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Review of policy: importation of potato (*Solanum tuberosum*) propagative material into Australia

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Biosecurity–Plant
Department of Agriculture, Fisheries and Forestry
GPO Box 858
CANBERRA ACT 2601
AUSTRALIA

Telephone	+61 2 6272 3933
Facsimile	+61 2 6272 3307
Email	plant@daff.gov.au
Website	daff.gov.au/biosecurity

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Acronyms and abbreviations

Term or abbreviation	Definition
ALOP	Appropriate level of protection
APPPC	Asia and Pacific Plant Protection Commission
APPD	Australian Plant Pest Database (Plant Health Australia)
CABI	CAB International
CMI	Commonwealth Mycological Institute
COSAVE	Comité de Sanidad Vegetal del Cono Sur
CPPC	Caribbean Plant Protection Commission
DAFF	Australian Government Department of Agriculture, Fisheries and Forestry
DBH	Dot-blot hybridization
ELISA	Enzyme-linked immunosorbent assay
EPPO	European and Mediterranean Plant Protection Organisation
FAO	Food and Agriculture Organization of the United Nations
IAPSC	Inter African Phytosanitary Council
IMF	Immunofluorescence
IPC	International Phytosanitary Certificate
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
IRA	Import Risk Analysis
ISPM	International Standard for Phytosanitary Measures
JUNAC	Comisión del Acuerdo de Cartagena
NAPPO	North American Plant Protection Organization
NPPO	National Plant Protection Organization
OEPP	Organisation Européenne et Méditerranéenne pour la Protection des Plantes
PCR	Polymerase chain reaction
PEQ	Post-entry quarantine
PRA	Pest risk analysis
RT-PCR	Reverse-transcription polymerase chain reaction
SPS	Sanitary and phytosanitary
TEM	Transmission electron microscopy
WTO	World Trade Organisation

Summary

Australia initiated this review as new pathogens have been identified on potatoes and several pathogens have extended their global range. Uncontrolled movement of infected propagative material has helped to spread these pathogens into new areas. This review recommends that:

- the current quarantine pest list be updated and additional measures be applied during quarantine screening;
- potato propagative material be allowed entry into Australia as true potato seed, tissue cultures (microplantlets) and microtubers/minitubers (produced in a protected environment);
- a framework to approve overseas sources (e.g. institutions, national plant protection organisations) be adopted to supply pathogen-tested potato propagative material; and
- the United Kingdom Potato Quarantine Unit (UKPQU) at Science and Advice for Scottish Agriculture (SASA) be approved as a high health source to supply pathogen tested tissues cultures (microplantlets). Approval of this overseas source means that more biosecurity risks are addressed off-shore and the Australian potato industry will have quicker access to new overseas varieties.

Recommended risk mitigation measures

Existing conditions are strengthened through the introduction of additional diagnostic measures to protect Australia from exotic pathogens. The recommended risk management measures for potato propagative material are detailed below.

All sources (unknown health status)

Tissue cultures (microplantlets)

- mandatory on arrival inspection, growth in a closed government post-entry quarantine (PEQ) facility for a minimum period of six months for visual observation; and
- active pathogen testing, including herbaceous indexing and molecular tests.

True potato seed

- mandatory on-arrival inspection, fungicidal treatment, surface sterilisation and growth in a closed government PEQ facility for a minimum period of six months for visual observation; and
- active pathogen testing, including molecular tests.

Microtubers or minitubers (produced in a protected environment)

- certification that microtubers or minitubers are produced in soilless media and tested free of nematodes of quarantine concern to Australia;
- mandatory on-arrival inspection, growth in a closed government PEQ facility for a minimum period of six months for visual observation; and
- active pathogen testing, including herbaceous indexing and molecular tests.

Approved sources (high health status)

Plant Biosecurity recommends that the United Kingdom Potato Quarantine Unit (UKPQU) at Science and Advice for Scottish Agriculture (SASA) be approved as a high health source for pathogen tested potato propagative material as it meets all framework requirements for approval of high health sources. However, Plant Biosecurity will consider requests for approval of other overseas high health sources based on the framework outlined in this review.

All potato propagative material produced by UKPQU, SASA will require:

- A phytosanitary certificate issued by the Scottish Government on behalf of the National Plant Protection Organisation (NPPO), the Food and Environment Research Agency (FERA), with an additional declaration that 'potato propagative material in this consignment has been tested and found free of pests identified by Australia'.
- Mandatory on-arrival inspection.
- Growth in a closed government PEQ facility for a minimum of three months to verify the application of phytosanitary measures, including verification testing for a range of pathogens.
  - If pathogens of quarantine concern are detected during verification tests, the whole consignment will be subject to the same conditions as potato propagative material from all sources.

Plant Biosecurity has made several changes following consideration of stakeholder comments on the *Draft review of policy: importation of potato (*Solanum tuberosum*) propagative material into Australia.* The main changes include:

- The additional requirement for mandatory surface sterilisation of true potato seeds to mitigate the risk of surface contaminants;
- The reassessment of *Spongospora subterranea* f. sp. *subterranea* (*Sss*) and the inclusion of this pathogen as a quarantine pest due to its status as a vector of Potato mop-top virus (PMTV);
- The reassessment of *Polyscytalum pustulans* due to its absence (no longer present) from Australia and inclusion as a quarantine pest;
- The reassessment of *Phacidiopycnis tuberivora* due to its status as a declared pest in Tasmania and inclusion as a quarantine pest;
- The removal of *Verticillium albo-atrum* as a quarantine pest due to its presence on potatoes in Australia;
- The removal Potato virus A (PVA) as a quarantine pest due to its presence on potatoes in Australia;
- The inclusion of Tomato chlorosis virus (ToCV) to the quarantine list due to its recent detection on potatoes;
- The removal of the generic PCR test for Crinivirus and replacement with generic Closteroviridae PCR for Potato yellow vein virus (PYVV) and Tomato chlorosis virus (ToCV);
- The removal of mandatory ELISA for Potato black ringspot virus (PBRSV) and Tomato black ring virus (TBRV) and replacement with generic nepovirus PCR;
- The removal of mandatory ELISA for Potato latent virus (PotLV) as mandatory generic carlavirus PCR is also recommended;
- The removal of mandatory ELISA for Potato Virus T (PVT), Potato yellowing virus (PYV) and Tobacco necrosis virus (TNV).
  - replacement with generic Betaflexiviridae PCR testing or ELISA for PVT.
  - replacement with specific PCR testing or ELISA for TNV.
  - replacement with generic Bromoviridae testing or ELISA for PYV.
- The removal of herbaceous indexing for Potato latent virus (PotLV), Potato yellowing virus (PYV), and as mechanical transmission may not be reliable and inclusion of molecular testing methods;

- The removal of herbaceous indexing for Beet curly top virus (BCTV), Potato yellow vein virus (PYVV) and Solanum apical leaf curling virus (SALCV) as these viruses are not mechanically transmitted and supplemented or replaced with molecular testing methods including ELISA or PCR;
- The removal of herbaceous indexing for Potato latent virus (PotLV), Potato mop-top virus (PMTV), Potato Virus T (PVT), Potato yellowing virus (PYV) and Tobacco necrosis virus (TNV) as these viruses may have issues with reliable mechanical transmission. Therefore, herbaceous indexing for these viruses is supplemented or replaced with molecular testing methods including ELISA or PCR; and
- The inclusion of a generic reverse-transcription PCR (RT-PCR) test or hybridisation using a cRNA probe for detection of all pospiviroids, including potato spindle tuber viroid (PSTVd).

1 Introduction

1.1 Australia's biosecurity policy framework

Australia's biosecurity policies aim to protect Australia against the risks that may arise from exotic pests[1] entering, establishing and spreading in Australia, thereby threatening Australia's unique flora and fauna, as well as those agricultural industries that are relatively free from serious pests.

The pest risk analysis (PRA) process is an important part of Australia's biosecurity policies. It enables the Australian Government to formally consider the risks that could be associated with proposals to import products into Australia. If the risks are found to exceed Australia's appropriate level of protection (ALOP), risk management measures are recommended to reduce the risk to an acceptable level. If it is not possible to reduce the risks to an acceptable level, then no trade will be allowed.

Successive Australian governments have maintained a conservative, but not a zero risk, approach to the management of biosecurity risks. This approach is expressed in terms of Australia's ALOP, which reflects community expectations through government policy and is currently described as providing a high level of protection aimed at reducing risk to a very low level, but not to zero.

Australia's PRAs are undertaken by the Department of Agriculture, Fisheries and Forestry (DAFF) (Plant Biosecurity and Animal Biosecurity) using teams of technical and scientific experts in relevant fields, and involves consultation with stakeholders at various stages during the process. DAFF provides recommendations for animal and plant quarantine policy to Australia's Director of Animal and Plant Quarantine (the Secretary of DAFF). The Director or delegate is responsible for determining whether or not an importation can be permitted under the *Quarantine Act 1908*, and if so, under what conditions. The Plant Import Operations branch within DAFF (formerly AQIS) is responsible for implementing appropriate risk management measures.

More information about Australia's biosecurity framework is provided in the *Import Risk Analysis Handbook 2007* (update 2009) located on the DAFF risk analysis website http://daff.gov.au/ba.

1.2 This review of existing policy

Australia has a long standing policy to import potato propagative material (tissue cultures and true potato seed) from all countries; however, this policy has not been reviewed for some time. Propagative material represents one of the highest plant quarantine risks as it can harbour various forms of pathogens and arthropod pests. The introduction of plant pathogens, especially with latent infection, is of particular concern in propagative material. A range of exotic arthropod pests and pathogens can be introduced and established via propagative material when imported in a viable state for ongoing propagation.

[1] A pest is any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2009).

Under the previous policy, there were no approved sources to supply pathogen tested potato propagative material to Australia and no framework for approving sources. This review recommends a framework for approval of high health sources.

1.2.1 Background

Many pathogens are associated with the production of potatoes worldwide. As potatoes are propagated mainly by vegetative means, there is considerable risk of introducing and spreading pests through international trade of potato propagative material. The introduction of economically important potato pests into Australia could result in substantial costs in eradication, containment or control. Pest establishment and spread could also lead to an increase in the use of chemical controls and could jeopardize export markets.

Australia's existing policy allows importation of potato propagative material (true potato seed, tissue culture) from any source. The policy includes on-arrival inspection and mandatory treatment and growth in a government post-entry plant quarantine (PEQ) facility, with appropriate disease screening.

Plant Biosecurity initiated this review as new pathogens have recently been detected on potatoes and several pathogens have extended their geographic range. For instance, Potato yellow vein virus has established and spread into new localities (Venezuela and Peru) and Pepino mosaic virus has been recently discovered in native potato cultivars in the Andes and has become a major threat to tomato production in several countries. Uncontrolled movement of infected propagative material has helped to spread these pathogens into new areas.

1.2.2 Scope

Potato propagative material can be imported as true potato seed, tissue cultures (microplantlets) and potato seed tubers (minitubers/microtubers). The scope of this review is limited to:

- the identification of biosecurity risks associated with potato propagative (true potato seed, tissue cultures and potato seed tuber) from all sources;
- the development of a framework for the approval of high health sources for potato propagative material; and
- the proposal of additional measures where appropriate.

This review does not consider existing phytosanitary measures during the pest risk assessment. Existing phytosanitary measures are only considered during the development of risk management measures, following the pest risk analysis.

This policy review is limited to recommending appropriate phytosanitary measures to address the risk of introducing quarantine pests of potato propagative material into Australia. It is the importer's responsibility to ensure compliance with the requirements of all other regulatory and advisory bodies associated with importing commodities to Australia. Among others, these could include the Australian Customs Service, Department of Health and Ageing, Therapeutic Goods Administration, Australian Pesticides and Veterinary Medicines Authority, Department of the Environment, Water, Heritage and the Arts and State Departments of Agriculture.

2 Pest risk analysis

Plant Biosecurity has conducted this pest risk analysis (PRA) in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for pest risk analysis* (FAO 2007) and ISPM 11: *Pest risk analysis for quarantine pests, including analysis of environmental risks and living modified organisms* (FAO 2004). The standards provide a broad rationale for the analysis of the scientific evidence to be taken into consideration when identifying and assessing the risk posed by quarantine pests.

Following ISPM 11, this pest risk analysis process comprises three discrete stages:

- Stage 1: Initiation of the PRA
- Stage 2: Pest Risk Assessment
- Stage 3: Pest Risk Management

Phytosanitary terms used in this PRA are defined in ISPM 5 (FAO 2009).

2.1 Stage 1: Initiation of the PRA

The *initiation* of a risk analysis involves identifying the reason for the PRA and the identification of the pest(s) and pathway(s) that should be considered for risk analysis in relation to the identified PRA area.

This commodity-based pest risk assessment was initiated by Plant Biosecurity as a basis for a review of the existing phytosanitary regulations to import potato propagative material into Australia.

In the context of this PRA, *Solanum tuberosum* propagative material (true potato seed, seed tuber and tissue cultures) is a potential import 'pathway' by which a pest can enter Australia. The pests associated with potatoes worldwide were tabulated from published scientific literature, such as reference books, journals and database searches. This information is set out in Appendix A and forms the basis of the pest categorisation.

For this PRA, the 'PRA area' is defined as Australia for pests that are absent from Australia or of limited distribution and under official control in Australia.

2.2 Stage 2: Pest Risk Assessment

A pest risk assessment is the 'evaluation of the probability of the introduction and spread of a pest and of the magnitude of the associated potential economic consequences' (FAO 2009, p. 13). The pest risk assessment provides technical justification for identifying quarantine pests and for establishing phytosanitary import requirements.

This is a commodity-initiated pest risk analysis and risk is estimated through a standard set of factors that contribute to introduction, establishment, spread and economic impact potential of pests. This pest risk assessment was conducted using three consecutive steps: pest categorisation; assessment of the probability of entry, establishment and spread; and assessment of potential consequences.

2.2.1 Pest categorisation

Pest categorisation is a process to examine, for each pest identified in Stage 1 (Initiation of the PRA process), whether the criteria for a quarantine pest is satisfied. In the context of propagative material, pest categorisation includes all the main elements of a full pest risk assessment but is done in less detail and is essentially a quick assessment to identify pests of quarantine concern. The process of pest categorisation is summarised by ISPM 11 (FAO 2004) as a screening procedure based on the following criteria:

- identity of the pest;
- presence or absence in the endangered area;
- regulatory status;
- potential for establishment and spread in the PRA area; and
- potential for economic consequences (including environmental consequences) in the PRA area.

Pests are categorised according to their association with the pathway, their presence or absence or regulatory status, their potential to establish or spread, and their potential for economic consequences. Pests associated with potatoes listed in Appendix A were used to develop a pathway-specific pest list for all pathways (true potato seed, minitubers/microtubers and tissue culture). This list identifies the pathway association of pests recorded on potatoes and their status in Australia, their potential to establish or spread, and their potential for economic consequences. Pests that are likely to be associated with propagative material, and are absent or under official control in Australia, may be capable of establishment or spread within Australia if suitable ecological and climatic conditions exist.

As part of the revision, the previous policy's pest list for potato propagative material was reviewed and subsequently, changes have been made to the list of quarantine pathogens. Solanum nodiflorum mottle virus, Tobacco etches virus, Tomato golden mosaic virus and Wild potato mosaic virus are not reported to naturally infect cultivated potatoes (*Solanum tuberosum*). Therefore, these viruses are not included in the pest categorisation (Appendix A).

Pseudomonas fluorescens was suggested as the causal agent of pink-eye in potatoes (Folsum and Friedman 1959; Frank *et al*. 1973). However, Koch's postulates have never been completed in the case of the causal organism responsible for pink eye. Pink-eye of potato is now recognized to be an aberrant periderm disorder caused by a several overlapping factors (Lulai *et al*. 2006; Copas *et al*. 2008). These factors include excessive moisture and high soil temperatures leading to cell damage and death of both the natural tuber periderm and the underlying cortical parenchyma cells (Zitter 2012). Therefore, this bacterium is not included in the pest categorisation (Appendix A).

The quarantine pests of potato propagative material from all sources identified in the pest categorisation are listed in Table 2.1. These pathogens fulfil the International Plant Protection Convention (IPPC) criteria for a quarantine pest, specifically:

- these pests are economically important (as they cause a variety of direct and indirect economic impacts, such as reduced yield, reduced commodity value, loss of foreign or domestic markets); and
- these pests are not present in Australia or have a limited distribution and are under official control.

Pests under official control in Australia have been taken into account in this review. If regional pests[2] are identified on plants during PEQ, DAFF will notify relevant State Departments of Agriculture.

[2] Regional pests are quarantine pests for specific Australian states and territories, but may be present in other Australian states.

Table 2.1 Quarantine pests for potato propagative material (true potato seed, minitubers/microtubers and tissue cultures)

Pathogen type	**Pathway association**[3]		
	True potato seed	**Minitubers/ Microtubers**	**Tissue cultures**
BACTERIA			
Candidatus Liberibacter solanacearum Liefting *et al*.		✓	✓
Clavibacter michiganensis subsp. *sepedonicus* (Spieckermann & Kotthoff) Davis *et al*.		✓	✓
Dickeya species (*D. dadantii*, *D. dianthicola*, *D. dieffenbachiae*, *D. paradisiaca*, *D. parthenii*, *D. solani*)		✓	✓
Pectobacterium species (*P. betavasculorum*, *P. carotovorum* subsp. *brasiliensis*, *P. wasabiae*)		✓	✓
Ralstonia solanacearum (Smith) Yabuuchi *et al*.*		✓	✓
Streptomyces species (*S. acidiscabies*, *S. caviscabiei*, *S. europaeiscabiei*, *S. luridiscabiei*, *S. niveiscabiei*, *S. puniciscabiei*, *S. reticuliscabiei*, *S. stelliscabiei*,*S. turgidiscabies*)		✓	
FUNGI			
Aecidium cantensis Arthur		✓	
Gerwasia pittieriana (Henn.) León-Gall. & Cummins		✓	
Phacidiopycnis tuberivora (H.T. Güssow & W.R. Foster) B. Sutton		✓	
Phoma andigena var. *andina* Turkenst.		✓	
Phoma crystalliniformis (Loer. *et al*.) Noordel. & Gruyter		✓	
Polyscytalum pustulans (M.N. Owen & Wakef.) M.B. Ellis		✓	
Synchytrium endobioticum (Schilb.) Percival		✓	
Thecaphora solani Barrus		✓	
STRAMINOPILA			
Phytophthora infestans (Mont.) de Bary[4]		✓	
PROTOZOA			
Spongospora subterranea (Wallr.) Lagerh. f. sp. *subterranea* Tomlinson (potentially carrying Potato mop-top virus [PMTV])		✓	
PHYTOPLASMA			
Candidatus Phytoplasma asteris [**16SrI** –Aster yellows group]		✓	✓
Candidatus Phytoplasma aurantifolia [**16SrII**–Peanut Witches' Broom Group]		✓	✓
Candidatus Phytoplasma pruni [**16SrIII** – X-Disease Group]		✓	✓
Candidatus Phytoplasma trifolii [1**6SrVI** – Clover Proliferation Group]		✓	✓
Candidatus Phytoplasma solani [**16SrXII** – **A** – Stolbur Group]		✓	✓
Mexican periwinkle virescence group (**16SrXIII)**		✓	✓
Candidatus Phytoplasma americanum [**16SrXVIII** – American Potato Purple Top Wilt Group]		✓	✓
VIROIDS			
Potato spindle tuber viroid (PSTVd)	✓	✓	✓

[3] This review considers that certain pathogens (bacteria, phytoplasma, viroids and viruses) may not be excluded from the pathway and remain associated with micropropagated plantlets. On the other hand, it considers that fungal or fungal-like pathogens do not form a pathway with micropropagated plantlets.

[4] *Phytophthora infestans* A2 mating strain and exotic strains of both A1 and A2 are considered to be quarantine pests for Australia.

Pathogen type	**Pathway association[3]**		
	True potato seed	**Minitubers/ Microtubers**	**Tissue cultures**
VIRUSES			
Alfalfa mosaic virus – potato strains (AMV)		✓	✓
Andean potato latent virus (APLV)	✓	✓	✓
Andean potato mottle virus (APMoV)		✓	✓
Arracacha virus B – Oca strain (AVB– O)	✓	✓	✓
Beet curly top virus (BCTV)		✓	✓
Eggplant mottled dwarf virus (EMDV)		✓	✓
Impatiens necrotic spot virus (INSV)		✓	✓
Pepino mosaic virus (PepMV)		✓	✓
Potato 14R virus		✓	✓
Potato black ringspot virus (PBRSV)	✓	✓	✓
Potato deforming mosaic virus (PDMV)		✓	✓
Potato latent virus (PotLV)		✓	✓
Potato mop-top virus (PMTV)		✓	✓
Potato rough dwarf virus (PRDV)		✓	✓
Potato virus M (PVM)		✓	✓
Potato virus S – Andean strain (PVS^A)		✓	✓
Potato virus T (PVT)	✓	✓	✓
Potato virus U (PVU)		✓	✓
Potato virus V (PVV)		✓	✓
Potato virus X* (PVX)		✓	✓
Potato virus Y* (PVY)		✓	✓
Potato yellow dwarf virus (PYDV)		✓	✓
Potato yellow vein virus (PYVV)		✓	✓
Potato yellowing virus (PYV)	✓	✓	✓
Solanum apical leaf curling virus (SALCV)		✓	✓
Tobacco mosaic virus– potato strain (TMV-P)		✓	✓
Tobacco necrosis virus* (TNV)		✓	✓
Tobacco rattle virus * (TRV)		✓	✓
Tobacco streak virus–potato strain (TSV-P)		✓	✓
Tomato black ring virus (TBRV)	✓	✓	✓
Tomato chlorosis virus (ToCV)		✓	✓
Tomato leaf curl New Delhi virus (ToLCNDV)		✓	✓
Tomato mottle Taino virus (ToMoTV)		✓	✓
Tomato yellow mosaic virus (ToYMV)		✓	✓
NEMATODES			
Ditylenchus destructor (Thorne)		✓	
Globodera pallida (Stone) Behrens		✓	
Globodera rostochiensis (Wollen.) Skarbilovich		✓	
Meloidogyne chitwoodii Golden *et al.*		✓	
Nacobbus aberrans (Thorne) Thorne & Allen		✓	

* Strains not present in Australia

2.2.2 Assessment of the probability of entry, establishment and spread

Details of how to assess the 'probability of entry', 'probability of establishment' and 'probability of spread' of a pest are given in ISPM 11 (FAO 2004).

In the case of propagative material imports, the concepts of entry, establishment and spread have to be considered differently. Propagative material intended for ongoing propagation purposes is deliberately introduced, distributed and aided to establish and spread. This material will enter and then be maintained in a suitable habitat, potentially in substantial numbers and for an indeterminate period. Significant resources are utilised to ensure the continued welfare of imported propagative material. Therefore, the introduction and establishment of plants from imported propagative material in essence establishes the pests and pathogens associated with the propagative material. Pathogens, in particular, may not need to leave the host to complete their life cycles, further enabling them to establish in the PRA area. Furthermore, propagative material is expected to be shipped at moderate temperatures and humidity, which is unlikely to adversely affect any pest that is present during shipment.

Several key factors contribute to the increased ability of pests and pathogens associated with propagative material to enter, establish and spread in Australia.

Probability of entry

- Association with host commodities provides the opportunity for the pest to enter Australia. Their ability to survive on, or in, propagative material acts to ensure their viability on route to, and during distribution across, Australia.
- Viruses, as a rule, infect host plants systemically and all plant parts, including parts used for vegetative propagation, are infected. Therefore, propagative material provides a pathway for viruses to enter Australia.
- Propagative material is assumed to come from areas where these pests specifically occur and no phytosanitary measures have been applied. The primary conditions for survival of pests are fulfilled by the presence of the live propagative material and the associated environmental conditions. Therefore, association with propagative material can provide long-term survival for the pests.
- Infected propagative material is the main pathway for the introduction of the pests into new areas. This mode of introduction is greatly enhanced if pests have latency periods before conspicuous symptoms develop. Long latency periods can lead to the propagation and distribution of infected propagative material suggesting the pests could be introduced into Australia.
- The pests associated with propagative material may be systemic or associated with the vascular system (or occur internally in the nursery stock) and they are unlikely to be dislodged during standard harvesting, handling and shipping operations. Therefore, pests associated with propagative material are likely to survive during transport.

Probability of establishment

- Association with the host will facilitate the establishment of pests, as they are already established with, or within, a suitable host. As host plant material is likely to be maintained in places with similar climates to the area of production, climatic conditions are expected to favour the pest's establishment. Some pest specific factors are likely to impact upon a pest's ability to establish in Australia. For example, the likelihood of establishment will vary if an alternative host is required for the pest to complete its life cycle or if multiple individuals are required to form a founder population. Where appropriate, these considerations are addressed in the potential for establishment and spread field of the pest categorisation.

- Propagative material intended for ongoing propagation or horticultural purposes is deliberately introduced, distributed and aided to establish. This material will enter and then be maintained in a suitable habitat, potentially in substantial numbers and for an indeterminate period. Therefore, the introduction and establishment of plants from imported propagative material in essence establishes the pests and pathogens associated with the propagative material.
- The latent period of infection before visible symptoms appear may result in non-detection of these pathogens; therefore, the pathogens will have ample time to establish into new areas.

Probability of spread

- The ability of the pest to be introduced and distributed throughout Australia on propagative material through human mediated spread is a high risk for continued spread post-border in Australia. Pest related factors which would aid the spread of the pest once it has established in Australia (such as wind, water or mechanical transmission) will increase the pest's ability to spread from an already high baseline.
- In the absence of statutory control, there are high probabilities for the pests to spread quickly in Australia by trade of propagative material. Planting of infected propagative material will bring the pests into the environment. Climatic conditions such as those found in propagation houses may be sufficient for pest survival and spread.
- The systemic nature of some of the pests associated with propagative material is a major pathway for dispersal. Accordingly, local and long-distance spread of these pathogens has been associated with the movement of infected propagative material.
- The symptomless nature of several pathogens may contribute to the inadvertent propagation and distribution of infected material that will help spread these pathogens within Australia. Additionally, insect vectors present in Australia will help spread viruses from infected plants to healthy plants.

