirus (WSMV)

WSMV causes a serious disease of wheat, particularly in the Great Plains region of the USA, where overall losses of up to 2% occur (Christian, 1993) and local losses can be 100% (McNeil *et al.*, 1996). WSMV is both seed-borne and seed-transmitted, and is transmitted by the wheat curl mite *Aceria tosichella*. High Plains virus is often found in association with WSMV, not surprisingly since they share a common vector. WSMV has also been found along with maize dwarf mozaic virus in the same maize plant (Hill *et al.*, 1974), and is seed-transmitted in maize.

WSMV has a relatively broad host range, encompassing many plants in the grass family. It infects wheat, barley, oats, maize and millets (*Panicum*, *Setaria* and *Echinochloa* spp.). It is the type member of the rymovirus group, whose members are all mite transmitted.

WSMV was first recorded in 1932 (McKinney, 1937). There is considerable molecular diversity in the virus (McNeil, 1996), and it is thought molecular groups may correlate with host adaptation.

Its entry and establishment in Australia would pose a greater national economic risk to the $5 billion wheat industry than to maize. In maize, it could also be expected to cause substantial losses but with a less significant national impact. Devitalisation of all seed should be an effective management strategy for this virus.

Comments were received from the USA on the low incidence of WSMV in maize and suggesting that risk of seed transmission in WSMV and HPV would be below 0.1%. The RAP accepts these comments and has modified the transmission risk ratings. However, WSMV and HPV have a common mode of transmission and there is evidence that they form a more virulent complex (Marcon *et al.* 1997). Given the uncertainty about the significance of HPV and possible interactions with WSMV, until this issue of the complex aetiology of these diseases is resolved, the RAP considers that both these viruses are of significant quarantine concern.

4.2 DISEASE RISK MANAGEMENT OPTIONS

Evans *et al.* (1996) concluded that any spillage during transport to feedlots in Australia could be readily contained. However, it is evident from previous experience that spillage of grain and associated admixtures, soil and trash, and the discharge of dust into the air during loading, transport, unloading, storage prior to processing of grain, and in the event of processing plant breakdowns, are extremely difficult to control. Such spillage and discharge could provide opportunities for the establishment of pathogens. On the basis of the request of the proponent and the previous experience with grain spillage, control of spillage of untreated grain has not been considered in this risk analysis.

The RAP does not consider that early detection and eradication of pests is a feasible risk management option.

Three recent incursions of quarantine pests show that it is difficult if not impossible to eradicate broad acre field pests once they are established:

- A major campaign in Western Australia failed to eradicate *Colletotrichum gloeosporioides*, the cause of lupin anthracnose.
- Efforts to prevent the spread of *Ascochyta rabiei* within chickpea-growing areas of eastern Australia have failed and a widespread epidemic of blight developed in 1998.
- *Sphacelia sorghi*, causing ergot of sorghum, spread rapidly throughout sorghum growing areas in 1996, making eradication impossible.

Possible options for managing the risk of entry of quarantine pathogens are sourcing grain from pest-free areas or sourcing resistant varieties, removal of soil and trash, devitalising seed by grinding, and pasteurising by heat or other treatments.

From assessment of the published literature, it may be possible to source seed from pest-free areas for each of the pathogens listed in Table 4.1. However, while some areas may be free of individual quarantine pathogens there are no obvious areas free of all quarantine pathogens. For example, humid areas in the southeastern USA have *Cercospora zeae-maydis* and arid regions in the southwestern USA have *Phymatotrichopsis omnivora*. The distribution of *Peronosclerospora sorghi* overlaps with *Phymatotrichopsis omnivora*, but would appear to extend further north to central Illinois. The bacterial pathogens *Pantoea stewartii* and *Clavibacter michiganensis* have a wider distribution, extending into northern USA. It is, therefore, unlikely that maize grain could be sourced from areas free of all of the quarantine pests contained in Table 4.1. Nevertheless, area freedom represents one possible risk management option if it can be adequately demonstrated that growing areas are free of diseases and the integrity of product sourced from such areas can be preserved in the transport chain. Advice provided by USDA, and confirmed by Professor McGee, is that under existing transport and storage systems in the USA, maize cannot be sourced exclusively from a specified area. Special arrangements would need to be developed for identity preservation of grain if an area free of quarantine pests could be identified.

Devitalisation of maize seed by grinding would be an effective strategy to prevent entry and establishment of the four viral diseases as they require living tissue to survive. However, this strategy alone would not be fully effective for management of quarantine bacterial and fungal pathogens associated with maize grain, which would be expected to largely survive mechanical processing.

Setting maximum levels for trash, soil and admixtures may not effectively manage the risk for trash- and soil-borne pathogens, since substantial quantities of these materials are likely to be present in bulk imports. Oospores of *Peronosclerospora sorghi* would be present in contaminated soil at levels of 1–95 propagules per gram and soil may be present, even in Grade 1 maize, at a level of up to 2%. Thus, there is a clear risk that soil or trash could provide a pathway for entry and establishment of pathogens such as *Peronosclerospora sorghi*, *Cercospora zeae-maydis*, *Sclerospora graminicola*, *Phymatotrichopsis omnivora.*

Treatment of grain to devitalise quarantine pests that may be present on maize seed, soil, trash and other seed admixtures, appears to be the only suitable strategy for managing all pathogen risks. From the available data, heat treatment would appear to be the most effective mechanism. Work by AQIS associated with grain imports in 1995 established treatment conditions that met quarantine requirements for a number of specific shipments. These shipments were steam heat treated at 95°C for 10 minutes. The RAP considered that further work would be needed to optimise a heat treatment effective against all quarantine pathogens while maintaining grain quality.

Although the RAP considered that heat treatment could satisfactorily manage the quarantine risks any treatment that provided a high degree of reliability that all quarantine pathogens were killed would be acceptable. Choice of a suitable treatment would need to consider the risks posed by seed admixtures, trash and soil. However, treatments such as heat would manage all quarantine pathogens including those associated with admixtures. Treatment could be done either at the port of entry to Australia, as is currently permitted, or offshore. If treatment is offshore, procedures will be needed to prevent re-infection. Depending on the point of treatment, particular issues that need to be considered include:

- Cleanliness of rail cars used to freight the sourced bulk maize in the USA. Spores of the Karnal bunt fungus (*Tilletia indica*) and other pathogens could be present in freight cars used to transport the bulk maize.
- Cleanliness of handling and loading equipment.
- Cleanliness of ship holds used to transport the bulk maize.

5. ARTHROPOD PEST RISK ANALYSIS

5.1 RISK IDENTIFICATION

The arthropod pest risk analysis covered potential insect, mite and mollusc pests present in the grain after harvest (principally stored maize grain) in North America (Canada, USA, and

Mexico). Insect, mite and mollusc pests of the plant, associated with organs such as stems, leaves and roots, were not considered in the analysis. This was due to the different environments present between field and storage, and the fact that very few pests are capable of surviving in both environments. Those species that do exist in both field and storage environments were included in the analysis. Also included in the analysis are 19 arthropod pests identified by the Pathogen TWG that are present in North America and are known to vector maize diseases.

Due to the nature of trade in grain between Canada, USA, and Mexico, and the fact that common railcars and transport are used between all three countries, arthropod pests of stored maize grain for North America as a whole have been included in the analysis. In addition, the use of common railcars and storage facilities in North America increases the likelihood of admixture of other grain commodities. For this reason, common pests of possible admixture commodities have also been included. The risk analysis process took into account factors such as the biology, host range, distribution, entry potential, establishment potential, spread potential and economic damage potential of pests capable of feeding and breeding on stored grains in North America and Australia. Species and genera considered, their distribution in North America and Australia, and their quarantine status in Australia are listed in Appendix 2, Table 14.2. Table 5.1 shows quarantine pests for Australia with a significant risk of being associated with bulk maize grain from the USA.

5.1.1 Insects

Pest species identified ranged from little known pests of limited worldwide distribution, through to well known and widespread pests such as *Prostephanus truncatus* and some *Trogoderma* species. As well as being pests associated with grain, all have the potential of establishing in natural habitats. Comments have been made in the data sheets (Arthropod pests TWG Report, Appendix 1) as to some possible adverse consequences that introduction of these pests may have to the natural environment. Once established in natural habitats, official control and eradication is likely to be difficult or impossible to accomplish.

Information on the status and distribution of important insect pests of stored grain is relatively reliable both in North America and in Australia, allowing a reasonable comparison to be made between the faunas of Australia and the USA in order to identify the quarantine pests. However, in comparison, knowledge of many mould-feeding and minor genera is limited. Insufficient information is available to ascertain if such species known to occur in North America are present in Australia. Some mould feeders can survive for substantial periods in clean, dry grain but are unlikely to be able to feed or reproduce in it; these species were included in the analysis but none were classified as quarantine pests.

A wide range of incidental insects can also be harvested along with grain. These form a sample of the local fauna and may include many species not found in Australia. The likely species involved are impossible to predict. Most of these incidental insects are unlikely to survive for significant periods in grain in storage, especially if it is clean with minimal admixture. No attempt was made to assess risks associated with parasites or predators that can be associated with pest species.

Measures that effectively control the identified quarantine arthropod pest species in maize grain can be expected to control other arthropod species, such as the mould feeding and incidental pests, contaminating the grain.

Most major economic pests of stored grain with the exception of those identified in Table 5.1, are common to both North America and Australia. While these species may be common, genotypes of a given species may be different in either continent. Strains in one place may be more resistant to pesticides and fumigants than elsewhere.

Importation of such strains could cause problems with using control treatments. Currently, there is no information indicating that strains of major storage insects present in the USA and Canada are significantly more tolerant to pest control treatments than those known to occur in Australia. However, this may be due to lack of data as survey results in the USA and Canada, particularly for phosphine resistance, are rudimentary. In the absence of data and because of the widespread use of phosphine fumigation in the USA it should be assumed that some degree of phosphine resistance is likely to be present, at least in common stored product pests. Dosages will need to be targeted accordingly if phosphine is chosen as a disinfestant.

An additional pest, *Trogoderma granarium* Everts, the khapra beetle, was identified as being of concern to Australia (Table 5.1d). *T. granarium* is not established in North America and is a legislated pest in the USA. However, this species has frequently been recorded in ships used for grain transport.

Table 5.1. Quarantine pests for Australia with a significant risk of being associated with bulk maize grain from the USA

a: Pests that are capable of breeding in stored grain

Cathartus quadricollis (Guérin-Méneville, 1829) [Coleoptera : Silvanidae]

Caulophilus oryzae (Gyllenhal, 1838) [Coleoptera : Curculionidae]

Cryptolestes turcicus (Grouvelle, 1876) [Coleoptera : Laemophloeidae]

Cynaeus angustus (Le Conte, 1852) [Coleoptera : Tenebrionidae]

Pharaxanotha kirschi Reitter, 1875 [Coleoptera : Languriidae]

Prostephanus truncatus (Horn, 1878) [Coleoptera : Bostrichidae]

Tribolium audax Halstead, 1969 [Coleoptera : Tenebrionidae]

Tribolium brevicornis (LeConte, 1859) [Coleoptera : Tenebrionidae]

Tribolium destructor Uyttenboogaart, 1933 [Coleoptera : Tenebrionidae]

Tribolium madens (Charpentier, 1825) [Coleoptera : Tenebrionidae]

Trogoderma glabrum (Herbst, 1783) [Coleoptera : Dermestidae]

Trogoderma inclusum LeConte, 1854 [Coleoptera : Dermestidae]

Trogoderma ornatum (Say, 1825) [Coleoptera : Dermestidae]

Trogoderma variabile Ballion 1878 [Coleoptera : Dermestidae]

b: Pests associated with damp maize grain from the USA

Glischrochilus fasciatus (Olivier, 1790) [Coleoptera : Nitidulidae]

Glischrochilus quadrisignatus (Say, 1835) [Coleoptera : Nitidulidae]

c: Pests associated with infestable pulses

Callosobruchus chinensis (Linnaeus 1758) [Coleoptera : Bruchidae]

Zabrotes subfasciatus (Boheman 1833) [Coleoptera : Bruchidae]

d: Additional pests of quarantine concern for Australia

Trogoderma granarium Everts, 1898 [Coleoptera : Dermestidae]

5.1.2 Mites

Our knowledge of the Australian mite fauna, native and exotic, associated with stored products is incomplete and no recent, in-depth surveys have been undertaken. It is not possible to assert that a given mite, not currently recorded here, is not present in Australia. No mite species listed by the USDA key (Smiley, 1991) and not recorded to date in Australia is known to be significantly destructive to well-stored grain. No assessment can be made as to the potential environmental impact of mites likely to be associated with stored maize, though some are likely to become established outside of grain stores, if not already present. However, well-managed clean, dry grain is unlikely to contain significant numbers of mites.

5.1.3 Molluscs

No specific references were found concerning snails as an agronomic problem associated with trade in maize grain in the USA and Canada. Snails may however be harvested as an incidental contaminant. As such they are likely to form a sample of the local fauna and may include species not found in Australia. Information does not appear to be available as to the ability of such species to survive in stored grain. Experience with the importation of bulk maize grain from the USA in 1995 indicates that the risk of importation of molluscs is low.

5.2 ARTHROPOD RISK MANAGEMENT OPTIONS

5.2.1 Grain quality

Many insect species find it much easier to become established in grain consignments containing admixture and damaged grains. Risk of infestation increases with the decline in grain quality, measured in terms of its physical condition (eg. % broken, immature or mouldy grains), increase in temperature and moisture content, and increase in admixture of trash and other material. Risk of importation of species identified as of quarantine concern to Australia, with the exception of *Caulophilus oryzae* and *Prostephanus truncatus* that attack whole grains, would be reduced if only high grade grain, in good condition with minimal admixture, was imported. Grain moisture content should be less than 14%, independent of grade. A number of species including *C. oryzae* and *Glischrochilus* spp., are adversely affected by low moisture content. Complete removal of admixture of pulses from maize reduces the risk of species from Table 5.1c being imported to negligible levels.

Sieving and grain cleaning will remove most snails and other incidental contaminants. It may however be difficult to remove contaminants that are of similar size and density to maize grains, such as pulses.

Grain quality has a significant effect on the efficacy of fumigation. Lower grades of maize are difficult to fumigate as trash and fines tend to segregate during handling and transport of bulk grain and forms pockets and layers through which fumigants may have difficulty passing. This results in non-uniform distribution of gas and an increased risk of fumigant survivors. These problems are compounded if fumigation is undertaken in-ship (see later discussion on fumigation). Clean grain is much easier to fumigate properly.

5.2.2 Selection of grain from areas free of pests (Area Freedom)

Several species identified as being of quarantine concern to Australia appear to have restricted distributions in the USA. *Caulophilus oryzae*, *Prostephanus truncatus* and *Cathartus quadricollis* appear to be restricted to southern States and the latter two are much more widely distributed in Mexico. If it is possible to guarantee the source of grain, obtaining it from northern States will reduce but not completely eliminate the risk of importation of these species. Other species identified as being of quarantine concern, however, appear to be widely distributed and it will not be possible to identify maize producing regions free of these pests. In general, however, infestation pressure declines the further north the grain growing areas are. If maize were to be sourced using the principle of "Area Freedom", this would require detection, monitoring and delimiting surveys for quarantine pests to be carried out annually, as well as the dedication and monitoring of rail cars. This is not normal practice in the USA.

5.2.3 Prevention of infestation during transportation, storage and handling

A number of species identified as being of quarantine concern, notably *Cryptolestes turcicus*, and the *Tribolium* and *Trogoderma* species, are not host specific and may infest residues present in grain handling systems. These species can infest maize grain when handled through contaminated facilities. Use of well managed handling and transportation systems will reduce this risk. Fumigation of these facilities would provide control of insects but this is a non-residual treatment and will not confer protection of the grain during subsequent handling and transportation.

Ships used for the importation of bulk maize need to be 'fit for purpose'. Vessels can become infested with insects of quarantine concern from previous cargoes and not necessarily only those associated with maize. This could often include species that are not established in North America including the khapra beetle, *Trogoderma granarium*. Prior to loading grain, ships must be clean and free of infestation, at least to the standard expected of vessels that handle Australian grain exports. This includes not only the hold, but all other areas of the vessel including crew quarters, engine room and related areas from which infestation could arise.

5.2.4 Fumigation

There is little or no data available on the effects of fumigants, contact insecticides or other control measures on most of the pests identified as of quarantine concern. Nonetheless, most are unlikely to be more tolerant than *Tribolium castaneum* to methyl bromide (Bond 1989), *Sitophilus oryzae* to phosphine (Anon 1997) or the lesser grain borer, *Rhyzopertha domininca* to heat (Banks and Fields 1995). These are the most tolerant pests that the Australian dosage rates are aimed at. Exceptions are larvae of *Trogoderma* species in diapause, which are tolerant of methyl bromide (Rees and Banks 1998), and species in the family Bruchidae, which can be tolerant of phosphine and many contact insecticides (Anon 1997). The pesticide resistance status is unknown for all these pests from North America and would need to be investigated if fumigation were to be used as a primary risk management measure.

It is also noted that fumigation of bulk grain in ship is an uncertain process. It is difficult to ensure adequate gas distribution in the hold or any other part of a ship, even if the ship is stationary. The problem is further compounded by grain quality (section 4.2.1).

The normal practice used by the USA for grain shipments is for grain to be treated with phosphine at US label rates as an in-ship treatment for the duration of the voyage. The RAP does not consider this methodology to be adequate for phytosanitary purposes due to difficulties in obtaining and assessing appropriate distribution of gas.

5.2.5 Devitalising treatments

Processing of maize prior to shipment can reduce the risk of importing the identified pest species of quarantine concern. The risk of importing species, such as *Caulophilus oryzae* and *Prostephanus truncatus* that infest whole grain, can be much reduced by milling the grain and other processing treatments such as steam pelleting. Other species present may be eliminated by the insecticidal nature of such processing.

Heat can be used for the processing or devitalisation of grain and may be insecticidal. Temperatures above 50°C are insecticidal, and become rapidly more so as temperatures increase above this. All storage pests are killed by a few seconds exposure to either wet or dry heat of 65°C (Field 1992, Banks 1998). Time allowance needs to be made for the heat to penetrate the grain kernel to this temperature.

However, after treatment, some species identified as of quarantine concern could reinfest, notably *Cryptolestes turcicus*, and the *Tribolium* and *Trogoderma* species. Therefore, if this option is adopted, continued phytosanitary security to prevent reinfestation must be assured.

6. WEED RISK ANALYSIS

6.1 RISK IDENTIFICATION

6.1.1 Definition of quarantine weeds

To be classified as a quarantine pest, a weed taxon needs to meet the IPPC definition[3]. Being under “official control” in this context is taken to mean that they are on a published list of Declared or Noxious Plants or Prohibited Plants and are subject to control by or under the legislated instruction of a State or local government body in some part of Australia.

The matter is complicated by the presence of different genotypes within many species of common weeds. The approach taken by the Weed TWG, and supported by the RAP, was to consider those weeds present in both the USA and Australia as non-quarantine pests unless there are particular and identifiable genotypes of the weed in the USA that are not known to be present in Australia and which could be expected to be of economic importance if established here (eg. herbicide resistant strains).

Appendix 2, Table 14.3 lists the weed species recorded in fields of maize, sorghum and soybean in the USA and species recorded as contaminants in maize exported from the USA. Weed species found in sorghum and soybean crops are included, not only because they are likely to share the same fields as part of a rotational cropping system, but also to share post-harvest facilities. There is a high chance of cross contamination among these species with maize. The species are mostly common summer weeds found in the USA. However, winter weeds, and other species, found recorded as contaminants in US maize exports to other countries (Anon 1994), are also listed. Quarantine weed pests are listed in Table 6.1.

6.1.2 Weed risk assessment

AQIS uses a Weed Risk Assessment (WRA) system to assess the weed potential of new plant species for which applications for importation into Australia have been lodged. The system is a question based scoring system. The information required to input into the system includes knowledge of the species’ ability to adapt to Australian climates, noxious and beneficial

[3] A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (Section 1, FAO 1999)

characteristics, and the ability to spread, reproduce and persist. The score is positively correlated to weed potential with species scoring in excess of 5 likely to become weeds in Australia. The system is described on the AQIS website (http://www.aqis.gov.au/docs/plpolicy/weeds1.htm) and details of the assessments may be obtained from AQIS.

Species from Appendix 2, Table 14.3 not recorded in Australia were assessed using the WRA system confirming that they have a high potential to establish, spread and become weeds in Australia, both in agricultural and environmental contexts.