As a result of these pathway specific factors, it would be inappropriate to assess the probability of entry, establishment and spread using the processes described in ISPM 11 (FAO 2004). For the purposes of this PRA, the overall likelihood for the probability of entry, establishment and spread is considered to be high for pests entering on potato propagative material.

2.2.3 Assessment of potential consequences

The purpose of assessment of potential consequences in the pest risk assessment process is to identify and quantify, as much as possible, the potential impacts that could be expected to result from a pest's introduction and spread.

The basic requirements for the assessment of consequences are described in the SPS Agreement, in particular Article 5.3 and Annex A. Further detail on assessing consequences is given in the 'potential economic consequences' section of ISPM 11. This ISPM separates the consequences into 'direct' and 'indirect' and provides examples of factors to consider within each.

The introduction of pests which meet the criteria of a quarantine pest will have unacceptable economic consequences in Australia as these pests will cause a variety of direct and indirect economic impacts. The identified pests are of economic concern and do not occur in Australia. A summary and justification is provided below:

- Direct impacts of the introduction and spread of multi-host pests in Australia will not only affect the imported host but also other hosts. Introduction and establishment of quarantine pests in Australia would not only result in phytosanitary regulations imposed by foreign or domestic trading partners, but also in increased costs of production, including pathogen control costs.
- Quarantine pest introduction and spread would also be likely to result in industry adjustment. The potential economic impact for the nursery trade is high. Without controls these pests have the potential to spread further in the trade network and could potentially expand their host range.
- One of the greatest phytosanitary hazards to the potato crop world-wide is a group of potato viruses which have remained limited in distribution to the potato's zone of origin in South America. These pathogens are considered important as they cause a variety of direct and indirect economic impacts, such as reduced yield, reduced commodity value and loss of foreign or domestic markets. Therefore, these pests have a potential for economic consequences in the PRA area. For example, some of these pathogens are identified as pests of quarantine concern by APPPC, COSAVE, CPPC, EPPO, IAPSC, JUNAC and NAPPO. The presence of these pathogens in Australia would impact upon Australia's ability to access overseas markets.

Pests listed in table 3.1 are of economic significance and are either absent from Australia, or if present, are under official control. Therefore, they meet the IPPC criteria for a quarantine pest and phytosanitary measures are justified to manage these pathogens.

2.3 Stage 3: Pest Risk Management

ISPM 11 (FAO 2004) provides details on the identification and selection of appropriate risk management options. Pest risk management describes the process of identifying and implementing phytosanitary measures to manage risks posed by identified quarantine pests, while ensuring that any negative effects on trade are minimised.

Pest risk management evaluates and selects risk management options to reduce the risk of entry, establishment or spread of identified pests for the identified import pathways. To effectively prevent the introduction of pests associated with an identified pathway, a series of important safeguards, conditions or phytosanitary measures must be in place. Propagative material represents a direct pathway for pests identified by the pest categorisation. This pathway is direct since the end-use is the planting of a known host plant.

2.3.1 Identification and selection of appropriate risk management options

Phytosanitary measures to prevent the establishment and spread of quarantine pests may include any combination of measures; including pre- or post-harvest treatments, inspection at various points between production and final distribution, surveillance, official control, documentation, or certification. A measure or combination of measures may be applied at any one or more points along the continuum between the point of origin and the final destination. Pest risk management explores options that can be implemented (i) in the exporting country, (ii) at the point of entry or (iii) within the importing country. The ultimate goal is to protect plants and prevent the introduction of identified quarantine pests.

Examples of phytosanitary measures which may be applied to propagative material consignments include:

- **Import from pest free areas only (ISPM 4, 10)—**the establishment and use of a pest free area by a NPPO provides for the export of plants from the exporting country to the importing country without the need for application of additional phytosanitary measures when certain requirements are met.
- **Inspections or testing for freedom from regulated pests—**this is a practical measure for visible pests or for pests which produce visible symptoms on plants.
- **Inspection and certification (ISPM 7, 12, 23)—**the exporting country may be asked to inspect the shipment and certify that the shipment is free from regulated pests before export.
- **Specified conditions for preparation of the consignment (ISPM 33)—**the importing country may specify steps which must be followed in order to prepare the consignment for shipment. These conditions can include the requirement for the plants to have been produced from appropriately tested parent material.
- **Pre-entry or post-entry quarantine—**the importing country may define certain control conditions, inspection and possible treatment of shipments upon their entry into the country. Post-entry quarantine of potato minitubers/microtubers, true potato seed and even *in vitro* plantlets can help avoid the introduction of new viruses or allied pathogens into the importing countries.
- **Removal of the pest from the consignment by treatment or other methods—**the importing country may specify chemical or physical treatments which must be applied to the consignment before it may be imported.

Measures can range from total prohibition to permitting import subject to visual inspection. In some cases, more than one phytosanitary measure may be required in order to reduce the pest risk to an acceptable level.

3 Recommended risk management measures for potato propagative material

The ultimate goal of phytosanitary measures is to protect plant health and prevent the introduction of identified quarantine pests associated with potato propagative material. Plant Biosecurity considers that the risk management measures recommended in this final review of policy will be adequate to mitigate the risks posed by the identified quarantine pests.

3.1 Propagative material from all sources

The recommended risk management measures for potato propagative material are detailed below.

3.1.1 Potato tissue cultures (microplantlets)

It is recommended that imported tissue cultures (microplantlets) should be well rooted prior to arrival as this helps in their establishment ex-agar.

Mandatory on-arrival inspection

The imported tissue cultures (microplantlets) must be subject to mandatory on-arrival inspection to verify freedom from bacterial and fungal infection, disease symptoms, live insects and other extraneous contamination of quarantine concern.

The agar culture media must be clear and not contain antibiotics. If diseased material is detected during on-arrival inspection, the material must be held and referred to a plant pathologist for identification/risk assessment.

Mandatory growth in PEQ facilities

The imported tissue culture (microplantlets) must be grown in a closed government PEQ facility for a minimum of 6 months for pathogen screening, until the required pathogen screening/testing is completed.

During growth in PEQ, the tissue cultures (microplantlets) must be subject to pathogen screening, visual inspection and pathogen testing, as outlined below.

Pathogen screening

It is recommended that during PEQ growth period, plants and plantlets are subjected to visual inspection, electron microscopy and active testing, including biological indexing and molecular testing.

Visual inspection

Pathogen screening (visual screening) during growth in PEQ is recommended to continue for the detection of symptomatic pathogens. Fungal and bacterial pathogens associated with potato may produce distinct symptoms that make them easy to identify by visual inspection during growth period in PEQ.

Pathogen testing

The recommended pathogen testing during growth in PEQ will include active testing for quarantine pathogens, using traditional and modern techniques. Laboratory methods; including culturing, biological indicators, electron microscopy and including but not limited to serological tests (ELISA) or molecular tests (PCR); may be used to detect quarantine pathogens.

Bacterial pathogens

- Visual inspection and active testing (including but not limited to PCR for *Candidatus* Liberibacter solanacearum) are recommended.
- Visual inspection, culturing, microscopy and if required, PCR tests, are recommended for *Clavibacter michiganensis* subsp. *sepedonicus*.
- Diagnostic tests, including culturing and microscopy, are recommended for *Dickeya* species, *Pectobacterium* species, *Streptomyces* species and *Ralstonia solanacearum*. However, if detected during culturing or symptoms develop during growth in the PEQ, molecular testing; including but not limited to PCR for *Dickeya* species, *Pectobacterium* species and *Ralstonia solanacearum*; is recommended.

Fungal pathogens

- Newly established plants (from imported propagative material) will be subject to growing season inspection and if symptoms develop during the PEQ period, further diagnostic testing; including culturing and microscopy; is recommended.

Phytoplasmas

- Newly established plants (from imported propagative material) will be subject to growing season inspection and active testing, including a mandatory generic PCR.

Viroids

- A generic reverse-transcription PCR (RT-PCR) test or hybridisation using a cRNA probe is recommended to detect all pospiviroids including PSTVd.

Viruses

It is recommended that in addition to visual inspection for symptoms during growth in PEQ facilities, effective and robust diagnostic methods based on a well established combination of biological, serological, and/or molecular tests are required to detect viruses. Recommended mandatory general methods for viruses include:

- Electron microscopy for the identified viruses
- Herbaceous host indexing
- Generic molecular tests for Begomovirus, Carlavirus, Nepovirus, Potexvirus and Potyvirus and Closteroviridae

A summary of recommended pathogen testing and virus indexing procedures is presented in Table 3.1. If symptoms are detected through electron microscopy, herbaceous indexing or visual inspection during growth in PEQ, specific testing will be conducted to detect viruses from other genera.

Some of the viruses including BCTV, PYVV and SALCV are not mechanically transmitted and other viruses including PotLV, PMTV, PYV and TRV may have issues with reliable mechanical transmission. Therefore, herbaceous indexing for these viruses is supplemented or replaced with ELISA or PCR.

Plant Biosecurity acknowledges that advances in serological or molecular techniques is an on-going process and therefore the recommended serological or molecular tests can be replaced when more up-to-date testing procedures are validated.

Table 3.1 Recommended pathogen screening and virus indexing procedures

Pathogen type	Mandatory tests						Additional tests required if disease symptoms develop	Reference(s)
	Growing season inspection	Culture & microscopy	Electron Microscopy	Herbaceous indexing	ELISA	PCR or RT-PCR		
BACTERIA								
Candidatus Liberibacter solanacearum	✓					✓	PCR	Hansen *et al*. 2008; Constable *et al*. 2011
Clavibacter michiganensis subsp. *sepedonicus*	✓	✓					PCR	Schaad 1988; Schneider *et al*. 1993; Li & De Boer 1995; van Beckhoven *et al*. 2002
Dickeya species	✓	✓					PCR; RT PCR	Cuppels and Kelman 1974 Hyman *et al*. 2001; Bdliya and Langerfeld 2005; Diallo *et al*. 2009; Laurila *et al*. 2008, 2010
Pectobacterium species	✓	✓					PCR	Czajkowski *et al*. 2009
Ralstonia solanacearum	✓	✓					PCR; RT-PCR	Cuppels and Kelman 1974; Diallo *et al*. 2009
Streptomyces species	✓							
FUNGI[5]								
Aecidium cantensis	✓							
Gerwasia pittieriana	✓							
Phacidiopycnis tuberivora	✓							
Phoma andigena var. *andina*	✓							
Phoma crystalliniformis	✓							
Polyscytalum pustulans	✓							
Synchytrium endobioticum	✓							
Thecaphora solani	✓							
STRAMINOPILA								
Phytophthora infestans	✓							
PROTOZOA								
Spongospora subterranea f. sp. *subterranea* (potentially carrying PMTV)	✓							
PHYTOPLASMA								
Candidatus Phytoplasma asteris	✓					✓		Gundersen and Lee 1996
Candidatus Phytoplasma aurantifolia	✓					✓		Gundersen and Lee 1996
Candidatus Phytoplasma pruni	✓					✓		Gundersen and Lee 1996
Candidatus Phytoplasma trifolii	✓					✓		Gundersen and Lee 1996

[5] Fungi detected during growing season inspection must be cultured and subjected to microscopic observations. Plant Biosecurity acknowledges that some of the fungi are obligate parasites and cannot be cultured.

Pathogen type	**Mandatory tests**						**Additional tests required if disease symptoms develop**	**Reference(s)**
	Growing season inspection	Culture & microscopy	Electron Microscopy	Herbaceous indexing	ELISA	PCR or RT-PCR		
Candidatus Phytoplasma solani	✓					✓		Gundersen and Lee 1996
Mexican periwinkle virescence group	✓					✓		Gundersen and Lee 1996
Candidatus Phytoplasma americanum	✓					✓		Gundersen and Lee 1996
VIROIDS								
Potato spindle tuber viroid	✓					✓		Verhoeven *et al*. 2004; Rodoni *et al*. 2011
VIRUSES								
Alfalfa mosaic virus (AMV) – potato infecting strains	✓		✓	✓			ELISA; RT-PCR	Jeffries 1998; Xu and Nie 2006
Andean potato latent virus (APLV)	✓		✓	✓			ELISA	Schroeder and Weidmann 1990
Andean potato mottle virus (APMoV)	✓		✓	✓			ELISA	Schroeder and Weidmann 1990
Arracacha virus B – Oca strain (AVB-O)	✓		✓	✓			ELISA	Jeffries 1998
Beet curly top virus (BCTV)	✓		✓				PCR/RT-PCR	Rojas *et al*. 1993
Eggplant mottled dwarf virus (EMDV)	✓		✓	✓			ELISA	Jeffries 1998
Impatiens necrotic spot virus (INSV)	✓		✓	✓			ELISA, RT-PCR	Mumford *et al*. 1996; Naidu *et al*. 2007
Pepino mosaic virus (PepMV)	✓		✓	✓		●	ELISA, RT-PCR	Salomone and Roggero 2002; Gutiérrez-Aguirre *et al*. 2009
Potato 14R virus	✓		✓	✓				
Potato black ringspot virus (PBRSV)	✓		✓	✓	*	* ✡	ELISA	Jeffries 1998
Potato deforming mosaic virus (PDMV)	✓		✓	✓		◆	PCR/RT-PCR	Rojas *et al.* 1993; Wyatt and Brown 1996
Potato latent virus (PotLV)	✓		✓			Δ	ELISA; RT-PCR	Badge *et al*. 1996
Potato mop-top virus (PMTV)	✓		✓	✓			ELISA; RT-PCR	Latvala-Kilby *et al*. 2009
Potato rough dwarf virus (PRDV)	✓		✓	✓		Δ	PCR/RT-PCR	Badge *et al*. 1996
Potato virus M (PVM)	✓		✓	✓		Δ	ELISA; RT-PCR	Badge *et al*. 1996
Potato virus S – Andean strain (PVS^A)	✓		✓	✓		Δ	ELISA	Lambert *et al*. 2012
Potato virus T (PVT)	✓		✓	✓	*	*		Lizárraga *et al*. 2000
Potato virus U (PVU)	✓		✓	✓				Jeffries 1998
Potato virus V (PVV)	✓		✓	✓		★	PCR/RT-PCR	Langeveld *et al.* 1991; Gibbs and Mackenzie 1997
Potato virus X (PVX)	✓		✓	✓		●		
Potato virus Y (PVY)	✓		✓	✓		★	ELISA; PCR/RT-	Fernandez-Northcote and

Pathogen type	Mandatory tests: Growing season inspection	Culture & microscopy	Electron Microscopy	Herbaceous indexing	ELISA	PCR or RT-PCR	Additional tests required if disease symptoms develop	Reference(s)
							PCR	Gugerli 1987; Nie and Singh 2003; Rodoni 2012
Potato yellow dwarf virus (PYDV)	✓		✓	✓			ELISA	Jeffries 1998
Potato yellow vein virus (PYVV)	✓		✓			Ω	PCR/RT-PCR	Salazar *et al*. 2000; Lopez *et al*. 2006
Potato yellowing virus (PYV)	✓		✓		*	*		Silvestre *et al*. 2011
Solanum apical leaf curling virus (SALCV)	✓		✓			◆	ELISA	Jeffries 1998
Tobacco mosaic virus – potato strain (TMV-P)	✓		✓	✓			RT-PCR	Jung *et al*. 2002
Tobacco necrosis virus (TNV)	✓		✓	✓	*	*		Zitikaite and Staniulis 2009
Tobacco rattle virus (TRV)	✓		✓	✓			PCR/RT-PCR	Robinson 1992; Crosslin and Thomas 1995; Weidmann 1995; Jeffries 1998;
Tobacco streak virus – potato strain (TSV-P)	✓		✓	✓			ELISA	Salazar *et al*. 1981
Tomato black ring virus (TBRV)	✓		✓	✓	*	* ✡	ELISA	Jeffries 1998
Tomato chlorosis virus (ToCV)	✓		✓			Ω		
Tomato leaf curl New Delhi virus (ToLCN-DV)	✓		✓	✓		◆	PCR/RT-PCR	Rojas *et al.* 1993; Wyatt and Brown 1996
Tomato mottle Taino virus (ToMoTV)	✓		✓	✓		◆	PCR/RT-PCR	Rojas *et al.* 1993; Wyatt and Brown 1996
Tomato yellow mosaic virus (ToYMV)	✓		✓	✓		◆	PCR/RT-PCR	Rojas *et al.* 1993; Wyatt and Brown 1996

◆ Generic PCR for Begomovirus
● Generic PCR for Potexvirus
✡ Genus PCR for Nepovirus
Ω Generic PCR for Closteroviridae
Δ Generic PCR for Carlavirus
★ Generic PCR for Potyvirus
* PCR or ELISA mandatory

3.1.2 True potato seed for sowing

Mandatory on arrival inspection

Imported true potato seed for sowing must be subject to mandatory on-arrival inspection to verify freedom from disease symptoms, live insects, soil and other extraneous contaminants of quarantine concern.

Mandatory sodium hypochlorite treatment

It is recommended that imported true potato seed must be subject to mandatory surface sterilisation with sodium hypochlorite treatment (1% NaOCl for 10 minutes).

Mandatory seed fungicide treatment

It is recommended that imported true potato seeds must undergo mandatory fungicide treatment with Ridomil® systemic seed fungicide (T9330).

Mandatory growth in PEQ facilities

It is recommended that imported true potato seeds must be grown for a minimum of six months in a closed government or DAFF approved PEQ facility for pathogen screening. The purpose of growth in PEQ facilities is to screen imported true potato seed for sowing for pathogens in order to prevent the introduction of quarantine pests into Australia.

It is recommended that in addition to visual inspection for symptoms during growth in PEQ facility, the seed-borne pathogens (APLV, AVB-O, PBRSV, PVT, PYV, TBRV and PSTVd) should be screened using biological indexing and molecular tests (Table 3.1).

3.1.3 Minitubers/microtubers (produced in a protected environment)

This review supports the prohibition of field-grown potato seed tubers as they are capable of introducing not only pathogens (fungi, bacteria, phytoplasma, viroids and viruses) but also nematodes (*Ditylenchus destructor*, *Globodera pallida*, *Globodera rostochiensis, Meloidogyne chitwoodi* and *Nacobbus aberrans*). Additionally, field-grown seed potatoes are capable of introducing certain insects (*Epitrix tuberis*, *Leptinotarsa decemlineata*, *Phthorimaea operculella*, *Premnotrypes latithorax*, *Premnotrypes sanfordi, Premnotrypes solani, Premnotrypes vorax, Rhigopsidius tucumanus* and *Tecia solanivora*).

To effectively prevent the introduction of these pests, a series of important safeguards, conditions or phytosanitary measures must be in place. Therefore, this review recommends that the importation of potato seed tubers should be limited to microtubers or minitubers produced under a protected environment (as outlined in section 4.2). Minitubers/microtubers must also be produced in soilless media (excluding coconut peat)[6] and tested free of nematodes of quarantine concern to Australia (Table 2.1).

Mandatory on-arrival inspection

It is recommended that imported minitubers/microtubers be subject to on-arrival inspection to verify freedom from disease symptoms, live insects, soil and extraneous contaminants of quarantine concern. If diseased material is detected during on-arrival inspection, the pathogen must be identified. Detection of bacterial or fungal pathogens may result in the destruction or re-export of the potato minitubers/microtubers.

Mandatory on-arrival fumigation

It is recommended that imported minitubers/microtubers be subject to mandatory on-arrival methyl bromide fumigation (T9060) to manage the risk posed by arthropod pests.

Alternative treatments to methyl-bromide fumigation for minitubers/microtubers, if requested by an exporting country, will be considered by Plant Biosecurity on a case by case basis. Prior to the acceptance of an alternative treatment for potato minitubers/microtubers, Plant

[6] Coconut peat must not be used as soilless media because it has been identified as a likely source of *Spongospora subterranea* f. sp. *subterranea* (*Sss*) inoculum (Wright *et al*. 2012). *Sss* is a vector of Potato mop-top virus (PMTV) (Santala *et al*. 2010), which is absent from Australia.

Biosecurity would need to assess the efficacy of that fumigant to ensure it gives an equal level of protection to methyl-bromide for all pests likely to be associated with the commodity.

Mandatory sodium hypochlorite treatment

It is recommended that minitubers/microtubers be subjected to sodium hypochlorite treatment (1% NaOCl for 2 hours) for surface sterilisation.

Mandatory growth in PEQ facilities with pathogen screening

It is recommended that imported potato minitubers/microtubers from unknown sources be grown in a closed government or DAFF approved PEQ facility for a minimum period of six months for visual observation of disease symptoms and pathogen screening, until the required pathogen screening/testing is completed.

During growth in PEQ, plants must be subject to pathogen screening, visual inspection and pathogen testing. Additionally, minitubers/microtubers must also be subjected to screening for fungal pathogens.

Fungal pathogens

Growing season inspection, culture media and microscopy, are recommended for identified fungal pathogens. It is acknowledged that some of the fungi are obligate parasites and cannot be cultured.

Other pathogens

Details of pathogen screening for bacteria, phytoplasma, viruses, and viroids are provided in section 3.1.1.

4 Framework for approval of high health sources, production requirements and evaluation of SASA

4.1 Framework for approval of high health sources

Prior to this review, there were no sources approved to supply pathogen tested potato propagative material to Australia. However, Plant Biosecurity will consider requests for approval of overseas sources (e.g. institutions, NPPOs etc.) based on the compliance with international standards and a rigorous examination of the recommended facilities.

Microplantlets and minitubers produced from tested material in aseptic and/or controlled environments are not exposed to field-borne pests, and therefore represent a low pest risk. ISPM 33 outlines the production requirements of pest free potato (*Solanum* spp.) micropropagative material and minitubers for international trade. Australia will approve facilities/institutions producing potato tissue culture plantlets and minitubers in accordance with ISPM 33 (FAO 2010) on a case by case basis, with particular reference to the following:

- **Capacity for National Authority oversight—**facilities producing pathogen tested propagative material must be authorized/approved or operated directly by the National Plant Protection Organization (NPPO), as import conditions routinely require phytosanitary certification to be provided by the NPPO.
- **Capacity to produce pathogen tested propagative material—**facilities must demonstrate their capacity to produce and maintain high health plant material through appropriate disease screening/testing and monitoring.
- **Capacity to meet containment and security requirements—**facilities for the establishment of pest-free propagative material and testing for pest freedom must be subject to strict physical containment and operational requirements to prevent contamination or infestation of material.
- **Audits and inspections**—all facilities producing pathogen tested propagative material should be officially audited by DAFF to ensure that they continue to meet Australia's requirements.
- **Identity preservation systems—**all facilities must be able to demonstrate their ability to maintain adequate and verifiable safeguards to ensure that propagative material undergoing post-entry quarantine procedures is not diverted, contaminated or intermingled with other material during and following completion of the quarantine measures.
- **On arrival verification—**the health status of all consignments of high health propagative material must be verified on-arrival through supporting documentation (e.g. Phytosanitary Certificate, NPPO reports, audit report etc.) and testing as required by the importing country.

Based on this framework, Australia will consider replacing the conditions for on-arrival pathogen screening with an equivalent set of conditions for approved sources. Under *ISPM 24: Guidelines for the determination and recognition of equivalence of phytosanitary measures* (FAO 2005), Australia is required to objectively examine alternative phytosanitary measures proposed by the exporting party to determine if the measures achieve Australia's appropriate level of protection. The key elements of material produced in approved sources require that:

- Pathogen screening/testing must be equivalent to Australia's post-entry quarantine screening/testing.
- Each consignment must have a certificate of testing issued by the approved source and certified by the NPPO of the exporting country.
- On-arrival verification inspection must occur and material must be grown in a closed government PEQ facility for a minimum of three months to verify the application of phytosanitary measures.
- Imported propagative material may be subjected to verification testing for a range of quarantine pathogens.
- Where any accredited source does not undertake the complete range of pathogen screening/testing required, those missing tests will be performed during growth in a closed government PEQ facility in Australia.

4.2 Production of potato propagative material in a protected environment

Production procedures for potato propagative material (tissue culture, microtubers/minitubers) will include:

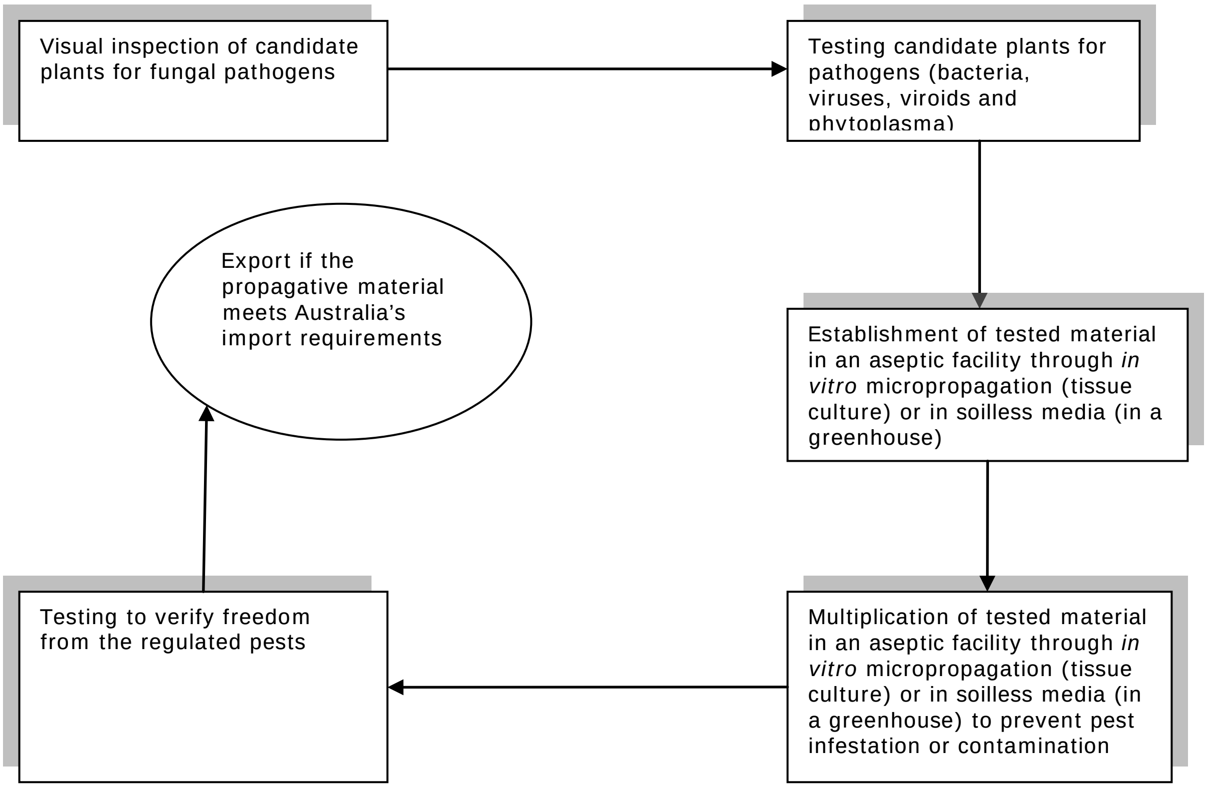
- **Sourcing potato propagules—**tissue culture will be sourced from visually inspected and pathogen tested mother plants. Minitubers will be sourced from pest-free potato micropropagative material (pests listed in Table 2.1). Propagation and laboratory testing must be conducted within a quality assurance program under the supervision of the NPPO.
- **Establishment in aseptic conditions—**pathogen tested potato propagative material will be established in an aseptic facility. Tissue culture will undergo *in vitro* micropropagation while microtubers/minitubers will be grown in a greenhouse using soilless media (excluding coconut peat) and irrigated with pest free water. Microplantlets must be visually inspected to ensure freedom from microbial contamination and maintenance of aseptic conditions. Pest free microplantlets must be kept clearly separated from pest vectors and non-pest-free plant material at all times during propagation, maintenance and shipping. Each consignment of microplantlets must be traceable to its mother plant.
- Minitubers/microtubers must be propagated from certified pest-free microplantlets. Production facilities must meet the requirements of a pest-free site of production. The minituber establishment facility (i.e. a glasshouse) must be insect-proof with a double door entrance and provision for footwear disinfection prior to entering the protected environment. The facility must have aphid-proof ventilation screening on all intakes and exhaust openings and there must be no holes in the structure that would allow aphids to enter the protected environment. Additionally, neither field-produced seed potatoes nor non-seed potatoes should be grown in the same protected environment facility.
- **Maintenance—**pathogen tested potato propagative material must be maintained in an aseptic facility or in a protected environment (e.g., growth chamber, greenhouse etc.). Microplantlets and minitubers must be propagated and maintained free from potato pests by ensuring their isolation from potato pests.
- **Multiplication—**pathogen tested potato propagules are multiplied in an aseptic facility and/or in a protected environment (e.g. growth chamber, greenhouse etc.). The production,

maintenance and multiplication facility must be operated as a pest free production site (as described in ISPM 10) with respect to pests of concern (Table 2.1).

- **Testing**—a sample of propagative material must be tested for freedom from pests of quarantine concern (Table 2.1). Pre-export testing of potato foliage is a useful monitoring or survey procedure. However, it is not an appropriate method for determining the absence of PVY^{N} and $PVY^{N:O}$-like virus isolates in seed potato shipments because the distribution of the virus in the plant is uneven, virus titre in aging plants is low, and late season infections cannot be detected. Therefore, a sample of tubers collected from the seed potato crop must be tested.
- **Visual crop inspection—**NPPO or NPPO approved inspectors should visually inspect crops during the vegetative phase of microtuber/minituber production to ensure pest freedom and adherence of the facility and operational processes to quality standards. Post-harvest audit testing of microtubers/minitubers for one or more pests, serving as sentinel indicators of pest freedom status, should be conducted for each consignment.

These procedures will minimise the risk of pests occurring on potato propagative material produced in a protected environment. A flow chart showing production of pest free potato micropropagative material and minitubers is presented in Figure 4.1.

Figure 4.1: Production of pathogen tested free propagative material



4.3 Review of Science and Advice for Scottish Agriculture (SASA)

Prior to this review, there were no sources approved to supply pathogen tested potato propagative material to Australia. The United Kingdom Potato Quarantine Unit (UKPQU) at Science and Advice for Scottish Agriculture (SASA) applied for accreditation to supply pathogen tested potato propagative material to Australia.

The UKPQU deals with the import and export of potato propagative material and has made a significant contribution to the development of potato quarantine procedures. The UKPQU procedures are based on the EPPO post-entry quarantine procedures for potato micropropagation (EPPO 2004), except that they are more stringent; for instance, microplantlets are tested by ELISA once and glasshouse grown plants tested twice. Glasshouse grown plants are also tested using herbaceous indexing. Where ELISA is not appropriate (or unreliable), viruses are tested using conventional RT-PCR. Microplantlets and glasshouse grown plants are tested for viroids using hybridisation with a digoxigenin cRNA probe. In addition, microplantlets and tubers are tested for bacteria (including *Clavibacter michiganensis* subsp. *sepedonicus*, *Dickeya* spp., *Pectobacterium atrosepticum*, *Pectobacterium carotovorum* and *Ralstonia solanacearum*). Since 2010, all material has also been tested for *Candidatus* Liberibacter solanacearum.

Propagative material at the UKPQU is also subjected to visual inspection. Tissue cultures are inspected for any sign of contamination or infestation (e.g. fungi, bacteria, arthropods) and glasshouse grown plants are inspected for any disease-like symptoms. A key element of the EPPO post-entry quarantine standard is that it addresses all regulated pests of potato. Additional tests are conducted on material for New Zealand.

Plant Biosecurity has assessed SASA against the framework for the approval of overseas sources for potato propagative material outlined in section 4.1:

- **Capacity for National Authority oversight—**facilities producing pathogen tested propagative material must be authorized/approved or operated directly by the National Plant Protection Organization (NPPO), as import conditions routinely require phytosanitary certification to be provided by the NPPO.
  - SASA runs the UKPQU on behalf of the UK Plant Health Authorities. The UKPQU is overseen by an Inter-Departmental Committee comprising of the Scottish Government; the Food and Environment Research Agency (FERA) on behalf of the Department for Environment and Rural Affairs; the Department of Agriculture and Rural Development for Northern Ireland (DARD-NI); the British Society of Plant Breeders; and research and commercial interest groups. The Food and Environment Research Agency is the NPPO for the United Kingdom.
- **Capacity to produce pathogen tested propagative material—**facilities must demonstrate their capacity to produce and maintain high health plant material through appropriate disease screening/testing and monitoring.
  - The UKPQU conducts testing (as required by EU legislation) for the following viruses: APLV, APMoV, PBRSV, PYV, Potato leafroll virus (PLRV), PVA, PVM, PVS, PVT, PVV, PVX, PVY. Additional viruses tested at the UKPQU include: AVB-O, PotLV, PMTV, Potato Virus P (PVP), PYVV, TRV and Tomato spotted wilt virus (ToSWV). TRV and PYVV are tested using real time RT-PCR and the other viruses by ELISA. Herbaceous indexing is done using a panel of nine indicator plant species (*Chenopodium amaranticolor*, *C. murale, C. quinoa*, *Nicotiana benthamiana*, *N. bigelovii*, *N. clevelandii*, *N. debneyi*, *N. occidentalis*-P1 and *N. tabacum* cv. White Burley).
  - Testing is also done for *Ca.* Liberibacter solanacearum, *Clavibacter michiganensis* subsp. *sepedonicus*, pectolytic bacteria (e.g. *Dickeya* and *Pectobacterium* spp.), and *Ralstonia solanacearum* using a range of different methods as appropriate (e.g. immunofluorescence (IF), selective medium and herbaceous indexing).

- The UKPQU also carries out quarantine testing of true potato seed from UK gene banks. Tested seed is held in the Commonwealth Potato Collection at the James Hutton Institute. The UKPQU collaborates with other potato quarantine scientists internationally to develop new methods for pathogen diagnosis, evaluate existing diagnostic methods and to develop guidelines for the safe movement of potato germplasm.
- The UKPQU is accredited by Ministry for Primary Industries (MPI), New Zealand to supply pathogen tested potato propagative material to New Zealand. To create a specific program for New Zealand, UKPQU included additional tests (electron microscopy and the use of genus-specific primers for detection of viruses) as required by NZ MPI (Table 4.1) to its current EU testing programme.

Table 4.1 Pathogen testing at the UKPQU for New Zealand

PATHOGEN TYPE	TESTS	PATHOGEN TYPE	TESTS
Bacteria			
Clavibacter michiganensis subsp. *sepedonicus*	V, IF, or E,M or P, M	*Dickeya paradisiaca*	V,S
Dickeya parthenii	V,S	*Pectobacterium betavasculorum*	V,S
Fungi			
Aecidium cantensis	V	*Phoma andigena* var. *andina*	V
Phytophthora infestans (A2 mating type)	V	*Synchytrium endobioticum*	V
Phytoplasma			
Eggplant little leaf phytoplasma	PP	Potato marginal flavescence	PP
Potato phyllody phytoplasma	PP	Potato purple top roll phytoplasma	PP
Potato purple top wilt phytoplasma	PP	Potato round leaf phytoplasma	PP
Potato stolbur phytoplasma	PP	Potato witches broom phytoplasma	PP
Viroids			
Potato spindle tuber viroid	R or D or P		
Viruses			
Andean potato latent virus	E, I	Andean potato mottle virus	E, I
Arracacha virus B – Oca strain	E, I	Beet curly top virus	PG
Eggplant mottled dwarf virus	I	Potato 14R virus	V
Potato black ringspot virus	E, I	Potato deforming mosaic virus	EG or PG
Potato latent virus	PG	Potato mop-top virus	E, I
Potato rough dwarf virus	PG	Potato virus P	PG
Potato virus T	E, I	Potato virus U	I
Potato virus V	EG or PG	Potato virus Y	EG or PG, I
Potato yellow dwarf virus	I	Potato yellow mosaic virus	I
Potato yellow vein virus	P or N	Potato yellowing virus	E
Solanum apical leaf curling virus	V	Solanum yellows virus	V
Southern potato latent virus	V	Sowbane mosaic virus	I
Tobacco necrosis virus	I	Tobacco rattle virus	I, P
Tobacco streak virus	I	Tomato black ring virus	E, I
Tomato infectious chlorosis virus	P	Tomato leaf curl New Delhi virus	I
Tomato yellow leaf curl virus	EG, or PG	Tomato yellow mosaic virus	EG or PG, I
Wild potato mosaic virus	I		

D: Digoxigenin probe **E:** pathogen specific ELISA **EG:** Genus specific ELISA
I: Indicator plants **IF:** Immunofluorescence microscopy
M: Visual examination of Murashige and Skoog medium **N:** Nucleic acid probe
P: pathogen specific PCR **PG:** Virus genus specific PCR **PP:** Phytoplasma PCR

R: Return PAGE   **S:** Selective pectate medium   **V:** Growing season inspection

- Pathogen screening/testing currently undertaken at UKPQU to meet EU legislation and New Zealand MPI requirements covers most of the pathogens of quarantine concern to Australia. However there are a few pathogens that are not covered by the testing in place at UKPQU. Therefore, Plant Biosecurity recommends that UKPQU develop a specific testing program for Australia to test for all pathogens identified by Australia (Table 2.1).

- **Capacity to meet containment and security requirements—**facilities for the establishment of pest free propagative material and testing for pest freedom must be subject to strict physical containment and operational requirements to prevent contamination or infestation of material.
  - All work at the UKPQU is conducted in a purpose built quarantine facility with glasshouses, growth rooms and laboratories. The quarantine facility also has two dedicated micropropagation laboratories and a tissue culture growth room, separate from the main quarantine facility.
- **Identity preservation systems—**all facilities must be able to demonstrate their ability to maintain adequate and verifiable safeguards to ensure that propagative material undergoing post-entry quarantine procedures is not diverted, contaminated or intermingled with other material during and following completion of the quarantine measures.
  - Each unit of potato propagative material is established as *in vitro* microplantlet cultures, observed over a growing season in the glasshouse for the presence of diseases and tested for specific pathogens. The testing done by the UKPQU exceeds EPPO requirements. Material released by the UKPQU is issued with a plant passport and may be planted without further testing anywhere in the European Union. The Plant Passport provided by the UKPQU is unique in that it specifies the pathogens tested and the testing done.
- **Audits and inspections—**all facilities producing pathogen tested propagative material should be officially audited by DAFF to ensure that they continue to meet Australia's requirements.
  - DAFF officials visited UKPQU in June 2010 and reviewed the facility against the framework outlined in Section 4.1 for approval of overseas sources to supply pathogen tested potato propagative material to Australia.

Based on technical discussions, production site visits to Scotland and assessment of SASA against the approval framework, Plant Biosecurity considers that SASA meets the criteria outlined in the framework for approval of sources of high health plant material. Therefore, Plant Biosecurity recommends that:

- The United Kingdom Potato Quarantine Unit (UKPQU) at Science and Advice for Scottish Agriculture (SASA) be approved as a high health source to supply pathogen tested potato propagative material; and
- Potato propagative material from UKPQU must be subjected to a reduced period of growth in a closed government PEQ facility in recognition of its high health status.

4.3.1 Phytosanitary requirements for potato propagative material from UKPQU

Recommended import requirements for potato propagative material produced in UKPQU are as follows:

- Each consignment must be accompanied by a phytosanitary certificate issued by the Scottish Government on behalf of the National Plant Protection Organisation (NPPO), the Food and Environment Research Agency (FERA), with the additional declaration that 'Potato propagative material in this consignment has been tested and found free of pests identified by Australia.'
- Consignments from UKPQU must be subjected to mandatory on-arrival verification inspection and growth in a closed government PEQ facility for a minimum of three months to verify the application of phytosanitary measures.
  - verification tests for a range of pathogens.
- If pathogens of quarantine concern are detected during verification tests the whole consignment will be subject to the same conditions as potato propagative material from all sources.

5 Conclusion

The findings of this final review of policy are based on a comprehensive analysis of the scientific literature. This review has identified pathogens of quarantine concern associated with potato propagative material (true potato seed, tissue culture and minitubers/microtubers) and recommended appropriate risk management measures.

Recommended risk mitigation measures

Existing conditions are strengthened through the introduction of additional diagnostic measures to protect Australia from exotic pathogens. The recommended risk management measures for potato propagative material are detailed below.

All sources (unknown health status)

Tissue cultures (microplantlets)

- mandatory on arrival inspection, growth in a closed government post-entry quarantine (PEQ) facility for a minimum period of six months for visual observation; and
- active pathogen testing, including herbaceous indexing and molecular tests.

True potato seed

- mandatory on-arrival inspection, fungicidal treatment, surface sterilisation and growth in a closed government PEQ facility for a minimum period of six months for visual observation; and
- active pathogen testing, including molecular tests.

Microtubers or minitubers (produced in a protected environment)

- Certification that microtubers or minitubers are produced in soilless media and tested free of nematodes of quarantine concern to Australia;
- mandatory on-arrival inspection, growth in a closed government PEQ facility for a minimum period of six months for visual observation; and
- active pathogen testing, including herbaceous indexing and molecular tests.

Approved sources (high health status)

Plant Biosecurity recommends that the United Kingdom Potato Quarantine Unit (UKPQU) at Science and Advice for Scottish Agriculture (SASA) be approved as a high health source for pathogen tested potato propagative material as it meets all framework requirements for approval of high health sources. However, Plant Biosecurity will consider requests for approval of other overseas high health sources based on the framework outlined in this review.

All potato propagative material produced by UKPQU, SASA will require:

- A phytosanitary certificate issued by the Scottish Government on behalf of the National Plant Protection Organisation (NPPO), the Food and Environment Research Agency (FERA), with an additional declaration that ‘potato propagative material in this consignment has been tested and found free of pests identified by Australia’.
- Mandatory on-arrival inspection
- Growth in a closed government PEQ facility for a minimum of three months to verify the application of phytosanitary measures, including verification testing for a range of pathogens.

- if pathogens of quarantine concern are detected during verification tests, the whole consignment will be subject to the same conditions as for potato propagative material from all sources.

Approval of UKPQU, SASA as a source of high health potato propagative material means that more biosecurity risks are addressed off-shore and the Australian potato industry will have quicker access to new overseas varieties.

Appendices

Appendix A: Pest categorisation: Potato propagative material (*Solanum tuberosum*) from all countries

Initiation identifies the pests which occur on *Solanum tuberosum*, their status in Australia and their pathway association. In this assessment **pathway** is defined as potato propagative material (true potato seed, minitubers/microtubers and tissue culture).

Pest categorisation is a screening procedure to determine whether the criteria for a quarantine pest are satisfied.

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
PATHOGENS					
BACTERIA					
Candidatus Liberibacter solanacearum Liefting *et al*. 2009 [Rhizobiales: Rhizobiaceae] (synonym *Candidatus* Liberibacter psyllaurous Hansen *et al*. 2008)	Not known to occur	**Yes**: *Candidatus* Liberibacter solanacearum is a phloem-limited bacterium and can be associated with all vegetative parts of host plants (MAFBNZ 2008; Cooke *et al.* 2009). This bacterium has been detected in symptomatic as well as asymptomatic plants (MAFBNZ 2008). Therefore, this bacterium could be introduced into Australia in infected propagative material.	**Yes**: This bacterium has established in areas with a wide range of climatic conditions (Munyaneza *et al*. 2007; Abdullah 2008; MAFBNZ 2008) and has spread naturally in infected propagative material (Cooke *et al*. 2009). The natural vector of this bacterium, *Bactericera cockerelli* (Hansen *et al*. 2008), is not present in Australia. However, the symptomless nature of this bacterium may contribute to the inadvertent propagation and distribution of infected material that will help it spread within Australia. Therefore, this bacterium has the potential for establishment and spread in Australia.	**Yes**: This bacterium affects solanaceous crops including capsicum, potato and tomato; however, symptoms of infection vary in severity and are influenced by host, cultivar, temperature and growing conditions (Liefting *et al*. 2009). This bacterium causes significant losses in potatoes, with yield losses reported to be up to 85% and 50% in western North America during 2001 and 2004, respectively (Hansen *et al*. 2008). Tubers from zebra chip affected plants produced potatoes unmarketable for potato chips (Munyaneza *et al*. 2008). This bacterium can also cause severe economic losses in all market classes of potatoes (Secor *et al*. 2009). Therefore, this bacterium has a potential for economic consequences in Australia.	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
Clavibacter michiganensis subsp. *sepedonicus* (Spieckermann & Kotthoff 1914) Davis *et al*. 1984 [Actinomycetales: Microbacteriaceae]	Not known to occur	**Yes**: This bacterium causes vascular disease and can be associated with all vegetative parts of the host (Pankova *et al*. 2007). Therefore, this bacterium could be introduced into Australia in infected propagative material.	**Yes**: This bacterium has established in areas with a wide range of climatic conditions (van der Wolf *et al*. 2005) and it can spread naturally in infected propagative material (van der Wolf *et al*. 2005; Pankova *et al*. 2007). Therefore, this bacterium has the potential for establishment and spread in Australia.	**Yes**: This bacterium is considered the most destructive pathogen of potatoes (Pankova *et al*. 2007) as it causes significant economic losses (van der Wolf *et al*. 2005). Losses caused by this bacterium are estimated €15 million annually (van der Wolf *et al*. 2005). Additionally, this bacterium is considered of quarantine significance by APPPC, IAPSC, COSAVE and JUNAC (van der Wolf *et al*. 2005). Presence of this bacterium in Australia would impact upon Australia's ability to access overseas markets. Therefore, this bacterium has the potential for economic consequences in Australia.	**Yes**
Dickeya chrysanthemi (Burkholder *et al*. 1953) Samson *et al*. 2005 [Enterobacteriales: Enterobacteriaceae]	Yes (Cother *et al*. 1992)	Assessment not required			
Dickeya dadantii Samson *et al*. 2005 [Enterobacteriales: Enterobacteriaceae]	Not known to occur	**Yes**: *Dickeya* species infect plants systemically (Czajkowski *et al*. 2010) and may remain latent for long periods (Jeffries 1998). This may lead to the propagation and distribution of infected propagative material (Tsror *et al*. 2009), suggesting that *Dickeya* species could be introduced	**Yes**: *Dickeya* species have established in areas with a wide range of climatic conditions (Palacio-Bielsa *et al*. 2006; Parkinson *et al*. 2009; Slawiak *et al*. 2009; Tsror *et al*. 2009; Toth *et al*. 2011; Tsror *et al*. 2011) and can spread naturally in infected propagative material (Czajkowski *et al*.	**Yes**: *Dickeya* species are economically important pathogens of potatoes (Toth *et al*. 2011) and ornamentals around the world (Parkinson *et al*. 2009). *Dickeya* infections can result in 20–25% yield reduction (Tsror *et al*. 2009). Direct losses caused by *Dickeya* infections result in downgrading or rejection of potatoes during seed certification (Toth *et al*. 2011).	**Yes**
Dickeya dianthicola Samson *et al*. 2005 [Enterobacteriales: Enterobacteriaceae]	Not known to occur	(as above)	(as above)	(as above)	**Yes**
Dickeya dieffenbachiae Samson *et al*. 2005 [Enterobacteriales: Enterobacteriaceae]	Not known to occur	(as above)	(as above)	(as above)	**Yes**
Dickeya paradisiaca (Fernandez-Borrero and Lopez-Duque 1970) Samson *et al*. 2005 [Enterobacteriales: Enterobacteriaceae]	Not known to occur	(as above)	(as above)	(as above)	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
Dickeya parthenii Samson *et al*. 2005 [Enterobacteriales: Enterobacteriaceae]	Not known to occur	into Australia.	2010). Therefore, *Dickeya* species have the potential for establishment and spread in Australia.	Therefore, *Dickeya* species have potential for economic consequences in Australia.	**Yes**
Dickeya solani sp. nov. [Enterobacteriales: Enterobacteriaceae]	Not known to occur				**Yes**
Dickeya zeae Samson *et al*. 2005 [Enterobacteriales: Enterobacteriaceae]	Yes (Samson *et al*. 2005)	Assessment not required			
Pectobacterium atrosepticum (van Hall 1902) Gardan *et al*. 2003 [Enterobacteriales: Enterobacteriaceae]	Yes (PHA 2001)	Assessment not required			
Pectobacterium betavasculorum (Thomson *et al*. 1984) Gardan *et al*. 2003	Not known to occur	**Yes:** *Pectobacterium* species are associated with soft rot of potatoes and are associated with seed tubers (van der Merwe *et al* 2010). These bacteria cause blackening and vascular discoloration (Duarte *et al*. 2004; El-Tassa and Duarte 2006; van der Merwe *et al*. 2010) and cause latent infection in tubers (Pérombelon 2002).Therefore, *Pectobacterium* species could be introduced into Australia in infected propagative material.	**Yes:** *Pectobacterium* species associated with potatoes have established in areas with a wide range of climatic conditions (Ma *et al*. 2007; Pitman *et al*. 2010; Marquez-Villavicencio *et al*. 2011) and can spread naturally in infected propagative material (El-Tassa and Duarte 2006; van der Merwe *et al*. 2010). Therefore, *Pectobacterium* species have the potential for establishment and spread in Australia.	**Yes:** *Pectobacterium* species cause wilting, soft rot and blackleg and affect plant health during field production and storage (Marquez-Villavicencio *et al*. 2011). Some strains of *Pectobacterium* species are more aggressive on tubers and stems, and infected plants may wilt and ultimately die (Duarte *et al*. 2004; Marquez-Villavicencio *et al*. 2011). *Pectobacterium* species cause severe economic losses to the potato seed and commercial production industries (van der Merwe *et al*. 2010). Therefore, these pathogens have potential for economic consequences in Australia.	**Yes**
Pectobacterium carotovorum subsp. *brasiliensis* Duarte *et al*. 2004 [Enterobacteriales: Enterobacteriaceae]	Not known to occur				**Yes**
Pectobacterium wasabiae (Goto & Matsumoto 1987) Gardan *et al*. 2003 [Enterobacteriales: Enterobacteriaceae]	Not known to occur				**Yes**
Pectobacterium carotovorum (Jones 1901) Gardan *et al*. 2003) [Enterobacteriales: Enterobacteriaceae]	Yes (Horne *et al*. 2002)	Assessment not required			
Pseudomonas marginalis pv. *marginalis* (Brown 1918) Stevens 1925	Yes (Bradbury 1986)	Assessment not required			

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
[Pseudomonodales: Pseudomonodaceae]					
Ralstonia solanacearum (Smith 1896) Yabuuchi *et al*. 1996 [Burkholderiales: Burkholderiaceae]	Not known to occur[7]	**Yes:** Strains of this bacterium cause potato plants to wilt and cause latent infection in seed tubers (Graham *et al*. 1979). Therefore, strains of this bacterium could be introduced into Australia in infected propagative material.	**Yes:** Strains of this bacterium that are associated with potatoes are established in areas with a wide range of climatic conditions (Fegan and Prior 2005) and can spread naturally in infected propagative material (Graham *et al*. 1979). Therefore, this bacterium has the potential for establishment and spread in Australia.	**Yes:** This soil-borne bacterial pathogen is a major limiting factor in the production of many crop plants around the world (Olson 2005). This bacterium causes brown rot of potato, bacterial wilt or southern wilt of tomato, tobacco, eggplant, and some ornamentals, and Moko disease of banana (Olson 2005). This bacterium is considered to be a quarantine pest by NAPPO and the presence of strains of this bacterium in Australia would impact upon Australia's ability to access overseas markets. Therefore, RS strains have a potential for economic consequences in Australia.	**Yes**
Streptomyces acidiscabies Lambert and Loria 1989 [Actinomycetales: Streptomycetaceae]	Not known to occur	**Yes**: *Streptomyces* species cause scab on tubers (Park *et al*. 2003; Wale *et al*. 2008) and are well adapted saprophytes that persist in	**Yes**: *Streptomyces* species associated with potatoes have established in areas with a wide range of climatic conditions (Park *et al*. 2003;	**Yes**: Plant pathogenic *Streptomyces* species cause diseases on a diverse range of root crops such as potato, radish, turnip, beet, carrot and sweet	**Yes**
Streptomyces caviscabiei Goyer *et al*. 1996 [Actinomycetales:	Not known to occur				**Yes**

[7] Race 1 and race 3 are present in Australia (Graham *et al*. 1979); however, other strains of *Ralstonia solanacearum* (RS) are not present in Australia. Strains of *Ralstonia solanacearum* are differentiated into five races according to host range and five biovars based on biochemical tests (He *et al*. 1983; Buddenhagen and Kelman 1964; Hayward 1964). However, the race and biovar classifications do not correspond to each other, except that race 3 strains causing potato brown rot are generally equivalent to biovar 2, and referred to as race 3 biovar 2 strains. There are no standard laboratory tests to define the "race" of RS because host ranges of RS strains are broad and often overlap. Recently, an interspecies characterization of *Ralstonia solanacearum* based on nucleotide sequence analysis has been introduced to distinguish RS strains (Fegan and Prior 2005). Based on nucleotide sequence analysis, four phylotypes of RS has been identified that accommodate sequevars as subgroups (Fegan and Prior 2005).