In summary the risk analysis identified 80 weeds of quarantine concern to Australia that have a significant risk of being associated with bulk maize grain from the USA (Table 6.1). A number of these are herbicide resistant variants of species present in Australia. A stakeholder responding to the draft IRA submitted an additional 6 weed species that are quarantine pests. The RAP has confirmed the quarantine status of these weeds and they are included in Table 6.1. Following release of the draft, three species (*Daucus carota, Polygonum convolvulus* and *Senecio vulgaris*) have been reassessed as non-quarantine pests because the weeds are not under official control and are widely distributed in Australia. *Xanthium pensylvanicum* is not described separately as it is part of the *X. strumarium* complex. *Salsola kali* remains as a quarantine pest because although it is present in Australia, taxa described as a distinct species or subspecies of *S. kali* are present in the USA but not recorded in Australia .Data sheets for these pests detailing their biological properties, potential impact, and entry and establishment potential are given in Appendix 1 of the Weed TWG report which is available from the public file.

Appendix 4 provides a numerical analysis of the probability of weed establishment via trade in bulk maize. A numerical analysis was not provided in the draft version of this risk analysis due to concerns of the RAP that there was insufficient data to allow this analysis to be done. However, the RAP has provided this numerical analysis in response to stakeholder comment.

In doing this analysis in the absence of a complete data set a number of assumptions have been made about the probability of various events in the pathways leading to weed establishment. The values of these probabilities are critical to the final outcome of the risk analysis. In simple terms this analysis is only as good as the assumptions used and, given the uncertainties, caution should be used in relying on the results.

This analysis supports the original conclusion that there was a significant risk of weed establishment via bulk imports of untreated maize. Nevertheless, the RAP considers that the strongest support for this conclusion is the abundant evidence for weed spread through movement of agricultural products and the firm data that indicates the potential weed contamination levels that could be present in bulk maize.

Table 6.1. Quarantine pest weed species associated with bulk maize grain imported from the USA.

Weed	QUARANTINE STATUS or WRA score[1]
Abutilon theophrasti (herbicide resistant)	Q
Acanthospermum hispidum	Q
Aeschynomene virginica	17
Amaranthus arenicola	13
Amaranthus chlorostachys	14
Amaranthus hybridus (triazine resistant)	Q
***Amaranthus palmeri* (herbicide resistant)**	11
Amaranthus retroflexus (triazine resistant)	Q
***Amaranthus** rudis* (triazine resistance)	14

Weed	QUARANTINE STATUS or WRA score[1]
Amaranthus tamariscinus	10
Ambrosia artemisiifolia	Q
Ambrosia grayi	Q[2]
Ambrosia trifida	Q
Apocynum cannabinum	13
Asclepias syriaca	Q
Bassia scoparia	Q[3]
Berteroa incana	14
Bidens aurea	Q
Brachiaria platyphylla	15
Brassica japonica	10
Bromus tectorum	Q
Brunnichia ovata	13
Cenchrus incertus	Q
Cenchrus longispinus	Q
Chamaesyce maculata	Q[3]
Chenopodium album (atrazine resistant)	Q
Cirsium arvense	Q
Cocculus carolinus	6
Conringia orientalis	Q
Convolvulus arvensis (herbicide resistant)	Q
Cynanchum laeve	15[3]
Cyperus esculentus	Q
Cyperus rotundus	Q
Datura inoxia	Q
Datura inoxia (resistant to ALS herbicides)	Q
Datura stramonium	Q
Echinochloa crus-galli (herbicide resistant)	Q
Equisetum arvense	Q
Erigeron annuus	Q[2]
Eriochloa villosa	17
Eupatorium capillifolium	19
Helianthus annuus (herbicide resistant)	Q
Ipomoea hederacea var. *integriuscula*	Q
Ipomoea lacunosa	12
Ipomoea purpurea	Q
Ipomoea turbinata	10
Jacquemontia tamnifolia	Q
Lolium multiflorum (herbicide resistant)	Q
Muhlenbergia frondosa	14
Panicum capillare (herbicide resistant)	Q
Panicum dichotomiflorum	16
Panicum fasciculatum var. *reticulatum*	Q
Panicum ramosum	14
Panicum texanum	16
Paspalum boscianum	Q[2]
Physalis heterophylla	Q[2]
Polygonum aviculare	Q
Polygonum bungeanum	Q[2]
Polygonum lapathifolium	Q
Polygonum pensylvanicum	Q
Raphanus raphanistrum	Q
Rubus allegheniensis	19
Rubus fruticosus	Q
Salsola collina	17
***Salsola kali* (*Salsola kali* subsp. *ruthenica*)**	17[3]
Salvia reflexa	Q
Senna obtusifolia	Q

Weed	QUARANTINE STATUS or WRA score[1]
Setaria faberi	Q
Setaria lutescens **(herbicide resistant)**	18
Sicyos angulatus	18
Solanum ptychanthum	13
Sorghum halepense	Q
Sorghum x almum	Q
Striga asiatica	Q
Thlaspi arvense	Q[2]
Verbesina encelioides	Q
Xanthium spinosum	Q
Xanthium strumarium	Q
Xanthium strumarium. (resistant to imidazolinone)	Q

1 Weed Risk Assessments (WRA) were done for species (in boldface) not known to be present in Australia and not yet prohibited. Species with scores in excess of 5 are likely to become weeds in Australia and are rejected by AQIS. The WRA system is described on the AQIS website at http://www.aqis.gov.au/docs/plpolicy/weeds1.htm. The remaining species (Q) are prohibited under Commonwealth legislation, noxious under State legislation or have herbicide resistant variants in the USA.

2 Additional weeds identified by Agriculture Western Australia in their response to the draft IRA.

3 Changed to preferred synonym

6.1.3 Risk assessment of herbicide resistant maize in bulk maize imported from the USA

The use of herbicide resistant maize varieties allows more effective weed control in crops by allowing application of a wider range of post-emergence herbicides without damaging the crop.

A number of maize hybrids with resistance to herbicides such as imidazolinone, sethoxydim and glufosinate ammonium, produced by Pioneer, ICI, and Cargill have been widely commercialised in the USA (Table 6.2). There is a significant risk that maize grain imports from the USA will contain a component of herbicide resistant varieties. Various activities during loading, transportation and processing of imported maize have the potential to unintentionally release genetically modified maize into the environment.

Table 6.2. Genetically modified herbicide resistant maize lines commercialised in the USA

Maize lines resistant to:	Gene modification technique	Status in Australia
Acetyl coenzyme A carboxylase (ACCase) group: sethoxydim, haloxyfop, cycloxydim	mutation, inbred lines developed *in vitro* selection and crossing with other lines to develop hybrid	not yet present
Glufosinate ammonium	gene transformation	not yet present
Imidazolinone groups: imazethapyr, imazapyr, imazaquin, clomazone	point mutation, inbred lines developed *in vitro* selection and crossing with other lines	not yet present

The risk of herbicide resistant maize becoming weedy

Although maize carrying herbicide resistant genes could germinate along the roadside, the chance of survival until the reproductive stage is low. Generally, maize appears as a volunteer in some fields and roadsides, but it has never been shown to become established and reproduce in the wild (Gould 1968). Maize is non-invasive in natural habitats and likely to be controlled by natural herbivores during early stages of growth. Shed pollen of maize can remain viable for 10-30 minutes (Coe *et al.* 1988). If viable pollen of herbicide resistant maize were to be transferred by wind to any receptive maize stigma within the 30 minute period of pollen viability, an escape of genetic material could take place. This potential transfer is very unlikely at a distance beyond 200 m. There is only a small chance that volunteer maize will survive until the flowering stage and transfer genes to other maize varieties.

Even if genes do escape into other maize varieties, the added characteristic of herbicide resistance would still not significantly increase weediness provided that none of the reproductive or growth characteristics were modified. Maize seed has little or no dormancy and loses germinability within 2 years under natural conditions and therefore does not develop a soil seed bank. If accidentally introduced into cropping systems, there is a risk of herbicide resistant volunteer maize persisting, particularly in soybean crops or in crop rotation systems (Young & Hart 1997, Vangessel *et al* 1996).

The risk of gene escape to wild relatives

No *Zea* species are either naturalised or recognised as weeds in Australia. However, there are wild relatives of maize imported from South America (Teosinte: *Euchlena mexicana*) whose distribution may overlap with that of cultivated maize. Teosinte is an ancient wild grass found in Mexico and Guatemala. Teosinte can be found in Queensland and Western Australia. Although teosinte has the ability to establish in the wild, it has no pronounced tendency to weediness (Gould, 1968). Cultivated maize and teosinte are sexually compatible and can produce fertile F1 hybrids. However, introgression between maize and teosinte rarely occurs naturally, probably because of the difference in flowering time. Related *Zea* species are geographically restricted and occur only in Mexico and Guatemala. There is low potential for interspecific gene flow to wild relatives to occur in Australia.

The importation of herbicide resistant maize in bulk feed grain for processing is therefore unlikely to present a significant risk to agricultural systems or the environment because it lacks other weedy characteristics, particularly the ability to naturalise in the wild. The risk of genes for herbicide resistance escaping from maize into agricultural and environmental areas is also low because sexually compatible species in Australia are rare.

6.1.4 Quarantine implications of *Striga asiatica* in the USA

Striga asiatica is the most serious root parasite of maize and other grass crops (including sorghum and sugarcane) in the world. Once established in an area it is extremely difficult (and expensive) to eradicate. Its seed size is very small (0.5x0.2 mm) and would be difficult to detect by normal sampling and analytical methods. The risk of it being imported into Australia with feed maize has been assessed.

The only *Striga* species present in Australia are 3 native species, *S. curviflora*, *S. multiflora* and *S. parviflora* (Hnatiuk 1990). *S. curviflora* and *S. parviflora* are minor weeds in sugar cane in Queensland (Anon 1989). *S. parviflora* has been recorded in maize crops in the Atherton tableland (Henderson 1984). *S. asiatica* was previously reported from the North Kennedy Grazing District of Queensland (Hnatiuk 1990), but is no longer considered to be present in Queensland (Phillips *et al.* 1994, Hucks 1999) since the herbarium record was shown to be a misidentification (Carter *et al*. 1997).

S. asiatica was first recorded in North Carolina in 1956 (Sand 1979), immediately triggering concerted efforts to limit its further spread and to eradicate it from the country; this program has continued over the last 48 years and is only now nearing completion.

The following advice was provided by Dr Robert Eplee, Senior Research Scientist and

Director of the Raleigh Plant Protection Centre, North Carolina, USA (August 1998):

"*Striga* has been under an intensive eradication program over the past years. All but about 10,000 acres of the original 435,000 infested acres has been declared eradicated. On the remaining infested areas, reproduction (seed production) is denied through the use of herbicides. Without seed production, it would only be possible to 'export' *Striga* seeds with the movement of soil. Movement of soil out of a maize field is inconsistent with our machine harvest methods. Our protocol requires that a site meet a set of conditions, accumulated over at least three years, before eradication can be declared. Nearly all of the infested acreage falls into this category."

Although the risk of *S. asiatica* being present as a contaminant species in maize imported from the USA is very low, maize grain should not be sourced from any area infested or previously infested with this weed.

6.2 WEED RISK MANAGEMENT OPTIONS

Weed risk identification and assessment confirmed the previous conclusion of Phillips (1994), Anon (1994) and Roberts *et al.* (1995) that bulk import of feed maize poses a significant risk of accidentally introducing a number of weed species into Australia. To reduce the risk to a manageable level, a number of phytosanitary management methods are reviewed (some of which have been proposed in the previous reviews of Roberts *et al* 1995, and Evans *et al* 1996).

6.2.1 Sourcing US maize from *Striga* free areas

Although it is concluded that the risk of exporting bulk grain contaminated by *S. asiatica* is low, consignments still may require phytosanitary certification declaring that the consignment of maize is bulked from maize grown in *S. asiatica* free areas. Relevant information in support of this declaration could include the source of maize, and a current map of *S. asiatica* infested or controlled areas.

6.2.2 Weed management in the field

A specific weed management program may have some capacity to significantly reduce the weed seed contamination in maize. However, given the large number of different weeds that could be present the RAP does not consider that a program based on weed management in the field would be a practical approach to managing all quarantine weeds risks.

6.2.3 Seed Cleaning

According to previous reviews (Evans *et al.* 1996), maize shipments contained a smaller number of contaminants than other imported grain. One of the reasons was that the size of maize seed is larger than that of most weed species and has a smooth surface. Consequently, appropriate screening and other seed cleaning treatments can exclude many weed seeds. In a technical report provided by a stakeholder, screening was considered to be an effective quarantine treatment.

A number of seed cleaning treatments are available which can exclude weed seed of different size, shape, texture or density to maize. Theoretically, if an intensive cleaning technique is adopted, many, but not all, quarantine weed seeds would be excluded. While these techniques are applicable and economically justified for the quantities of maize seed normally imported for sowing, the technique may be too expensive for low cost feed grain and a risk of introducing a significant number of new quarantine weed species into Australia would remain.

6.2.4 Seed Sampling Intensity

One risk management measure sometimes used in quarantine is to test or inspect the product at a particular sampling intensity on the basis that if no quarantine pests are found the shipment meets quarantine requirements.

Statistical advice was sought on the appropriate representative sample size of bulk maize grain in which a nil tolerance for quarantine weed seeds could be imposed. After mechanical reduction of the composite sample and submitted sample, practical operational constraints restrict the working sample to a maximum of 50 kg. Although this sample size is quite large seed technologists could use appropriate screening techniques to assist in isolating weed contaminants before performing identification of any seeds found. The statistical analysis indicated that even if no weed seeds were found in the 50 kg working sample, up to 70 weed seeds may be present in each tonne of maize grain (Roberts *et al*, 1995). Extrapolating from this, if the bulk grain consignment size were 50,000 tonnes, up to 3,500,000 weed seeds could be present.

It was concluded that an intensive sampling method for bulk grain shipments would be operationally difficult and costly to implement and would not provide sufficient assurance of the absence of quarantine weeds in a shipment. A technical report provided by a stakeholder also stated that phytosanitary certification based on representative seed samples would not be practical.

6.2.5 Devitalisation treatments

Steam heat treatments

Preliminary studies indicated that steam treatment at 95-100°C for 12-15 minutes killed the following species: *Ambrosia trifida*, *Abutilon* spp., *Amaranthus* spp., *Cirsium arvense*, *Setaria italica*, *Sorghum bicolor*, *Glycine max*, *Triticum* sp., *Chenopodium* sp., *Avena sativa*, *Raphanus raphanistrum*, *Hordeum* sp., *Xanthium spinosum*, *Xanthium strumarium*, *Secale cereale*, *Galium* sp., *Polygonum convolvulus*, *Brassica* spp., *Stellaria media*, *Spergula arvensis*, *Galeopsis bifida*, *Thlaspi arvense* and *Rapistrum rugosum* (Imported Grain Taskforce file, 1995) .

Steam heat treatment of imported maize would manage the risk effectively, particularly if the treatment could be conducted at the port of entry or just prior to export, minimising the opportunities for post-treatment re-contamination. To optimise the temperature and time required to be effective for all weed species and admixtures, further work may be necessary. If the steam heat treatment is carried out at the point of export, additional operational requirements should include appropriate hygienic measures during the pre-entry handling process to avoid re-contamination.

Infrared energy management system

Infrared radiation converts to heat in an absorbent material. In contrast to microwave radiation, which is dependent to a large extent on sufficient moisture content in the material to be successful, infrared systems can effectively heat dry material. An infrared heat treatment facility for treatment of linseed has been approved by AQIS. Infrared heat has the potential to devitalise grain in a shorter time frame than steam heat treatment and may be less likely to damage grain but the treatment method needs further testing for efficacy against weed species of quarantine concern.

Fumigation

In 1995, CSIRO scientists, as AQIS consultants, undertook trials on devitalisation of maize using methyl bromide and chloropicrin (Cossells *et al*. 1995). The results indicated that despite the very high dosage of methyl bromide used, all samples of maize maintained some viability after treatments. After five times the dosage and twice the exposure period normally specified by AQIS for disinfestation of consignments, more than 10% of the treated maize germinated. Chloropicrin at 4 times the commercial dosage was also found to be ineffective in devitalising maize, reducing germination by only few percent.

Extrapolating from these results, many weed seeds are likely to survive these fumigation treatments, and there would be practical difficulties in their use and chemical residue problems in the treated maize. Fumigation treatments are unlikely to be effective in killing weed contaminants in maize consignments.

7. OTHER ASSESSMENTS

Environmental Impact

The RAP is satisfied that the importation of bulk maize from the USA under the specified conditions will present negligible risk to the environment and accordingly that the obligations arising from the Administrative Procedures made under the Environment Protection (Impact of Proposals) Act 1974 have been met.

8. COMPARISON WITH AUSTRALIA'S APPROPRIATE LEVEL OF PROTECTION

Australia has an obligation under the SPS Agreement to avoid arbitrary or unjustified distinctions in the levels of phytosanitary protection it considers appropriate in different situations if such distinctions result in discrimination or disguised restrictions on international trade. In broad terms this means that Australia must manage risk in a consistent manner. Therefore a comparison of the assessed risks of a specific proposal against other quarantine measures is an important part of the risk assessment.

The action taken by AQIS to protect Australia against significant cereal diseases is most relevant to consideration of maize. Wheat and other related cereals are generally prohibited entry to Australia, except under strict quarantine conditions including growth under quarantine for seed imports, because of concerns about a number of serious cereal diseases. In addition, AQIS imposes a nil tolerance for cereal contamination during inspection of samples of some other bulk commodities, such as fertiliser shipments. These are inspected and rejected or required to be cleaned or treated if cereal contamination is found. Although there are arrangements that allow the entry of some cereals for processing in metropolitan areas under quarantine control, bulk shipments of cereals are not allowed unrestricted entry and release in Australia.

Importation of maize seed for sowing is subject to a set of strict quarantine conditions that reduce the risks of pest entry to a very low level. AQIS has extensive programs covering airports, ports and mail to intercept illegal entry of plant material and minimise the chances of pest entry via this pathway. The risk of entry of maize pests by accidental contamination of people or objects is considered to be low.

At least 17 pathogens, 14 arthropods and 80 weed species, likely to be associated with bulk maize imports from the USA, are quarantine pests that could become established in Australia and cause significant economic damage. Imported bulk maize maize is likely to be transported to rural areas for processing and use as animal feed. There are significant risks of these pests finding a suitable environment for establishment and spread following spillage during transport, storage and processing, and, in some cases, even after passage of the feed through the gut of animals that have been in feedlots.

On the basis of a comparison of these phytosanitary risks with the action taken by AQIS on other imported commodities and the risks of entry via other pathways the RAP considers that the unrestricted import of bulk maize from the USA would not be consistant with Australia's appropriate level of protection.

9. RISK MANAGEMENT MEASURES

This section discusses the risk management measures that could be used to manage the quarantine risks associated with imports of bulk maize from the USA.

9.1 Area Freedom

Freedom from relevant pests and diseases in the source area is an option if it can be demonstrated that the region in the USA has continuing area freedom and the integrity of the grain can be satisfactorily maintained in transporting the grain from this area to Australia. Maize sourced from areas free of quarantine pests would be acceptable to AQIS, if appropriate phytosanitary measures are taken to prevent contamination during transport. Similarly, a sufficiently low incidence of a pest in areas from which the bulk maize is sourced could reduce the phytosanitary risk to a level acceptable to AQIS.

While not all quarantine pests identified in this analysis are distributed evenly throughout the USA, pest distribution data indicate that no maize-producing State of the USA is free of all quarantine pests. In addition to this, there are considerable practical difficulties in preserving the identity of maize sourced from such areas. Given these difficulties, localised area freedom or low incidence for all quarantine pests has not been addressed in detail in this IRA. A proposal involving localised area freedom may be acceptable to AQIS as a phytosanitary measure if current deficiencies are adequately addressed in the future.

Although outside of the scope of this IRA, the use of stringent controls to prevent spillage of untreated grain in Australia during transport, storage and processing was considered. A previous review (Evans, *et al.* 1996) examining risks associated with the importation of bulk grain considered a number of issues including sourcing from low risk areas and secure transport to feedlots. A number of stakeholders have used this report to support a range of arguments. Nevertheless, recommendations contained within that report are clear:

Rec. 1. That AQIS reassess the likelihood of introducing exotic seed-borne and seed transmitted pests of maize, sorghum and barley taking account of the occurrence of pests of concern in exporting countries, the opportunities for obtaining grain from low risk sources and provisions for preserving the identity of grain in transit;

Rec. 6. That before considering applications for permits to import maize for processing in rural areas, AQIS seeks confirmation of the capacity of US authorities to preserve the identity of maize from low risk sources destined for Australia; and

Rec. 7. That the results of the transport trials be re-assessed on the understanding that any future approval to move imported grain into rural areas will be restricted to consignments originating from sources where risk can be managed offshore.

This report implements the first recommendation for maize and the substance of recommendations 6 and 7 are addressed.

An analysis provided by a stakeholder in response to the draft IRA discussed grain transport arrangements in the USA under which the identity of grain sourced from a specified area could be preserved. The USDA response to the draft IRA, however, clearly stated that domestic grain transport arrangements were not suited for this purpose and Professor Denis McGee endorsed this view.

The RAP considers that area freedom is unlikely to be achievable for imports of bulk maize from the USA. Furthermore, if a low risk source could be found there may be significant difficulties in implementing adequate arrangements to preserve the identity and integrity of bulk grain sourced from a specific area.