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
Streptomycetaceae]		soil on decaying organic matter (Wale *et al*. 2008). Therefore, potato tubers provide a pathway for these pathogens.	Jaekyeong *et al*. 2004; Bouchek-Mechiche *et al*. 2006) and can spread naturally in infected propagative material (El-Tassa and Duarte 2006; van der Merwe *et al*. 2010). Therefore, *Streptomyces* species have the potential for establishment and spread in Australia.	potato (Labeda and Lyons 1992; Goyer and Beaulieu 1997). Scab diseases are characterized by corky lesions on potato tubers and expanded tap roots and cause economically significant losses in yield (Jaekyeong *et al*. 2004). *Streptomyces* species are considered to be of quarantine concern by several countries. The presence of *Streptomyces* species in Australia would impact upon Australia's ability to access overseas markets. Therefore, *Streptomyces* species have the potential for economic consequences in Australia.	
Streptomyces europaeiscabiei Bouchek-Mechiche *et al*. 2000 [Actinomycetales: Streptomycetaceae]	Not known to occur				**Yes**
Streptomyces luridiscabiei Park *et al* 2003 [Actinomycetales: Streptomycetaceae]	Not known to occur				**Yes**
Streptomyces niveiscabiei Park *et al* 2003 [Actinomycetales: Streptomycetaceae]	Not known to occur				**Yes**
Streptomyces puniciscabiei Park *et al* 2003 [Actinomycetales: Streptomycetaceae]	Not known to occur				**Yes**
Streptomyces reticuliscabiei Bouchek-Mechiche *et al*. 2000 [Actinomycetales: Streptomycetaceae]	Not known to occur				**Yes**
Streptomyces scabiei (Thaxter 1891) Waksman and Henrici 1948 [Actinomycetales: Streptomycetaceae]	Yes (Horne *et al*. 2002)	Assessment not required			
Streptomyces stelliscabiei Bouchek-Mechiche *et al*. 2000 [Actinomycetales: Streptomycetaceae]	Not known to occur	**Yes**: *Streptomyces* species cause scab on tubers (Wale *et al*. 2008) and are well adapted saprophytes that persist in soil on decaying organic matter (Song *et al*. 2004; Wale *et al*. 2008). Therefore, potato tubers provide a pathway for these pathogens.	**Yes**: *Streptomyces* species associated with potatoes have established in areas with a wide range of climatic conditions (Park *et al*. 2003; Jaekyeong *et al*. 2004; Bouchek-Mechiche *et al*. 2006) and can spread naturally in infected propagative material (El-Tassa and Duarte 2006; van der Merwe *et al*. 2010). Therefore, *Streptomyces* species have the potential	**Yes**: *Streptomyces* species cause diseases on a diverse range of root crops such as potato, beet, carrot and sweet potato (Labeda and Lyons 1992; Goyer and Beaulieu 1997). Scab diseases are characterized by corky lesions on potato tubers and expanded tap roots and cause economically significant losses in yield (Jaekyeong *et al*. 2004). *Streptomyces* species are considered to be of quarantine concern by several countries. The	**Yes**
Streptomyces turgidiscabies Miyajima *et al*. 1998 [Actinomycetales: Streptomycetaceae]	Not known to occur				**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
			for establishment and spread in Australia.	presence of *Streptomyces* species would impact upon Australia's ability to access overseas markets. Therefore, *Streptomyces* species have a potential for economic consequences in Australia.	
FUNGI					
Aecidium cantensis Arthur [Pucciniales: Pucciniaceae]	Not known to occur	**Yes**: This fungus is associated with foliage causing rust pustules on leaves, petioles and stems (Hooker 1981). The fungus can survive throughout the year on plants (Stevenson *et al*. 2001). Therefore, this fungus could be introduced into Australia in infected propagative material.	**Yes:** This pathogen has established in areas with a wide range of climatic conditions (Stevenson *et al*. 2001) and can spread naturally in infected propagative material. Therefore, it has the potential for establishment and spread in Australia.	**Yes**: This pathogen can cause economic losses under rainy conditions in potatoes (Stevenson *et al*. 2001). Additionally, this fungus also affects tomatoes (Hooker 1981; Stevenson *et al*. 2001). Therefore, this fungus has the potential for economic consequences in Australia.	**Yes**
Alternaria alternata (Fr.) Keissl. [Pleosporales: Pleospraceae]	Yes (PHA 2001)	Assessment not required			
Alternaria solani Sorauer [Pleosporales: Pleospraceae]	Yes (Horne *et al.* 2002)	Assessment not required			
Athelia rolfsii (Curzi) C.C. Tu & Kimbr [Atheliales : Atheliaceae]	Yes (PHA 2001)	Assessment not required			
Botrytis cinerea Pers. [Helotiales: Screotiniaceae]	Yes (Floyd 2010)	Assessment not required			
Cercospora solani-tuberosi Thirum. [Capnodiales: Mycosphaerellaceae]	Not known to occur	No: This fungus is associated with foliage (Tian *et al.* 2008) and propagative material does not provide a pathway for this species.	Assessment not required		

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
Choanephora cucurbitarum (Berk. & Ravenel) Thaxt. [Mucorales : Choanephoraceae]	Yes (PHA 2001)	Assessment not required			
Colletotrichum coccodes (Wallr.) S. Hughes [Incertae sedis: Glomerellaceae]	Yes (Horne *et al.* 2002)	Assessment not required			
Fusarium acuminatum Ellis & Everh [Hypocreales: Nectriaceae]	Yes (PHA 2001)	Assessment not required			
Fusarium arthrosporioides Sherbakoff [Hypocreales: Nectriaceae]	Yes (PHA 2001)	Assessment not required			
Fusarium avenaceum (Fr.) Sacc. [Hypocreales: Nectriaceae]	Yes (Summerell *et al*. 2011)	Assessment not required			
Fusarium coeruleum Lib. ex Sacc. [Hypocreales: Nectriaceae]	Yes (Chambers and Millington 1974)	Assessment not required			
Fusarium crookwellense Burgess *et al.* [Hypocreales: Nectriaceae]	Yes (Summerell *et al*. 2011)	Assessment not required			
Fusarium culmorum (W. G. Smith) Sacc. [Hypocreales: Nectriaceae]	Yes (Summerell *et al*. 2011)	Assessment not required			
Fusarium equiseti (Corda) Sacc. [Hypocreales: Nectriaceae]	Yes (Summerell *et al*. 2011)	Assessment not required			
Fusarium graminearum Schwabe [Hypocreales: Nectriaceae]	Yes (Summerell *et al*. 2011)	Assessment not required			
Fusarium javanicum Koord. [Hypocreales: Nectriaceae]	Not known to occur	**Yes**: This soil-borne fungus causes vascular wilt in potatoes (Wale *et al*. 2008). It spreads from infected mother tubers (Wale *et al.* 2008). Therefore, this fungus could be introduced into Australia on infected or contaminated propagative material.	**Yes:** This pathogen has established in areas with a wide range of climatic conditions (Farr and Rossman 2011) and can spread naturally in infected propagative material. Therefore, it has the potential for establishment and spread in Australia.	No: Information on the economic consequences of this fungus is almost non-existent. *Fusarium javanicum* is considered of little significance on potatoes in Europe (Wale *et*. 2008). Therefore, this fungus does not have the potential for significant economic consequences in Australia.	

Pest	**Present within Australia**	**Potential to be on pathway**	**Potential for establishment and spread**	**Potential for economic consequences**	**Quarantine pest?**
Fusarium oxysporum Schltdl. [Hypocreales: Nectriaceae]	Yes (Summerell *et al*. 2011)	Assessment not required			
Fusarium sambucinum Fuckel [Hypocreales: Nectriaceae]	Yes (Summerell *et al*. 2011)	Assessment not required			
Fusarium solani (Mart.) Appel & Wollenweber emend. Snyder & Hansen [Hypocreales: Nectriaceae]	Yes (Summerell *et al*. 2011)	Assessment not required			
Fusarium sulphureum Schltdl [Hypocreales: Nectriaceae]	Yes (Osborn 1995)	Assessment not required			
Fusarium tabacinum (J.F.H. Beyma) W. Gams [Hypocreales: Nectriaceae]	Yes (Osborn 1995)	Assessment not required			
Fusarium trichothecioides Wollenweber [Hypocreales: Nectriaceae]	Yes (PHA 2001)	Assessment not required			
Gerwasia pittieriana (Henn.) León-Gall. & Cummins [Pucciniales: Pucciniaceae] (synonyms: *Puccinia pittieriana* Henn.)	Not known to occur	**Yes**: This microcyclic fungus is associated with foliage and causes rust pustules on leaves and stems (Hooker 1981). The fungus could be introduced on the stems of living material (e.g. material imported for breeding purposes), or on dead plant material or crop residues	**Yes**: This pathogen has established in areas with a wide range of climatic conditions (Hooker 1981) and can spread naturally in infected propagative material (OEPP/EPPO 1988). Therefore, it has the potential for establishment and spread in Australia.	**Yes**: This pathogen is of significant economic importance in several countries. Epidemic development may result in the death of most plants and severe yield loss (Stevenson *et al*. 2001). This fungus is considered of quarantine significance by EPPO (OEPP/EPPO 1988). The presence of this species in Australia would impact upon	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		(OEPP/EPPO 1988). Therefore, this fungus could be introduced into Australia on infected or contaminated propagative material.		Australia's ability to access overseas markets. Therefore, this fungus has the potential for economic consequences in parts of Australia.	
Golovinomyces cichoracearum var. *cichoracearum* (DC.) V.P. Heluta [Erysiphales Erysiphaceae]	Yes (PHA 2001)	Assessment not required			
Helicobasidium brebissonii (Desm.) Donk [Helicobasidiales: Helicobasidiaceae] (synonym: *Helicobasidium purpureum* Donk)	Yes (Shivas 1989)	Assessment not required			
Helminthosporium solani Durieu & Mont. [Pleosporales: Massarinaceae]	Yes (Horne *et al.* 2002)	Assessment not required			
Macrophomina phaseolina (Tassi) Goid. [Botryosphaeriales: Botryosphaeriaceae]	Yes (PHA 2001)	Assessment not required			
Passalora concors (Casp.) U. Braun & Crous [Capnodiales: Mycosphaerellaceae]	Yes (PHA 2001)	Assessment not required			
Phacidiopycnis tuberivora (H.T. Güssow & W.R. Foster) B. Sutton [Leotiales: Bulgariaceae]	Yes (PHA 2001), quarantine pest for Tasmania	**Yes:** *Phacidiopycnis tuberivora* is reported to cause tuber rot of potatoes (Laundon 1970). Tubers become infected at the stem end, where a hard, dry, corky rot develops (Foster and MacLeod 1932). This species is a wound pathogen on some hosts (Harvey and Braithwaite 1982), but wounds are not necessary for potato infection (Foster	**Yes:** This pathogen has established in areas with a wide range of climatic conditions (Sutton 1980) and can spread naturally in infected propagative material (Foster and MacLeod 1932). Therefore, this pathogen has the potential for establishment and spread in Australia.	**Yes:** This species is reported to infect potato, *Medicago sativa*, hop, *Hoya* spp. and *Olearia traversii* (Sutton 1980; Gent *et al*. 2013). It causes lesions on potato tubers that vary in size from pin heads to covering the whole tuber (Foster and MacLeod 1932). Immature tubers can be completely mummified (Foster and MacLeod 1932). In hop, this fungus causes underdeveloped branches, chlorotic leaves and in severe cases plant death (Gent *et*	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		and MacLeod 1932). Therefore, this fungus may be on the pathway of potato propagative material.		*al*. 2013). Therefore, this species has the potential for economic consequences in Australia.	
Phoma andigena var. *andina* Turkenst. [Pleosporales: Incertae sedis]	Not known to occur	**Yes**: These pathogens are associated with foliage and stems (Agrios 1997; Stevenson *et al*. 2001). These pathogens survive in soil on crop debris or as chlamydospores in the soil (Stevenson *et al*. 2001). Therefore, *Phoma* species could be introduced into Australia in soil adhering to the potato tubers.	**Yes**: These pathogens have established in areas with a wide range of climatic conditions (Cline 2005a, b) and can spread naturally in infected or contaminated propagative material. Therefore, these pathogens have the potential to establish and spread in Australia.	**Yes**: *Phoma* leaf spot is an important disease in areas where it is established. In susceptible cultivars, yield reductions due to *P. andigena* var. *andina* may reach 80% (Stevenson *et al*. 2001). Therefore, these *Phoma* species have potential for economic consequences in parts of Australia.	**Yes**
Phoma crystalliniformis (Loer. *et al*.) Noordel. & Gruyter [Pleosporales: Incertae sedis]	Not known to occur				**Yes**
Phoma eupyrena Sacc [Anamorphic Leptosphaereceae]	Yes (PHA 2001)	Assessment not required			
Phoma exigua var. *exigua* Sacc. [Pleosporales: Incertae sedis]	Yes (Wale *et al*. 2008)	Assessment not required			
Phoma exigua var. *foveate* Foister [Pleosporales: Incertae sedis]	Yes (Stevenson *et al*. 2001)	Assessment not required			
Pleospora herbarum (Pers.) Rabenh [Pleosporales: Pleosporaceae]	Yes (Irwin *et al*. 1986)	Assessment not required			
Polyscytalum pustulans (M.N. Owen & Wakef.) M.B. Ellis [Incertae sedis: Incertae sedis] (synonym *Oospora pustulans* M.N. Owen & Wakef.)	Not known to occur[8]	**Yes:** *Polyscytalum pustulans* is primarily tuberborne (Stephenson *et al*. 2001). Infected tubers	**Yes:** This fungus has established in a wide range of climatic conditions (Stephenson *et al*. 2001). It	**Yes:** *Polyscytalum pustulans* causes skin spots on potato tubers that detract from the tuber's appearance and can	**Yes**

[8] Stevenson *et al*. (2001) report that *Polyscytalum pustulans* is present in Australia, but further information is not provided to support the claim. This species has been reported to occur in Tasmania (Sampson and Fountain 1960; Sampson and Walker 1982), but is not reported to occur in mainland Australia. There are no recent records of this species occurring in Tasmania (DPIPWE 2013, pers. comm.), therefore this species is considered to be absent (no longer present) from Australia.

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		usually appear symptomless when harvested and symptoms may take two months to appear (Stephenson *et al*. 2001). Conidia produced on skin spots spread infection during storage (Stephenson *et al*. 2001). This fungus can also infect the haulm, stem bases, roots and stolons of potato plants (Wale 2008). Therefore, this pathogen has the potential to occur on the pathway of potato propagative material.	can spread naturally in infected propagative material from inoculum in the soil (Stephenson *et al*. 2001). Tuber infection can be symptomless (Stephenson *et al*. 2001) and this may contribute to the inadvertent propagation and distribution of infected material. Therefore, this pathogen has the potential to establish and spread in Australia.	reduce the market value of the potato (Wale 2008). The fungus can also cause non-emergence or uneven emergence of seed tubers after planting due to invasion of eyes and buds (Wale 2008). In severe cases, extensive areas of the potato crop may fail to emerge (Wale 2008). Therefore, this fungus has the potential for economic consequences in Australia.	
Rhizoctonia solani JG Kuhn [Ceratobasidiales: Ceratobasidiaceae]	Yes (Horne *et al.* 2002)	Assessment not required			
Sclerotinia sclerotiorum (Lib.) de Bary [Helotiales: Sclerotiniaceae]	Yes (Horne *et al.* 2002)	Assessment not required			
Septoria lycopersici var. malagutii Ciccar. & Boerema ex E.T. Cline [Capnodiales: Mycosphaerellaceae]	Not known to occur	No: This pathogen is associated with foliage, causing leaf spot, and survives in plant debris (Stevenson *et al*. 2001). Therefore, propagative material does not provide pathway for this fungus.	Assessment not required		
Synchytrium endobioticum (Schilb.) Percival) [Chytridiales: Synchytriaceae]	Not known to occur	**Yes:** This pathogen infects meristematic tissues of growing points, buds, stolons tips, or young leaf primordia (Stevenson *et al*. 2001). Therefore, this	**Yes:** This fungus has established in areas with a wide range of climatic conditions and can spread naturally in infected propagative material (Wale	**Yes:** *Synchytrium endobioticum* is a serious pathogen of potatoes. Once the pathogen has been introduced to a field of cultivated potatoes the whole crop may be devastated and unmarketable	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		fungus could be introduced into Australia in infected propagative material.	*et al*. 2008). Therefore, it has the potential for establishment and spread in Australia.	(EPPO 1982). Moreover, introduction into the soil not only renders the crop unusable but the soil itself cannot be used for further crop production due to the longevity of the fungus (EPPO 1982). Crops other than potato grown in this soil cannot be used for export (Hooker 1981; EPPO 1982). Therefore, this fungus has the potential for economic consequences in Australia.	
Thecaphora solani Barrus [Urocystidiales: Glomosporiaceae]	Not known to occur	**Yes:** This pathogen is soil-borne and infects the meristem region of young sprouts and the hyphae are intercellular (Stevenson *et al*. 2001; Wale *et al*. 2008). The fungus produces galls below the soil-line on stems, stolons and tubers (Stevenson *et al*. 2001). The fungus survives in soil (Wale *et al*. 2008) and soil adhering to seed tubers may contain spores of this fungus. Therefore, propagative material provides a pathway for this fungus.	**Yes:** This pathogen has established in areas with a wide range of climatic conditions (Wale *et al*. 2008) and it can spread naturally in infected propagative material, irrigation water and by grazing livestock (Stevenson *et al*. 2001). Therefore, this pathogen has the potential for establishment and spread in Australia.	**Yes:** This fungus is an important pathogen of potato crops (Bazan de Segura 1960). Losses of up to 85% have been reported (Stevenson *et al*. 2001). It directly infects the tubers, reducing the quantity and quality of the yield. Additionally, this fungus is considered of quarantine significance by EPPO (OEPP/EPPO 1979). The presence of this species in Australia would impact upon Australia's ability to access overseas markets. Therefore, this fungus has the potential for economic consequences in Australia.	**Yes**
Ulocladium atrum Preuss [Pleosporales: Pleosporaceae]	Yes (PHA 2001)	Assessment not required			

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
Verticillium albo-atrum Reinke & Berthold [Incertae sedis: Plectosphaerellaceae]	Yes (Walker 1990)[9].	Assessment not required			
Verticillium dahliae Kleb. [Incertae sedis: Plectosphaerellaceae]	Yes (Horne *et* al. 2002)	Assessment not required			
STRAMINOPILA					
Phytophthora cryptogea Pethybr. & Laff. [Peronosporales: Peronosporaceae]	Yes (PHA 2001)	Assessment not required			
Phytophthora drechsleri Tucker [Peronosporales: Peronosporaceae]	Yes (PHA 2001)	Assessment not required			
Phytophthora erythroseptica Pethybr. [Peronosporales: Peronosporaceae]	Yes (Horne *et al*. 2002)	Assessment not required			
Phytophthora infestans (Mont.) de Bary [Peronosporales: Peronosporaceae] [A2 mating strain and exotic strains of both the A1 and A2)	Not known to occur[10]	**Yes:** This pathogen infects foliage and stems and symptom development is weather dependent (Wale *et al*. 2008). Therefore, propagative material provides a pathway for this fungus.	**Yes**: This pathogen has established in areas with a wide range of climatic conditions (Wale *et al*. 2008) and it can spread naturally in infected propagative material (Wale *et al*. 2008). Therefore, this pathogen has the potential to establish and spread in Australia.	**Yes:** This pathogen is one of the most serious pathogens of potatoes (Stevenson *et al*. 2001; Wale *et al*. 2008). The pathogen can result in 100% crop loss (Wale *et al*. 2008). Therefore, this fungus has the potential for economic consequences in Australia.	**Yes**
Phytophthora megasperma Drechsler [Peronosporales: Peronosporaceae]	Yes (PHA 2001)	Assessment not required			
Phytophthora nicotianae Breda de Haan [Peronosporales: Peronosporaceae]	Yes (PHA 2001)	Assessment not required			
Pythium aphanidermatum (Edson) Fitzp. [Pythiales: Pythiaceae]	Yes (PHA 2001)	Assessment not required			

[9] Many records of *Verticillium albo-atrum* in Australia are misidentifications of *Verticillium dahliae*. However, *V. albo-atrum* has been confirmed to occur on potatoes in Australia (Walker 1990).

[10] Some A1 strains of *Phytophthora infestans* are known to occur in Australia (Forbes *et al*. 1998; Burges *et al*. 2005), however A2 strains are not known to occur.

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
Pythium debaryanum R. Hesse [Pythiales: Pythiaceae]	Yes (PHA 2001)	Assessment not required			
Pythium deliense Meurs [Pythiales: Pythiaceae]	Yes (PHA 2001).	Assessment not required			
Pythium ultimum Trow [Pythiales: Pythiaceae]	Yes (PHA 2001)	Assessment not required			
PROTOZOA					
Spongospora subterranea (Wallr.) Lagerh. f. sp. *subterranea* Tomlinson (potentially carrying Potato mop-top virus [PMTV]) [Plasmodiophorida: Plasmodiophoraceae]	No[11]	**Yes:** This soil-borne pathogen is a vector of PMTV and is associated with potato tubers causing powdery scab (Hutchison and Kawchuk 1998). Therefore, potato propagative material may provide a pathway for this fungus to enter Australia carrying PMTV.	**Yes:** The fungus and PMTV have established in areas with a wide range of climatic conditions (Van Hoof and Rozendaal 1969; Salazar and Jones 1975; Imoto *et al*. 1981; Stevenson *et al*. 2001) and can spread naturally in infected propagative material. Therefore, these pathogens have the potential to establish and spread in Australia.	**Yes:** PMTV causes spraing disease, which is characterised by necrotic arcs and brown flecks inside of potato tubers (Santala *et al*. 2010).The incidence of spraing symptoms in sensitive cultivars often exceeds 25 and 30–50% in Sweden and Denmark, respectively (Stevenson *et al*. 2001). Therefore, introduction and spread of PMTV with *Sss* has the potential for economic consequences in Australia.	**Yes**
PHYTOPLASMAS[12]					
Candidatus Phytoplasma asteris [**16SrI** – Aster yellows group] **[13]** (Strains: Chinese	Not known to	**Yes**: Phytoplasmas are restricted to host phloem	**Yes**: These phytoplasmas have established in areas	**Yes**: These pathogens cause phyllody and virescence	**Yes**

[11] This pathogen is present in Australia (Stevenson *et al*. 2001; Gau *et al*. 2010), but the virus it vectors, potato-mop-top-virus (Carnegie *et al*. 2012), is absent from Australia. Therefore, *S. subterranea* f. sp. *subterranea* carrying PMTV is considered as a potential pathway for entry of this virus into Australia.

[12] Phytoplasmas are classified on the basis of molecular data obtained from 16S rDNA and other conserved genes into distinct groups, subgroups and species belonging to the newly-established '*Candidatus* Phytoplasma' taxon (IRPCM 2004). Initially, differentiation of the phytoplasma was based on the geographical origins of the diseases, the specific hosts and insect vectors and the symptoms exhibited by the host plant. However, given that the same phytoplasma strain may induce different symptoms in different hosts and different strains may share common vectors or cause diseases showing similar symptoms, this approach did not provide an accurate means of phytoplasma classification (Weintraub and Jones 2010). Therefore, the designation of a new/distinct '*Candidatus* Phytoplasma' species is based on the nucleotide sequence of the 16S rRNA gene.

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
potato phytoplasma, El Salvador potato phytoplasma, Iranian potato phytoplasma, Nebraska potato purple top phytoplasma, Peruvian (Andahuaylas) potato phytoplasma, Potato marginal flavescence phytoplasma, Potato phyllody phytoplasma, Potato purple-top roll phytoplasma, Potato purple-top wilt phytoplasma, Russian potato purple top phytoplasma, Texas potato purple top phytoplasma)	occur	tissues (McCoy 1984; Stevenson *et al*. 2001). Symptom severity and type vary with different potato cultivars, environmental conditions, and the strain of pathogen involved (Jones *et al*. 2009). These phytoplasmas are associated with all vegetative parts of host plants, including tubers (Jones *et al*. 2009). Therefore, propagative material provides a pathway for phytoplasmas.	with a wide range of climatic conditions (Jones *et al*. 2009) and can spread naturally in infected propagative material (Stevenson *et al*. 2001). Multiplication and marketing of infected propagative material and leafhopper vectors present in Australia will help spread these phytoplasmas within Australia. Therefore, they have the potential to establish and spread in Australia.	(Stevenson *et al*. 2001). Affected plants may exhibit vascular discoloration and wilting and may die prematurely (Stevenson *et al*. 2001). Agents of the aster yellows group of diseases cause considerable losses when incidences of infection are high (Jones *et al*. 2009). Therefore, this phytoplasma group has the potential for economic consequences in Australia.	
Candidatus Phytoplasma aurantifolia [**16SrII** – Peanut Witches' Broom Group][14] (Mexican potato purple top phytoplasma, Peruvian potato phytoplasma, Potato phytoplasma isolate Islamabad, Potato phytoplasma isolate Pot001)	Not known to occur[15]	**Yes**: These phytoplasmas are associated with potato purple top disease. Symptoms include upward rolling of the top leaves with reddish or purplish discoloration, proliferation	**Yes**: Phytoplasmas associated with potato purple top disease (PPT) have established in areas with a wide range of climatic conditions (Leyva-Lopez *et al*. 2002; Munyaneza 2010;	**Yes**: Phytoplasmas associated diseases are an important limiting factor of potato production (Leyva-Lopez *et al*. 2002). These diseases cause significant yield loss and reduction in tuber and seed quality (Munyaneza 2005;	**Yes**

[13] The aster yellows group of diseases includes a broad spectrum of allied diseases caused by multiple groups of phytoplasmas (Leyva-López *et al.* 2002). There is considerable confusion over nomenclature in the potato literature as many different names have been used to describe the symptoms and to name the individual diseases in the group.

[14] Five different phytoplasma groups (16SrI, 16SrII, 16SrIII, 16SrVI, and 16SrXVIII) have been associated with PPT disease in different regions of North America and Mexico (Santos-Cervantes *et al*. 2010) and three different phytoplasma groups (16SrI, 16SrII and16SrXII-A) have been associated with PPT disease in Iran (Hosseini *et al*. 2011). Phytoplasmas are phloem-limited and insect-transmitted plant pathogens and mixed infections are common (Leyva-López *et al*. 2002; Santos-Cervantes *et al*. 2010; Hosseini *et al*. 2011).

[15] *Candidatus* Phytoplasma aurantifolia has been recorded in Australia (Davis *et al*. 1997, 2003; Streten and Gibb 2006); however, strains causing potato purple top disease are not present in Australia.

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
Candidatus Phytoplasma pruni [**16SrIII** – X-Disease Group] (Alaska potato purple top phytoplasma, Mexican potato purple top phytoplasma COAHP, Mexican potato purple top phytoplasma GTOP, Montana potato purple top phytoplasma)	Not known to occur	of buds, shortened internodes, swollen nodes, aerial tubers, and early senescence (Lee *et al*. 2004; Munyaneza *et al*. 2009a). These phytoplasmas are associated with propagative material (Crosslin *et al*. 2011). Therefore, propagative material provides a pathway for these phytoplasmas.	Hosseini *et al*. 2011) and can spread naturally in infected propagative material (Crosslin *et al*. 2011). Multiplication and marketing of infected propagative material and leafhopper vectors present in Australia will help spread these phytoplasmas within Australia. Therefore, the PPT phytoplasmas have the potential to establish and spread in Australia.	Munyaneza *et al*. 2007). These phytoplasmas are included among the non-European potato viruses of the EPPO A1 quarantine list (OEPP/EPPO 1984a, b). The presence of these phytoplasmas in Australia would impact upon Australia's ability to access overseas markets. Therefore, PPT associated phytoplasmas have the potential for economic consequences in Australia.	**Yes**
Candidatus Phytoplasma trifolii [1**6SrVI** – Clover Proliferation Group] (Columbia Basin potato purple top phytoplasma, Potato purple top phytoplasma PPT, Potato purple top phytoplasma YN-6, Potato witches' broom phytoplasma, Washington potato purple top phytoplasma)	Not known to occur				**Yes**
Candidatus Phytoplasma australiense (**16SrXII-B**)	Yes (Streten and Gibb 2006)[16]	Assessment not required			
Candidatus Phytoplasma solani [**16SrXII-A** – Stolbur Group] (strains: Eggplant little leaf phytoplasma, Potato stolbur phytoplasma, Potato round leaf phytoplasma, Potato witches' broom phytoplasma, Iranian potato purple top phytoplasma, Russian potato purple top phytoplasma Rus-PPT, Turkish potato stolbur phytoplasma)	Not known to occur	**Yes**: This phytoplasma group is associated with potato purple top disease (Secor *et al*. 2006; Hosseini *et al*. 2011). Foliar symptoms include stunting, chlorosis, slight purple coloration of new growth, swollen nodes, proliferated axillary buds, and aerial tubers. Tuber symptoms include mild vascular	**Yes**: Phytoplasmas associated with potato purple top disease have established in areas with a wide range of climatic conditions (Secor *et al*. 2006; Hosseini *et al*. 2011) and can spread naturally in infected propagative material. Multiplication and marketing of infected propagative material and	**Yes**: Phytoplasma associated diseases are an important limiting factor of potato production (Munyaneza 2006). This phytoplasma is involved in the disease complex contributing to defective processed products produced from infected potatoes. The defect consists of patchy brown discoloration of chips and can be a cause for rejection of contracted potatoes by the	**Yes**

16 This pathogen is present in Australia, but is not known to infect potatoes (Liefting *et al.* 2009; Liefting *et al*. 2011). Tuf 1 clade, variant IX has been dectected on the NZ potatoes (Liefting *et al*. 2011). This clade (Tuf 1) is present in Australia (Andersen *et al*. 2006), but the variant does not appear to be. However, there is insufficient evidence to justify listing this species as a quarantine pest at the variant level.

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		discoloration and brown flecking of medullary rays (Secor *et al*. 2006). Phytoplasmas are generally restricted to phloem sieve tubes and are associated with all vegetative parts of host plants. Therefore, propagative material provides a pathway for these phytoplasmas.	leafhopper vectors present in Australia will help spread these phytoplasmas within Australia. Therefore, this phytoplasma group has the potential to establish and spread in Australia.	processor (Secor *et al*. 2006). This phytoplasma group is included among the non-European potato viruses of the EPPO A1 quarantine list (OEPP/EPPO 1984 a, b). The presence of this phytoplasma group in Australia would impact upon Australia's ability to access overseas markets. Therefore, this phytoplasma group has the potential for economic consequences in Australia.	
Mexican periwinkle virescence group (**16SrXIII)**	Not known to occur	**Yes**: This phytoplasma group is associated with potato purple top disease (Lee *et al*. 2009; Santos-Cervantes *et al*. 2010). Symptoms of the disease are purple top or yellowing of upper leaflets, apical leafroll, axillary buds, and the formation of aerial tubers. Phytoplasmas are generally restricted to phloem sieve tubes and are associated with all vegetative parts of host plants. Therefore, propagative material provides a pathway for this phytoplasma group.	**Yes**: Phytoplasmas associated with potato purple top disease have established in areas with a wide range of climatic conditions (Lee *et al*. 2009; Santos-Cervantes *et al*. 2010) and can spread naturally in infected propagative material. Multiplication and marketing of infected propagative material and leafhopper vectors present in Australia will help spread these phytoplasmas within Australia. Therefore, this phytoplasma group has the potential to establish and spread in Australia.	**Yes:** Potato purple top is a devastating disease that causes great economic loss to the potato industry through substantially reduced tuber yield and quality (Lee *et al*. 2009; Santos-Cervantes *et al*. 2010). Chips and fries processed from infected tubers often develop brown discoloration, greatly reducing their marketability (Lee *et* al. 2009; Santos-Cervantes *et al*. 2010). Therefore, this phytoplasma group has the potential for economic consequences in Australia.	
Candidatus Phytoplasma americanum	Not known to	**Yes**: This phytoplasma	**Yes**: The Potato purple top	**Yes**: This group of phytoplasmas	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
[**16SrXVIII** – American Potato Purple Top Wilt Group] [17] (Strains APPTW1-TX, APPTW2-TX, APPTW9-NE and APPTW12- NE (subgroup 16SrXVIII-A) and APPTW 1883 #6-TX, APPTW10-NE and APPTW13-NE (subgroup 16SrXVIII-B)	occur	group is associated with potato purple top wilt and symptoms include stunting, chlorosis, slight purple discoloration of new growth, leaf curl, swollen nodes, broken axillary buds and the formation of aerial tubers (Lee *et al*. 2006). Phytoplasmas are generally restricted to phloem sieve tubes (McCoy 1984) and are associated with all vegetative parts of host plants (Jones *et al*. 2009). Therefore, propagative material provides a pathway for this phytoplasma group.	wilt phytoplasma group has established in areas with a wide range of climatic conditions (Lee *et al*. 2006) and can spread naturally in infected propagative material (Lee *et al*. 2006). Multiplication and marketing of infected propagative material and leafhopper vectors present in Australia will help spread these phytoplasmas within Australia. Therefore, the PPT phytoplasma group has the potential to establish and spread in Australia.	causes 'dark chips' produced from infected tubers. Chip defect has resulted in a considerable economic loss in the local potato industry in Texas and Nebraska (Lee *et al*. 2006). This phytoplasma group is included among the non-European potato viruses of the EPPO A1 quarantine list (OEPP/EPPO 1984a, b). The presence of this phytoplasma group in Australia would impact upon Australia's ability to access overseas markets. Therefore, this phytoplasma group has the potential for economic consequences in Australia.	
VIROIDS					
Potato spindle tuber pospiviroid (PSTVd) [Pospiviroidae: Pospiviroid]	Not known to occur[18]	**Yes**: As this viroid infects host plants systemically, all plant parts, including parts used for vegetative propagation, are likely to be infected (Stevenson *et al*. 2001; Wale *et al*. 2008). Mild strains cause symptomless infection or	**Yes**: PSTVd has established in areas with a wide range of climatic conditions (Stevenson *et al*. 2001; Wale *et al*. 2008) and it can spread naturally in infected propagative material (Jones *et al*. 2009). PSTVd is transmitted through true	**Yes**: PSTVd causes spindle tuber disease in potato and bunchy top in tomato. Yield losses can be up to 65% in potato and up to 50% in tomato (Owens *et al*. 2009; EPPO 2010). Loss of tuber yield with individual secondarily infected plants is about 20% and 65% with the mild and severe strains,	**Yes**

[17] At least four distinct phytoplasma strains belonging to three different phytoplasma groups have been associated with this disease (Banttari *et al*. 1990; Khadhair *et al*. 1997; Lee *et al*. 2000; Leyva-Lopez *et al*. 2002; Lee *et al*. 2004; Lee *et al*. 2006).

[18] PSTVd has entered Australia on tomato seed on several occasions and has been eradicated (EPPO 2003).

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		subtle symptoms which are difficult to diagnose (Jones *et al*. 2009). However, leaves of plants infected with severe strains are duller in appearance than normal foliage (Jones *et al*. 2009). Therefore, propagative material may provide a pathway for this viroid.	potato seed and potato tubers (Jones *et al*. 2009). The symptomless nature of this virus may contribute to the inadvertent propagation and distribution of infected material that will help spread PSTVd within Australia. Therefore, PSTVd has the potential to establish and spread in Australia.	respectively (Jones *et al*. 2009). PSTVd is considered of quarantine significance in many parts of the world (Jones *et al*. 2009). The presence of this viroid in Australia would impact upon Australia's ability to access overseas markets. Therefore, PSTVd has the potential for economic consequences in parts of Australia.	
VIRUSES					
Alfalfa mosaic virus (AMV) [Bromoviridae: Alfamovirus] – Potato infecting strains	Not known to occur[19]	**Yes**: AMV-potato strains cause calico and tuber necrosis and may also cause systemic chlorotic spots and necrotic flecking (Xu and Nie 2006). AMV-potato strain is associated with true potato seeds (Valkonen *et al*. 1992b) and potato tubers. Therefore, propagative material provides a pathway for this virus.	**Yes:** AMV-potato strains have established in areas with a wide range of climatic conditions (Xu and Nie 2006) and it can spread naturally in infected propagative material (Valkonen *et al*. 1992b). Distribution of infected propagative material and aphid vectors present in Australia will help spread AMV-potato strains within Australia. Therefore, AMV-potato strains have the potential to establish and spread in Australia.	**Yes**: AMV-potato strains can cause problems in regions where aphid vectors move from reservoir hosts to potato fields (Jeffries 1998). AMV-potato strains causing tuber necrosis are of economic significance (Jeffries 1998). Infected tubers may be misshapen, cracked and fewer in number (Jeffries 1998). Aphid vectors and reservoir hosts (Alfalfa and *Trifolium*) are widespread in Australia; therefore, this virus has the potential for economic consequences in Australia.	**Yes**
Andean potato latent virus (APLV)[20]	Not known to	**Yes**: APLV infection is	**Yes**: APLV has established	**Yes**: APLV can cause serious	**Yes**

[19] Alfalfa mosaic virus is present in Australia (Norton and Johnstone 1998); however, potato infecting strains (Xu and Nie 2006) are not present in Australia.

Pest	**Present within Australia**	**Potential to be on pathway**	**Potential for establishment and spread**	**Potential for economic consequences**	**Quarantine pest?**
[Tymoviridae: Tymovirus] Strains: Hu, CCC, Col-Caj	occur	latent (Jones *et al*. 2009), symptomless (Gibbs and Harrison 1973) or shows mild mosaic on potato (Jeffries 1998). APLV is associated with potato tubers or true potato seeds (Jones *et al*. 2009) and tuber infection is symptomless (Jones *et al*. 2009). Therefore, propagative material provides a pathway for APLV.	in areas with a wide range of climatic conditions (Gibbs and Harrison 1973; Koenig *et al*. 1979; Jeffries 1998) and it can spread naturally in infected propagative material (OEPP/EPPO 1990). The symptomless nature of this virus may contribute to the inadvertent propagation and distribution of infected material that will help spread APLV within Australia. Therefore, APLV has the potential to establish and spread in Australia.	symptoms in secondarily infected potato plants (Jones and Fribourg 1978). Yield reduction in potato has not been studied. However, APLV is included among the non-European potato viruses of the EPPO A1 quarantine list (OEPP/EPPO 1984a, b). APLV is considered of quarantine concern by NAPPO and all regional plant protection organisations outside South America. The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	
Andean potato mottle virus (APMoV) [Comoviridae: Comovirus] Strains H, C and B	Not known to occur	**Yes**: APMoV causes mosaic and mottle symptoms and may also cause systemic necrosis (Fribourg *et al*. 1979). APMoV is associated with potato tubers (OEPP/EPPO 1990). Therefore, propagative material provides a pathway for APMoV.	**Yes**: APMoV has established in areas with a wide range of climatic conditions (Fribourg *et al*. 1979; Jeffries 1998) and it can spread naturally in infected propagative material (OEPP/EPPO 1990). The symptomless nature of this virus may contribute to the inadvertent propagation and distribution of infected material that will help spread APMoV within	**Yes**: Direct effects on yield have not been studied, but may be severe in susceptible cultivars (Jones *et al*. 1982). In Central America, mixed infections of APMoV with other viruses can lead to severe symptoms and substantially lower yields in pepper (Valverde 2003). APMoV is included among the non-European potato viruses of the EPPO A1 quarantine list (OEPP/EPPO 1984a, b). APMoV is considered of quarantine	**Yes**

[20] APLV is sometimes considered to be a strain of Eggplant mosaic virus but sequence comparisons show them to be distinct species.

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
			Australia. APMoV is also able to spread by plant-to-plant contact (Jeffries 1998). Therefore, APMoV has the potential for establishment and spread in Australia.	concern by NAPPO and all regional plant protection organisations outside South America. The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	
Arracacha virus B – Oca strain (AVB-O) [Comoviridae: Cheravirus]	Not known to occur	**Yes**: AVB-O causes symptomless infection in potato plants (Jones 1981) and infected plants produce tubers containing the virus (Jones 1982). AVB-O is also associated with true potato seeds (Jones *et al*. 2009). Therefore, propagative material provides a pathway for AVB-O.	**Yes**: AVB-O has established in areas with a wide range of climatic conditions (Jones 1981; Jones and Kenten 1983; Jeffries 1998) and it can spread naturally in infected propagative material (Jones 1981; Jones *et al*. 2009). The symptomless nature of this virus may contribute to the inadvertent propagation and distribution of infected material that will help spread AVB-O within Australia. Therefore, AVB-O has the potential for establishment and spread in Australia.	**Yes**: AVB-O is not known to have any direct economic importance in potato (Jeffries 1998). However, AVB-O is of south American origin and is included among the non-European potato viruses of the EPPO A1 quarantine list (OEPP/EPPO 1984a, b). AVB-O is considered of quarantine concern by NAPPO and all regional plant protection organisations outside South America. The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	**Yes**
Beet curly top virus (BCTV) [Geminiviridae: Curtovirus]	Not known to occur	**Yes**: Symptoms caused by BCTV vary with potato cultivar and environmental conditions (Jones *et al*. 2009). Primary symptoms	**Yes**: BCTV has established in areas with a wide range of climatic conditions (Thomas and Mink 1979; Jeffries 1998; Stevenson *et al*. 2001)	**Yes:** BCTV occurs rarely in potatoes; however, a high incidence of infection in localised areas can cause severe disease problems (Jeffries 1998). BCTV is	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		include retarded growth, small cluttered leaves and misshapen leaflets that are cupped and become pale green (Jones *et al*. 2009). Infected tubers are symptomless (Jones *et al*. 2009). Propagative material therefore provides a pathway for BCTV to enter Australia.	and it can spread naturally in infected propagative material (Jeffries 1998; Jones *et al*. 2009). Therefore, BCTV has the potential for establishment and spread in Australia.	also capable of causing yield loss in both susceptible and resistant cultivars of sugar beet (Duffus and Skoyen 1977). BCTV is considered of quarantine concern by IAPSC and CPPC. The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	
Cucumber mosaic virus (CMV) [Bromoviridae: Cucumovirus]	Yes (PHA 2001)	Assessment not required			
Eggplant mottled dwarf virus (EMDV) [Rhabdoviridae: Nucleorhabdovirus]	Not known to occur	**Yes**: EMDV is rarely found in potatoes (Jeffries 1998) but it causes severe stunting, chlorosis, wilting and systemic necrosis (Jeffries 1998). Viruses, as a rule, infect host plants systemically and all plant parts, including parts used for vegetative propagation, are infected (Bos 1999). Therefore, propagative material provides a pathway for EMDV.	**Yes:** EMDV has established in areas with a wide range of climatic conditions (Jeffries 1998; Stevenson *et al*. 2001) and multiplication and marketing of infected propagative material will help spread EMDV. Therefore, EMDV has the potential for establishment and spread in Australia.	**Yes:** EMDV is highly damaging to vegetable crops. It causes severe stunting, chlorosis and wilting in primary infection (Jeffries 1998). Serious economic losses have been reported in plants infected by EMDV (Jackson *et al*. 2005). EMDV is considered of quarantine concern by the South Korean NPPO. The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	**Yes**
Impatiens necrotic spot virus (INSV) [Bunyaviridae: Tospovirus]	Not known to occur	**Yes**: INSV infects potato systemically (Jones *et al*. 2009) and causes necrotic lesions on leaves and	**Yes:** INSV is established in areas with a wide range of climatic conditions (Brunt *et al.* 1996; Elliott *et al*. 2009;	**Yes**: INSV causes damage and losses largely on ornamental hosts, but also on some vegetable crops (Vicchi *et al*. 1999). The	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		necrosis of petioles and stems (Crosslin and Hamlin 2010). Viruses, as a rule, infect host plants systemically and all plant parts, including parts used for vegetative propagation, are infected (Bos 1999). Therefore, propagative material provides a pathway for INSV.	Kuwabara *et al*. 2010). Multiplication and marketing of infected propagative material and presence of its vector (western flower thrips) in Australia would help spread INSV into new areas. Therefore, INSV has the potential for establishment and spread in Australia.	detection of INSV in tomato in Italy represents a progressive adaptation of INSV to outdoor vegetable crops (Finetti Sialer and Gallitelli 2000). The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	
Pepino mosaic virus (PepMV) [Flexiviridae: Potexvirus]	Not known to occur	**Yes**: PepMV has been detected in potato in the field and in a potato germplasm collection in Peru (CSL 2005). PepMV infects host plants systemically and infection may be latent (Salomone and Roggero 2002). This may lead to the propagation and distribution of infected propagative material, suggesting that PepMV could enter Australia on propagative material.	**Yes:** PepMV has established and spread in areas with a wide range of climatic conditions (Jones *et al*. 1980; CSL 2005; Ling 2008). PepMV is highly contagious and can spread by contact and by infected planting material (CSL 2005). Multiplication and marketing of infected propagative material would help spread PepMV into new areas. Therefore, PepMV has the potential for establishment and spread in Australia.	**Yes**: Although PepMV has been recorded on potatoes, no information is available on yield losses in this crop. However, PepMV has become a major threat to tomato production around the world. PepMV in tomato was first reported in The Netherlands in 1999, but has since spread rapidly in Europe and beyond, causing epidemics and severe economic losses (Gómez *et al*. 2009). PepMV has caused serious losses in the quality of tomato fruit in trials in the UK (CSL 2005). PepMV has become a major threat to tomato production in several countries. Therefore, PepMV has the potential for economic consequences in Australia.	**Yes**
Potato 14R virus [Tombusviridae: Tobamovirus]	Not known to occur	**Yes:** This virus causes yellowish mosaic on leaves	**Yes**: This virus has established in areas with a	**Yes**: Information on the economic consequences of this virus is	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		(Brunt *et al*. 1996). Viruses, as a rule, infect host plants systemically and all plant parts, including parts used for vegetative propagation, are infected (Bos 1999). Therefore, propagative material may provide a pathway for this virus.	wide range of climatic conditions (Brunt *et al*. 1996) and could spread naturally by infected propagative material (Brunt *et al*. 1996). Multiplication and marketing of infected propagative material will help spread this virus within Australia. Therefore, this virus has the potential for establishment and spread in Australia.	almost non-existent and it is not known how it will behave in potato growing areas of Australia. Several viruses known to be less important are increasing in importance in several South American countries. The presence of this virus in Australia may result in overseas restrictions on market access for Australian nursery stock. Therefore, this virus has the potential for economic consequences in Australia.	
Potato aucuba mosaic virus (PAMV) [Flexiviridae: Potexvirus]	Yes (Büchen-Osmond *et al.* 1988)	Assessment not required			
Potato black ringspot virus (PBRSV) [Comoviridae: Nepovirus] (synonym: Tobacco ringspot virus, potato calico strain (TRSV-Ca)	Not known to occur	**Yes**: PBRSV naturally infects potatoes and infected plants are symptomless (Jones *et al*. 2009). PBRSV is readily transmitted through tubers to progeny plants, most of which are symptomless but systemically infected (Salazar and Harrison 1978). PBRSV is also associated with true potato seed (Jeffries 1998). Therefore, propagative material does provide a pathway for PBRSV.	**Yes:** PBRSV has established in areas with a wide range of climatic conditions (Jeffries 1998; Stevenson *et al*. 2001) and could be spread naturally by infected potato tubers or by true potato seed (Jeffries 1998). Multiplication and marketing of infected propagative material will help spread PBRSV within Australia. Therefore, PBRSV has the potential for establishment and spread in Australia.	**Yes:** PBRSV has been recorded to cause damaging symptoms on potatoes under certain conditions (Fribourg 1977), but no information is available on yield losses in this crop. PBRSV is included among the non-European potato viruses of the EPPO A1 quarantine list (OEPP/EPPO 1984a, b). PBRSV is considered of quarantine concern by NAPPO and all regional plant protection organisations outside South America. The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
				virus has the potential for economic consequences in Australia.	
Potato deforming mosaic virus (PDMV) [Geminiviridae: Begomovirus] (synonym: Tomato yellow vein streak virus)	Not known to occur	**Yes**: PDMV naturally infects tomatoes and potatoes causing symptoms of leaf deformation and yellow mosaic (Jeffries 1998; Ribeiro *et al*. 2006). Primary infected plants produce healthy as well as diseased tubers (Delhey *et al*. 1981). Therefore, propagative material provides a pathway for PDMV.	**Yes**: PDMV has established in areas with a wide range of climatic conditions (Ribeiro *et al*. 2006) and can spread naturally in infected propagative material (Delhey *et al.* 1981; Ribeiro *et al*. 2006). Multiplication and marketing of infected propagative material and vector (*Bemisia tabaci*) presence in Australia will help spread this virus. Therefore, PDMV has the potential for establishment and spread in Australia.	**Yes:** PDMV causes leaf deformation and yellow mosaic in potatoes and tomatoes (Delhey *et al.* 1981; Ribeiro *et al*. 2006). Yield reductions of up to 35% have been reported in some cultivars (Hooker 1981; Jeffries 1998). PDMV is considered of quarantine concern by NAPPO and all regional plant protection organisations outside South America. The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	**Yes**
Potato latent virus (PLV) [Flexiviridae: Carlavirus]	Not known to occur	**Yes:** PLV is symptomless in potato plants and tubers (Jeffries 1998; Nie 2009), and infection is systemic (Goth *et al*. 1999). Therefore, propagative material provides a pathway for PLV.	**Yes**: PLV has established in potato growing areas with a wide range of climatic conditions (Jeffries 1998; Goth *et al*.1999), and could spread with planting materials (Jeffries 1998). The symptomless nature of this virus may contribute to the inadvertent propagation and distribution of infected material that will help spread PLV. Therefore, PLV has the	**Yes:** Information on the economic consequences of this virus is almost non-existent. However, as a member of potato infecting carlaviruses, its presence in Australian potato growing areas will have a significant economic effect on the potato industry due to limitations on access to overseas markets where the pathogen is absent. Therefore, this virus has the potential for economic consequences in	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
			potential for establishment and spread in Australia.	Australia.	
Potato leafroll virus (PLRV) [Luteoviridae: Polerovirus]	Yes (DPIPWE 2011)	Assessment not required			
Potato mop-top virus (PMTV) [Virgaviridae: Pomovirus]	Not known to occur	**Yes**: PMTV infects potato systemically (Latvala-Kilby *et al*. 2009). Primary infection is almost entirely restricted to roots and tubers. Infected tubers may be symptomless or often show raised, concentric rings on their surface at a radius from the point of infection through viruliferous vector zoospores (Jones *et al*. 2009). Therefore, propagative material may provide a pathway for PMTV.	**Yes:** PMTV has established in areas with a wide range of climatic conditions (Jeffries 1998; Harrison and Reavy 2002; Latvala-Kilby *et al*. 2009; Santala *et al*. 2010). Multiplication and marketing of infected propagative material and vector (powdery scab fungus) presence in Australia will help spread this virus (Jeffries 1998; Latvala-Kilby *et al*. 2009). Therefore, PMTV has the potential for establishment and spread in Australia.	**Yes**: PMTV is an economically important pathogen of potato since serious yield and quality reductions can occur in some cultivars. Yield loss can occur with secondarily infected plants (Jeffries 1998). The incidence of spraing symptoms in sensitive cultivars often exceeds 25% and 30–50% in Sweden and Denmark, respectively (Stevenson *et al*. 2001), which could significantly affect the quality of tubers produced for the potato chip industry. Therefore, this virus has the potential for economic consequences in Australia.	**Yes**
Potato rough dwarf virus (PRDV) [Flexiviridae: Carlavirus] (synonym: Potato Virus P-Ar strain)	Not known to occur	**Yes**: PRDV infects potato systemically and may remain symptomless (Jeffries 1998; Massa *et al.* 2006; Nisbet *et al*. 2006). Therefore, propagative material may provide a pathway for PRDV.	**Yes:** PRDV has established in areas with a wide range of climatic conditions (Jeffries 1998; Massa *et al*. 2006). The symptomless nature of this virus may contribute to the inadvertent propagation and distribution of infected material. Therefore, PRDV has the potential for establishment and spread in Australia.	**Yes:** Potato cultivars infected by PRDV show dwarfing, and a thickening of old leaves. PRDV is reported to be of little importance in the host country (Jeffries 1998). However, it is not known how it will behave in potato growing areas of Australia. Several viruses known to be less important are increasing in importance in several South American countries. The presence of this virus in Australia may result in overseas	**Yes**