9.2 Treatment

The TWGs proposed various treatments. The RAP considered that any treatment, in which it was demonstrated to a high degree of certainty that maize and potential admixtures were devitalised and pests destroyed, could achieve Australia's appropriate level of protection. On the basis of available information the RAP considered that the only likely candidate at this time is steam heat treatment. Irradiation and infrared heat treatment are examples of other treatments that should be capable of achieving the desired level of protection. However, given the lack of reliable efficacy data on these treatments more extensive development work may be required to demonstrate their efficacy compared to the work required for steam heat treatment.

Under WTO rules quarantine requirements must be the least restrictive measures necessary to manage the quarantine risk to an acceptably low level. On this basis, treatment efficacy may not need to be as high for grain that is sourced from lower risk areas, transported under identity preservation arrangements and subjected to detailed analysis to confirm the risk status of the grain compared to the efficacy of treatments applied to grain sourced from any area of the USA and potentially containing the full range of quarantine risks.

Offshore treatment of bulk maize would be acceptable provided effective measures were taken to prevent post-treatment infection, infestation or contamination of the shipment.

The common practice of grain drying has been proposed as a treatment for reducing quarantine risks. Commercial grain drying uses temperature and exposure periods aimed at conditioning the product for subsequent safe storage without damaging the viability of the grain or its processing qualities and characteristics. The viability of at least some of the potential weed seed contaminants in particular is unlikely to be affected by this procedure. Furthermore, given that the dried maize may be stored for some time prior to transport from inland regions of the USA and shipment, the risk of reinfestation and cross contamination would be a significant problem. On the basis of available information the RAP does not consider that conventional grain drying practices are likely to be adequate to manage all significant quarantine risks.

10. ANALYSIS OF OPERATIONAL ISSUES

The analyses of the pathogen, arthropod and weed risks have all indicated that bulk maize would need to be treated to reduce the risk to a level that meets Australia's appropriate level of protection. This section discusses a range of operational issues related to the application of a suitable treatment and maintenance of the integrity of the maize after treatment.

10.1 USA CORN GRADES

Given the earlier conclusion that grain must be rendered sterile and disinfected at the port of export in the USA, the likelihood of achieving this outcome is greater if a higher grade of corn is used, since a cleaner starting product provides greater confidence that the treatment will be effective. On the basis of USA Corn Grades and taking into account Australia's experience with previous shipments of bulk maize from the USA for animal feed, the RAP considers that Australia's grade specification for any future shipments of maize feedgrain should be US No. 2 or better. It is noted however that if the process used to treat the grain can be shown to be equally effective on other grades of corn then lower grades may be an acceptable alternative.

10.2 POST TREATMENT RISK MANAGEMENT OPTIONS

There are a number of operational issues related to maintenance of the integrity of treated maize from the point of treatment to arrival in Australia.

10.2.1 Inspection Agencies

The USA export grain industry is regulated by the Federal Government which provides an infrastructure for Government Certification of documented quality grades. There is an accreditation and qualification system for individuals, agencies and certification companies to maintain certification integrity.

The following inspection agencies are involved in inspection and certification of grain in the USA:

- APHIS, the organisation responsible for the issuance of phytosanitary certificates. Certificates are issued on the basis of FGIS inspections and sampling, and analysis of the samples by the Federal Seed Laboratory.
- FGIS. The role of FGIS and FGIS Agencies is primarily to maintain a recognised system of grading for commercial grain trading.
- State Departments of Agriculture. Many State Departments of Agriculture in the USA have a memorandum of understanding with APHIS. They conduct surveys for diseases in seed crops and specific pests and have a capacity to provide seed laboratory services.

The RAP considers that there is adequate infrastructure in the USA to provide certification on grain shipments. However, specific arrangements would need to be negotiated with appropriate agencies.

10.2.2 Inspection standards

Some members of the Australian Grain Mission 1995 expressed the view that hygiene and operational standards were poor at some USA elevators (Roberts *et al.* 1995 Report of Grain Mission). Unlike Australia, where hygiene standards are enforced by legislation and are a mandatory condition for the export of prescribed grains and prescribed goods, inspection and certification in the USA is based solely on inspection, sampling and analysis of the grain lot. The FGIS sample and inspection procedures as documented in their Grain Inspection Handbook therefore lack the second tier hygiene and treatment controls that underpin Australia's sample and inspection rates. Specific agreements on inspection standards would be needed.

10.2.3 Export Terminals

Grain is mainly transported by truck from farm/farm storage to elevator. Harvest and transport to storage is often performed by contractors who 'follow the season' from south to north. Transport from elevators to sub-terminals to export terminals in the Pacific Northwest and Texas Gulf is by rail. In addition, large quantities of grain are moved by barge down the Missouri/Mississippi River systems.

Export terminals are situated in the Pacific NorthWest, Texas Gulf, Louisiana and California. They tend to operate on a ‘just in time’ principle with consolidated cargo moving from inland elevators just prior to the vessel arrival at the port. The terminals visited by the Grain Mission 1995 were flow through systems with little buffer storage capacity.

The Grain Mission 1995 found that:

- Export Terminals have a capacity to blend grains and screenings similar to inland elevators and sub-terminals. This blending to achieve quality grades is normal practice in the USA grain market.
- Vessel loading is controlled by FGIS who release shipping bins for loading after grade standards have been checked.
- In relation to post treatment security of maize consolidated for export to Australia the following factors require consideration:
    1. Management practices, particularly in usage of common elevators and flow paths, and segregation capacity of export terminals for storage of the treated lot.
    2. Hygiene/pest control practices, especially the potential for inadequate treatments to mask infestations of quarantine pests or encourage insecticide resistant strains of cosmopolitan (non-regulated) pests, and the capacity of these pests to cross infest/infect post treatment.
    3. Reject/treat/reinstate procedures for export grain, and capacity to inspect and if necessary divert grain from shipping bins.

Detailed procedures for storage, handling, hygiene and inspection/rejection of the treated maize and standards for pre loading verification of compliance will need to be supplied to the export terminal and to APHIS. In the absence of data, it is assumed that APHIS and/or FGIS do not have inspection/certification standards or accreditation training for acceptable procedures. An initial pre-clearance visit by an Australian inspector may be required to ensure correct interpretation of the procedures. In addition this visit could ensure that all stakeholders understand issues such as ‘how clean is clean’. Subsequent shipments may be ‘pre-cleared’ on the basis of representative samples submitted for analysis prior to shipment, and a grain flowpath hygiene condition certificate endorsed by APHIS or an approved certifier supplied.

10.2.4 Ship inspection

The Grain Mission 1995 reported that FGIS has responsibility for carrying out stowage examinations on vessels in accordance with the provisions of the USA Grain Standards Act.

Stowage space is examined for:

- residues of previous cargoes
- rust scale and paint scale
- unsanitary conditions such as animal/rodent excreta or decaying matter
- unknown substances
- standing water in the hold
- objectionable foreign odours
- infestations with rodents or insects.

Holds that have been passed by FGIS as fit to load grain are listed on an Official Stowage Examination Certificate issued by FGIS. This certifies that the stowage areas were examined on a given date and found to be substantially clean, dry, free of insect infestation and suitable to carry grain or commodity.

Experience of residues in recent fertiliser vessels from the USA, that are required by AQIS to be free of infestation or contamination by live insects, seeds, soil and other plant or animal debris, suggest that USA certification bodies, particularly private surveyors, either have a different interpretation as to what constitutes ‘substantially clean, dry, free from insect infestation’ or their ship survey procedures are inadequate. Schedule 4 of the Australian Export Control Act, Grain, Plants and Plant Products Orders, made under the Export Control Act (1982) and the Ship Inspection section of the Field Crops Manual provide extensive instruction on the required ship survey standards and procedures used in Australia.

Experience from inspection of bulk carriers arriving in Australia and from the USA Grain Mission in 1995 has clearly shown that the interpretation of ‘substantially clean’ by FGIS is not as rigorously enforced as the Australian standards. This will require further clarification by AQIS to the USA authorities to ensure that ship inspection meets the AQIS export standard. In technical comment provided by a stakeholder, it was recommended that FGIS apply the USA Food Grade Standard for inspection of stowage space as this may minimise the inconsistencies between Australian and USA inspection requirements.

A protocol for offshore treatment of maize needs to include ship survey standards and procedures equivalent to the Australian standard. A pre-clearance visit by an Australian inspector would be required to ensure that the certification body understands the interpretation and application of these standards.

11. CONDITIONS FOR IMPORT

Given the disease, arthropod and weed quarantine risk identified, and the practical problems associated with control measures, bulk maize permitted to be imported from the USA to meet the proponent’s request must be subject to the conditions set out below.

The conditions are based on treatment in the USA and reflect the need for an integrated approach given the wide range of pests involved. However, it should be noted that these conditions represent the full range of measures that could be available. Specific conditions for individual shipments may vary depending on the configuration of sourcing, place of treatment and transport systems used.

1. *Sourcing*

   To minimise the chance of post-treatment contamination, infection or infestation, the commodity should be sourced from the northern USA States in the maize growing areas, where the incidence of several of the more significant maize diseases is lower than in the southern States and from where Karnal bunt has not been detected in surveys of wheat crops. The northern States also have the advantage of a lower incidence of arthropod pests of concern compared to the southern States, and the weed, *Striga asiatica*, is not present. Note: This requirement may be varied depending on the demonstrated treatment efficacy and the ability to maintain the integrity of the grain after treatment.

2. *Grade*

   The permitted maize grade standard should be US No. 2 Grade or better.

   Note: Given the earlier conclusion that grain would need to be rendered sterile and disinfected at the port of export in the USA, the likelihood of achieving this outcome is greater if a higher grade of corn is used, since a cleaner starting product provides more latitude in the application of the treatment. It is noted however that if the process used to treat the grain can be shown to be equally effective on other grades of corn then lower grades may be an acceptable alternative.

3. *Transportation*

   The selected maize should be transported, for subsequent shipment, to a port on the Pacific Northwest in a manner that preserves its identity.

   Note: The USDA stated that grain transport arrangements in the USA are not suited to identity preservation. The RAP therefore considers that certification of source and transport arrangements may be adequate for grain being handled before treatment but would not be sufficient for dealing with grain that was being sourced from specific areas on the basis of area freedom or low prevalence as an alternative to treatment.

4. *Treatment*

   The maize should be treated in a facility at the export port to provide a high degree of confidence that all seeds present (ie maize, other crop seed admixture and weed seeds) are rendered non-viable and all plant pathogens and arthropod pests present in the grain are killed.

5. *Post-Treatment Conditioning*

   The treated maize should be conditioned immediately after treatment in a well cleaned plant to ensure that it is cooled to near ambient temperature and that its inherent moisture content is not more than 14% (wet basis).

   Note: The requirement to condition grain to a moisture content of not more than 14% is primarily to maintain quality but does fall within sanitary and phytosanitary regulatory considerations, as it is essential to minimise heating of the grain to prevent the development of mycotoxin producing fungi in the maize, and to reduce the risk of re-infestation or re-infection.

6. *Verification of treatment process*

   Samples of the treated maize should be collected by either FGIS authorised/licensed personnel or APHIS personnel and forwarded by secure express air freight to AQIS for analysis to determine the efficacy of treatment. AQIS should also require documentary evidence of the treatment process such as records showing exposure period/temperature details for audit purposes.

   Note: The tests for treatment efficacy could be carried out in the USA under FGIS or APHIS supervision subject to agreement with AQIS on conditions for carrying out and reporting these tests.

7. *Storage prior to shipment*

   The treated and conditioned maize stocks should be stored in a well cleaned, segregated facility to prevent any contact with untreated grain stocks or confusion as to the special status of the treated maize.

8. *Loading path to export vessel*

   The grain loading path from the storage location to the ship must be thoroughly clean and free from residues from previous grain handling operations.

9. *Phytosanitary certification*

   AQIS would require a phytosanitary certificate issued by APHIS including the treatment details for the maize and certifying that no object of quarantine was detected in representative samples inspected during loading of the vessel. Alternatively, vessels may be precleared by AQIS staff.

10. *Ship hygiene*

The ship to be loaded would require preinspection and certification by FGIS grain inspection staff that stowage space is free from previous cargo residues and live insects, in accordance with AQIS standards for inspection of export grain vessels.

Note: Standard stowage examination procedures are used by FGIS to certify all stowage space examined and result in the issuance of a certificate stating that: "Stowage space examined on the above date and found to be substantially clean, dry, free of insect infestation, and suitable to store or carry grain."

11. *On-arrival inspection*

On arrival of the ship in Australia, the treated maize cargo would be inspected by AQIS prior to and during discharge of the cargo, to verify that the condition of the cargo is consistent with the analysis conducted on preshipment samples and that the treated maize has not been infested or in any other way contaminated in post-treatment storage or from the ship. Following successful AQIS inspection and any other testing or analysis deemed necessary, the cargo would be released from quarantine for unrestricted movement.

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13. APPENDIX 1 Analysis of Stakeholder Comment on Draft IRA

Table 13.1 Issues raised by stakeholders

Issues were raised by 22 stakeholders. The following table addresses these issues, many of which were raised by more than one stakeholder. Numbers in brackets refer to stakeholders named in Table 12.3

Stakeholder Concerns and Issues	RAP response
A number of stakeholders, commenting that USA maize is or may be imported by Japan, India and Chile, considered that the conditions under which this trade is allowed should be taken into account (10, 12, 16a, 17, 18, 19).	The RAP does not know the conditions under which USA maize may be exported to these countries and is not aware of any published pest risk analysis in relation to such trade. Decisions made by other countries on maize imports from the USA would be based on risk profiles, pest status and the appropriate level of protection specific to those countries and therefore are not relevant for Australia.
Economic benefits were not evaluated and weighted against costs to be incurred from an incursion of a quarantine pest (10, 11, 12, 16, 16a, 17, 18, 19, 20). The RAP used a 'nil risk' approach (10, 14, 15, 16a). Economic and social issues were not addressed in accordance with the 1996 Review of Australian Quarantine (11, 16).	Consistent with WTO rules, individual quarantine access decisions cannot take into account the economic benefits which might be derived from trade, or "social issues". However, the potential impacts of pests are a legitimate issue for risk analysis and are the subject of this IRA. Pest Risk Analysis procedures recommended by the International Plant Protection Convention (IPPC) have been followed (see Annex 2 Part 2 of the AQIS Import Risk Analysis Process Handbook). These procedures set out the criteria for assessing economic importance based on establishment potential, spread potential and potential economic importance of a pest.
Information contained in an international database on maize pathogens was not utilised (10).	The pathogen TWG undertook an exhaustive examination of the literature on maize pathogens, which would include the database alluded to. This resulted in the production of an annotated list of maize pathogens more comprehensive than any previously produced. Judgements were made on the basis on all available evidence.
At least some of the 17 quarantine pathogens identified by the RAP had low prevalence in the USA and/or negligible chance of seed transmission (10, 12, 13, 14, 17, 18, 19, 20).	In general the RAP accepts this view and specific comments on pathogens are addressed in Table 13.2. Considered individually, low prevalence or seed transmission of a disease may be sufficient to reduce the risk associated with a specific pathogen to an acceptable level. However there are at least 10 high risk quarantine pathogens of serious economic concern and on the available data no area of the USA is known to be free of all of these pathogens. Furthermore, seed transmission is not the only route; the RAP regarded admixtures and soil and trash contamination to be a significant pathway for the introduction of several of the pathogens.
As risk analysis has not been done on 106 pathogens of potential quarantine concern, the IRA is not complete and a decision to grant or refuse import cannot be made until the analysis on these pathogens is complete (2)	Risk analyses have not been done on the 106 pathogens with insufficient data for judgement or quarantine pathogens of other crops potentially present in admixtures. However, the RAP considered that risks associated with these pathogens would be managed by treatments to control the major maize pathogens already considered.

Stakeholder Concerns and Issues	RAP response
The presence of soil means that soil borne pests, such as nematodes should be assessed. *Hoplolaimus galeatus* and *Melodogyne chitwood*i should have equivalent or greater ranking to those nematodes identified as quarantine pests (1)	The RAP accepts this view, although there is some uncertainty that non-cyst forming nematodes would survive transport to Australia. The nematodes referred to in table 4.1 should be regarded as examples of low but real risks that would be managed by the disinfecting treatment protocol recommended in the IRA.
Six additional weeds associated with maize in the USA were identified as quarantine pests (1)	These have been noted and included in the IRA. The proposed phytosanitary measures should manage these additional weeds.
A number of arthropod pests potentially associated with bulk maize from the USA but not identified in the IRA are declared in Western Australia (1)	These insects would be managed by the disinfestation treatment protocol recommended in the IRA.
The introduction of crops genetically modified for herbicide resistance present a greater likelihood of transferring resistance into weeds present in Australia than as herbicide resistant biotypes of these weeds present as contaminants of bulk maize imports (16a)	The risks associated with the introduction of transgenic crops are subject to close scrutiny for various reasons including those raised by the stakeholder. The RAP is not aware of the release of propagable material in Australia containing genes, introduced by modern techniques, for herbicide resistance. Of the 80 weeds of quarantine concern identified in the IRA, 14 are weeds present in Australia for which resistance to herbicides has developed in the USA. While individually, a case may be made for the development of resistance in some of these weeds by processes other than the introduction of genetic material from outside Australia, collectively this presents a significant and increased phytosanitary risk to Australia.
Draft IRA contradicts findings of earlier BRS reports (10, 16a)	Although earlier reports suggested that USA maize may lower qurantine risk to Australia relative to other cereals, a detailed reassessment of the risks was recommended. This IRA provides that detailed assessment. Much of the findings related to security of transport within Australia as a component of risk management. The proponent specified that all risk be managed offshore; transport of maize after arrival was assumed to be unmanaged.
No quantitative measurement of risk management options other than heat treatment (availability of more cost effective treatments) (12, 15, 16a, 17, 18, 19, 20). Additional data is needed on the efficacy of grain treatment and testing (2, 4, 5).	From the draft IRA: “The RAP considered that any treatment, in which it was demonstrated to a high degree of certainty that maize was devitalised and pathogens and pests destroyed, could achieve Australia’s appropriate level of protection.” Steam heat treatment was identified as a method, available with current technology, to achieve this. AQIS would nevertheless consider any other technology shown to provide equivalent protection. AQIS will require technical data to demonstrate that an appropriate level of protection is achieved under specified conditions. This includes the need, in the case of heat treatment, to properly quantify the time (exposure period) and temperature required.
Decision is open to WTO challenge or USA retaliation (12, 13, 16a, 17, 18, 19).	The RAP considers the decision is technically sound and conforms to the requirements of the SPS agreement and standards established under the IPPC.
The IRA should take account of security of feedgrain supply (4)	This is not a phytosanitary issue

Stakeholder Concerns and Issues	RAP response
The term risk is not used consistently; The IRA identifies hazards but does not measure risk ; The draft IRA is not sufficiently quantitative; Equal emphasis is given to all pests (11, 16, 16a, 20)	AQIS uses the term 'risk' to mean the combination of likelihood and consequences of an event. This is consistent with the normal usage of the term under the International Plant Protection Convention. Risk can be evaluated qualitatively, semi-quantitatively or quantitatively. The International Plant Protection Convention and associated standards recognise the validity of both quantitative and qualitative risk analysis, as does the 1996 Review of Australian Quarantine. Quantitative risk assessment can be used to measure the level of risk, based on the probability of a pest establishment in combination with the cost of such an establishment. Such analysis depends upon the availability of reliable data. Nevertheless, the number of quarantine pests identified and the likely volume of trade clearly result in a high overall risk with little scope for management other than by treat6ment to kill any quarantine pests present. AQIS has intercepted weed contaminants in bulk grain shipments. An additional quantitative analysis, extrapolating to some degree from this experience, is included (Appendix 4) for illustrative purposes. The analysis indicated that with imports of bulk maize from the USA, using reasonable estimates of the possible level of contamination and effectiveness of management options, new weeds are likely to establish in Australia if an effective treatment is not applied.
Stakeholders did not have sufficient opportunity for comment during preparation of draft IRA (11, 16)	Stakeholder input was welcome at all times, and stakeholders have had opportunities to formally comment on the issues paper and the draft IRA. Stakeholders were notified initially in August 1997 and the RAP considers there have been adequate opportunities for comment. During the preparation of the IRA the RAP has consulted with and received comment from a number of stakeholders and experts.
Lack of economic expertise and overseas experience within TWGs (16a)	The purpose of the IRA is to assess phytosanitary risk and risk management options and the skills contained within the TWGs were well suited to this task. The RAP sought comment from USDA on a range of technical issues raised by the TWGs and has received technical comment from USDA/ APHIS.
Undue emphasis was placed on pests of lesser concern, such as Karnel bunt and Striga (16a)	The RAP holds the view that the importance of these pests warrants consideration but the level of risk with bulk maize shipments was not overstated. For example, it was concluded that the Striga issue could be managed by not sourcing maize from the region in the USA in which it is known to be present. Management of the karnal bunt issue would require, *inter alia*, selection of maize from production regions in which this disease has not been found in wheat crops with careful attention to the hygiene of transport employed.
Soil contamination risks are exaggerated (16a) Soil contamination is a serious concern; the list of nematodes of quarantine concern could be expanded because of this (1).	Soil, trash and other plant seeds are extremely likely to be present in bulk maize from the USA, having regard to experience with imported grain in the past, direct observation of the USA grain system, and the USDA grains standards.