Pest	**Present within Australia**	**Potential to be on pathway**	**Potential for establishment and spread**	**Potential for economic consequences**	**Quarantine pest?**
				restrictions on market access for Australian nursery stock. Therefore, this virus has the potential for economic consequences in Australia.	
Potato virus A (PVA) [Potyviridae: Potyvirus]	Yes (Büchen-Osmond *et al*. 1988; Crump 2013, pers. comm.)	Assessment not required			
Potato virus M (PVM) [Flexiviridae: Carlavirus]	Not known to occur	**Yes:** PVM infects plants systemically (Stevenson *et al*. 2001). It is usually symptomless, but occasionally causes leaf symptoms (Jeffries 1998; Stevenson *et al*. 2001). Viruses, as a rule, infect host plants systemically and all plant parts, including parts used for vegetative propagation, are infected (Bos 1999). Therefore, propagative material could provide a pathway for PVM.	**Yes:** PVM has established in areas with a wide range of climatic conditions (Brunt *et al*. 1996; Stevenson *et al*. 2001). The symptomless nature of this virus may contribute to the inadvertent propagation and distribution of infected material, and aphid vectors (potato aphid and green peach aphid) presence in Australia (Dillard *et al*. 1993; Berlandier 1997) will help spread this virus. Therefore, PVM has the potential for establishment and spread in Australia.	**Yes**: PVM causes potato leaf rolling mosaic and paracrinkle diseases. The effects on the plant include stunting of shoots and rolling of the tops (Jeffries1998; Stevenson *et al*. 2001). Yield losses can be significant in some situations, ranging from 14 to 45% (Jeffries 1998; Stevenson *et al*. 2001). PVM is reported to be economically important in Europe and Russia where 100% of some potato cultivars may be infected (Jeffries 1998). Therefore, this virus has the potential for economic consequences in Australia.	**Yes**
Potato virus S [Flexiviridae: Carlavirus] – Andean strain (PVS^A)	Not known to occur[21]	**Yes**: PVS^A may be symptomless or may produce symptoms of vein deepening, leaf rugosity,	**Yes**: PVS^A has established in areas with a wide range of climatic conditions (Lambert *et al*. 2012) and spreads	**Yes**: PVS^A causes premature senescence and loss of leaves and this may result in potato yield losses of up to 20% (Wetter	**Yes**

[21] Some strains of PVS are present in Australia, including PVS^O (Ordinary strain) and $PVS^{O\text{-}CS}$ (Ordinary-Chenopodium strain) (Lambert *et al*. 2012).

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		interveinal chlorosis, premature senescence and leaf loss, especially in secondarily infected plants (Rose 1983; Dolby and Jones 1987). The concentration of this strain in leaves is high (Rose 1983). This strain PVS[A] has been detected in imported tubers (Dolby and Jones 1987), indicating that propagative material could provide a pathway for this virus.	naturally in infected propagative material (Rose 1983; Slack 1983; Dolby and Jones 1987). The distribution of infected material, contact between plants and the presence of aphid vectors (Slack 1983; Dolby and Jones 1987) in Australia (Dillard *et al*. 1993; Berlandier 1997) will help spread this virus. Therefore, PVS[A] has the potential for establishment and spread in Australia.	1971). Yield losses may be higher from mixed infection with Potato virus X (Jeffries 1998). Therefore, this virus has the potential for economic consequences in Australia.	
Potato virus T (PVT) [Betaflexiviridae: Tepovirus]	Not known to occur	**Yes**: Primary infection is normally symptomless; however, some cultivars develop initial symptoms of slight vein necrosis and chlorotic spotting, or vein clearing and mosaic, or top necrosis (Jones *et al*. 2009). PVT is associated with true potato seeds as well as potato tubers (Stevenson *et al*. 2001). Therefore, propagative material could provide a pathway for PVT.	**Yes:** PVT has established in areas with a wide range of climatic conditions (Jeffries 1998; Stevenson *et al*. 2001; Jones *et al*. 2009) and spreads naturally in infected propagative material (Jeffries 1998; Stevenson *et al*. 2001). The symptomless nature of this virus may contribute to the inadvertent propagation and distribution of infected material that will help spread PVT. Therefore, PVT has the potential for establishment and spread in Australia.	**Yes**: Little is known about diseases caused by PVT. However, PVT is included among the EPPO A1 quarantine list (OEPP/EPPO 1999). PVT is considered of quarantine concern by NAPPO and all regional plant protection organisations outside South America. The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	**Yes**
Potato virus U (PVU) [Comoviridae: Nepovirus]	Not known to occur	**Yes**: PVU infected plants show yellow leaf markings	**Yes:** PVU has established in areas with a wide range of	**Yes:** Little is known about economic losses caused by PVU;	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		(Jones *et al*. 1983). Viruses, as a rule, infect host plants systemically and all plant parts, including parts used for vegetative propagation are infected (Bos 1999). Therefore, propagative material provides a pathway for PVU.	climatic conditions (Jeffries 1998) and spreads naturally in infected propagative material (Jones *et al*. 1983). Multiplication and marketing of infected propagative material will help spread this virus within Australia. Therefore, PVU has the potential for establishment and spread in Australia.	however, losses up to 10% have been reported (Salazar 2003). PVU is of South American origin and the principal risk is market access loss and possible yield losses from single or mixed virus infections. Therefore, this virus has the potential for economic consequences in Australia.	
Potato virus V (PVV) [Potyviridae: Potyvirus]	Not known to occur	**Yes:** PVV can be symptomless, but can also cause symptoms that range in severity from leaf pallor, mild mottle and slight distortion to mild mottle, mosaic and veinal necrosis of lower leaves (Jones *et al*. 2009). Viruses, as a rule, infect host plants systemically and all plant parts, including parts used for vegetative propagation are infected (Bos 1999). Therefore, propagative material provides a pathway for PVV.	**Yes:** PVV has established in areas with a wide range of climatic conditions (Jeffries 1998) and spreads naturally in infected propagative material. The symptomless nature of this virus may contribute to the inadvertent propagation and distribution of infected material and aphid vectors (potato aphid and green peach aphid) presence in Australia (Dillard *et al*. 1993; Berlandier 1997) would help spread this virus. Therefore, PVV has the potential for establishment and spread in Australia.	**Yes:** PVV causes severe systemic necrosis and leaf dropping in some potato cultivars (Jeffries 1998). In Bolivia, the virus is reported to cause severe damage in some native potato cultivars (Jeffries 1998). PVV is known to cause losses of up to 10% (Salazar 2003). This virus is of South American origin and several countries may consider it of quarantine concern. The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	**Yes**
Potato virus X (PVX) [Flexiviridae: Potexvirus]	Not known to occur[22]	**Yes:** PVX can be symptomless, but can also cause variable symptoms	**Yes:** PVX has established in areas with a wide range of climatic conditions (Jeffries	**Yes:** Yield losses from PVX may be up to 40% (Salazar 2003). This virus is most damaging when it is	**Yes**

[22] Although this virus is present in Australia (Kirkwood 2009; Holmes and Teakle 1980), certain strains, including PVX_{HB}, are not present in Australia.

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		(Partridge 2008). PVX infects plants systemically and is also associated with tubers (Partridge 2008). Therefore, propagative material may provide a pathway for PVX.	1998) and spreads naturally in infected propagative material, including tubers. Therefore, PVX has the potential for establishment and spread in Australia	found in combination with PVY or PVA (Banttari *et al*. 1993; Partridge 2008). Therefore, this virus has the potential for economic consequences in Australia.	
Potato virus Y (PVY) [Potyviridae: Potyvirus] (strains not present in Australia)	Not known to occur[23]	**Yes:** PVY induces various foliar symptoms ranging from mosaic to leaf-drop streaks and stunting, depending on cultivars and virus strains (Nie *et al*. 2011). PVY causes systemic necrotic (Delgado-Sanchez and Grogan 1970) or mosaic symptoms (Singh *et al*. 2003) and is also tuber- borne (Singh *et al*. 2003; Crosslin *et al*. 2006). Therefore, propagative material could provide a pathway for PVY.	**Yes:** PVY has established in areas with a wide range of climatic conditions (Jeffries 1998; Crosslin *et al*. 2006; Nie *et al*. 2011). It spreads naturally in infected propagative material (Singh *et al*. 2003; Crosslin *et al*. 2006). Aphid vectors (potato aphid and green peach aphid) presence in Australia (Dillard *et al*. 1993; Berlandier 1997; Stevenson *et al*. 2001) will help spread PVY. Therefore, PVY has the potential for establishment and spread in Australia.	**Yes:** PVY is one of the most economically important viruses of potato crops worldwide (Singh *et al*. 2008; Gray *et al*. 2010). The virus is not only responsible for decreases in yield and quality, but may also result in the rejection of certified seed resulting in a significant reduction in crop value, and at times in a shortage of certified seed (Gray *et al*. 2010). PVY is considered of quarantine concern by NAPPO. The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	**Yes**
Potato yellow dwarf virus (PYDV) [Rhabdoviridae: Nucleorhabdovirus]	Not known to occur	**Yes:** PYDV causes stunting, chlorosis; vein yellowing and systemic vein and leaf necrosis (Lockhart, 1989). Viruses, as a rule, infect host plants	**Yes:** PYDV has established in areas with a wide range of climatic conditions (Jeffries 1998; Stevenson *et al*. 2001). It spreads naturally in infected propagative	**Yes**: Infected plants produce few tubers, and tubers are small and misshapen with generalised necrosis (Jones *et al.* 2009). PYDV is included among the non-European potato viruses of the	**Yes**

[23] PVY^{C} (Jeffries 1998), PVY^{NTN} (Rodoni 2012; Moran and Rodoni 2010) and PVY^{O} (Heath *et al*. 1987) strains are present in Australia.

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		systemically and all plant parts, including parts used for vegetative propagation, are infected (Bos 1999). Infected potato tubers provide a pathway for this virus (OEPP/EPPO1980) to enter Australia. Therefore, propagative material could provide a pathway for PYDV.	material (Jones *et al*. 2009). Multiplication and marketing of infected propagative material will help spread this virus within Australia. Therefore, PYDV has the potential to establish and spread in Australia.	EPPO A1 quarantine list (OEPP/EPPO 1984a, b). The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	
Potato yellow vein virus (PYVV) [Closteroviridae: Crinivirus]	Not known to occur	**Yes**: PYVV causes yellow vein and can be latent in some cultivars (Jeffries 1998; Salazar *et al*. 1998). Trade in seed potatoes provides a major pathway for the virus dissemination in South America (Salazar *et al*. 2000). Therefore, propagative material provides a pathway for PYVV.	**Yes:** PYVV has established in areas with a wide range of climatic conditions (Jones *et al*. 2009) and spreads naturally in infected propagative material (Salazar *et al.* 2000; Jones *et al*. 2009). Multiplication and marketing of infected propagative material will help spread this virus within Australia. Therefore, PYVV has the potential to establish and spread in Australia.	**Yes**: PYVV is recognised as an important constraint to potato production in South America (Salazar *et al*. 2000). Affected potato plants produce fewer and deformed tubers, and yield reductions of about 50% have been reported (Saldarriaga *et al.* 1988; Salazar *et al.* 2000). The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	**Yes**
Potato yellowing virus (PYV) [Bromoviridae: Alfamovirus]	Not known to occur	**Yes**: PYV is symptomless in some potato cultivars (Jeffries 1998). Viruses, as a rule, infect host plants systemically and all plant parts, including parts used for vegetative propagation, are infected (Bos 1999).	**Yes:** PYV has established in areas with a wide range of climatic conditions (Jeffries 1998; Stevenson *et al*. 2001) and spreads naturally in infected propagative material (Jeffries 1998). The symptomless nature of this	**Yes:** PYV was found in field samples of potato from Peru with up to 88% infection and causes yellowing symptoms on some potato cultivars (OEPP/EPPO 1984a, b; Jeffries 1998). Yield losses of up to 10% have been reported (Salazar 2003). In	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		PYV is associated with true potato seed and potato tubers (Jeffries 1998). Therefore, propagative material provides a pathway for PYV.	virus may contribute to the inadvertent propagation and distribution of infected material and presence of aphid vectors will assist the spread of the virus in Australia. Therefore, PYV has the potential to establish and spread in Australia.	general, all regional plant protection organisations outside South America recommend very strict measures for potato material from that continent. The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	
Solanum apical leaf curling virus (SALCV) [Geminiviridae: Begomovirus]	Not known to occur	**Yes**: SALCV causes red, purple or pink discoloration, curling, crinkling and dwarfing of apical leaves (Hooker and Salazar 1983). Viruses, as a rule, infect host plants systemically and all plant parts, including parts used for vegetative propagation, are infected (Bos 1999). SALCV is also tuber-borne (Hooker and Salazar 1983). Therefore, propagative material, including seed tubers, could provide pathway for SALCV.	**Yes:** SALCV has established in areas with a wide range of climatic conditions and spreads naturally in infected propagative material (Hooker and Salzar 1983). The virus is reported to be best adapted to tropical regions (Jeffries 1998). Multiplication and marketing of infected propagative material will help spread this virus within Australia. Therefore, SALCV has the potential to establish and spread in Australia.	**Yes:** SALCV potentially causes losses of up to 10% (Salazar 2003). Infected tubers either do not sprout, or produce short, thin sprouts (Jeffries 1998). As this virus is of South American origin, several countries may consider it of quarantine concern. In general, all regional plant protection organisations outside South America recommend very strict measures for potato material from that continent. The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	**Yes**
Southern potato latent virus (SoPLV) [Flexiviridae: Carlavirus]	Not known to occur	**Yes**: No information is available on the biology of SoPLV. However, viruses infect host plants	**Yes**: SoPLV has established in areas with a wide range of climatic conditions (Brunt *et al*. 1996) and may spread	No: There is little information available on this virus and no evidence that it causes significant economic consequences.	

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		systemically and all plant parts, including parts used for vegetative propagation, are infected (Bos 1999). Therefore, propagative material may provide a pathway for SoPLV.	naturally in infected propagative material. Multiplication and marketing of infected propagative material will help spread this virus within Australia. Therefore, SoPLV has the potential to establish and spread in Australia.	Therefore, this virus is unlikely to have the potential for economic consequences in Australia.	
Sowbane mosaic virus (SoMV) [Sobemovirus]	Yes (PHA 2001)	Assessment not required			
Tobacco mosaic virus— Potato strain (TMV-P) [Tombusviridae: Tobamovirus] (Strains: TMV-potato 1, 2, 3, 4)	Not known to occur [24]	**Yes:** TMV potato infecting strains produce necrotic spotting and systemic veinal necrosis (Jung *et al*. 2002; Talens and Talens 2009). Viruses, as a rule, infect host plants systemically and all plant parts, including parts used for vegetative propagation, are infected (Bos 1999). TMV-P is also tuber-borne (Jung *et al*. 2002; Talens and Talens 2009). Therefore, propagative material provides a pathway for TMV-P.	**Yes:** TMV potato infecting strains have established in areas with a wide range of climatic conditions (Phatak and Verma 1967; Talens and Talens 2009) and spread naturally with infected propagative material (Talens and Talens 2009). Multiplication and marketing of infected propagative material will help spread this virus within Australia. Therefore, TMV-P has the potential to establish and spread in Australia.	**Yes**: There is no specific information on effects on yield caused by TMV-P. However, viruses occur on potatoes in mixed infections (Talens and Talens 2009). Therefore, PMV-P may cause severe symptoms in combination with other potato viruses. Given the high risk of mechanical transmission in the field, TMV has high potential to cause increased damage in potato fields (Jung *et al*. 2002). Therefore, this virus has the potential for economic consequences in Australia.	**Yes**

[24] Tobacco mosaic virus has been reported on various hosts (Büchen-Osmond *et al*. 1988), but it is unknown if the strains that infect potato are present in Australia. TMV has rigid, rod-shaped particles about 300 nm long, a linear 6.3-kb plus-sense ssRNA genome, and is readily detected by inoculation of sap to *N. glutinosa* and other indicator hosts (Zaitlin 2000). A virus with similarly shaped particles was found in Chilean potato cultivars (Accatino 1966). Salazar (1977) reported a virus from potatoes in Peru that also had TMV-like particles and code-named it 14R. It resembled the Chilean virus but did not become systemic in potato. No serological relationship with TMV was demonstrated (Jones *et al*. 2009). TMV-P has rigid rod-shaped particles which measures 15nm x 300-350 nm in dimension (Talens and Talens 2009).

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
Tobacco necrosis virus (TNV) [Tombusviridae: Necrovirus] (Strains: A, B, C, D, E, S, AC36, AC38, AC39; AC43; and Urbana strain)	Not known to occur[25]	**Yes**: TNV potato infecting strains produce symptoms on tubers (Jeffries 1998). Viruses, as a rule, infect host plants systemically and all plant parts, including parts used for vegetative propagation, are infected (Bos 1999). Therefore, propagative material provides a pathway for TNV.	**Yes:** TNV potato infecting strains have established in areas with a wide range of climatic conditions (Jeffries 1998) and spread naturally with infected propagative material (Jones *et al*. 2009). Multiplication and marketing of infected propagative material will help spread this virus within Australia. Therefore, TNV has the potential to establish and spread in Australia.	**Yes**: There is no specific information on effects on yield, but the quality of tubers is seriously affected in sensitive cultivars. Infected tubers have lesions on the skin (Jones *et al*. 2009). Superficial, light brown lesions and blisters collapse during storage to give dark brown, sunken lesions (Jones *et al*. 2009). Crops with a high incidence of surface blisters and/or dark brown sunken lesions are unmarketable (Jones *et al*. 2009). Therefore, this virus has the potential for economic consequences in Australia.	**Yes**
Tobacco rattle virus (TRV) [Tombusviridae: Tobamovirus]	Not known to occur	**Yes**: TRV infects plants systemically and primary infection is almost entirely limited to roots and tubers (Jones *et al*. 2009). TRV produces corky ringspot in tuber stems and mottle in foliage (Jones *et al*. 2009). Depending on potato cultivar and TRV strain, infected tubers can be symptomless (Jones *et al*.	**Yes:** TRV has established in areas with a wide range of climatic conditions (Jeffries 1998; Jones *et al*. 2009) and spreads naturally in infected propagative material (Jones *et al*. 2009). The symptomless nature of this virus may contribute to the inadvertent propagation and distribution of infected material. Furthermore, aphid	**Yes**: TRV causes significant loss of saleable yield because of spraing damage to potatoes (Jeffries 1998; Stevenson *et al*. 2001). In the USA, frequencies of tubers with corky ring spot of 5–10% have been reported, sometimes compromising the sale of the entire production field (Williams *et al*.1996). In Italy, pepper fields with 30–40% plant infection and significant yield	**Yes**

[25] The taxonomy of 'tobacco necrosis virus' (TNV) has been revised. *Tobacco necrosis virus A* (TNV-A) and *Tobacco necrosis virus D* (TNV-D) have been recognised as distinct species in the *Necrovirus* genus (Meulewaeter *et al*. 1990; Coutts *et al*. 1991), as have *Chenopodium necrosis* virus (ChNV) and *Olive mild mosaic virus* (OMMV), which were previously considered TNV isolates (Tomlinson *et al*. 1983; Cardoso *et al*. 2005). Although TNVs have been reported in Queensland and Victoria (Findlay and Teakle 1969; Teakle 1988), it is not known if the species or strains that infect potato are present in Australia.

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		2009). Therefore, propagative material may provide a pathway for TRV.	and nematode vectors present in Australia will also help spread this virus. Therefore, TRV has the potential to establish and spread in Australia.	losses have been reported (Marte *et al*. 1979). Yearly losses in carrot from virus diseases, including TRV, are reported to exceed 50% in Germany (Wolf and Schmelzer 1973). Therefore, this virus has the potential for economic consequences in Australia.	
Tobacco streak virus—Potato strain (TSV-P) [Bromoviridae: Ilarvirus]	Not known to occur[26]	**Yes:** TSV-P is primarily symptomless in potato (Salazar *et al*. 1981). Viruses, as a rule, infect host plants systemically and all plant parts, including parts used for vegetative propagation, are infected (Bos 1999). Therefore, propagative material could provide a pathway for TSV-P.	**Yes:** TSV-P has established in areas with a wide range of climatic conditions (Smith *et al*. 1992) and spreads naturally in infected propagative material (Smith *et al*. 1992; Stevenson *et al*. 2001). The symptomless nature of this virus may contribute to the inadvertent propagation and distribution of infected material. Therefore, TSV-P has the potential for establishment and spread in Australia.	**Yes:** There is no specific information on effects on yield. This virus is of South American origin and several countries may consider it of quarantine concern. In general, all regional plant protection organisations outside South America recommend very strict measures for potato material from that continent. The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	**Yes**
Tomato black ring virus (TBRV) [Comoviridae: Nepovirus]	Not known to occur	**Yes**: TBRV symptoms vary with different potato cultivars, and the infection is symptomless on some cultivars (Jones *et al*. 2009). Primary infection is mainly restricted to potato	**Yes:** TBRV has established in areas with a wide range of climatic conditions (Jones *et al*. 2009) and spreads naturally in infected propagative material (Harrison 1959). The	**Yes**: Individual plants with severe stunting may show 80% yield loss, and those with no apparent symptoms may show a 30% yield loss (Jeffries 1998). Loss of tuber yield in individual secondarily infected plants can reach 20–30%	**Yes**

[26] TSV is present in Australia (Sharman *et al*. 2009) but the potato strain is not recorded in Australia.

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		roots and tubers, but when it does spread to shoots, necrotic spots and rings may develop in leaves (Jones *et al*. 2009). Therefore, propagative material could provide a pathway for TBRV.	symptomless nature of this virus may contribute to the inadvertent propagation and distribution of infected material. Nematode vectors (*Longidorus* species) present in Australia will help spread this virus. Therefore, TBRV has the potential to establish and spread in Australia.	(Jones *et al*. 2009). TBRV is a quarantine organism for NAPPO (EPPO 1990). The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	
Tomato chlorosis virus (ToCV) [Closteroviridae: Crinivirus]	Not known to occur	**Yes:** ToCV been detected in potato tubers and causes leaf roll and interveinal chlorosis (Freitas *et al*. 2012). Therefore, propagative material may provide a pathway for ToCV.	**Yes:** ToCV has established in areas with a wide range of climatic conditions (OEPP/EPPO 2005; Freitas *et al*. 2012). Multiplication and marketing of infected propagative material and the presence of the insect vector, *Bemisia tabaci*, in Australia (Stonor *et al.* 2003), will help spread this virus within Australia. Therefore, ToCV has the potential to establish and spread in Australia.	**Yes**: There is no specific information on effects on potato yield. However, ToCV presents a significant risk to the tomato industry since the known vector is present and widespread in Australia. It causes reduced plant vigour and severe yield loss in tomato (Navas-Castillo *et al*. 2000). ToCV is expected to cause considerable damage to glasshouse tomato crops and outdoor crops in Australia. ToCV is also included in the EPPO A2 action list (OEPP/EPPO 2005). The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
Tomato leaf curl New Delhi virus (ToLCNDV) [Geminiviridae: Begomovirus]	Not known to occur	**Yes:** ToLCNDV infects potato causing a severe leaf curl disease (Usharani *et al*. 2003) and infection is systemic in host plants (Hussain *et al*. 2005). Viruses, as a rule, infect host plants systemically and all plant parts, including parts used for vegetative propagation, are infected (Bos 1999). Therefore, propagative material may provide a pathway for ToLCNDV.	**Yes:** ToLCNDV has established in areas with a wide range of climatic conditions (Usharani *et al*. 2004; Jones *et al*. 2009). Multiplication and marketing of infected propagative material and the presence of the insect vector, *Bemisia tabaci*, in Australia (Stonor *et al.* 2003), will help spread this virus within Australia. Therefore, ToLCNDV has the potential to establish and spread in Australia.	**Yes:** There is no specific information on the effects on yield. However, ToLCNDV has the potential to cause large losses in production in potato growing areas where its whitefly vector is common (Jones *et al*. 2009). Whitefly transmitted geminiviruses are economically important pathogens causing serious losses in food crops globally (Stonor *et al*. 2003). The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	**Yes**
Tomato mosaic virus (ToMV) [Bunyaviridae: Tobamovirus]	Yes (PHA 2001)	Assessment not required			
Tomato mottle Taino virus (ToMoTV) [Geminiviridae: Begomovirus]	Not known to occur	**Yes**: ToMoTV causes systemic infection in host plants (Hussain *et al*. 2005; Collazo *et al.* 2006). The virus can therefore be found in all parts of the host plant. The virus is reported to be transmitted via tubers (Cordero *et al.* 2003). Therefore, propagative material, including seed tubers, may provide a pathway for ToMoTV.	**Yes**: ToMoTV has been reported to spread in South America (Cordero *et al.* 2003) and occur across a wide range of climatic conditions. The virus is a pathogen of solanaceous species, such as potato, tomato and tobacco (Collazo *et al*. 2006), which are widely cultivated crops in Australia. Furthermore, ToMoTV is spread by whiteflies, which are present	**Yes**: ToMoTV is a pathogen of several economically important solanaceous species (Collazo *et al*. 2006). Yield losses due to begomovirus-like symptoms in some potato cultivars in Cuba ranged from 19 to 56% (Cordero *et al*. 2003). The presence of this virus in Australia would impact upon Australia's ability to access overseas markets. Therefore, this virus has the potential for economic consequences in Australia.	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
			in Australia (EPPO 2006). Therefore, ToMoTV has the potential to establish and spread in Australia.		
Tomato spotted wilt virus (ToSWV) [Bunyaviridae: Tosp*ovirus*]	Yes (Jones *et al*. 2009)	Assessment not required			
Tomato yellow mosaic virus (ToYMV) [Geminiviridae: Begomovirus] (synonyms: Potato yellow mosaic virus (PYMV)	Not known to occur	**Yes:** ToYMV infects potato systemically (Buragohain *et al*. 1994). Viruses, as a rule, infect host plants systemically and all plant parts, including parts used for vegetative propagation, are infected (Bos 1999). Therefore, propagative material may provide a pathway for ToYMV.	**Yes:** ToYMV has established in areas with a wide range of climatic conditions and has a wide host range, including potato (Jones *et al*. 2009). Multiplication and marketing of infected propagative material and the presence of its insect vector, *Bemisia tabaci*, in Australia (Stonor *et al.* 2003), will help spread this virus within Australia. Therefore, ToYMV has the potential to establish and spread in Australia.	**Yes:** ToYMV is widespread in the Caribbean region, causes significant losses in tomato, and has the potential to cause significant losses in potato growing areas where its whitefly vector is common (Jones *et al*. 2009). ToMYV has caused millions of dollars in losses in tomato commercial fields in Venezuela (Piven *et al*. 1995). If tomato plants are infected at an early stage they do not produce tomato fruit (Piven *et al*. 1995). Natural infection by ToYMV has once been reported in potato, causing up to 70% losses in potato cv. Sebago (Debrot and Centeno 1985). Therefore, this virus has the potential for economic consequences in Australia.	**Yes**
NEMATODES					
Belonolaimus longicaudatus Rau 1958 [Tylenchina: Belonolaimidae]	Not known to occur	No: Sting nematodes are ectoparasites of plant roots, as such the nematodes remain in the soil and do not enter the plant's tissues	Assessment not required		

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		(Luc *et al*. 2005). These nematodes feed by inserting their stylet or mouth spear into the roots of host plants (Luc *et al*. 2005). Potato tubers being fed on by sting nematodes may be stunted and misshapen (Crow and Brammer 2011). Therefore, potato tubers do not provide a pathway for sting nematodes.			
Criconemoides ornatus (Raski 1958) Luc & Raski [Tylenchina: Circonematidae]	Not known to occur	No: This ring nematode is an ectoparasite of plant roots, as such the nematode remains in the soil and does not enter the plant's tissues (Luc *et al*. 2005). It feeds by inserting a long stylet or mouth spear into the roots of host plants (Luc *et al*. 2005). Therefore, potato tubers do not provide a pathway for ring nematodes.	Assessment not required		
Ditylenchus destructor Thorne 1945 [Tylenchina: Anguinidae]	Not known to occur[27]	**Yes**: This species is an endoparasitic nematode and all life stages can be found within plant tissue. It enters potato tubers through lenticels (Wale *et*	**Yes**: This nematode has established in areas with a wide range of climatic conditions (Wale *et al*. 2008) and it can spread naturally in infested potato tubers (Wale	**Yes**: This species occurs on a variety of commodities and is a quarantine pest to a number of Australia's trading partners. This nematode is considered to be a quarantine pest by several	**Yes**

[27] *Ditylenchus destructor* was reported as present in Australia in 1958 on the basis of misidentifications. It is now not considered to be present in Australia.

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
		al. 2008). Therefore, propagative material (seed potatoes) provides a pathway for this nematode.	*et al*. 2008). This species has many hosts, allowing its rapid build up and distribution. Therefore, this nematode has the potential for establishment and spread in Australia.	countries (CABI/EPPO 1990; Evans *et al*. 1993). The presence of this species in Australia would impact upon Australia's ability to access overseas markets. Therefore, this nematode has the potential for economic consequences in Australia.	
Ditylenchus dipsaci (Kuhn) Filipjev) [Tylenchina: Anguinidae]	Yes (Taylor and Szot 2000)[28]	Assessment not required			
Globodera pallida (Stone 1973) Behrens [Tylenchina: Heteroderidae]	Not known to occur	**Yes**: These species are obligate parasites and attack the roots of the potato (Wale *et al*. 2008). These species can survive as cysts in soil adhering to tubers. Therefore, both infested soil and infested soil adhering to potato tubers can serve as pathways of introduction.	**Yes**: These species have established in areas with a wide range of climatic conditions (Wale *et al*. 2008) and can spread naturally in infested soil adhering to potato tubers (Luc *et al*. 2005). Therefore, potato cyst nematodes have the potential for establishment and spread in Australia.	**Yes**: Potato cyst nematodes are major pests of the potato crop in cool-temperate areas, especially in areas where no resistant cultivars are available. They are also of quarantine significance for APPPC and NAPPO. In addition, *G. rostochiensis* is a quarantine pest for CPPC and IAPSC (CABI/EPPO 1990). The presence of these species in Australia would impact upon Australia's ability to access overseas markets. Therefore, these nematodes have potential for economic consequences in Australia.	**Yes**
Globodera rostochiensis (Wollenweber) Behrens [Tylenchina: Heteroderidae]	Yes (under official control)				**Yes**
Meloidogyne arenaria Chitwood 1949 [Tylenchina: Meloidogynidae]	Yes (Pullman and Berg 2010)	Assessment not required			
Meloidogyne chitwoodii Golden *et al*.	Not known to	**Yes:** This root knot	**Yes**: This nematode has	**Yes**: This species occurs on a	**Yes**

[28] Biological races of *Ditylenchus dipsaci* are described based on their host plant preferences (Esquibet *et al*. 2003). *Ditylenchus dipsaci* is known to infest potatoes in Australia (McLeod *et al*. 1994).

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
[Tylenchina: Meloidogynidae]	occur	nematode is able to survive under the skin of potato tubers (Finley 1981; Viaene *et al*. 2007) and in the soil. Potato tubers may contain nematode eggs, second-stage juveniles and mature females (Viaene *et al*. 2007). Therefore, both infested soil and infected tubers can serve as pathways of introduction.	established in areas with a wide range of climatic conditions (Viaene *et al*. 2007; Wale *et al*. 2008) and it can spread naturally in infected propagative material (Viaene *et al*. 2007). This species has many hosts, allowing its rapid build up and distribution. Therefore, this nematode has the potential for establishment and spread in Australia.	variety of commodities and is a quarantine pest to a number of Australia's trading partners. This nematode is considered a quarantine pest by the European Union (Anon. 2000; Viaene *et al*. 2007). Special requirements exist for the planting and movement of seed potatoes to prevent the spread of this nematode (Anon. 2000). The presence of this species in Australia would impact upon Australia's ability to access overseas markets. Therefore, this nematode has the potential for economic consequences in Australia.	
Meloidogyne fallax Karssen 1996 [Tylenchina: Meloidogynidae]	Yes (Nobbs *et al*. 2001; Vanstone and Nobbs 2007; Nambiar *et al*. 2008)	Assessment not required			
Meloidogyne hapla Chitwood (1949) [Tylenchina: Meloidogynidae]	Yes (Pullman and Berg 2010)	Assessment not required			
Meloidogyne incognita (Kofoid & White, 1919) Chitwood, 1949 [Tylenchina: Meloidogynidae]	Yes (Pullman and Berg 2010)	Assessment not required			
Meloidogyne javanica (Treub 1885) Chitwood 1949 [Tylenchina: Meloidogynidae]	Yes (Pullman and Berg 2010)	Assessment not required			
Nacobbus aberrans (Thorne 1935) Thorne & Allen 1944 [Tylenchina:	Not known to occur	**Yes**: This false root knot nematode is able to survive	**Yes:** This nematode has established in areas with a	**Yes**: This species occurs on a variety of commodities (Luc *et* al.	**Yes**

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
Pratylenchidae]		under the skin of tubers and in the dry soil attached to tubers (Hardy 1996). Therefore, both infested soil and infected tubers can serve as pathways of introduction.	wide range of climatic conditions (Luc *et al*. 2005) and it can spread naturally in infected propagative material (Luc *et al*. 2005). This species has many hosts, allowing its rapid build up and distribution. Therefore, this nematode has the potential for establishment and spread in Australia.	2005) and estimated losses as high as 65% on potato are reported in South America (Anon 2003). This nematode is a quarantine pest to a number of Australia's trading partners. The presence of this species in Australia would impact upon Australia's ability to access overseas markets. Therefore, this nematode has the potential for economic consequences in Australia.	
Paratrichodorus minor (Colbran 1956) Siddiq, 1974 [Diphtherophorina: Trichodoridae]	Yes (Sauer 1981)	Assessment not required			
Pratylenchus brachyurus (Goodfrey 1929) [Tylenchina: Pratylenchidae]	Yes (Riley and Kelly 2002)	Assessment not required			
Pratylenchus coffeae Goodey 1951 [Tylenchina: Pratylenchidae]	Yes (McLeod *et al*. 1994)	Assessment not required			
Pratylenchus crenatus Loof 1960 [Tylenchina: Pratylenchidae]	Yes (McLeod *et al*. 1994)	Assessment not required			
Pratylenchus neglectus (Rensch 1924) Filipjev & Schuurmans-Stekhoven 1941 [Tylenchina: Pratylenchidae]	Yes (Riley and Kelly 2002)	Assessment not required			
Pratylenchus penetrans (Cobb 1917) Filipjev & Schuurmans-Stekhoven 1941 [Tylenchina: Pratylenchidae]	Yes (Riley and Kelly 2002)	Assessment not required			
Pratylenchus scribneri Steiner 1943 [Tylenchina: Pratylenchidae]	Yes (Riley and Kelly 2002)	Assessment not required			
Pratylenchus thornei Sher & Allen 1953 [Tylenchina: Pratylenchidae]	Yes (Riley and Kelly 2002)	Assessment not required			

Pest	Present within Australia	Potential to be on pathway	Potential for establishment and spread	Potential for economic consequences	Quarantine pest?
Pratylenchus vulnus Allen & Jensen 1951 [Tylenchina: Pratylenchidae]	Yes (McLeod *et al*. 1994)	Assessment not required			
Pratylenchus zeae Graham 1951 [Rhabditida: [Tylenchina: Pratylenchidae]	Yes (McLeod *et al*. 1994)	Assessment not required			
Rotylenchulus reniformis Linford & Oliveira 1940 [Tylenchina: Haplolaimidae]	Yes (McLeod *et al*. 1994)	Assessment not required			
Trichodorus andina Allen 1951 [Diphtherophorina: Trichodoridae]	Not known to occur	No: These nematodes feed on tap roots (Wale *et al*. 2008). Therefore, propagative material is not a pathway for the entry of these nematodes.	Assessment not required		
Trichodorus proximus Allen 1957 [Diphtherophorina: Trichodoridae]	Not known to occur		Assessment not required		
Trichodorus viruliflerus Hooper [Diphtherophorina: Trichodoridae]	Not known to occur		Assessment not required		
Tylenchorhynchus claytoni Steiner 1937 [Tylenchina: Belonolaimidae]	Yes (McLeod *et al*. 1994)	Assessment not required			

Appendix B: Additional quarantine pest data

BACTERIA	
Quarantine pest	*Candidatus* Liberibacter solanacearum Liefting *et al*. 2009
Synonyms	*Candidatus* Liberibacter psyllaurous Hansen *et al*. 2008
Common name(s)	Zebra Chip
Main hosts	*Capsicum annuum* L., *Capsicum frutescens* L., *Lycopersicon esculentum* Mill, *Physalis peruviana* L., *Solanum betaceum* Cav., *Solanum tuberosum* L. (Biosecurity Australia 2009; Crosslin and Bester 2009)
Distribution	Canada, Mexico, New Zealand, United States (Crosslin and Bester 2009; Munyaneza *et al*. 2009b).
Quarantine pest	*Clavibacter michiganensis* subsp. *sepedonicus* (Spieck & Kotth.) Davis *et al*. 1984
Synonyms	*Corynebacterium sepedonicum*
Common name(s)	Potato ring rot; Bacterial ring rot of potato
Main hosts	*Solanum tuberosum* (Potato) (Jeffries 1998)
Distribution	Canada, Europe (e.g. Germany, Russia), northern Asia, United States (Jeffries 1998)
Quarantine pest	*Dickeya dadantii* Samson *et al*. 2005
Synonyms	*Erwinia chrysanthemi* biovar 3 (some strains), Pectobacterium *chrysanthemi* biovar 3 (some strains) (Toth *et al*. 2011).
Common name(s)	Bacterial soft rot
Main hosts	*Ananas comosus, Dianthus spp., Euphorbia pulcherrima*, *Ipomoea batatas*, *Musa* spp., *Pelargonium capitatum, Saintpaulia ionantha, Solanum tuberosum*, *Zea mays* (Jeffries 1998; Samson *et al*. 2005; Toth *et al*. 2011).
Distribution	Brazil, Cuba, Finland, Germany, Israel, Malaysia, Netherlands, Poland, Peru, Zimbabwe (Slawiak *et al*. 2009; Tsror *et al*. 2009; Toth *et al*. 2011).
Quarantine pest	*Dickeya dianthicola* Samson *et al*. 2005
Synonyms	*Erwinia chrysanthemi* biovars 1, 7 and 9, *E. chrysanthemi* pv. *dianthicola*, *Pectobacterium chrysanthemi* pv. *dianthicola* (Toth *et al*. 2011).
Common name(s)	Bacterial soft rot
Main hosts	*Cichorium intybus*, *Cynara scolymus*, *Dahlia* spp., *Dianthus caryophyllus, Dianthus* spp.*, Lycopersicon esculentum, Solanum tuberosum* (Samson *et al*. 2005; Slawiak *et al*. 2009; Toth *et al.* 2011).
Distribution	Colombia, Denmark, England, Finland , France, Germany, Greece, Italy, Japan, Poland, Sweden, Romania, Netherlands, New Zealand, Norway, Spain, USA (Samson *et al*. 2005; Slawiak *et al.* 2009; Toth *et al*. 2011).
Quarantine pest	*Dickeya dieffenbachiae* Samson *et al*. 2005
Synonyms	*Erwinia chrysanthemi* biovar 2, *E. chrysanthemi* pv. *dieffenbachiae, Pectobacterium chrysanthemi* pv *dieffenbachiae* (Toth *et al*. 2011).
Common name(s)	Bacterial soft rot
Main hosts	*Dieffenbachia* sp., *Lycopersicon esculentum*, *Musa paradisiaca*, *Solanum tuberosum* (Slawiak *et al*. 2009; Toth *et al*. 2011).
Distribution	Cuba, France, Germany, USA (Samson *et al*. 2005; Slawiak *et al*. 2009).

Quarantine pest	*Dickeya paradisiaca* (Fernandez-Borrero and Lopez-Duque 1970) Samson *et al*. 2005
Synonyms	*Erwinia chrysanthemi* biovar 4, *E. chrysanthemi* pv. *paradisiaca*, *E. paradisiaca*, *Brenneria paradisiaca* (Toth *et al*. 2011).
Common name(s)	Bacterial soft rot
Main hosts	*Musa paradisiaca, Solanum tuberosum, Zea mays* (Slawiak *et al*. 2009; Toth *et al*. 2011).
Distribution	Colombia, Cuba (Slawiak *et al*. 2009).
Quarantine pest	*Dickeya parthenii* Samson *et al*. 2005
Synonyms	*Erwinia chrysanthemi* biovar 6, *E. chrysanthemi* pv. *parthenii*, *Pectobacterium chrysanthemi* pv. *parthenii* (Toth *et al*. 2011).
Common name(s)	Bacterial soft rot
Main hosts	*Cichorium intybus, Cynara scolymus, Dahlia* spp., *Parthenium argentatum, Philodendron oxycardium*, *Solanum tuberosum* (Samson *et al*. 2005; Toth *et al*. 2011).
Distribution	Denmark, France, Romania, Switzerland, Taiwan, USA (Samson *et al*. 2005; Slawiak *et al*. 2009).
Quarantine pest	*Dickeya solani* sp. nov.
Synonyms	*Erwinia chrysanthemi* biovar 3 (some strains)
Common name(s)	Blackleg of potato
Main hosts	*Solanum tuberosum* (Toth *et al*. 2011).
Distribution	Finland, Israel, Netherlands, Poland, Spain, UK (Toth *et al*. 2011)
Quarantine pest	*Pectobacterium betavasculorum* (Thomson *et al*. 1984) Gardan *et al*. 2003
Synonyms	*Erwinia carotovora* subsp. *betavasculorum* Thomson *et al*. 1984; *Pectobacterium carotovorum* subsp. *betavasculorum* (Thomson *et al*. 1984) Hauben *et al*. 1999.
Common name(s)	Pectobacterium bacterium
Main hosts	*Beta vulgaris, Eutrema wasabi, Solanum tuberosum* (Gardan *et al*. 2003; Pitman *et al*. 2010).
Distribution	Japan, Mexico, New Zealand, Romania, USA (Gardan *et al*. 2003; Pitman *et al*. 2010).
Quarantine pest	*Pectobacterium carotovorum* subsp. *brasiliensis* Duarte *et al*. 2004
Synonyms	*Erwinia carotovorum* subsp. *brasiliensis* (Pitman *et al*. 2010)
Common name(s)	Bacterial soft rot, Blackleg of potato.
Main hosts	*Solanum tuberosum* (Pitman *et al*. 2010).
Distribution	Brazil, USA (Pitman *et al*. 2010).
Quarantine pest	*Pectobacterium wasabiae* (Goto & Matsumoto 1987) Gardan *et al*. 2003
Synonyms	*Erwinia carotovora* subsp. *wasabiae* Goto and Matsumoto 1987 (Gardan *et al*. 2003).
Common name(s)	Bacterial soft rot
Main hosts	*Eutrema wasabi, Solanum tuberosum* (Gardan *et al*. 2003; Pitman *et al*. 2010)
Distribution	Japan, New Zealand, USA (Gardan *et al*. 2003; Pitman *et al*. 2010).
Quarantine pest	*Ralstonia solanacearum* (Smith 1896) Yabuuchi *et al*. (1995)
Synonyms	*Pseudomonas solanacearum* (Smith 1896) Smith 1914; *Burkholderia solanacearum* (Smith, 1896) Yabuuchi *et al*. 1992; many other synonyms in literature

Common name(s)	brown rot of potato, bacterial wilt
Main hosts	Race 1 attacks tobacco, many other solanaceous crops and many hosts in other plant families. Race 2 attacks bananas and *Heliconia* (causing so called Moko disease), but also in the Philippines (causing so-called bugtok disease on plantains). Race 3 attacks potato, tomato, occasionally *Pelargonium zonale,* aubergine and capsicum, some solanaceous weeds like *Solanum nigrum* and *Solanum dulcamara.* A number of non-solanaceous weed hosts have also been found to harbour race 3 infections, often asymptomatically (Strider *et al*. 1981; Wenneker *et al*. 1999; Pradhanang *et al*. 2000). Race 4 is particularly aggressive on ginger and race 5 (biovar 5) is specialized on *Morus* (OEPP/EPPO 2004)
Distribution	Race 1 occurs in tropical areas all over the world, Race 2 occurs mainly in tropical areas of South America, Race 3, occurring at higher altitudes in the tropics and in subtropical and temperate areas and race 4 and 5 occurs in Asia, the Americas and Australia. Detailed geographical distribution is provided in CABI/EPPO (1999).
Quarantine pest	*Streptomyces acidiscabies* Lambert and Loria 1989
Synonyms	
Common name(s)	Scab
Main hosts	*Solanum tuberosum*
Distribution	China (Zhao *et al*. 2009), Korea (Park *et al*. 2003), UK (Thwaites *et al*. 2009), USA (Loria *et al*. 1997)
Quarantine pest	*Streptomyces caviscabiei* Goyer *et al*. 1996
Synonyms	
Common name(s)	Scab
Main hosts	*Solanum tuberosum*
Distribution	Canada (Goyer *et al*. 1996)
Quarantine pest	*Streptomyces europaeiscabiei* Bouchek-Mechiche *et al*. 2000
Synonyms	
Common name(s)	Netted scab
Main hosts	*Solanum tuberosum*
Distribution	Europe (Wale *et al*. 2008)
Quarantine pest	*Streptomyces luridiscabiei* Park *et al* 2003
Synonyms	
Common name(s)	Scab
Main hosts	*Solanum tuberosum*
Distribution	Korea (Park *et al*. 2003).
Quarantine pest	*Streptomyces niveiscabiei* Park *et al* 2003
Synonyms	
Common name(s)	Scab
Main hosts	*Solanum tuberosum*
Distribution	Korea (Park *et al*. 2003).

Quarantine pest	*Streptomyces puniciscabiei* Park *et al* 2003
Synonyms	
Common name(s)	Scab
Main hosts	*Solanum tuberosum*
Distribution	Korea (Park *et al*. 2003).
Quarantine pest	*Streptomyces reticuliscabiei* Bouchek-Mechiche *et al*. 2000
Synonyms	
Common name(s)	Scab
Main hosts	*Solanum tuberosum*
Distribution	Canada, Europe (Wanner *et al*. 2006)
Quarantine pest	*Streptomyces stelliscabiei* Bouchek-Mechiche *et al*. 2000
Synonyms	
Common name(s)	Scab
Main hosts	*Solanum tuberosum*
Distribution	Canada and eastern United States (Bukhalid *et al*. 2002)
Quarantine pest	*Streptomyces turgidiscabies* Miyajima *et al*. 1998
Synonyms	
Common name(s)	Netted scab
Main hosts	*Solanum tuberosum*
Distribution	Finland, Japan, Korea, Sweden (Wanner 2006), UK (Thwaites *et al*. 2009)
FUNGI	
Quarantine pest	*Aecidium cantensis* Arthur
Synonyms	
Common name(s)	Potato deforming rust, Peruvian rust
Main hosts	*Solanum tuberosum* and *Lycopersicon esculentum* (Stevenson *et al*. 2001).
Distribution	South America (Argentina, Peru) (Stevenson *et al.* 2001).
Quarantine pest	*Gerwasia pittieriana* (Henn.) León-Gall. & Cummins
Synonyms	*Puccinia pittieriana* Henn. 1904
Common name(s)	Potato rust
Main hosts	*Lycopersicon esculentum*, *Solanum* spp. including *Solanum tuberosum* (Stevenson *et al.* 2001; Farr and Rossman 2011).
Distribution	Bolivia, Brazil, Colombia, Costa Rica, Ecuador, Mexico, Peru, Venezuela (Stevenson *et al.* 2001).
Quarantine pest	*Phacidiopycnis tuberivora* (H.T. Güssow & W.R. Foster) B. Sutton
Synonyms	*Phomopsis tuberivora* H.T. Güssow & W.R. Foster
Common name(s)	Dry rot
Main hosts	Potato, hop, *Hoya* spp., *Medicago sativa* and *Olearia traversii* (Sutton 1980; Gent *et al*. 2013)

Distribution	Australia (PHA 2001), India, United States (CABI 2007; Gent *et al*. 2013)
Quarantine pest	*Phoma andigena* var. *andina* Turkenst
Synonyms	*Stagonosporopsis andigena*
Common name(s)	Phoma leaf spot
Main hosts	*Solanum* spp. including *Solanum tuberosum, Lycopersicon esculentum* (Stevenson *et al.* 2001; Farr and Rossman 2011).
Distribution	Peru, Bolivia (Stevenson *et al* 2001).
Quarantine pest	*Phoma crystalliniformis* (Loer. *et al*.) Noordel. & Gruyter
Synonyms	
Common name(s)	Carate disease of tomato and potato
Main hosts	*Solanum tuberosum, Lycopersicon esculentum* (Stevenson *et al.* 2001).
Distribution	Colombia, Venezuela (Stevenson *et al.* 2001).
Quarantine pest	*Polyscytalum pustulans* (M.N. Owen & Wakef.) M.B. Ellis
Synonyms	*Oospora pustulans* M.N. Owen & Wakef.
Common name(s)	Skin spot
Main hosts	Potato (Wale 2008)
Distribution	Canada, England, Estonia, Germany, Iran, Ireland, Lithuania, New Zealand, Norway, Romania, Russian Federation, Scotland, South Africa, United States, Wales (CABI 2007)
Quarantine pest	*Synchytrium endobioticum* (Schilb.) Percival)
Synonyms	*Chrysophlyctis endobioticum* Schilb. 1896, *Synchytrium solani* Massee 1910
Common name(s)	Potato wart disease
Main hosts	*Solanum tuberosum* (Stevenson *et al.* 2001; Farr and Rossman 2011).
Distribution	Europe, Asia, Africa, South America, Canada, USA, New Zealand (Stevenson *et al.* 2001; Farr and Rossman 2011).
Quarantine pest	*Thecaphora solani* (Thirum. & M. O'Brien) Mordue 1988
Synonyms	*Angiosorus solani* Thirum. & M. O'Brien 1974 [1972], *Thecaphora solani* (Barrus & Muller ex Thirum. & M. O'Brien) Vánky 1988
Common name(s)	Potato smut, Thecaphora smut
Main hosts	*Solanum tuberosum*, *Solanum stoloniferum, Datura stramonium* (Stevenson *et al.* 2001; Farr and Rossman 2011).
Distribution	Bolivia, Chile, Colombia, Ecuador, Peru, Venezuela, Mexico, Panama (Stevenson *et al.* 2001; Farr and Rossman 2011).
STRAMINOPILA	
Quarantine pest	*Phytophthora infestans* (Mont.) de Bary [A2 mating strain and exotic strains of both the A1 and A2]
Synonyms	*Botrytis infestans* Mont. 1845, *Peronospora infestans* (Mont.) Casp. 1854
Common name(s)	Late blight of potato
Main hosts	*Solanum* spp. including *Solanum tuberosum, Lycopersicon esculentum* (Farr and Rossman 2011; Stevenson *et al.* 2001). Also occurs on hosts in 15 other genera and in 10 other families (Farr and Rossman 2011).