Stakeholder Concerns and Issues	RAP response
Existing systems in the USA make it impractical and uneconomic to identity preserve bulk maize from specific areas (21) High reliance is placed on USA cooperation for offshore risk management that will require close scrutiny by AQIS (8)	The RAP was unable to identify regions entirely free of all quarantine pests identified. Demonstrated area freedom remains a possible management option, however the USDA response to the draft IRA clearly indicated that the current grain transport and loading systems in the USA are not suited to ensuring identity preservation of bulk maize consignments.
Corn Sourcing Evaluation Report (16b)	
Commented on 10 pathogens	Addressed in table 13.2
Commented on arthropod pests	Stored product pests are not included in this list of surveyed pests.
Weed seed issues best addressed using screening equipment to remove contaminants	The weed TWG determined that screening would not be sufficiently effective particularly as some of the weeds seeds are similar to maize in size, and for seeds of any size, screening is not highly efficient
Of 13 weeds quarantine of concern listed by AQIS in earlier correspondence, APHIS indicated that 4 were present in Australia but at least 4 were a problem in US grains	These weed species, in addition to many others associated with maize were considered by the Weed TWG
Applying the highest grade specification would provide additional assurance that the corn is free of weed seeds	The Operations TWG dealt at length with the issue of grade. High US grade specifications do not eliminate the risk
Overall view is that USA suppliers are reluctant to supply identity preserved low cost high volume grain	This view is confirmed by the USDA response to the draft IRA. In their response, ALFA accepts that the principle of area freedom may not be a viable option (this concern is compounded by the possibility of grain originating from a third, unidentified country).
Grain drying is a common practice. A determination should be made on the efficacy of the practice as a quarantine treatment	Commercial grain drying uses temperature and exposure periods aimed at conditioning the product for subsequent safe storage without damaging the viability of the grain or its end use processing quite and characteristics. Weed contaminants in particular are unlikely to be affected by this procedure. Furthermore, given that the dried maize may be stored for some time prior to transport from inland regions and shipment, the likelihood of infestation and cross contamination could be a significant problem.
Inspection should be conducted by FGIS at Food Grade Standard	This is the only USA standard applied by FGIS that applies a nil tolerance to rust scale and injurious insect pests. The RAP agrees that this would most closely correspond to Australian standards and should be the minimum standard applied for the inspection of ship stowage space.
On board fumigation is an option for consignments failing inspection	This was dealt with by the arthropod TWG. Ship fumigation cannot be carried out to a reasonable quarantine standard without exacting and inconvenient procedures and then only on certain types of ships.

Table 13.2 Technical Comments on Pathogens

Specialist technical comment on pathogens identified as quarantine concerns in the draft IRA was commissioned by stakeholders. Additional technical comment provided by stakeholders is also noted here.

Pathogen	Specialist comment	RAP Comment
Peronosclerospora sorghi	• Transmission will only occur in seed with moisture content greater than 20%[6]. • Rarely found in USA maize crops with exception of central Illinois. Infected plants are barren[6, 8]. • Oospores are potentially wind-borne but dispersal depends on significant numbers of oospores from a spillage wind dispersed to a suitable site, incorporating into soil and infecting emerging host seedlings[6.] • Oospores in trash or soil is a legitimate, albeit low risk, pathway[7] • A serious disease of sorghum that could be present in sorghum admixtures in maize consignments[7] • Should the pathogen infect a plant, it could remain undetected until widespread; USA pathologists would be reluctant to provide area freedom assurances[7] • Legitimate quarantine issue[8] • Seed transmission in immature or freshly harvested seed only[8] • Survives in soil[8]	• Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen (refer page 4 of pathogen TWG report). • Distribution of viable oospores is a risk. Wind dispersal of viable oospores from soil or trash is a particular concern; note detailed comments in 3.1.1 of IRA.
Maize dwarf mosaic potyvirus	• A strain of sugarcane mosaic virus, already present in Australia[6] • Extremely low rate of seed transmission[6] • Seed transmission not recorded[8] • Volunteer infected plants arising from spillage could be a risk[7] • Widespread but of little economic consequence in USA although it causes severe damage in other countries such as Africa[7]	• Strains A, D, E & F are not recorded in Australia • The virus is seed transmitted[1]
High Plains virus	• Not recorded in maize east of the Missouri[6] • No published evidence or unequivocal proof that it is transmitted from seed to seedlings[7, 8] • Present in Australia? [9]	• With diagnostic tests only recently developed, the distribution is unclear. There are no confirmed records of this virus in Australia. • It is seed transmitted, according to at least one report[2] • The vector is in Australia.
Wheat streak mosaic rymovirus (WSMV)	• Rarely found as a maize pathogen in USA[6] • Seed transmission rate is < 0.1%[6] • Seed transmission not recorded[8] • Corn is bridging crop for this virus[9] • Sweet corn is more susceptible than maize[9]	• There is convincing evidnece that it is seed transmitted[3] and the vector is in Australia. • WSMV and HPV have a common mode of transmission and there is evidence that they form a more virulent complex[10]

Pathogen	Specialist comment	RAP Comment
Sclerospora graminicola	• Reported just once in the USA on two plants in 1928[6, 8] • Not shown to be seed-borne on maize[6]	• Agree that prevalence is low • Nevertheless, the pathogen is prevalent in other poaceae such as *Pennistem* and *Sorghum* that could be present as admixtures
Phymatotrichopsis omnivora	• Maize not shown to be a natural host[6] • Maize and cotton growing areas distinct - midwest sourced maize has no association with cotton[7] • Common root pathogen of may plants[8] • Soil borne[8] • No seed transmission[8]	• Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen. Sclerotia are long lived in soil. • Contamination remains a problem because of difficulties with identity preservation. • Feedlots in Australia are present in cotton growing areas
Maize chlorotic mottle machlomovirus	• Little economic impact[6] • Seed transmitted at very low rate[6] • Seed transmission not recorded[8]	• Agree the risk is lower for this pathogen. • The virus is seed transmitted[4]
Cercospora zeae-maydis	• No evidence for seed transmission[6, 8] • A serious and growing concern in the USA with quarantines on corn in place. This did constitute a real risk[7]	• Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen.
Pantoea stewartii subsp. *stewartii*	• Occurs at low levels in inbred maize lines of seed production fields; rarely found in corn grain fields[6] • Seed infected sufficiently to transmit pathogen could only arise from severely infected fields[6] • Seed transmission not demonstrated under field conditions[8] • Seed transmission under lab conditions only for sweet corn[8] • Flea beetle vector required to spread this pathogen[7] • Dent corns highly resistant[8]	• Agree that maize resistance reduces risk; this is reflected in the lower ranking. • The pathogen can survive in trash and soil. • At least one known vector, *Delia platura*, is present in Australia.
Clavibacter michiganensis subsp. *nebraskensis*	• Rarely found in maize fields in USA[6] • Seed transmission only likely in highly infected (inoculated) seeds[6] • No evidence of seed transmission[8] • Detected at low rates in seed of susceptible germplasm[8] • Maize hybrids are highly resistant, accounting for the limited spread[6, 8]	• Agree that maize resistance reduces risk; this is reflected in the lower ranking. • The pathogen can survive in plant debris.
Heterodera zeae	• Soil inhabitant only[8]	• Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen.
Ustilaginoidea virens	• Obscure disease, one unsubstantiated record in USA in 1929[6, 8] • No evidence that it is seed-borne or transmitted in maize[6, 8] • World wide on rice[8]	• Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen. • The pathogen is also seed borne[5] • The pathogen is present on other poaceae such as *Oryza. Digitaria* and *Panicum* that could be present as admixtures
Dolichodorus heterocephalus	• Soil inhabitant only[8]	• Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen.

Pathogen	Specialist comment	RAP Comment
Hoplolaimus columbus	• Soil inhabitant only[8]	• Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen.
Longidorus breviannulatus	• Soil inhabitant only[8]	• Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen.
Pratylenchus scribneri	• Soil inhabitant only[8]	• Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen.
General comments	• The grain handling system in the USA is such that shipments would consist of a "cocktail of corn" with no control over origin[7] • Throughput pressures do not allow for delays during transport for pathogen testing[7] • Saprophytic fungi only recorded on stalks and decaying seed therefore unlikely to be associated with sound seed shipments[8]	• Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of pathogens that may not have a high risk of being seed borne or seed transmitted.

1. Mikel M. A., D'arcy C. J., Rhodes A. M. and Ford R. E. (1984). Seed transmission of maize dwarf mosaic virus in sweet corn. *Phytpathologische Zeitschrift* **110**: 185-191.
2. Forster R. P., Strausleaugh C. A., Jensen S. G., Harvey T. and Seifers D. L. (1996). Investigation of seed transmission of the High Plains disease in sweet corn. International Seed Testing Association Pant Disease Committee Symposium. Cambridge, England.
3. Hill J. H., Martinson C. A. and Russell W. A. (1974). Seed transmission of maize dwarf mozaic and wheat streak mozaic virus in maize and response of inbred lines. *Crop Science* **14**: 232-5.
4. Jenson S. G., Wysong D. S., Ball E. M. and Higley P. M. (1991). Seed transmission of maize chlorotic virus. *Plant Disease* **75**: 497-8.
5. Richardson M. J. (1990). An annotated list of seed-borne diseases. The International Seed Testing Association. Zurich. 335 pp.
6. McGee D. – written technical comment included in the submissions of several stakeholders (Table 13.3)
7. McGee D. – telephone discussion with RAP, October 1999.
8. Jacobsen B. - written technical comment included in the submission of a stakeholder (Table 13.3)
9. Other technical comment provided by stakeholders
10. Marcon A., Kaeppler S.M. and Jensen S.G. 1997. Genetic variability among maize inbred lines for resistance to the High Plains virus - wheat streak mosaic virus complex. Plant Disease **81**: 195–198.

Table 13.3 Stakeholders responding to draft IRA

Stakeholder	Comments
1. Agriculture WA	
2. AWB Limited	
3. Grains Council	
4. National Agricultural Commodities Marketing Association (NACMA)	
5. Natural Resources and Environment	
6. Pacific Seeds	
7. Primary Industries and Resources SA	
8. Queensland Department of Primary Industries	
9. Weed Science Consultancy	
10. ALFA	Includes Technical Reviews by - Professor Denis C. McGee, Iowa State University and - Barry Jacobsen
11. Australian Chicken Meat Federation	
12. Australian Grain Exporters Association	Includes Technical Review by Professor Denis C. McGee, Iowa State University
13. Australian Meat Council	
14. Australian Meat Holdings	
15. Cargill	
16. Meat and Livestock Australia 16a. ACIL Consulting 16b. Corn Sourcing Evaluation Report	 Separately supplied ACIL Consulting submission was on behalf of MLA Corn Sourcing Evaluation Report supplied in confidence, following request from the RAP.
17. National Meat Association of Australia	Includes Technical Review by Professor Denis C. McGee, Iowa State University
18. Rangers Valley	
19. Red Meat Advisory Council Limited	Includes Technical Review by Professor Denis C. McGee, Iowa State University
20. Stock Feed Manufacturers' Association	
21. USDA	
22. South Pacific Trade Commission	

14. APPENDIX 2: Quarantine status of pests, pathogens and weeds associated with bulk grain imports from the USA

Table 14.1. Quarantine status of pathogens associated with bulk grain imports from the USA

Pathogen	Disease	Present in USA	Present in Australia	Australian Quarantine Status	Present in Pathway	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
BACTERIA								
Acidovorax avenae subsp. ***avenae*** (Manns) Willems *et al*. 1992	Bacterial leaf blight	Yes	Yes	races?	Yes	Yes		?
Bacillus subtilis (Ehrenberg) Cohn	Kernel rot; blight	Yes	Yes	Non-quarantine				
Burkholderia andropogonis (Smith) Gillis *et al*. 1995	Bacterial stripe	Yes	Yes	Non-quarantine				
Clavibacter michiganensis subsp. ***nebraskensis*** (Vidaver & Mandel) Davis *et al*. 1984	Goss's bacterial wilt and blight	Yes	No	Quarantine	yes	yes	Medium	yes
Erwinia carotovora subsp. ***carotovora*** (Jones) Bergey *et al*.1923	Bacterial stalk and top rot	Yes	Yes	Non-quarantine				
Erwinia chrysanthemi pv. ***zeae*** (Sabet) Victoria *et al*. 1975	Bacterial stalk and top rot	Yes	Yes	Non-quarantine				
Erwinia dissolvens (Rosen) Burkholder 1948	Bacterial stalk rot	Yes	No	Quarantine	yes	No		
Erwinia herbicola (Lohnis) Dye 1964	halo blight of corn	Yes	Yes	Non-quarantine				
Pantoea stewartii subsp. ***stewartii*** (Smith) Mergaert *et al*. 1993	Stewart's bacterial wilt	Yes	No	Quarantine	yes	yes	Medium	yes
Pseudomonas syringae pv. ***lapsa*** (Ark) Young *et al*. 1978	Bacterial stalk rot	Yes	No	Quarantine	yes	No		
Pseudomonas syringae pv. ***syringae*** van Hall 1902	Holcus bacterial spot	Yes	Yes	Non-quarantine				
Pseudomonas syringae pv. ***coronafaciens*** (Elliott) Young *et al*. 1978	Chocolate spot	Yes	Yes	Non-quarantine				
Xanthomonas vasicola pv. ***holcicola*** (Elliott) Vauterin *et al*. 1995	Bacterial leaf spot	Yes	Yes	Non-quarantine				
FUNGI								
Absidia corymbifera (Cohan) Sacc. & Trott.		Yes	No	Quarantine	Yes	no		

Pathogen	Disease	Present in USA	Present in Australia	Australian Quarantine Status	Present in Pathway	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Absidia repens Tiegh		Yes	No	Quarantine	Yes	no		
Acremonium strictum Gams	Black bundle	Yes	Yes	Non-quarantine				
Acremonium zeae Gams & Sumner	Acremonium stalk rot	Yes	Yes	Non-quarantine				
Acrodictys erecta (Ellis & Everh.) Ellis		Yes	No	Quarantine	Yes	no		
Actinomucor elegans (Eidam) Benjamin & Hesseltine		Yes	Yes	Non-quarantine				
Alternaria alternata (Fr.:Fr.) Keissl.	Alternaria leaf blight	Yes	Yes	Non-quarantine				
Alternaria longissima Deighton & MacGarvie	stalk rot	Yes	Yes	Non-quarantine				
Ascochyta ischaemi Sacc.	Yellow leaf blight	Yes	No	Quarantine	Yes	no		
Ascochyta maydis Stout.	Ascochyta leaf blight	Yes	No	Quarantine	Yes	no		
Ascochyta tritici Hori & Enjoji		Yes	No	Quarantine	Yes	no		
Ascochyta zeicola Ellis & Everh.	Ascochyta leaf spot	Yes	Yes	Non-quarantine				
Aspergillus alliaceus Thom & Church		Yes	Yes	Non-quarantine				
Aspergillus caespitosus Raper & Thom		Yes	No	Quarantine	yes	no		
Aspergillus candidus Link		Yes	Yes	Non-quarantine				
Aspergillus carbonarius (Bainier) Thom		Yes	Yes	Non-quarantine				
Aspergillus chevalieri (Mangin) Thom & Church var. ***intermedius***		Yes	No	Quarantine	Unknown			?
Aspergillus clavatus Desmaz.		Yes	Yes	Non-quarantine				
Aspergillus echinulatus (Delacr.) Thom & Church		Yes	No	Quarantine	Unknown			?
Aspergillus elegans Gasp.		Yes	No	Quarantine	Unknown			?
Aspergillus equitis Samson & Gams		Yes	Yes	Non-quarantine				
Aspergillus flavipes (Bainier & Sartory) Thom & Church		Yes	Yes	Non-quarantine				
Aspergillus flavus Likn:Fr.		Yes	Yes	Non-quarantine				

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Aspergillus fumigatus Fresen.		Yes	Yes	Non-quarantine				
Aspergillus glaucus Link:Fr.	Aspergillus ear rot; yellow mould	Yes	Yes	Non-quarantine				
Aspergillus hollandicus Samson & Gams		Yes	Yes	Non-quarantine				
Aspergillus mangini Thom & Raper		Yes	No	Quarantine	Unknown			?
Aspergillus nidulellus Samson & Gams		Yes	Yes	Non-quarantine				
Aspergillus niger Tiegh.	Aspergillus ear rot; black mould	Yes	Yes	Non-quarantine				
Aspergillus ochraceus Wilh.		Yes	Yes	Non-quarantine				
Aspergillus parasiticus Speare		Yes	Yes	Non-quarantine				
Aspergillus reptans Samson & Gams		Yes	Yes	Non-quarantine				
Aspergillus restrictus Sm.		Yes	Yes	Non-quarantine				
Aspergillus rubrobrunneus Samson & Gams		Yes	No	Quarantine	Unknown			?
Aspergillus stellifer Samson & Gams		Yes	No	Quarantine	Unknown			?
Aspergillus sulphureus (Fresen.) Wehmer		Yes	No	Quarantine	Unknown			?
Aspergillus sydowii (Bainier & Startory) Thom & Church		Yes	Yes	Non-quarantine				
Aspergillus tamarii Kita		Yes	No	Quarantine	Unknown			?
Aspergillus unguis (EmilenoWeil & Gaudin) Thom & Raper		Yes	No	Quarantine	Unknown			?
Aspergillus ustus (Bainier) Thom & Raper		Yes	Yes	Non-quarantine				
Aspergillus versicolor (Vuill.) Tiraboschi		Yes	Yes	Non-quarantine				
Aspergillus wentii Wehmer		Yes	Yes	Non-quarantine				
Aureobasidium pullulans (de Bary) Arnaud	brown spot	Yes	Yes	Non-quarantine				
Aureobasidium zeae (Narita & Hiratsuka) Dingley	eye spot; brown spot	Yes	No	Quarantine	Unknown			?

Pathogen	Disease	Present in USA	Present in Australia	Australian Quarantine Status	Present in Pathway	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Basidiobotrys pallida (Berk. & Curtis) Hughes		Yes	No	Quarantine	Unknown			?
Bipolaris australiensis (Ellis) Tsuda & Ueyama	leaf spot	Yes	Yes	Non-quarantine				
Bipolaris cynodontis (Marig.) Shoemaker	leaf spot	Yes	Yes	Non-quarantine				
Bipolaris hawaiiensis (Ellis) Uchida & Aragaki	Helminthosporium leaf spot	Yes	Yes	Non-quarantine				
Bipolaris maydis (Nisikadad Miyaka) Shoemaker	southern leaf blight	Yes	Yes	Races?	Yes	Yes		?
Bipolaris sacchari (Butler) Shoemaker		Yes	Yes	Non-quarantine				
Bipolaris setariae (Sawada) Shoemaker	spot blotch	Yes	Yes	Non-quarantine				
Bipolaris sorghicola (Lefebvre & Sherwin) Alcorn		Yes	Yes	Non-quarantine				
Bipolaris sorokiniana (Sacc.) Shoemaker	Helminthosporium root rot	Yes	Yes	Non-quarantine				
Bipolaris urochloae (Putterill) Shoemaker	leaf spot	Yes	Yes	Non-quarantine				
Bipolaris victoriae (Meehan & Murphy) Shoemaker		Yes	Yes	Non-quarantine				
Bipolaris zeicola (Stout) Shoemaker	northern leaf blight	Yes	Yes	Races?	Yes	Yes		?
Blakeslea trispora Thaxt.		Yes	Yes	Non-quarantine				
Botryosphaeria disrupta (Berk. & Curtis) Arx & Mueller	ear rot	Yes	No	Quarantine	Unknown			?
Botryosphaeria festucae (Lib.) Arx & Mueller	ear rot	Yes	Yes	Non-quarantine				
Botryosphaeria quercuum (Schwein.) Sacc.	ear rot	Yes	Yes	Non-quarantine				
Botryosphaeria rhodina (Cooke) Arx	ear rot	Yes	No	Quarantine	Unknown			?
Botryosphaeria zeae (Stout) Arx & Mueller	gray ear rot	Yes	No	Quarantine	Unknown	No		
Botrytis cineria Pers.: Fr.	Botrytis stalk rot	Yes	Yes	Non-quarantine				
Byssochlamys nivea Westling		Yes	No	Quarantine	Unknown			?

Pathogen	Disease	Present in USA	Present in Australia	Australian Quarantine Status	Present in Pathway	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Candida albicans (Robin) Berkhout		Yes	No	Quarantine	Unknown			?
Candida guilliermondii (Castellani) Langeron & Guerra		Yes	No	Quarantine	Unknown			?
Candida intermedia (Cif. & Ashford) Langeron & Guerra		Yes	No	Quarantine	Unknown			?
Candida krusei (Castellani) Berkhout		Yes	Yes	Non-quarantine				
Candida parapsilosis (Ashford) Langeron & Talice		Yes	No	Quarantine	Unknown			?
Candida pseudotropicalis (Castellani) Basgal		Yes	No	Quarantine	Unknown			?
Ceratocystis paradoxa (Dade) Moreau	leaf spot	Yes	Yes	Non-quarantine				
Cercospora sorghi Ellis & Evrh.	gray leaf spot	Yes	Yes	Non-quarantine				
Cercospora zeae-maydis Tehon & Daniels	gray leaf spot	Yes	No	Quarantine	yes	yes	Medium	yes
Chaetomium bostrychodes Zopf		Yes	No	Quarantine	Unknown			?
Chaetomium brasiliense Batista & Pontual		Yes	No	Quarantine	Unknown			?
Chaetomium dolichptrichum Ames		Yes	No	Quarantine	Unknown			?
Chaetomium funicola Cooke		Yes	Yes	Non-quarantine				
Chaetomium globosum Kunze:Fr.		Yes	Yes	Non-quarantine				
Chaetomium indicum Corda		Yes	Yes	Non-quarantine				
Chaetomium murorum Corda		Yes	No	Quarantine	Unknown			?
Chaetomium torulosum Bainier		Yes	No	Quarantine	Unknown			?
Chrysonilia sitophilia (Mont.) Arx		Yes	Yes	Non-quarantine				
Ciccinella muscae (Sorokin) Berl. & DE Toni		Yes	No	Quarantine	Unknown			?
Cladosporium cladosporioides (Fresen.) De Vries	Cladosporium rot	Yes	Yes	Non-quarantine				
Cladosporium herbarum (Pers.:Fr.) Link	cob mould	Yes	Yes	Non-quarantine				
Cladosporium macrocarpum Preuss	cob mould	Yes	Yes	Non-quarantine				

Pathogen	Disease	Present in USA	Present in Australia	Australian Quarantine Status	Present in Pathway	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Cladosporium tenuissimum Cooke		Yes	Yes	Non-quarantine				
Cladosporium zeae Peck		Yes	No	Quarantine	Unknown			?
Colletotrichum cereale Manns in Selby & Manns		Yes	No	Quarantine	Unknown			?
Colletotrichum graminicola (Ces.) Wils.	anthracnose	Yes	Yes	Races?	Yes	Yes		?
Coniothyrium scirpi Trail	leaf spot	Yes	Yes	Non-quarantine				
Corynascus sepedonium (Emmons) Arx		Yes	Yes	Non-quarantine				
Cryptococcus laurentii (Kuff.) Skinner		Yes	No	Quarantine	Unknown			?
Curvularia brachyspora Boedijn	leaf spot	Yes	Yes	Non-quarantine				
Curvularia clavata P.C.Jain	leaf spot	Yes	Yes	Non-quarantine				
Curvularia eragrostidis (Henn.) Meyer	Curvularia leaf spot	Yes	Yes	Non-quarantine				
Curvularia geniculata (Tracy & Earle) Boedijn	Curvularia leaf spot	Yes	Yes	Non-quarantine				
Curvularia gudauskasii (Morgan-Jones & Karr)	leaf spot	Yes	Yes	Non-quarantine				
Curvularia inaequalis (Shear) Boedijn	Curvularia leaf spot	Yes	Yes	Non-quarantine				
Curvularia intermedia Boedijn	Curvularia leaf spot	Yes	Yes	Non-quarantine				
Curvularia lunata (Wakk.) Boedijn	Curvularia leaf spot	Yes	Yes	Non-quarantine				
Curvularia pallescens Boedijn	Curvularia leaf spot; leaf spot of maize; corn leaf spot	Yes	Yes	Non-quarantine				
Curvularia senegalensis (Speg.) Subramanian	Curvularia leaf spot	Yes	Yes	Non-quarantine				
Curvularia tuberculata P.C.Jain	leaf spot	Yes	Yes	Non-quarantine				
Dendrophoma zeae Tehon		Yes	Yes	Non-quarantine				

Pathogen	Disease	Present in USA	Present in Australia	Australian Quarantine Status	Present in Pathway	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Diaporthe phaseolorum (Cooke & Ellis) Sacc.	seedling blight	Yes	Yes	Non-quarantine				
Dictyochaeta fertilis (Hughes & Kendrick) Holubova-Jechova	root rot	Yes	Yes	Non-quarantine				
Dictyochora gambellii Fairm.		Yes	No	Quarantine	Unknown			?
Didymella exitialis (Morini) Mueller	Didymella leaf spot	Yes	Yes	Non-quarantine				
Didymium iridis (Ditmar) Fr.		Yes	No	Quarantine	Unknown			?
Didymosphaeria graminicola Ellis & Everh.		Yes	No	Quarantine	Unknown			?
Diplodia maydis (Berk.) Sacc.	Diplodia ear and stalk rot	Yes	Yes	Non-quarantine				
Doratomyces stemonitis (Per.:Fr.) Morton & Sm.	ear rot	Yes	Yes	Non-quarantine				
Epicoccum nigrum Link	red kernel; red kernel disease	Yes	Yes	Non-quarantine				
Exserohilum monoceras (Drechs.) Leonard & Suggs	leaf blotch	Yes	Yes	Non-quarantine				
Exserohilum pedicellatum (Henry) Leonard & Suggs	Helminthosporium root rot	Yes	Yes	Non-quarantine				
Exserohilum prolatum Leonard & Suggs	Exserohilum leaf spot	Yes	Yes	Non-quarantine				
Exserohilum rostratum (Drechs.) Leonard & Suggs	Helminthosporium leaf disease	Yes	Yes	Non-quarantine				
Exserohilum turcicum (Pass.) Leonard & Suggs	northern leaf blight	Yes	Yes	Races?	Yes	Medium	Yes	?
Fusarium acuminatum Ellis & Everh.	root and stem rot	Yes	Yes	Non-quarantine				
Fusarium avenaceum (Fr.: Fr.) Sacc.	stalk and root rot	Yes	Yes	Non-quarantine				
Fusarium chlamydosporum Wollenweb. & Reinking		Yes	Yes	Non-quarantine				
Fusarium crookwellense Burgess *et al.*	stem rot	Yes	Yes	Non-quarantine				
Fusarium culmorum (Wm. G. Sm.) Sacc.	stalk rot	Yes	Yes	Non-quarantine				
Fusarium episphaeria (Tode) Snyder & Hans.	stalk rot	Yes	Yes	Non-quarantine				

Pathogen	Disease	Present in USA	Present in Australia	Australian Quarantine Status	Present in Pathway	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Fusarium equiseti (Corda) Sacc.	stalk rot	Yes	Yes	Non-quarantine				
Fusarium graminearum Schwabe	Gibberella stalk rot; red ear rot; pink ear rot	Yes	Yes	Non-quarantine				
Fusarium merismoides Corda	stalk rot	Yes	Yes	Non-quarantine				
Fusarium moniliforme Sheld.	Fusarium ear and stalk rot; Fusarium kernel rot	Yes	Yes	Non-quarantine				
Fusarium oxysporum Schlechtend.:Fr.	root rot	Yes	Yes	Non-quarantine				
Fusarium pallidoroseum (Cooke) Sacc.	root rot	Yes	Yes	Non-quarantine				
Fusarium poae (Peck) Wollenweb.	white cob rot; silver top	Yes	Yes	Non-quarantine				
Fusarium proliferatum (Matsushima) Nirenberg	root rot	Yes	Yes	Non-quarantine				
Fusarium roseum Link: Fr.	root rot	Yes	Yes	Non-quarantine				
Fusarium sacchari (Butler) Gams		Yes	No	Quarantine	Yes	no		
Fusarium solani (Mart.) Sacc.	stalk rot	Yes	Yes	Non-quarantine				
Fusarium subglutinans (Wollenweb. & Reinking) Nelson *et al.*	Fusarium stalk and ear rot	Yes	Yes	Non-quarantine				
Fusarium tricinctum (Corda) Sacc	root rot	Yes	Yes	Non-quarantine				
Fusisporium cerealis Cooke		Yes	No	Quarantine	Unknown	No		
Gaeumannomyces graminis (Sacc.) Arx & Olivier	root rot	Yes	Yes	Non-quarantine				
Geotrichum candidum Link	stalk rot	Yes	Yes	Non-quarantine				
Gibberella cyanogena (Desmaz.) Sacc.	root rot	Yes	Yes	Non-quarantine				
Gibberella pulicaris (Fr.:Fr.) Sacc.	root rot	Yes	Yes	Non-quarantine				
Glabrocyphella ellisiana Cooke		Yes	No	Quarantine	Unknown			?
Gloeocercospora sorghi Bain & Edgerton ex Deighton	zonate leaf spot	Yes	No	Quarantine	Unknown			?

Pathogen	Disease	Present in USA	Present in Australia	Australian Quarantine Status	Present in Pathway	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Glomerella tucumanensis (Speg.) Arx & Mueller		Yes	Yes	Non-quarantine				
Gonatobotrys simplex Corda	Gonatobotrys seed rot	Yes	Yes	Non-quarantine				
Gonatobotrys zeae Futrell & Bain	Gonatobotrys seed rot	Yes	No	Quarantine	Yes	no		
Graphium penicillioides Corda	leaf spot	Yes	No	Quarantine	Yes	no		
Hansenula anomala (Hans.) Syd. & Syd.		Yes	No	Quarantine	Yes	no		
Harzia acremonioides (Harz) Costantin		Yes	Yes	Non-quarantine				
Helminthosporium ahmadii Ellis		Yes	No	Quarantine	Yes	no		
Illosporium pallidum Cooke		Yes	No	Quarantine	Unknown	No		
Isariopsis subulata Ellis & Everh.		Yes	No	Quarantine	Unknown	No		
Lasiodiplodia theobromae (Pat) Griffon & Maubl.	black kernel rot	Yes	Yes	Non-quarantine				
Lecanidion atratum (Hedw.) Rabenh.		Yes	Yes	Non-quarantine				
Leptosphaeria macrospora (Fuckel) Thuem.	leaf spot	Yes	No	Quarantine	Yes	no		
Leptosphaeria maydis Stout	leaf spot	Yes	No	Quarantine	Unknown	No		
Leptosphaeria variisepta Stout	Leptosphaeria leaf spot	Yes	No	Quarantine	Yes	no		
Leptosphaerulina trifolii (Rostr.) Petr.		Yes	Yes	Non-quarantine				
Leptothyrium zeae Stout	leaf spot	Yes	No	Quarantine	Yes	no		
Ligniera junci (Schwartz) Maire & Tison		Yes	No	Quarantine	Yes	no		
Lophiosphaera zeicola Ellis & Everh.		Yes	No	Quarantine	Unknown			?
Lophiostoma arundinis (Pers.:Fr.) Ces. & De Not)		Yes	No	Quarantine	Unknown			?
Macrophomina phaseolina (Tassi) Goidanich	charcoal rot	Yes	Yes	Non-quarantine				
Macrosporium maculatum Cooke & Ellis in Sumstein, nom. nud.		Yes	No	Quarantine	Yes	no		
Marasmius graminum (Lib.) Berk.	seedling and foor rot	Yes	Yes	Non-quarantine				
Marasmius sacchari Wakk.	Marasmius root and stalk rot	Yes	Yes	Non-quarantine				
Mariannaea elegans (Corda) Samson	stalk rot	Yes	Yes	Non-quarantine				

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Massarina arundinacea (Sowerby:Fr.) Leuchtmann		Yes	No	Quarantine	Yes	no		
Melanospora zamiae Corda		Yes	No	Quarantine	Unknown			?
Microascus cinereus (EmilenoWeil & Gaudin) Curzi		Yes	No	Quarantine	Yes	no		
Microascus cirrosus Curzi		Yes	No	Quarantine	Yes	no		
Microascus desmosporus (Lechmere) Curzi		Yes	No	Quarantine	Unknown			?
Microascus longirostris Zukal		Yes	No	Quarantine	Yes	no		
Microdochium bolleyi (Sprague) De Hoog & Hermanides-Nijhof	Microdochium root rot	Yes	Yes	Non-quarantine				
Microdochium nivale (Fr.) Samuels & Hallett	Microdochium root rot	Yes	Yes	Non-quarantine				
Monascus purpureus Went	silage mold	Yes	No	Quarantine	Unknown			?
Monascus ruber Diegh.	silage mold	Yes	No	Quarantine	Unknown			?
Mucor circinelloides Teigh.		Yes	Yes	Non-quarantine				
Mucor fragilis Bainier	seedling rot	Yes	Yes	Non-quarantine				
Mucor heimalis Wehmer		Yes	No	Quarantine	Yes	no		
Mucor mucedo Mich. Ex Saint-Amans		Yes	No	Quarantine	Yes	no		
Mucor plumbeus Bonord.		Yes	Yes	Non-quarantine				
Mucor racemosus Fresen.		Yes	Yes	Non-quarantine				
Mycosphaerella zeae (Sacc.) Woronow	leaf blight	Yes	No	Quarantine	Yes	no		
Myrothecium cinctum (Corda) Sacc.	root rot	Yes	Yes	Non-quarantine				
Myrothecium gramineum Lib.	shuck rot	Yes	No	Quarantine	Yes	no		
Myrothecium verrucaria (Albertini & Schwein.) Ditmar.:Fr.	root rot	Yes	Yes	Non-quarantine				
Nigrospora oryzae (Berk. & Broome) Petch	Nigrospora ear rot	Yes	Yes	Non-quarantine				
Nigrospora sphaerica (Sacc.) Mason	stalk rot	Yes	Yes	Non-quarantine				
Olpitrichum macrosporum (Farl.) Sumstine		Yes	Yes	Non-quarantine				

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Olpitrichum tenellum (Berk. & Curtis) Holubova-Jechova		Yes	No	Quarantine	Unknown			?
Ophiliosphaerella herpotricha (Fr.:Fr.) Walker		Yes	No	Quarantine	Unknown			?
Paraphaeosphaeria michotii (Westend.) Eriksson	leaf spot	Yes	Yes	Non-quarantine				
Penicillium aurantiogriseum Dierckx		Yes	Yes	Non-quarantine				
Penicillium brevicompactum Dierckx		Yes	Yes	Non-quarantine				
Penicillium canescens Sopp		Yes	Yes	Non-quarantine				
Penicillium chrysogenum Thom		Yes	Yes	Non-quarantine				
Penicillium citrinum Thom		Yes	Yes	Non-quarantine				
Penicillium clarviforne Bainier		Yes	No	Quarantine	Unknown			?
Penicillium crustosum Thom		Yes	Yes	Non-quarantine				
Penicillium expansum Link	Penicillium ear rot	Yes	Yes	Non-quarantine	Unknown			?
Penicillium felludanum Biourge		Yes	No	Quarantine	Unknown			?
Penicillium funiculosum Thom		Yes	Yes	Non-quarantine				
Penicillium glabrum (Wehmer) Westling		Yes	No	Quarantine	Unknown			?
Penicillium granulatum Bainier		Yes	No	Quarantine	Unknown			?
Penicillium grisefulvum Dierckx		Yes	No	Quarantine	Unknown			?
Penicillium herquei Bainier & Sartory		Yes	No	Quarantine	Unknown			?
Penicillium implicatum Biourge		Yes	No	Quarantine	Unknown			?
Penicillium janthinellum Biourge		Yes	No	Quarantine	Unknown			?
Penicillium oxalicum Currie & Thom		Yes	No	Quarantine	Unknown			?
Penicillium puberulum Bainier		Yes	No	Quarantine	Unknown			?
Penicillium purpurogenum Stoll		Yes	No	Quarantine	Unknown			?
Penicillium roquefortii Thom		Yes	No	Quarantine	Unknown			?
Penicillium rugulosum Thom		Yes	No	Quarantine	Unknown			?
Penicillium sclerotiorum Van Beyma		Yes	No	Quarantine	Unknown			?
Penicillium thomii Maire		Yes	No	Quarantine	Unknown			?
Penicillium variabile Sopp		Yes	No	Quarantine	Unknown			?

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Penicillium verrucosum Dierckx		Yes	No	Quarantine	Unknown			?
Penicillium viridicatum Westling		Yes	No	Quarantine	Unknown			?
Penicillium waksmanii Zaleski		Yes	No	Quarantine	Unknown			?
Perichaena vermicularis (Schwein.) Rostr.		Yes	Yes	Non-quarantine				
Periconia circinata (Mangin) Sacc.	root rot	Yes	Yes	Non-quarantine				
Periconia macrospinosa Lefebvre & Johnson in Lefebvre *et al*.		Yes	Yes	Non-quarantine				
Perisporium zeae Berk. & Curtis		Yes	No	Quarantine	Unknown			?
Peronosclerospora sorghi (Weston & Uppal) Shaw	sorghum downy mildew	Yes	No	Quarantine	yes	yes	High	yes
Phaeocytostroma ambiguum (Mont.) Petr. in Petr. & Syd.	Phaeocytosporella stalk infection	Yes	Yes	Non-quarantine				
Phaeosphaeria eustoma (Fuckel) Holm	Phaeosphaeria leaf spot	Yes	Yes	Non-quarantine				
Phaeosphaeria herpotricha (De Not) Holm	Phaeosphaeria leaf spot	Yes	Yes	Non-quarantine				
Phaeotrichoconis crotalariae (Salam & Rao) Subram.		Yes	Yes	Non-quarantine				
Phoma americana Morgan-Jones & White	root rot	Yes	No	Quarantine	Yes	no		
Phoma terrestris Hans.	pink root; stalk rot	Yes	Yes	Non-quarantine				
Phoma zeicola Ellis & Evrh.	root rot	Yes	No	Quarantine	Yes	no		
Phomopsis sp.	Phomopsis seed rot	Yes	Yes	Non-quarantine				
Phycomyces nitens Kunze		Yes	Yes	Non-quarantine				
Phyllosticta maydis Arny & Nelson	yellow leaf blight	Yes	No	Quarantine	Yes	no		
Phyllosticta zeae Stout	Phyllosticta leaf spot	Yes	No	Quarantine	Yes	no		
Phymatotrichopsis omnivora (Duggar) Hennebert	root rot	Yes	No	Quarantine	Yes	yes	Low	Yes
Physalospora abdita (Berk. & Curtis) Stevens in Voorhees		Yes	No	Quarantine	Unknown			?
Physarum pusillum (Berk. & Curtis) List.	slime mould	Yes	Yes	Non-quarantine				

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Physoderma maydis (Miyabe) Miyabe	brown spot of maize	Yes	Yes	Non-quarantine				
Physopella pallescens (Arth.) Cummins & Ramachar	leaf rust	Yes	No	Quarantine	Yes	no		
Phytophthora cactorum (Lebert & Cohn) Schroet.	root rot	Yes	Yes	Non-quarantine				
Phytophthora drechsleri Tucker	root rot	Yes	Yes	Non-quarantine				
Phytophthora nicotianae Breda de Haan var. ***parasitica*** (Dastur) Waterhouse	root rot	Yes	Yes	Non-quarantine				
Pithoascus intermedius (Emmons & Dodge) Arx		Yes	No	Quarantine	Unknown			?
Pithoascus schumachrei (Hans.) Arx		Yes	No	Quarantine	Unknown			?
Pithomyces maydicus (Sacc.) Ellis	ear rot	Yes	No	Quarantine	Yes	no		
Pleospora straminis Sacc. & Speg.		Yes	No	Quarantine	Unknown			?
Podospora minor Ellis & Everh.		Yes	No	Quarantine	Unknown			?
Polyschema olivacea (Ellis & Everh.) Ellis		Yes	No	Quarantine	Unknown			?
Puccinia polysora Underw.	southern rust	Yes	Yes	Non-quarantine				
Puccinia sorghi Schwein.	common maize rust	Yes	Yes	Non-quarantine				
Pyricularia grisea (Cooke) Sacc.	white leaf spot	Yes	Yes	Non-quarantine				
Pyronema omphalodes (Bull.:Fr.) Fuckel		Yes	Yes	Non-quarantine				
Pythium acanthicum Drechs.	root rot	Yes	No	Quarantine	Yes	no		
Pythium adhaerens Sparrow	root rot	Yes	No	Quarantine	Yes	no		
Pythium angustatum Sparrow	root rot	Yes	No	Quarantine	Yes	no		
Pythium aphanidermatum (Edson) Fitzp.	Pythium stalk rot	Yes	Yes	Non-quarantine				
Pythium arrhenomanes Drechs.	root rot	Yes	Yes	Non-quarantine				
Pythium graminicola Subramanian	root rot	Yes	Yes	Non-quarantine				
Pythium irregulare Buisman	seedling blight, damping off	Yes	Yes	Non-quarantine				

Pathogen	Disease	Present in USA	Present in Australia	Australian Quarantine Status	Present in Pathway	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Pythium myriotylum Drechs.	root rot	Yes	Yes	Non-quarantine				
Pythium paroecandrum Drechs.	root rot	Yes	Yes	Non-quarantine				
Pythium pulchrum Minden	root rot	Yes	No	Quarantine	Yes	no		
Pythium rostratum Butler	root rot	Yes	Yes	Non-quarantine				
Pythium splendens Braun	root rot	Yes	Yes	Non-quarantine				
Pythium sylvaticum Campbell & Hendrix	seed rot	Yes	No	Quarantine	Yes	no		
Pythium ultimum Trow	root rot	Yes	Yes	Non-quarantine				
Ramulispora sorghi (Ellis & Everh.) Olive & Lefebvre in Olive *et al*.	brown leaf spot	Yes	Yes	Non-quarantine				
Rhizoctonia solani Kühn	Rhizoctonia root rot	Yes	Yes	Non-quarantine				
Rhizoctonia zeae Voorhees	sclerotial rot	Yes	Yes	Non-quarantine				
Rhizopus arrhizus Fischer	Rhizopus ear rot	Yes	Yes	Non-quarantine				
Rhizopus microsporus Tiegh.	Rhizopus ear rot	Yes	No	Quarantine	Yes	no		
Rhizopus microsporus Tiegh. Var. ***rhizopodiformis*** (Cohn) Schipper	Rhizopus ear rot	Yes	No	Quarantine	Yes	no		
Rhizopus stolonifer (Ehrenb.:Fr.) Vuill.	Rhizopus ear rot	Yes	Yes	Non-quarantine				
Rhopographus zeae Pat.	stalk rot	Yes	No	Quarantine	Yes	no		
Sclerophthora macrospora (Sacc.) Thirumalachar *et al*.	crazy top	Yes	Yes	Non-quarantine				
Sclerospora graminicola (Sacc.) Schröt.	Graminicola downy mildew; green ear	Yes	No	Quarantine	Yes	yes	Low	Yes
Sclerotinia sclerotiorum (Lib) de Bary	Sclerotinia stalk rot	Yes	Yes	Non-quarantine				
Sclerotium rolfsii Sacc.	Sclerotium ear rot	Yes	Yes	Non-quarantine				
Scopulariopsis brevicaulis (Sacc.) Bainier	ear rot	Yes	Yes	Non-quarantine				

Pathogen	Disease	Present in USA	Present in Australia	Australian Quarantine Status	Present in Pathway	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Scopulariopsis brumptii Salvanet-Duval	ear rot	Yes	Yes	Non-quarantine				
Septoria zeae Stout	leaf spot	Yes	No	Quarantine	Yes	no		
Septoria zeicola Stout	leaf spot	Yes	Yes	Non-quarantine				
Septoria zeina Stout	leaf spot	Yes	No	Quarantine	Yes	no		
Sphaerella paulula Cooke		Yes	No	Quarantine	Unknown			?
Sporidesmium folliculatum (Corda) Mason & Hughes		Yes	No	Quarantine	Unknown			?
Sporisorium holci-sorghi (Rivolta) Vanky	head smut	Yes	Yes	Races?	Yes	Yes	High	?
Stachybotrys zeae Morgan-Jones & Karr		Yes	No	Quarantine	Unknown			?
Stauronema cruciferum (Ellis) Syd *et al.*		Yes	No	Quarantine	Unknown			?
Stenocarpella macrospora (Earle) Sutton	Diplodia ear and stalk rot	Yes	Yes	Non-quarantine				
Stenocarpella maydis (Berk.) Sutton	Diplodia ear and stalk rot	Yes	Yes	Non-quarantine				
Sterile white basidiomycete *(SWB)*	SWB root rot	Yes	No	Quarantine	Yes	no		
Stictis radiata Pers.:Fr.		Yes	No	Quarantine	Unknown			?
Stictis stellata Schwein.		Yes	Yes	Non-quarantine				
Syncephalastrum racemosum Cohn ex Schroet		Yes	Yes	Non-quarantine				
Talaromyces luteus (Zukal) Benjamin		Yes	No	Quarantine	Unknown			?
Talaromyces stipitatus (Thom) Benjamin		Yes	No	Quarantine	Unknown			?
Thamnidium elegans Link:Fr		Yes	No	Quarantine	Unknown			?
Trichoderma koningii Oudem.		Yes	Yes	Non-quarantine				
Trichoderma viride Pers.:Fr.	Trichoderma ear rot	Yes	Yes	Non-quarantine				
Trichothecium roseum (Pers.:Fr.) Link	pink mould	Yes	Yes	Non-quarantine				
Tritirachium oryzae (Vincens) De Hoog		Yes	No	Quarantine	Unknown	No		
Tubeufia cylindrothecia (Seaver) Höhn		Yes	No	Quarantine	Unknown			?
Typhula phacorrhiza (Reichard:Fr.) Fr.	snow mould	Yes	No	Quarantine	Unknown			?
Ulocladium lanuginosum (Harz.) Simmons		Yes	No	Quarantine	Unknown			?
Ustilaginoidea virens (Cooke) Takah.	false smut	Yes	No	Quarantine	Yes	yes	Low	Yes

Pathogen	Disease	Present in USA	Present in Australia	Australian Quarantine Status	Present in Pathway	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Ustilago zeae (Beckm.) Unger	boil smut	Yes	Yes (under official control)	Quarantine	Unknown			?
Verticillium tenerum (Pers.:Fr.) Link		Yes	Yes	Non-quarantine				
Wolfiporia cocos (Wolf) Ryvarden & Gilbertson	wood rot	Yes	No	Quarantine	Yes	no		
NEMATODES								
Belonolaimus longicaudatus Rau 1958	sting nematode	Yes	Yes	Non-quarantine				
Criconema mutabile (Taylor) Raski & Luc	ring nematode	Yes	Yes	Non-quarantine				
Ditylenchus dipsaci (Kuhn) Flipjev 1936	bulb and stem nematode	Yes	Yes	Non-quarantine				
Dolichodorus heterocephalus Cobb, 1914	awl nematode	Yes	No	Quarantine	Yes	Yes	Low	Yes
Filenchus exiguus (de Man) Ebsary		Yes	Yes	Non-quarantine				
Helicotylenchus multicinctus (Cobb) Golden 1956	spiral nematode	Yes	Yes	Non-quarantine				
Helicotylenchus multicinctus (Cobb) Sher 1956	spiral nematode	Yes	Yes	Non-quarantine				
Helicotylenchus pseudorobustus (Steiner) Golden 1956	spiral nematode	Yes	yes	Non-quarantine				
Heterodera avenae Wollenweber 1924	cereal cyst nematode	yes	yes	Non-quarantine				
Heterodera zeae Koshy *et al*. 1970	corn cyst nematode	Yes	No	Quarantine	Yes	Yes	Low	Yes
Hoplolaimus columbus Sher 1963	lance nematode	Yes	No	Quarantine	Yes	Yes	Low	Yes
Hoplolaimus galeatus (Cobb) Thorne 1935	lance nematode	Yes	No	Quarantine	Yes	No		
Longidorus breviannulatus Norton & Hoffman 1975	needle nematode	Yes	No	Quarantine	Yes	Yes	Low	Yes
Macroposthonia ornata (Raski) de Grisse & Loof, 1965	ring nematode	yes	yes	Non-quarantine				
Meloidogyne arenaria (Neal) Chitwood 1949	root-knot nematode	yes	yes	Non-quarantine				
Meloidogyne chitwoodi Golden *et al*. 1980	root-knot nematode	Yes	No	Quarantine	Yes	Yes	Low	Yes

Pathogen	Disease	Present in USA	Present in Australia	Australian Quarantine Status	Present in Pathway	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Meloidogyne incognita (Kofold & White) Chitwood 1949	root-knot nematode	yes	yes	Non-quarantine				
Meloidogyne javanica (Treub) Chitwood 1949	root-knot nematode	yes	yes	Non-quarantine				
Nacobbus dorsalis Thorne & Allen		yes	no	Quarantine	Yes	No	Low	
Paratrichodorus christiei (Allen) Siddiqi 1974	stubby-root nematode	Yes	No	Quarantine	Yes	No		
Pratylenchus brachyurus (Godfrey) Filipjev & Schuurmans Stekhoven 1941	root lesion nematode	yes	yes	Non-quarantine				
Pratylenchus crenatus Loof	root lesion nematode	yes	yes	Non-quarantine				
Pratylenchus hexincisus Taylor & Jenkins 1957	root lesion nematode	yes	yes	Non-quarantine				
Pratylenchus neglectus (Rensch) Filipjev & Schuurmans Stekhoven 1941	root lesion nematode	yes	yes	Non-quarantine				
Pratylenchus penetrans (Cobb) Chitwood & Oteifa 1952	root lesion nematode	yes	yes	Non-quarantine				
Pratylenchus scribneri Steiner, 1943	root lesion nematode	Yes	No	Quarantine	Yes	Yes	Low	Yes
Pratylenchus thornei Sher & Allen 1953	root lesion nematode	yes	yes	Non-quarantine				
Pratylenchus zeae Graham 1951	root lesion nematode	yes	yes	Non-quarantine				
Quinisulcius acutus (Allen) Siddiqi 1974	stubby-root nematode	Yes	No	Quarantine	Yes	No		
Radopholus similis (Cobb) Thorne 1949	burrowing nematode	yes	yes	Non-quarantine				
Rotylenchulus parvus (Williams) Sher 1961	reniform nematode	yes	yes	Non-quarantine				
Tylenchorhynchus dubius (Butschli) Filipjev 1936	stunt nematode	yes	yes	Non-quarantine				
Xiphinema americanum Cobb 1913	dagger nematode	yes	yes	Non-quarantine				
PHYTOPLASMAS								
Maize bushy stunt phytoplasma	maize bush stunt	yes	no	Quarantine	Unknown			?
Spiroplasma kunkelii Whitcomb *et al*	corn stunt	yes	no	Quarantine	Unknown			?
VIRUSES								

Pathogen	Disease	Present in USA	Present in Australia	Australian Quarantine Status	Present in Pathway	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Barley yellow dwarf luteovirus (BSMV)	barley yellow dwarf	yes	yes	Non-quarantine				
Brome mosaic bromovirus (BMV)	brome mosaic	yes	yes	Non-quarantine				
Cucumber mosaic cucumovirus (CMV)	cucumber mosaic	yes	yes	Non-quarantine				
High Plains virus	High Plains disorder	yes	no	Quarantine	Yes	Yes	Medium	Yes
Johnsongrass mosaic potyvirus (JGMV)	Johnson grass mosaic	yes	yes	Non-quarantine				
Maize chlorotic dwarf waikavirus (MCDV)	maize chlorotic dwarf	yes	no	Quarantine	Unknown			?
Maize chlorotic mottle machlomovirus (MCMV)	maize chlorotic mottle	yes	no	Quarantine	Yes	Yes	High	Yes
Maize dwarf mosaic potyvirus (MDMV)	maize dwarf mosaic	yes	no	Quarantine	Yes	Yes	High	Yes
Maize mosaic nucleorhabdovirus (MMV)	maize mosaic	yes	no	Quarantine	Unknown			?
Maize rayado fino marafivirus (MRFV)	maize rayado fino	yes	no	Quarantine	Unknown	Yes		?
Maize stripe tenuivirus (MSpV)	maize stripe	yes	yes	Non-quarantine	Unknown			?
Maize white line mosaic satellivirus	maize white line mosaic	yes	no	Quarantine	Unknown			?
Maize white line mosaic virus (MWLMV)	maize white line mosaic	yes	no	Quarantine	Unknown			?
Wheat streak mosaic rymovirus (WSMV)	wheat streak mosaic	yes	no	Quarantine	Yes	Yes	Medium	Yes
Wheat striate virus (WStMV)	wheat striate	yes	no	Quarantine	No			

Table 14.2. Quarantine status of pests associated with stored maize grain and admixture grain commodities and arthropod pests known to vector maize diseases in North America.

Economic pests that either do not occur on stored maize grain in Australia or are under official control are quarantine pests in accordance with the FAO definition of a quarantine pest. However, specific phytosanitary measures are only needed if the pest is associated with the part of the plant proposed to be imported, in this case the seeds. Taking account of this, the final column in the table identifies those pests which require quarantine management. Action, however, will be taken against any of the quarantine pests if found with the commodity on arrival in Australia.

Pest	Common name/s	Present in North America, Canada, USA or Mexico	Present in Australia	Australian Quarantine Status	Present on Pathway (seeds)	Potential Economic Impact	Probabillity of Introduction	Quarantine Management Required[4]
Acanthoscelides obtectus	bean weevil	North America	yes	Non-quarantine	yes	low		
Aceria tosichella	grass mite	USA	yes	Non-Quarantine	no	medium		
Aglossa caprealis	murky meal moth	USA	yes	Non-quarantine	yes	low		
Agriotes mancus	wheat wireworm	North America	no	Quarantine	no	medium	low	
Ahasverus advena	foreign grain beetle	Canada, USA	yes	Non-quarantine	yes	medium		
Alphitobius diaperinus	lesser mealworm	North America	yes	Non-quarantine	yes	low		
Alphitobius laevigatus	black fungus beetle	North America	yes	Non-quarantine	yes	low		
Alphitophagus bifasciatus	twobanded fungus beetle	Canada, USA	yes	Non-quarantine	yes	low		
Anthicus spp.	ant beetles	North America	yes	Non- quarantine	yes	low		
Anthrenus spp.	museum beetle, carpet beetle	North America	yes	Non-Quarantine	yes	low		
Attagenus spp.	black carpet beetle, fur beetle	North America	yes	Non-quarantine	yes	low		
Bruchus pisorum	pea weevil	Canada, USA	yes	Non-quarantine	yes	high		
Cadra cautella	tropical warehouse moth	North America	yes	Non-quarantine	yes	high		
Cadra figulilella	raisin moth	USA	yes	Non-quarantine	yes	medium		
Callosobruchus chinensis	southern cowpea weevil	possible in southern USA	no	Non-quarantine	yes	high	low	yes
Callosobruchus maculatus	cowpea weevil	USA	yes	Non-quarantine	yes	high		
Carpophilus spp.	sap beetles, dried fruit beetles	North America	yes	Non-quarantine	yes	low		

4 Pests assessed as quarantine pests present in the pathway will be addressed by routine inspection procedures. The risks posed by these pests are reduced to negligibly low levels with a combination of inspection and management strategies which are outlined in other parts of this document.

Pest	Common name/s	Present in North America, Canada, USA or Mexico	Present in Australia	Australian Quarantine Status	Present on Pathway (seeds)	Potential Economic Impact	Probabillity of Introduction	Quarantine Management Required[4]
Cathartus quadricollis	square-necked flour beetle	USA-south, Mexico	no	Quarantine	yes	high	high	yes
Caulophilus oryzae	broadnosed grain weevil	SE USA, Mexico	no	Quarantine	yes	high	medium	yes
Chaetocnema pulicaria	corn flea beetle	North America	no	Quarantine	no	high		
Corcyra cephalonica	rice moth	USA, Mexico	yes	Non-quarantine	yes	high		
Corticaria spp.	minute mould beetle	North America	yes	Non-quarantine	yes	medium		
Cryptolestes ferrugineus	rusty grain beetle	North America	yes	Non-quarantine	yes	high		
Cryptolestes pusilleodes	flat grain beetle	Mexico	yes	Non-quarantine	yes	medium		
Cryptolestes pusillus	flat grain beetle	North America	yes	Non-quarantine	yes	medium		
Cryptolestes turcicus	flat grain beetle, flour mill beetle	Canada, USA	no	Quarantine	yes	high	medium	yes
Cryptophagus spp.		USA, Canada	yes	Non-quarantine	yes	medium		
Cynaeus angustus	large black flour beetle	Canada, Mexico, USA	no	Quarantine	yes	high	medium	yes
Dalbulus maidis	corn leafhopper	USA	no	Quarantine	no	medium		
Deinerella spp.		North America	yes	Non-quarantine	yes	low		
Delia platura	seed corn maggot	North America	yes	Non-quarantine	no	medium		
Dermestes spp.	hide beetles	North America	yes	Non-quarantine	yes	low		
Diabrotica sp.	corn rootworm	North America	yes	Non-quarantine	no	low		
Diabrotica longicornis	northern corn rootworm	Canada, USA	no	Quarantine	no	medium		
Diabrotica undecimpunctata	southern corn rootworm	Canada, USA	no	Quarantine	no	medium		
Diabrotica virgifera	western corn rootworm	USA	no	Quarantine	no	medium		
Dinoderus minutus	bamboo powderpost beetle	North America	yes	Non-quarantine	yes	medium		
Endrosis sarcitrella	whiteshouldered house moth	North America	yes	Non-quarantine	yes	low		
Enicumus minutus		USA, Canada	yes	Non-quarantine	yes	medium		
Ephestia elutella	tobacco moth	North America	yes	Non-quarantine	yes	high		
Ephestia kuehniella	Mediterranean flour moth	North America	yes	Non-quarantine	yes	high		
Eriophyes tulipae	wheat curl mite	North America	yes	Non-quarantine	no	medium		

Pest	Common name/s	Present in North America, Canada, USA or Mexico	Present in Australia	Australian Quarantine Status	Present on Pathway (seeds)	Potential Economic Impact	Probabillity of Introduction	Quarantine Management Required[4]
Exitianus exitosus	leafhopper	USA	no	Quarantine	no	medium		
Gibbium aequinoctiale	spider beetle	North America	yes	Non-quarantine	yes	low		
Gibbium psylloides	spider beetle	USA, Mexico	yes	Non-quarantine	yes	low		
Glischrochilus fasciatus	redspotted sap beetle, picnic beetle	Canada, USA	no	Quarantine	yes	high	medium	yes
Glischrochilus quadrisignatus	fourspotted sap beetle, picnic beetle	Canada, USA	no	Quarantine	yes	high	medium	yes
Gnatocerus cornutus	broadhorned four beetle	North America	yes	Non-quarantine	yes	low		
Graminella nigrifrons	grass leafhopper	USA	no	Quarantine	no	medium		
Graminella sonora	grass leafhopper	USA	no	Quarantine	no	medium		
Henoticus spp.		North America	yes	Non-quarantine	yes	low		
Hofmannophila pseudospretella	brown house moth	North America	yes	Non-quarantine	yes	low		
Lachesilla pedicularia	booklouse	North America	yes	Non-quarantine	yes	low		
Lachesilla quercus	booklouse	North America	yes	Non-quarantine	yes	low		
Lasioderma serricorne	cigarette beetle	North America	yes	Non-quarantine	yes	high		
Latheticus oryzae	longheaded flour beetle	North America	yes	Non-quarantine	yes	low		
Lathridius spp.	plaster beetle	North America	yes	Non-quarantine	yes	low		
Lema melanopa	cereal beetle	Canada, USA	no	Quarantine	no	medium		
Lepinotus inquilinus	booklouse	USA	yes	Non-quarantine	yes	medium		
Lepinotus patruelis	booklouse	USA	yes	Non-quarantine	yes	medium		
Liposcelis bostrychophila	booklouse	North America	yes	Non-quarantine	yes	medium		
Liposcelis brunnea	booklouse	USA	yes	Non-quarantine	yes	medium		
Liposcelis corrodens	booklouse	USA	yes	Non-quarantine	yes	medium		
Liposcelis decolor	booklouse	USA	yes	Non-quarantine	yes	medium		
Liposcelis entomolphila	booklouse	North America	yes	Non-quarantine	yes	low		
Liposcelis paeta	booklouse	North America	yes	Non-quarantine	yes	medium		
Liposcelis rufa	booklouse	USA	yes	Non-quarantine	yes	medium		
Litargus balteatus		Canada, USA	yes	Non-quarantine	yes	low		
Mezium affine	spiny spider beetle	North America	yes	Non-quarantine	yes	low		
Mezium americanum	American spider beetle	North America	yes	Non-quarantine	yes	low		

Pest	Common name/s	Present in North America, Canada, USA or Mexico	Present in Australia	Australian Quarantine Status	Present on Pathway (seeds)	Potential Economic Impact	Probabillity of Introduction	Quarantine Management Required[4]
Murmidius ovalis	murmidius beetle	Canada, USA	yes	Non-quarantine	yes	low		
Mycetophagus quadriguttatus	spotted hairy fungus beetle	Canada, USA	yes	Non-quarantine	yes	low		
Nemapogon granella	European grain moth	USA	yes	Non-quarantine	yes	low		
Niptus hololeucus	golden spider beetle	Canada, USA	yes	Non-quarantine	yes	low		
Oryzaephilus mercator	merchant grain beetle	North America	yes	Non-quarantine	yes	high		
Oryzaephilus surinamensis	sawtoothed grain beetle	North America	yes	Non-quarantine	yes	high		
Palorus ratzeburgii	broadhorned flour beetle	North America	yes	Non-quarantine	yes	low		
Palorus subdepressus	depressed flour beetle	North America	yes	Non-quarantine	yes	low		
Peregrinus maidis	corn planthopper	USA	yes	Non-quarantine	no	medium		
Pharaxanotha kirschi	Mexican grain beetle	USA, Mexico	no	Quarantine	yes	low	medium	yes
Phyllophaga spp.	May beetle	North America	no	Quarantine	no	medium		
Plodia interpunctella	Indian meal moth	North America	yes	Non-quarantine	yes	high		
Prostephanus truncatus	larger grain borer, greater grain borer	USA-south, Mexico	no	Quarantine	yes	high	medium	yes
Pseudeurostus hilleri		Canada, USA	yes	Non-quarantine	yes	low		
Psocathropos microps		USA	yes	Non-quarantine	yes	low		
Ptinus spp.	spider beetles	North America (temperate regions)	yes	Non-quarantine	yes	low		
Pyralis farinalis	meal moth	Canada, USA	yes	Non-quarantine	yes	medium		
Rhopalosiphum maidis	corn leaf aphid	North America	yes	Non-quarantine	no	medium		
Rhopalosiphum padi	bird cherry-oat aphid	North America	yes	Non-quarantine	no	medium		
Rhyzopertha dominica	lesser grain borer	North America	yes	Non-quarantine	yes	high		
Sitophilus granarius	granary weevil	Canada, USA	yes	Non-quarantine	yes	high		
Sitophilus oryzae	rice weevil	North America	yes	Non-quarantine	yes	high		
Sitophilus zeamais	maize weevil	North America	yes	Non-quarantine	yes	high		
Sitotroga cerealella	angoumois grain moth	USA, Mexico	yes	Non-quarantine	yes	low		

Pest	Common name/s	Present in North America, Canada, USA or Mexico	Present in Australia	Australian Quarantine Status	Present on Pathway (seeds)	Potential Economic Impact	Probabillity of Introduction	Quarantine Management Required[4]
Stegobium paniceum	drugstore beetle	North America	yes	Non-quarantine	yes	medium		
Tenebrio molitor	yellow mealworm	North America	yes	Non-quarantine	yes	low		
Tenebrio obscurus	dark mealworm	North America	yes	Non-quarantine	yes	low		
Tenebroides mauritanicus	cadelle	Canada, USA	yes	Non-quarantine	yes	low		
Tineola bisselliella	common clothes moth	USA	yes	Non-quarantine	yes	low		
Tortricidae spp.	budworm	North America	yes	Non-quarantine	no	medium		
Tribolium audax	American black flour beetle	Canada, USA	no	Quarantine	yes	medium	medium	yes
Tribolium brevicorne	flour beetle	Canada, USA	no	Quarantine	yes	low	medium	yes
Tribolium castaneum	red flour beetle	North America	yes	Non-quarantine	yes	high		
Tribolium confusum	confused flour beetle	North America	yes	Non-quarantine	yes	high		
Tribolium destructor	large flour beetle	Canada, USA	no	Quarantine	yes	high	medium	yes
Tribolium madens	black flour beetle	Canada, USA	no	Quarantine	yes	high	medium	yes
Trigonogenius globulus	globular spider beetle	Canada, USA	yes	Non-quarantine	yes	low		
Trogoderma glabrum	glaberous cabinet beetle	Canada, Mexico, USA	no	Quarantine	yes	low	high	yes
Trogoderma granarium	khapra beetle	not present but interceptions recorded	no	Quarantine	yes	high	high	yes
Trogoderma inclusum	large cabinet beetle, mottled dermestid	Canada, USA	no	Quarantine	yes	high	high	yes
Trogoderma ornatum	ornate cabinet beetle	USA	no	Quarantine	yes	low	high	yes
Trogoderma variabile	warehouse beetle	USA	yes (under official control in WA)	Quarantine	yes	high	high	yes
Typhaea stercorea	hairy fungus beetle	North America	yes	Non-quarantine	yes	low		
Zabrotes subfasciatus	Mexican bean beetle	southern USA, Mexico	no	Non-quarantine	yes	high	low	yes

Table 14.3. Quarantine status of weed species associated with maize grain imported from the USA.

Weed	Common name/s	Present in USA	Present in Australia	Australian Quarantine Status	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Abutilon theophrasti (herbicide resistant)	velvet leaf	yes	no	Quarantine	high	medium	yes
Acanthospermum hispidum	star burr, goat's head	yes	yes*	Quarantine	medium-high	high	yes
Aeschynomene virginica	Northern jointvetch	yes	no	Quarantine	medium-high	medium	yes
Alopecurus myosuroides	slender foxtail	yes	yes	Non-quarantine			
Amaranthus albus	tumble pigweed	yes	yes	Non-quarantine			
Amaranthus arenicola	sandhills amaranth	yes	no	Quarantine	high	low	yes
Amaranthus chlorostachys		yes	no	Quarantine	high	low	yes
Amaranthus hybridus	smooth pigweed	yes	yes	Non-quarantine			
Amaranthus hybridus (triazine resistant)	smooth pigweed	yes	no	Quarantine	high	high	yes
Amaranthus palmeri (herbicide resistant)	palmer amaranth	yes	no	Quarantine	high	high	yes
Amaranthus retroflexus	redroot pigweed	yes	yes	Non-quarantine			
Amaranthus retroflexus (triazine resistant)	redroot pigweed	yes	no	Quarantine	high	high	yes
Amaranthus rudis (triazine resistant)	common waterhemp	yes	no	Quarantine	high	high	yes
Amaranthus tamariscinus	pigweed	yes	no	Quarantine	high	low	yes
Ambrosia artemisiifolia	common ragweed	yes	yes*	Quarantine	low-medium	high	yes
Ambrosia grayi	woollyleaf bursage	yes	no	Quarantine	medium	medium	yes
Ambrosia trifida	giant ragweed	yes	no	Quarantine	medium-high	high	yes
Anoda cristata	spurred anoda	yes	yes	Non-quarantine			
Apocynum cannabinum	hemp dogbane	yes	no	Quarantine	high	high	yes
Artemisia annua	wormwood	yes	yes	Non-quarantine			
Asclepias syriaca	common milkweed	yes	no	Quarantine	high	medium	yes
Avena fatua	wild oat	yes	yes	Non-quarantine			
Avena sativa	oat	yes	yes	Non-quarantine			
Barbarea vulgaris	wintercress	yes	yes	Non-quarantine			
Bassia scoparia (Kochia scoparia)	kochia	yes	yes*	Quarantine	medium-high	high	yes
Berteroa incana	hoary Alison	yes	no	Quarantine	medium	low	yes
Bidens aurea		yes	no	Quarantine	low	low	yes
Brachiaria platyphylla	broadleaf signalgrass	yes	no	Quarantine	high	high	yes
Brassica japonica	wild mustard	yes	no	Quarantine	medium	low	yes
Brassica kaber	charlock	yes	yes	Non-quarantine			
Brassica nigra	black mustard	yes	yes	Non-quarantine			

Weed	Common name/s	Present in USA	Present in Australia	Australian Quarantine Status	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Bromus tectorum	downy brome, drooping brome	yes	no	Quarantine	medium	high	yes
Brunnichia ovata	redvine	yes	no	Quarantine	medium	medium	yes
Calystegia sepium	hedge bindweed	yes	yes	Non-quarantine			
Campsis radicans	trumpet creeper	yes	yes	Non-quarantine			
Cardiospermum halicacabum	balloonvine	yes	yes	Non-quarantine			
Cenchrus incertus	spiny burgrass	yes	yes*	Quarantine	medium-high	medium	yes
Cenchrus longispinus	longspine sandbur	yes	yes*	Quarantine	medium-high	medium	yes
Chamaesyce maculata (*Euphorbia supina*)	prostrate spurge	yes	yes*	Quarantine	medium	medium	yes
Chenopodium album	common lambsquaters	yes	yes	Non-quarantine			
Chenopodium album (atrazine resistant)	fathen	yes	no	Quarantine	medium-high	high	yes
Cirsium arvense	Canada thistle, perennial thistle	yes	yes*	Quarantine	medium-high	high	yes
Citrullus vulgaris var. *citroides*	wild watermelon	yes	yes	Non-quarantine			
Cocculus carolinus	redberry moonseed	yes	no	Quarantine	medium	low	yes
Conringia orientalis	hare's ear	yes	yes*	Quarantine	medium	low	yes
Convolvulus arvensis (herbicide resistant)	field bindweed	yes	no	Quarantine	high	medium	yes
Conyza canadensis	horseweed	yes	yes	Non-quarantine			
Cynanchum laeve (*Ampelamus albidus*)	honeyvine milkweed	yes	no	Quarantine	medium	medium	yes
Cynodon dactylon	bermuda grass	yes	yes	Non-quarantine			
Cyperus esculentus	yellow nutgrass	yes	yes*	Quarantine	high	high	yes
Cyperus rotundus	purple nutsedge	yes	yes*	Quarantine	high	high	yes
Datura inoxia	downy thornapple	yes	yes*	Quarantine	low-medium	low	yes
Datura inoxia (resistant to ALS herbicides)	downy thornapple	yes	no	Quarantine	medium	low	yes
Datura stramonium	jimsonweed	yes	yes*	Quarantine	high	high	yes
Daucus carota	wild carrot	yes	yes	Non-Quarantine			
Desmodium tortuosum	Florida beggarweed	yes	yes	Non-quarantine			
Digitaria ischaemum	smooth summer grass	yes	yes	Non-quarantine			
Digitaria sanguinalis	crabgrass	yes	yes	Non-quarantine			
Echinochloa colonum	awnless barnyard grass	yes	yes	Non-quarantine			
Echinochloa crus-galli	barnyard grass	yes	yes	Non-quarantine			
Echinochloa crus-galli (herbicide resistant)	barnyard grass	yes	no	Quarantine	high	high	yes
Eleusine indica	goosegrass	yes	yes	Non-quarantine			
Equisetum arvense	common horsetail	yes	yes*	Quarantine	medium	medium	yes

Weed	Common name/s	Present in USA	Present in Australia	Australian Quarantine Status	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Elytrigia repens	quackgrass	yes	yes	Non-quarantine			
Eragrostis cilianensis	stinkgrass	yes	yes	Non-quarantine			
Eriochloa villosa	woolly cupgrass	yes	no	Quarantine	high	medium	yes
Erigeron annuus	annual fleabane	yes	no	Quarantine	medium	medium	yes
Eupatorium capillifolium	dog fennel	yes	no	Quarantine	low	medium	yes
Helianthus annuus (herbicide resistant)	sunflower	yes	no	Quarantine	low	medium	yes
Hibiscus trionum	venice mallow	yes	yes	Non-quarantine			
Ipomoea hederacea	entireleaf morningglory, ivyleaf morningglory	yes	yes*	Quarantine	high	high	yes
Ipomoea lacunosa	morningglory	yes	no	Quarantine	high	high	yes
Ipomoea purpurea	tall morningglory	yes	yes*	Quarantine	high	high	yes
Ipomoea turbinata	morningglory	yes	no	Quarantine	high	low	yes
Jacquemontia tamnifolia	morningglory	yes	no	Quarantine	medium	low	yes
Lamium amplexicaule	hen bit	yes	yes	Non-quarantine			
Lolium multiflorum (herbicide resistant)	Italian ryegrass	yes	no	Quarantine	high	medium	yes
Lychnis alba	white campion	yes	yes	Non-quarantine			
Malva neglecta	dwarf mallow	yes	yes	Non-quarantine			
Melochia corchorifolia	redweed	yes	yes	Non-quarantine			
Mollugo verticillata	Indian chickweed	yes	yes	Non-quarantine			
Muhlenbergia frondosa	wirestem muhlys	yes	no	Quarantine	medium	low	yes
Panicum capillare	witchgrass	yes	yes	Non-quarantine			
Panicum capillare (herbicide resistant)	witchgrass	yes	no	Quarantine	medium	medium	yes
Panicum dichotomiflorum	fall panicum	yes	no	Quarantine	medium	high	yes
Panicum fasciculatum		yes	no	Quarantine	medium	medium	yes
Panicum miliaceum	wild proso millet	yes	yes	Non-quarantine			
Panicum racemosum		yes	yes	Non-quarantine			
Panicum ramosum		yes	no	Quarantine	medium	low	yes
Panicum texanum	Texas panicum	yes	no	Quarantine	medium	medium	yes
Paspalum boscianum		yes	no	Quarantine	medium	medium	yes
Paspalum ciliatifolium		yes	yes	Non-quarantine			
Paspalum dilatatum	paspalum	yes	yes	Non-quarantine			
Passiflora incarnata	mayhop passionfruit	yes	yes	Non-quarantine			
Physalis heterophylla	clammy groundcherry	yes	no	Quarantine	medium	medium	yes
Poa pratensis	kentucky bluegrass	yes	yes	Non-quarantine			
Polygonum aviculare	knotweed	yes	yes*	Quarantine	medium-high	medium	yes

Weed	Common name/s	Present in USA	Present in Australia	Australian Quarantine Status	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Polygonum bungeanum		yes	no	Quarantine	medium	medium	yes
Polygonum convolvulus (AQIS status changed to permitted since release of draft)	knotweed	yes	yes	Non-quarantine			
Polygonum lapathifolium	knotweed	yes	yes*	Quarantine	medium-high	low	yes
Polygonum pensylvanicum	Pennsylvania smartweed	yes	yes*	Quarantine	high	high	yes
Portulaca oleracea	pigweed	yes	yes	Non-quarantine			
Raphanus raphanistrum	wild radish	yes	yes*	Quarantine	high	high	yes
Richardia scabra		yes	yes	Non-quarantine			
Rottboellia cochinchinensis	itchgrass	yes	yes	Non-quarantine			
Rubus allegheniensis	wild blackberry	yes	no	Quarantine	medium	low	yes
Rubus fruticosus	blackberry	yes	yes*	Quarantine	medium	low	yes
Rumex crispus	curled dock	yes	yes	Non-quarantine			
Salsola collina	tumble thistle	yes	no	Quarantine	medium-high	low	yes
Salsola kali (*Salsola kali* subsp. *ruthenica*)	Russian thistle	yes	yes	Quarantine	medium high	high	yes
Salvia reflexa	mintweed	yes	yes*	Quarantine	low-medium	low	yes
Senecio vulgaris (revised to non-quarantine following release of draft)	common groundsel	yes	yes	Non-quarantine			
Senna obtusifolia	Java bean	yes	yes*	Quarantine	high	high	yes
Senna occidentalis		yes	yes	Non-quarantine			
Sesbania exaltata	Hemp sesbania	yes	yes	Non-quarantine			
Setaria faberi	giant foxtail	yes	no	Quarantine	medium	high	yes
Setaria glauca	yellow foxtail	yes	yes	Non-quarantine			
Setaria italica	foxtail	yes	yes	Non-quarantine			
Setaria lutescens (herbicide resistant)	foxtail	yes	no	Quarantine	medium	medium	yes
Setaria verticillata	foxtail	yes	yes*	Quarantine	medium	low	yes
Setaria viridis	foxtail	yes	yes	Non-quarantine			
Sicyos angulatus	burcucumber	yes	no	Quarantine	high	high	yes
Sida spinosa	prickly sida	yes	yes	Non-quarantine			
Sinapis arvensis	charlock	yes	yes	Non-quarantine			
Solanun nigrum	black nightshade	yes	yes	Non-quarantine			
Solanum sarrachoides	nightshade	yes	yes	Non-quarantine			
Solanum ptycanthum	eastern black nightshade	yes	no	Quarantine	medium-high	high	yes
Sorghum x almum	Columbus grass	yes	yes*	Quarantine	medium	low	yes

Weed	Common name/s	Present in USA	Present in Australia	Australian Quarantine Status	Potential Economic Impact	Probability of Introduction	Quarantine Management Required
Sorghum bicolor	shattercane	yes	yes	Non-quarantine			
Sorghum halepense	johnson grass	yes	no	Quarantine	high	high	yes
Stellaria media	common chickweed	yes	yes	Non-quarantine			
Striga asiatica	witchweed	yes	no	Quarantine	high	low	yes
Taraxacum officinale	dandelion	yes	yes	Non-quarantine			
Thlaspi arvense	penny cress	yes	yes*	Quarantine	high	medium	yes
Verbesina encelioides	crownbeard	yes	yes*	Quarantine	medium	low	yes
Xanthium spinosum	common cocklebur	yes	yes*	Quarantine	high	high	yes
Xanthium strumarium (complex that includes *X. pensylvanicum*)	noogoora burr	yes	yes*	Quarantine	high	high	yes
Xanthium strumarium. (resistant to imidazolinone)	noogoora burr	yes	no	Quarantine	high	medium	yes

* Regulated taxa in Australia by AQIS or State Legislation

15. APPENDIX 3: Technical Working Group Membership and Terms of Reference

Technical Working Group 1: Disease Risk Analysis

Membership

Professor John Irwin (Chair)	Professor and CEO Cooperative Research Centre for Tropical Plant Pathology University in Queensland
Dr Sharan Singh	Manager, Grains and Seeds Market Access Plant Quarantine Policy Branch Policy and International Division Australian Quarantine and Inspection Service
Dr Joe Kochman	Principal Plant Pathologist Queensland Department of Primary Industries
Mr Gordon Murray	Plant Pathologist NSW Agriculture

Terms of reference

- Identify quarantine diseases associated with imports of maize grain from the USA consistent with the International Standard for Phytosanitary Measures (ISPM), Guidelines for Pest Risk Analysis, developed by the Food and Agriculture Organization of the United Nations (FAO), and in particular assess the potential of these diseases to
  - enter, establish and spread in Australia and,
  - cause economic damage, including crop losses and loss of export markets.
- Consider various risk management options consistent with the Australian government policy, the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) and relevant international standards, including the FAO International Standards for Phytosanitary Measures (ISPMs).
- Liaise on relevant issues with other Technical Working Groups (TWGs) established under the Risk Analysis Panel (RAP) on the import of maize grain from the USA, and other national and international technical experts, as necessary.
- Assess the key disease risks associated with contamination of bulk maize shipments with seeds of other agricultural plant species such as barley, oat, millet, sorghum, soybean and wheat.
- Report the findings of the working group to the RAP.

Technical Working Group 2: Arthropod Pest Risk Analysis

Membership

Dr Bob Ikin (Chair)	Senior Manager Plant Quarantine Policy Branch Policy and International Division Australian Quarantine and Inspection Service
Dr Jonathan Banks, Dr David Rees	CSIRO Division of Entomology Stored Grain Research Laboratory
Ms Alison Roach	Professional Officer Plant Quarantine Policy Branch Policy and International Division Australian Quarantine and Inspection Service

Terms of reference

- Identify quarantine arthropod pests associated with imports of maize grain from the USA consistent with the International Standard for Phytosanitary Measures (ISPM), Guidelines for Pest Risk Analysis, developed by the Food and Agriculture Organization of the United Nations (FAO), and in particular assess the potential of these pests to
  - enter, establish and spread in Australia and,
  - cause economic damage, including crop losses and loss of export markets.
- Consider various risk management options consistent with the Australian government policy, the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) and relevant international standards, including the FAO International Standards for Phytosanitary Measures (ISPMs).
- Liaise on relevant issues with other Technical Working Groups (TWGs) established under the Risk Analysis Panel (RAP) on the import of maize grain from the USA, and other national and international technical experts, as necessary.
- Report the findings of the working group to the RAP.

Technical Working Group 3: Weed Risk Analysis

Membership

Dr Bill Roberts (Chair)	Chief Plant Protection Officer Office of the Chief Plant Protection Officer Agriculture, Forestry and Fisheries, Australia
Dr Acharee Pheloung	Professional Officer Plant Quarantine Policy Branch Australian Quarantine and Inspection Service
Dr. John Swarbrick	Weed Science Consultant (former Associate Professor of Weed Science, University of Queensland)

Terms of reference

- Identify quarantine weeds associated with imports of maize grain from the USA consistent with the International Standard for Phytosanitary Measures (ISPM), Guidelines for Pest Risk Analysis, developed by the Food and Agriculture Organization of the United Nations (FAO), and in particular assess the potential of these weeds to
  - enter, establish and spread in Australia and,
  - cause economic damage, including crop losses and loss of export markets.
- Consider various risk management options consistent with the Australian government policy, the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) and relevant international standards, including the FAO International Standards for Phytosanitary Measures.
- Liaise on relevant issues with other Technical Working Groups (TWGs) established under the Risk Analysis Panel (RAP) on the import of maize grain from the USA, and other national and international technical experts, as necessary.
- Report the findings of the working group to the RAP.

Technical Working Group 4: Operational Issues

Membership

Mr Mev Connell (Chair)	Private Consultant
Mr Bill Magee	Program Manager, Grain Animal and Plant Programs Branch Quarantine and Exports Operations Division Australian Quarantine and Inspection Service
Mr Mike Robbins	Manager/Senior Inspector Technical Services Western Australia Quarantine Inspection Service Australian Quarantine and Inspection Service

Terms of reference

- Identify operational issues relevant to the importation of maize grain from the USA.
- Consider various risk management options consistent with the Australian government policy, the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) and relevant international standards, including the FAO International Standards for Phytosanitary Measures.
- Liaise with other Technical Working Groups (TWGs) and national and international technical experts, as necessary, on relevant issues identified by other TWGs and this working group.
- Develop and assess operational procedures for implementation of management options recommended by other TWGs.
- Report the findings of the working group to the Risk Analysis Panel (RAP).

16. APPENDIX 4. Impact of management options on maximum weed seed number in maize shipments and potential for establishment

Acharee Pheloung and Bill Roberts
Technical Working Group (Weeds) for bulk maize IRA

1 SUMMARY

A quantitative model based on available weed contamination data was developed to explore different strategies for managing the risk of weed establishment. Without management options to reduce weed seeds in a maize consignment, the model indicated that there will be the potential of 123–441 quarantine weed establishments depending on the level of contamination. The results support the previous conclusions that devitalisation treatment was the most effective treatment for reducing weed establishment potential. The second best option was to increase sample size, in which a nil tolerance for weed seeds is required, to 10 kg. This option would reduce establishment potential to 5 weed seed establishments per shipment. Screening at 70% efficiency reduced weed establishment to 37 per shipment. Integration of sampling and screening did not reduce weed risk as much as devitalisation treatment alone. If the level of quarantine weed seed contamination is at 0 seed/kg of maize (in the sample tested) then devitalisation at 99% efficacy can reduce weed establishment potential to less than 1 per shipment.

2 PURPOSE

2.1. To compare the effect of management options on the number of quarantine weed seeds in a shipment and in spilt maize.

2.2. To predict the establishment of quarantine weeds after spillage during transport and storage in Australia.

3 BACKGROUND

3.1 Qualitative weed risk analysis

The qualitative weed risk analysis of bulk maize grain imported from the USA indicated a high risk of introducing quarantine weeds as contaminants. The Bulk Maize Import Risk Analysis Technical Working Group (TWG) on weeds examined three major management options to reduce the risk to an acceptable level:

- Basic screening
- Increased sample size in which a nil tolerance for quarantine weed contaminants in grain shipment is imposed
- Devitalisation treatments
- The efficacy of these management options will affect the number of viable quarantine weed seeds that could be present in shipments of maize to be imported, and the probability that these weed seeds would be spilt and establish in Australia.

3.2 Estimating the proportion of grain spillage

A high level of grain spillage during loading, storage and transportation was found from survey data in farms on the Darling Downs, Queensland (Sinclair, 1982). Transportation of maize imported in

1994-1995 was conducted under a stringent protocol to minimise spillage; the trucks were sealed with plastic. There was, however, evidence of spillage during loading and unloading in the feed lots and processing plants, many of which were situated close to agricultural fields. The amount of spilt grain was estimated to be 500-1000 kg per shipment of 30,000 tonnes (Phillips *et al*, 1994).

4 QUANTITATIVE ANALYSIS

The efficiency of management options was compared to determine the number of viable weed seeds that may be present in spilt grain.

4.1 Management Option 1. Basic seed cleaning

Effect of basic screening method on weed seed number in bulk maize

The efficacy of basic seed cleaning procedures was estimated to be 70-95%. The efficiency of screening depends on the type of screen used and the seed size of grain and weeds. These range from a single screen with or without a small fan to six or seven screens with multiple fans (Linnett, 1981). Based on our previous analysis, there were 22 out of 72 weed species which are similar in seed size to that of maize. These seeds may not be easily separated from maize by basic screening techniques.

Table 1. Estimation of quarantine weeds expected to remain as contaminants after basic seed cleaning methods

Weed species found in sample of grain	**Before screening**		**Cleaning efficiency (%)**	
	Weed seed* (No/kg)	Weed seed (No/tonne)	70% Weed seed (No./tonnes)	95% Weed seed (No./tonnes)
Abutilon theophrasti	10	10,000	3,000	500
Amaranthus spp.	314	314,000	94,200	15,700
Ambrosia spp.	6	6,000	1,800	300
Ipomoea spp	1	1,000	300	50
Bassia sp	29	29,000	8,700	1,450
Panicum spp.	62	62,000	18,600	3,100
Polygonum pensylvanicum	4.4	4,400	1,320	220
Setaria spp.	201	201,000	60,300	10,050
Sorghum halepense	100	100,000	50,000	5,000
Xanthium spp.	4	4,000	1,200	200

*****Data from seed analysis of grains imported from the USA, Source: Grain Taskforce file (1995)

4.2 Management Option 2: Requirement of nil tolerance for quarantine weed seeds in a larger sample size

Effect of sample size on weed seed number in 1 tonne of spilt maize

AQIS routinely uses ISTA sampling guidelines, which require a 1 kg working sample for maize in which a nil tolerance for quarantine weed seeds is imposed. From the sample size used and number of weed seeds found (if any) in the sample the maximum number of weed seeds that could be present in a maize shipment can be predicted (Cannon and Roe, 1982; Roberts, *et al*, 1995). This approach is also described in the TWG (Weeds) report.

The expected number of weed seeds present in 1 tonne of grain, when no weed seeds are detected in various sample sizes is shown in Table 2.

Table 2 The maximum number of weed seeds that could be present if no quarantine weeds are found in samples of varying sizes. These figures are based on a ninety five percent confidence level.

Total maize shipment (tonnes)	Total maize working sample size (kg)	Maximum weed seeds (No/kg)	Maximum weed number (in shipment)	Maximum weed seed number in 1 tonne
50,000	1	3.64	109,200,000	3,640
	2	1.82	54,600,000	1,820
	5	0.73	21,900,000	730
	10	0.36	10,800,000	360
	20	0.18	5,400,000	180
	50	0.07	2,100,000	70

4.3 Management Option 3: Devitalisation of grain shipment

Effect of devitalisation on weed seed number in spilt maize

Devitalisation by steam heat treatment at 95-100°C for 10-30 min was found to be 93-100% effective in killing weed seeds (Grain Taskforce File, 1994-1995). The efficiency of this treatment alone or combined with other management options is shown in Table 3a, b and c.

Table 3a. Effect of devitalisation treatments with varying efficacy on weed seed number in bulk maize with and without cleaning at 70 and 90% efficiency. This example uses *Xanthium*, which has been found in imported maize at 4 seeds/kg.

Treatment	Expected *Xanthium* seeds/tonne		
	No cleaning	Cleaning at 70 % efficiency	Cleaning at 90% efficiency
No devitalisation treatment	4,000	1,200	400
Devitalisation (99% efficacy)	40	12	4
Devitalisation (99.99% efficacy)	0.4	0.12	0.04

Table 3b. Effect of devitalisation treatments with varying efficacy on weed seed number in spilt maize with and without cleaning at 70% and 90% efficiency. This example uses *Bassia*, which has been found in imported grain at 29 seeds/kg.

Treatment	Expected viable *Bassia* seeds/tonne		
	No cleaning	Cleaning at 70% efficiency	Cleaning at 90 % efficiency
No devitalisation treatment	29,000	8,700	2,900
Devitalisation treatment (99% efficacy)	290	87	29
Devitalisation treatment (99.99% efficacy)	2.9	0.87	0.29

Table 3c. Effect of varying sampling intensity and varying devitalisation treatments on viable weed seed number in maize.

Treatment	Maximum number of viable weed seeds/tonne where no seed is found when using a sample size of:			
	1 kg	2 kg	5 kg	20 kg
No devitalisation treatment	3640	1820	730	180
Devitalisation treatment (99% efficacy)	36.4	18.2	7.3	1.8
Devitalisation treatment (99.99% efficacy)	0.364	0.182	0.073	0.018

4.4 Prediction of weed seed establishment as affected by various management strategies

Phillips *et al* (1994) identified three key factors for which information is needed for quarantine decision making on the probability of pest establishment:

a) a particular pest is likely to present in the shipment;
b) it is likely to pass the quarantine barrier, (ie. undetected by conventional sampling procedures) and;
c) the pest has a high potential to establish and spread in Australia.

In the current analysis, the presence of these factors have been established and supported by published data. Some other parameters that would effect the establishment potential of quarantine weeds are reviewed below.

The analysis in the previous section focused on weed seeds that have been detected using the conventional sampling methods, however, previous reports identified a number of other quarantine weed species that were likely to be contaminants in bulk maize grain imported from the USA. Many of these species would not be detected, particularly when present at lower than 1 seed/kg. Based on a sampling intensity of 1 kg quarantine weed seeds could be present at up to 3640 seeds in 1 tonne of maize grain and not be detected (Table 2).

4.4.1 Estimate of seed germination and seedling survival

The probability that spilt weed seed would establish and spread in Australia depends on many biological factors. These include seed viability, persistence (seed dormancy, drought tolerance or ability to adapt to a broad range of climates, unpalatability, absence of natural enemies etc.), and the ability to produce many viable seed, particularly by self-pollination. The identified quarantine weeds have many of these characteristics and were assessed as presenting a high risk of becoming established in the Australian environment.

Germination ability of maize grain imported from the USA during 1994-1995 was found to be around 70-80%. After cracking, imported maize grain remained viable with a germination ability of 55% (Grain Taskforce file, 1995). This suggests that even mechanical processing such as cracking is unlikely to destroy the viability of weed seeds. A number of weed contaminants were identified during seed analysis and generally their viability, tested before heat treatment trials, was high (90-98%) indicating that if weed seeds are present they are likely to be viable. Many experiments indicate that quarantine weed seeds such as *Bassia*, *Xanthium*, *Ipomoea*, *Panicum, Ampelamus, Apocynum* and *Amaranthus* remained highly viable in the environment for more than 3 years (Evetts and Burnside, 1972; Egley and Chandler, 1978; Zorner *et al*, 1980). After being buried for 10 years, germination ability of *Amaranthus* spp., *Ampelamus* sp. and *Panicum* sp. did not decrease (Burnside *et al*, 1981).

Spillage along roadsides, railways or feedlots often does not provide suitable conditions for seed to germinate. In this analysis, the chance of a weed seed being spilt in an environment suitable for germination was estimated at 10%. Of the weed seed that did germinate a further assumption was made that only 10% of the germinating weed seeds would reach a reproductive stage and produce another generation. This gives a probability of 1% that a weed seed that was spilt would establish and reproduce. . These estimates are based on published data on weed establishment capability (eg. Louda *et al*, 1990; Piggin, 1976; Johnson and Thomas, 1978). Climate similarity analysis (Pheloung, 1990) also indicates that the climate in Australian production areas is suited to the establishment of quarantine weeds identified in the TWG (Weeds) report.

4.4.2 Model developed to predict potential weed seed establishment

Based on above information and assumptions, a simple mathematical model was developed to predict the chance of quarantine weed establishment under different management options. The calculation may be collectively applied to all weed species in a shipment, or applied to each of weed seed species individually, if required.

Sample Size

Total weed seeds in shipment estimated from the number of weed seeds found in a 1 kg sample. This step allows the estimation of weed seeds present in a shipment before management is applied.

$W = C*L_x*1000$ ....(Equation 1)

Where:

W is the estimated total weed seed in a maize shipment;
C is the shipment size (tonnes);
L is the expected maximum quarantine weed seed number in x kg of maize before application of management options (derived from the number of quarantine weed seeds found in x kg; Appendix 2)

If a conventional sampling system is applied, the shipment is required to be cleaned to a level such that no quarantine weeds are found in a 1 kg sample size. This is the current requirement for seed/grain imported into Australia.

Alternatively, if the required sample size in which no quarantine weed seeds are to be found were increased to 10 kg, the maximum expected weed seeds in the whole shipment would be reduced. The maximum number of weed seed in the shipment is calculated as in equation 1 by altering the sample size (x). The expected maximum seed number in 1 kg of maize where no weed seeds was found in a given sample size is shown at Appendix 2.

Screening and devitalisation

Having calculated the maximum level of weed seed contamination in a shipment, the effect of screening and devitalisation on weed seed number can be calculated. The required treatment efficacy may be varied depending on the level of quarantine weed seeds found in a shipment and the practicality of treatments applied.
Management options may be incorporated into the equation:

$T=1-(1-F)*(1-D)$ ....(Equation 2)

Where:

T is overall management efficiency (%)
F is screening efficiency (%)
D is devitalisation efficiency (%)

Where either screening or devitalisation is not applied, the respective parameters, F or D, are set to 0.

Example: When two management options are combined, if the efficacy of F is 80% and the efficacy of D is 90%, then T efficacy will be 98%.

Weed Establishment

The potential for weed establishment is dependent on how much grain is spilt and the capacity of weed seed in the spilt grain to establish under a range of conditions. Establishment potential may be predicted by incorporating these parameters into the model. In this analysis, the establishment is based on two parameters, the probability of weed seed germinating and then surviving until the reproductive stage and producing seed in subsequent generations. To predict potential weed establishment, these parameters can be incorporated into either of the above equations.
Potential weed establishment may be predicted as follows:

$G = S*V*R$ ....(Equation 3)

Where:
G is probability of weed seed being spilt, germinating and reproducing (%)
S is the rate of maize spillage per shipment (in this analysis set at 0.003% of a shipment)
V is the estimate of weed seed germination (%) (in this analysis estimated at 10%)
R is seedling survival (in this analysis estimated at 10%)

Incorporating all the components
Incorporation of shipment levels of weed seed, management and establishment is achieved as follows:

E = W*(1-T)*G .... (equation 4)

Where
E is the overall weed establishment potential (plants per shipment)

The use of several management options may be useful when the practical efficacy of each option applied alone is insufficient. For example, the basic cleaning technique may not be sufficient on its own to eliminate quarantine weed seeds, a severe heat treatment may cause adverse effects to maize nutrition quality or storage ability. Or the sample size required to effectively reduce the chance of weed establishment is too high and not practical.

Using this equation, the parameters can be varied to predict potential of weed establishment. Varying efficiency of management options and other parameters in the model may facilitate decision making on implementing an appropriate management strategy. Examples of how to generate management options and parameters using an excel spreadsheet to calculate the results are shown at Appendix 1.

Model Outcomes

Table 4a-d are various scenarios to estimate the likelihood of weed establishment based on efficiency of management options at different sampling regimes.

Table 4. Predicted number of weed seed in spilt grain and establishment potential as influenced by different management options; based on a shipment size (C) of 50,000 tonnes, spillage (S) of 0.003%

a Four quarantine weed seeds found[1] in 1 kg sample with screening (F) at 70% efficiency and devitalisation treatment at (D) 99% efficiency

Management option	Predicted potential viable number of weed seed:		
	In shipment	In spilt grain	Established per shipment
No management	410,666,060	12320	123.2
Screening	123199818	3696	36.95
Devitalisation	4106661	123.2	1.232
Devitalisation and screening	1231998	36.960	0.3696

b Twenty nine quarantine weed seeds found[1] in 1 kg sample with screening at (F) 90% efficiency and devitalisation treatment at (D) 99% efficiency

Management option	Viable weed seed in shipment	Viable weed seed in spilt grain	Potential weed established per shipment
No management	1,470,843,326	44,125.300	441.25
Screening	147,084,333	4,412.530	44.125
Devitalisation	14,708,433	441.253	4.412
Screening and devitalisation	1,470,843	44.125	0.4412

c No quarantine weed seed found in 1 kg sample with screening at (F) 70% efficiency and devitalisation treatment at (D) 99% efficiency

Management option	Viable weed seed number in shipment	Viable weed seed in spilt grain	Potential weed established per shipment
Sampling	18,1823,268	5455	54.54
Screening	54546980	1636.409	16.364
Devitalisation	1818233	54.547	0.5455
Screening and devitalisation	545470	16.364	0.1636

d No quarantine weed seed found in 10 kg sample with screening (F) at 70% efficiency and devitalisation treatment (D) at 99% efficiency

Management option	Viable weed seed number in shipment	Viable weed seed in spilt grain	Potential weed established per shipment
Sampling	18,183,831	546	5.45
Screening	5,455,149	164	1.63
Devitalisation	181,838	5.455	0.0546
Screening and devitalisation	54,551	1.637	0.0164

1 Based on averaged results from samples of grain shipments imported to Australia

5 DISCUSSION

This quantitative risk analysis of management options supports the previous qualitative analysis that an effective devitalisation treatment is the best option to reduce the risk of quarantine weeds establishing in Australia. This is a consequence of the significant number and range of weed seeds that would be present in imported grain. Devitalisation at 99% efficiency could reduce weed establishment potential to 1.23 per shipment when contamination level was at 4 seeds/kg of maize (Table 4a) and to 4.412 when contamination level was higher (Table 4b). Using a conventional sampling requirement of nil tolerance in 1 kg of maize combined with a devitalisation treatment could reduce weed establishment potential to 0.545 (Table 4c). Further increasing sampling intensity from 1 kg to 10 kg combined with a devitalisation treatment could reduce the chance of weed establishment to 0.0546 (Table 4d). Sampling at 10 kg and screening at efficiency of 70% reduced the establishment potential to 1.63 per shipment (Table 4d).

The calculation in Table 4a was based on 4 quarantine weed seeds being found in one kg sample of maize which is the working sample size required based on ISTA sample guidelines. This sample size is currently being used to detect quarantine weed seeds. Often, there may be more than 4 quarantine weed seeds found in a 1 kg working sample of maize before screening or without management procedures. If there were higher numbers of quarantine weed seeds found in 1 kg of maize, particularly likely in lower grades of grain, the risk of weed establishment would be higher when based on similar management efficacy. Therefore, the efficiency of devitalisation would need to be higher than 99% when lower grade grain consignments were imported.

The calculation is based on a shipment of 50,000 tonnes, as was recorded for one of the shipments in 1995. To predict the likelihood of quarantine weed establishment per year, the total annual tonnage of maize imported would need to be considered. The analysis showed that if no quarantine weed seeds are found in a 1 kg sample from a shipment size of 50,000 tonnes, a 99% effective devitalisation treatment is sufficient to reduce the risk to less than 1 weed establishment.

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Appendix 1. An Excel spreadsheet used to calculate the establishment potential of weed seeds

Each parameter in Equation 1 can be varied and input into the excel spreadsheet to generate the output which is the prediction of weed establishment. The maximum seed number for the sample size specified is derived from Table 2; only sample size was required as input into spreadsheet.

Example 1 *Xanthium* spp.

Contaminant calculator	
Weed:	*Xanthium*
Contaminants in consignment (#/kg)	4
X: Sample size (nil tolerance in # kg)):	10
F: Screening efficiency (%)	70%
D: Devitalisation efficiency (%)	99%
S: Spillage (%)	0.003%
V: Seed germination (%)	10%
R: Seedling survival (%)	10%
C: Shipment size	50 000

Number of weeds:

Management	/tonne	in consignment	spilled	established
No management	8213	410 666 060	12320	123
Sampling	364	18 183 831	546	5.5
Screening	2464	123 199 818	3 696	40
Sampling & Screening	109.10	5 455 149	164	1.6
Treatment	82.13	4 106 661	123	1.2
Sampling and Treatment	3.64	181 838	5.5	0.055
Treatment and Screening	24.64	1 231 998	37	0.37
Sampling, Treatment and Screening	1.09	54 551	1.64	0.016

Example 2 *Bassia* sp.

Contaminant calculator

Weed:	*Bassia*
Contaminants in consignment (#/kg)	29
X: Sample size (nil tolerance in # kg)):	10
F: Screening efficiency (%)	90%
D: Devitalisation efficiency (%)	99%
S: Spillage (%)	0.003%
V: Seed germination (%)	10%
R: Seedling survival (%)	10%
C: Shipment size	50 000

Number of weeds:

Management	/tonne	in consignment	Spilled	established
No management	29417	1 470 843 326	44125	441
Sampling	364	18 183 831	546	5.5
Screening	2942	147084 333	4413	44
Sampling & Screening	37	1 818 383	55	0.55
Treatment	294	14 708 433	441	4.4
Treatment and Sampling	3.6	181 838	5.5	0.055
Treatment and Screening	29	1 470 843	44	0.44
Treatment and Sampling and Screening	0.36	18 184	0.55	0.0055

Appendix 2. Maximum number of weed seeds per kg of grain (95% confidence) for a given number found in a given sample size

Sample size (kg)	Number of weed seeds found in the sample							
	0	1	2	3	5	10	20	50
0.25	14.54	21.11	27.13	32.84	43.74	69.37	117.61	254.23
0.5	7.27	10.56	13.57	16.42	21.88	34.69	58.82	127.18
0.75	4.85	7.04	9.04	10.95	14.59	23.13	39.22	84.80
1	3.64	5.28	6.78	8.21	10.94	17.35	29.42	63.60
2	1.82	2.64	3.39	4.11	5.47	8.68	14.71	31.81
3	1.21	1.76	2.26	2.74	3.65	5.78	9.81	21.20
4	0.91	1.32	1.70	2.05	2.74	4.34	7.36	15.90
5	0.73	1.06	1.36	1.64	2.19	3.47	5.88	12.72
10	0.36	0.53	0.68	0.82	1.09	1.74	2.94	6.36
20	0.18	0.26	0.34	0.41	0.55	0.87	1.47	3.18
50	0.07	0.11	0.14	0.16	0.22	0.35	0.59	1.27