Distribution	Cosmopolitan (Stevenson *et al.* 2001; Farr and Rossman 2011).
PROTOZOA	
Quarantine pest	*Spongospora subterranea* (Wallr.) Lagerh. f. sp. *subterranea* Tomlinson (*Sss*) (potentially carrying Potato mop-top virus [PMTV])
Synonyms	*Spongospora subterranea* (Wallr.) Lagerh.
Common name(s)	Powdery scab
Main hosts	*Solanum tuberosum* (Santala *et al*. 2010)
Distribution	Andean region of South America (Salazar and Jones 1975; Santala *et al*. 2010), Canada, China, Japan (Imoto *et al*. 1981; Hutchison and Kawchuk 1998; Merz 2008; Santala *et al*. 2010), Northern Europe (Van Hoof and Rozendaal 1969; Santala *et al*. 2010).
PHYTOPLASMA	
Quarantine pest	*Candidatus* Phytoplasma asteris [**16SrI** – Aster yellows group]
Synonyms	
Strains	Chinese potato phytoplasma, El Salvador potato phytoplasma, Iranian potato phytoplasma, Nebraska potato purple top phytoplasma, Peruvian (Andahuaylas) potato phytoplasma, Potato marginal flavescence phytoplasma, Potato phyllody phytoplasma, Potato purple-top roll phytoplasma, Potato purple-top wilt phytoplasma, Russian potato purple top phytoplasma, Texas potato purple top phytoplasma
Common name(s)	Aster yellows
Main hosts	Wide host range including *Solanum tuberosum* (Cheng *et al*. 2011b; Santos-Cervantes *et al*. 2010; Firrao *et al*. 2005)
Distribution	China, El Salvador, India, Mexico, USA (Lee *et al*. 2006; Lee *et al*. 2007; Santos-Cervantes *et al*. 2010; Cheng *et al*. 2011b), Russia (Girsova *et al*. 2008)
Quarantine pest	*Candidatus* Phytoplasma aurantifolia [**16SrII** – Peanut Witches' broom Group]
Synonyms	
Common name(s)	
Strains	Mexican potato purple top phytoplasma, Peruvian potato phytoplasma, Potato phytoplasma isolate Islamabad, Potato phytoplasma isolate Pot001
Main hosts	*Solanum tuberosum* (Santos-Cervantes *et al*. 2010)
Distribution	Strains associated with potato purple top are found in Mexico (Santos-Cervantes *et al*. 2010).
Quarantine pest	*Candidatus* Phytoplasma pruni [**16SrIII** – X-Disease Group]
Synonyms	
Common name(s)	
Strains	Alaska potato purple top phytoplasma, Mexican potato purple top phytoplasma COAHP, Mexican potato purple top phytoplasma GTOP, Montana potato purple top phytoplasma
Main hosts	*Solanum tuberosum* (Lee *et al*. 2006)
Distribution	Iran, Mexico, Sudan, Taiwan, Thailand, United Arab Emirates (Lee *et al*. 1998; Firrao *et al*. 2005; Santos-Cervantes *et al*. 2010)
Quarantine pest	*Candidatus* Phytoplasma trifolii [1**6SrVI** – Clover Proliferation Group]
Synonyms	

Common name(s)	Potato purple top disease
Strains	Columbia Basin potato purple top phytoplasma, Potato purple top phytoplasma PPT, Potato purple top phytoplasma YN-6, Potato witches' broom phytoplasma, Washington potato purple top phytoplasma
Main hosts	Wide host range including *Solanum tuberosum* (Munyaneza 2010)
Distribution	Canada (Lee *et al*. 2009); China (Cheng *et al*. 2011a); Iran (Hosseini *et al*. 2011); Mexico (Lee *et al*. 2009); Russia (Girsova *et al*. 2008); USA (Munyaneza 2010)
Quarantine pest	*Candidatus* Phytoplasma solani [**16SrXII-A** – Stolbur Group]
Synonyms	
Common name(s)	Potato purple top disease
Strains	Eggplant little leaf phytoplasma, Potato stolbur phytoplasma, Potato round leaf phytoplasma, Potato witche's broom phytoplasma, Iranian potato purple top phytoplasma, Russian potato purple top phytoplasma Rus-PPT, Turkish potato stolbur phytoplasma
Main hosts	Wide host range including *Capsicum annuum*, *Lotus corniculatus*, *Lycopersicon esculentum*, *Medicago sativa*, *Solanum melongena*, *S. tuberosum*, *Trifolium pratense, T. repens* (Jeffries 1998; Girosova *et al.* 2008; Munyaneza 2010).
Distribution	Asia, Canada, Europe, Iran, Israel, Mexico, Russia, South America, Turkey, USA (Jeffries 1998; Girosova *et al.* 2008; Lee *et al*. 2009; Munyaneza 2010; Hosseini *et al*. 2011).
Quarantine pest	Mexican periwinkle virescence group [**16SrXIII**]
Synonyms	
Common name(s)	Potato purple top disease
Strains	
Main hosts	Potato (Lee *et al*. 2009; Santos-Cervantes *et al*. 2010).
Distribution	Canada, Mexico, Russia, United States (Lee *et al*. 2009)
Quarantine pest	*Candidatus* Phytoplasma americanum [**16SrXVIII** – American Potato Purple Top Wilt Group]
Synonyms	
Common name(s)	American potato purple top wilt phytoplasma, Purple top syndrome
strains	APPTW1-TX, APPTW2-TX, APPTW9-NE and APPTW12- NE (subgroup 16SrXVIII-A) and APPTW 1883 #6-TX, APPTW10-NE and APPTW13-NE (subgroup 16SrXVIII-B
Main hosts	*Solanum tuberosum* (Lee *et al*. 2006)
Distribution	USA (Lee *et al*. 2006; Lee *et al*. 2007)
VIROID	
Quarantine pest	Potato spindle tuber viroid (PSTVd)
Synonyms	
Common name(s)	Tomato bunchy top (South Africa), Potato "gothic" disease (old USSR)
Main hosts	The natural host range of PSTVd includes many solanaceous species including *Solanum tuberosum* (potato), *S. lycopersicum* (tomato), and *Capsicum annuum* (pepper). Infections in other hosts are symptomless; e.g., *Brugmansia* spp., *Datura* sp., *Lycianthes rantonneti* (syn. *S. rantonneti*), *Persea americana* (avocado), *Physalis peruviana* (Cape gooseberry), *S. jasminoides*, *S. muricatum* (pepino) and *Streptosolen*

	jamesonii (Owens and Verhoeven 2009).
Distribution	Asia, Africa, Europe, New Zealand, North America and South America, (Mackie and Jones 2006).
VIRUSES	
Quarantine pest	Alfalfa mosaic virus – Potato strains (AMV)
Synonyms	
Common name(s)	Calico and tuber necrosis
Main hosts	Wide host range (150 species in 22 families): *Lycopersicon esculentum*, *Medicago sativa*, *Pisum sativum*, *Solanum tuberosum* (Jaspars and Bos 1980; Xu and Nie 2006).
Distribution	Canada, Italy, Korea, New Zealand (Xu and Nie 2006)
Quarantine pest	Andean potato latent virus (APLV)
Synonyms	
Common name(s)	
Main hosts	*Solanum tuberosum*, *Ullucus tuberosus* (Jeffries 1998).
Distribution	Widespread in the Andean Region of South America including Bolivia, Chile, Colombia, Ecuador and Peru (Fribourg *et al*. 1977; Contreras and Banse1982; Jeffries 1998), especially at higher altitudes (Koenig *et al*. 1979).
Quarantine pest	Andean potato mottle virus (APMoV)
Synonyms	Potato Andean mottle virus, Potato Andean mottlevirus
Common name(s)	Andean mottle of potato
Main hosts	*Solanum tuberosum, S. melongena* (Brioso *et al.* 1993; Jeffries 1998).
Distribution	Andean region of South America including Brazil (Avila *et al*. 1984), Chile (Contreras *et al*. 1981), Ecuador (Smith *et al*. 1997a) and Peru (Fribourg 1977)
Quarantine pest	Arracacha B virus – Oca strain (AVB-O)
Synonyms	Arracacha virus B
Common name(s)	
Main hosts	*Solanum tuberosum, Oxalis tuberose* (Jeffries 1998).
Distribution	Bolivia (Atkey and Brunt 1982), Peru (Jones 1981; Jones and Kenten 1981)
Quarantine pest	Beet curly top virus (BCTV)
Synonyms	Sugarbeet curly top virus, Potato green dwarf virus, Western yellow blight virus
Common name(s)	Potato green dwarf, Curly top of beet, Beet curly top
Main hosts	Wide host range including *Beta vulgaris*, *Capsicum* spp., various cucurbits, *Lycopersicon esculentum*, *Phaseolus* spp., *Spinacia oleracea* and *Solanum tuberosum* (Jeffries 1998).
Distribution	Arid and semi-arid regions of the Eastern Mediterranean basin, Middle East, North, Central and South America (Jones *et al*. 1982; Jeffries 1998).
Quarantine pest	Eggplant mottled dwarf virus (EMDV)
Synonyms	Eggplant mottled dwarf nucleorhabdovirus
Common name(s)	Tomato vein yellowing virus, Tomato vein clearing virus
Main hosts	*Lycopersicon esculentum*, *Solanum melongena, Solanum tuberosum* (Roggero *et al*. 1995; Jeffries 1998).

Distribution	In potatoes, only reported in Iran (Danesh and Lockhart 1989). In other solanaceous hosts, found in the Mediterranean basin and the Middle East (Jeffries 1998).
Quarantine pest	Impatiens necrotic spot virus (INSV)
Synonyms	Impatiens necrotic spot topsovirus
Common name(s)	
Main hosts	This species occurs on a range of ornamental and vegetable crops (CABI 2007), including potato (CABI 2007; Crosslin and Hamlin 2010). The main hosts of INSV are impatiens and chrysanthemums (CABI 2007).
Distribution	Canada, Costa Rica, Chile, China, Germany, Iran, Italy, Japan, The Netherlands, New Guinea, New Zealand, Portugal, United Kingdom, and the USA (Lisa *et al*. 1990; de Avila *et al*. 1992; Adam and Lesemann 1994; EPPO/CABI 1996; Louro 1996; Elliott *et al.* 2009; Kuwabara *et al.* 2010).
Quarantine pest	Pepino mosaic virus (PepMV)
Synonyms	
Common name(s)	Pepino mosaic potexvirus
Main hosts	*Lycopersicon esculentum* (Martínez-Culebras *et al*. 2002; van der Vlugt *et al*. 2002), wild *Lycopersicon* spp. (Soler *et al*. 2002), *Solanum muricatum* (pepino) (van der Vlugt *et al*. 2002), *S. tuberosum* (CSL 2005), weed spp. (CSL 2005).
Distribution	Africa, Asia, Europe, North America, South America (CSL 2005).
Quarantine pest	Potato 14R virus
Synonyms	
Common name(s)	
Main hosts	*Solanum tuberosum* ssp. *andigena* × *S. tuberosum* ssp. *tuberosum* (Brunt *et al*. 1996).
Distribution	Peru (Brunt *et al.* 1996).
Quarantine pest	Potato black ringspot virus (PBRSV)
Synonyms	Potato calico strain of tobacco ringspot virus, Potato Andean calico virus
Common name(s)	Calico disease of potato
Main hosts	*Arracacia xanthorrhiza* (arracacha)*, Oxalis tuberosa* (oca), *Solanum tuberosum* (Jeffries 1998).
Distribution	Peru (Fribourg 1977)
Quarantine pest	Potato deforming mosaic virus (PDMV)
Synonyms	Potato deforming mosaic disease, Potato mosaic deformante virus; Tomato yellow vein streak virus
Common name(s)	Deforming mosaic of potato
Main hosts	*Solanum chacoense*, *S. sisymbrifolium*, *S. tuberosum* (Jeffries 1998).
Distribution	Argentina and Southern Brazil (Daniels and Castro 1985).
Quarantine pest	Potato latent virus (PotLV)
Synonyms	
Common name(s)	
Main hosts	*Solanum tuberosum* (Jeffries 1998).
Distribution	North America (Jeffries 1998).

Quarantine pest	Potato mop-top virus (PMTV)
Synonyms	Potato mop-top pomovirus
Common name(s)	Potato mop-top
Main hosts	*Solanum tuberosum* (Jeffries 1998).
Distribution	Andean region of South America (Salazar and Jones 1975), Canada, China, Japan (Imoto *et al*. 1981), Northern Europe (Van Hoof and Rozendaal 1969), the US (Washington, North Dakota, Maine and Idaho) (Whitworth and Crosslin, 2013).
Quarantine pest	Potato rough dwarf virus (PRDV)
Synonyms	
Common name(s)	
Main hosts	*Solanum tuberosum* (Jeffries 1998).
Distribution	Argentina, Uruguay (Jeffries 1998).
Quarantine pest	Potato virus M (PVM)
Synonyms	Potato paracrinkle virus, Potato interveinal mosaic virus, Potato virus E, Potato virus K
Common name(s)	
Main hosts	*Solanum tuberosum* (Jeffries 1998).
Distribution	Worldwide except the Andean region of South America (Salazar 1990).
Quarantine pest	Potato virus S (Andean strain) (PVS^A)
Synonyms	
Common name(s)	
Main hosts	*Solanum muricatum* (Dolby and Jones 1988), *Solanum tuberosum* (Jeffries 1998).
Distribution	Bolivia, Chile, Colombia, Ecuador, Germany, Netherlands, New Zealand, Peru, United Kingdom and the USA (Hinostroza-Orihuela 1973; Santillan *et al*. 1980; Slack 1983; Dolby and Jones 1987; Fletcher 1996).
Quarantine pest	Potato virus T (PVT)
Synonyms	
Common name(s)	
Main hosts	*Oxalis tuberosa*, *Solanum tuberosum*, *Tropaeolum tuberosum*, *Ullucus tuberosus* (Jeffries 1998).
Distribution	Bolivia, Peru (Jeffries 1998; Salazar and Harrison 1978).
Quarantine pest	Potato virus U (PVU)
Synonyms	
Common name(s)	
Main hosts	*Solanum tuberosum* (Jeffries 1998; Brunt *et al*. 1996).
Distribution	Peru (Jeffries 1998).
Quarantine pest	Potato virus V (PVV)
Synonyms	
Common name(s)	
Main hosts	*Lycopersicon esculentum*, *Solanum tuberosum* (Jeffries 1998).

Distribution	Bolivian highlands, France, Germany, the Netherlands, Peru, United Kingdom (Brunt *et al*. 1996; Jeffries 1998).
Quarantine pest	Potato virus X (PVX) (strains not present in Australia)
Synonyms	
Common name(s)	
Main hosts	*Solanum tuberosum*, *Brassica campestris* ssp. *rapa*, *Cyphomandra betacea, Datura stramonium*, *Lycopersicon esculentum*, *Nicotiana* spp., *Petuna hybrid*, *Solanum nigrum* (Lobenstein 2001).
Distribution	PVX strains occur in potato growing areas worldwide (Lobenstein 2001). PVX_{HB} strain occurs in Bolivia (Lobenstein 2001).
Quarantine pest	Potato virus Y (PVY)
Synonyms	
Common name(s)	
Main hosts	*Lycopersicon esculentum*, *Solanum tuberosum* (Jeffries 1998).
Distribution	Canada (Xu *et al*. 2005)
Quarantine pest	Potato yellow dwarf virus (PYDV)
Synonyms	
Common name(s)	
Main hosts	*Chrysanthemum leucanthemum, Solanum tuberosum, Trifolium incarnatum* (Jeffries 1998; Brunt *et al*. 1996).
Distribution	Canada, USA (Brunt *et al*. 1996; Jeffries 1998).
Quarantine pest	Potato yellow vein virus (PYVV)
Synonyms	Potato vein-yellowing disease, Potato yellow vein disease
Common name(s)	Yellow vein of potato, Vein-yellowing of potato
Main hosts	Wild *Lycopersicon* spp., *Polygonum mepalense*, *Solanum tuberosum, S. nigrumare* (Jeffries 1998).
Distribution	Columbia, Ecuador, Peru (Jeffries 1998).
Quarantine pest	Potato yellowing virus (PYV)
Synonyms	Andean potato yellowing virus , Virus SB-22
Common name(s)	
Main hosts	*Solanum tuberosum* (Jeffries 1998)
Distribution	Bolivia, Chile, Peru (Valkonen *et al.* 1992a; Jeffries 1998).
Quarantine pest	Solanum apical leaf curling virus (SALCV)
Synonyms	Solanum apical leaf curling virus
Common name(s)	
Main hosts	*Datura tatula, Nicandra physalodes, Physalis peruviana, Solanum basendopogon, S. nigrum, S. tuberosum* (Hooker and Salazar 1983; Brunt *et al*. 1996).
Distribution	Peru (Brunt *et al*. 1996; Jeffries 1998).
Quarantine pest	Tobacco mosaic virus – Potato infecting strain (TMV-P)
Synonyms	

Common name(s)	
Main hosts	Solanaceous crops including pepper, potato, tobacco and tomato (Jung *et al*. 2002).
Distribution	China, Hungary, India (Horvath 1977), Korea (Jung *et al*. 2002), the Peruvian Andes (Phatak and Verma 1967), Philippines (Talens and Talens 2009), Saudi Arabia (Al-Shahwan *et al*. 1997)
Quarantine pest	Tobacco necrosis virus (TNV)—potato infecting strains
Synonyms	
Common name(s)	
Main hosts	Potato (*Solanum tuberosum*)
Distribution	Europe, North America (Jones *et al*. 2009)
Quarantine pest	Tobacco rattle virus (TRV)
Synonyms	Aster ringspot virus, Potato stem mottle virus, Potato corky ringspot virus, Oregon yellow virus, Spinach yellow mottle virus (CABI 2007).
Common name(s)	Spraing of potato, Corky ringspot of potato, Internal rust of potato (CABI 2007).
Main hosts	Wide host range, including *Beta vulgaris*, *Gladiolus* spp., *Hyacinthus* spp., *Lactuca sativa*, *Narcissus* spp., *Nicotiana* spp., *Solanum tuberosum, Spinacia oleracae*, *Tulipa* spp., and many weed species (Jeffries 1998).
Distribution	Central America, China, Europe, Japan, New Zealand, North America, South America, USSR (Jeffries 1998).
Quarantine pest	Tobacco streak virus—potato strain (TSV-P)
Synonyms	
Common name(s)	
Main hosts	*Solanum tuberosum* (Salazar *et al*. 1981).
Distribution	TSV-P was found in a clone plant of the International Potato Center (CIP) germplasm collection in Peru and is possibly restricted to the Andean region (Anon. 2000)
Quarantine pest	Tomato black ring virus (TBRV)
Synonyms	Potato bouquet virus, Potato pseudo-aucuba virus, Tomato black ring virus.
Common name(s)	Ring spot of beet
Main hosts	Wide host range, including *Solanum tuberosum*, *Vitis Vinifera* and other species of fruit vegetables, ornamentals and weeds (Jeffries 1998).
Distribution	Africa, Asia, Germany, North America, Poland, South America, UK (Smith *et al*. 1997b; Jeffries 1998).
Quarantine pest	Tomato chlorosis virus (ToCV)
Synonyms	
Common name(s)	Yellow leaf disorder of tomato
Main hosts	*Capsicum annuum* (Lozano *et al*. 2004), *Lycopersicon esculentum* (Wisler *et al*. 1998), *Solanum tuberosum* (Fortes and Navas-Castillo 2012; Freitas *et al*. 2012) and *Zinnia* (Tsai *et al*. 2004).
Distribution	France, Greece, Italy, Morocco, Portugal, Puerto Rico, South Africa, Spain, Taiwan, USA (EPPO 2005). On potatoes this virus has been reported from Brazil (Freitas *et al*. 2012) and Spain (Fortes and Navas-Castillo 2012).

Quarantine pest	Tomato leaf curl New Delhi virus (ToLCNDV)
Synonyms	Indian tomato leaf curl virus
Common name(s)	Potato leaf curl
Main hosts	*Capsicum annuum, Citrullus lanatus*, *Lycopersicon esculentum, Momordica charantia, Solanum tuberosum* (Usharani *et al*. 2003; Hussain *et al*. 2005; Tahir and Haider 2005).
Distribution	India, Pakistan (Usharani *et al*. 2003; Tahir and Haider 2005).
Quarantine pest	Tomato mottle Taino virus (ToMoTV)
Synonyms	
Common name(s)	
Main hosts	*Lycopersicon esculentum*, *Solanum tuberosum* (Cordero *et al*. 2003; Ramos *et al* 2003).
Distribution	Cuba (Cordero *et al*. 2003; Ramos *et al*. 2003).
Quarantine pest	Tomato yellow mosaic virus (ToYMV)
Synonyms	Potato yellow mosaic virus
Common name(s)	Yellowish mosaic of tomato
Main hosts	*Lycopersicon esculentum*, *Solanum tuberosum* (Polston and Anderson 1997; Morales *et al*. 2001).
Distribution	Guadeloupe, Martinique, Puerto Rico, Trinidad, Tobago, Venezuela (Polston and Anderson 1997).
NEMATODES	
Quarantine pest	*Ditylenchus destructor* Thorne 1945
Synonyms	
Common name(s)	Potato rot nematode, Tuber rot-eelworm
Main hosts	A wide range of plants, especially root crops such as carrots, garlic, potatoes and sugar beets (CFIA 2011). Potatoes are the main host of *D. destructor*, but the nematode can also be found on dahlia, gladiolus, groundnuts, hops, iris, onion, sweet potato, *Trifolium* spp. and tulip (CFIA 2011).
Distribution	Temperate regions; China, Europe, North America (Marin County, California), South Africa (CABI/EPPO 2009).This nematode has been detected in parts of Africa, Asia, Canada, Europe, Mexico, Oceania, South America and the United States (CFIA 2011).
Quarantine pest	*Globodera pallida* (Stone, 1973) Behrens, 1975
Synonyms	*Heterodera pallida* (Stone)
Common name(s)	White potato cyst nematode, Pale potato cyst nematode
Main hosts	Potatoes are by far the most important host crop. Aubergines and tomatoes are also attacked. Other *Solanum* spp. and their hybrids can also act as hosts (EPPO 2011).
Distribution	The centre of origin of this species is in the Andes Mountains in South America from where it was introduced to other areas. Its range includes Algeria, Argentina, Austria, Belgium, Bolivia, Canada, Chile, Colombia, Costa Rica, Cyprus, Ecuador, France, Germany, Iceland, India, Ireland, Italy, Luxembourg, Malta, Netherlands, New Zealand, Norway, Pakistan, Panama, Peru, Poland, Portugal, Romania, Slovenia, Spain, South Africa, Sweden, Switzerland, Tunisia, Turkey, USA, Venezuela, Ukraine, UK and Yugoslavia (EPPO 2011).
Quarantine pest	*Globodera rostochiensis* (Wollenweber, 1923) Behrens, 1975

Synonyms	*Heterodera rostochiensis* Wollenweber
Common name(s)	Yellow potato cyst nematode, Golden potato cyst nematode, Golden nematode
Main hosts	Potatoes are by far the most important host crop. Aubergines and tomatoes are also attacked. Other *Solanum* spp. and their hybrids can also act as hosts (EPPO 2011).
Distribution	The centre of origin of this species is in the Andes Mountains in South America from where it was introduced to other areas. Its range includes Albania, Algeria, Argentina, Austria, Belarus, Belgium, Bolivia, Brazil, Bulgaria, Canada, Chile, Colombia, Costa Rica, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Estonia, Faroe Islands, Finland, France, Germany, Greece, Iceland, India, Ireland, Japan, Latvia, Lebanon, Libya, Lithuania, Luxembourg, Malta, Mexico, Morocco, Netherlands, New Zealand, Norfolk Island, Norway, Panama, Pakistan, Peru, Philippines, Poland, Portugal, Russia, Sierra Leone, Slovakia, South Africa, Spain, Sri Lanka, Sweden, Switzerland, Tajikistan, Tunisia, UK, USA and Venezuela (EPPO 2011) .
Quarantine pest	*Meloidogyne chitwoodi* Golden *et al*. 1980
Synonyms	
Common name(s)	Columbia root-knot nematode
Main hosts	*Meloidogyne chitwoodi* has a wide host range among several plant families (Santo *et al*. 1980; O'Bannon *et al*. 1982), including crop plants and common weed species. Potatoes (*Solanum tuberosum*) and tomatoes (*Lycopersicon esculentum*) are good hosts, while barley (*Hordeum vulgare*), maize (*Zea mays*), oats (*Avena sativa*), sugarbeet (*Beta vulgaris* var. *saccharifera*), wheat (*Triticum aestivum*) and various Poaceae (grasses and weeds) will maintain the nematode. In the Netherlands, host crops recorded to be attacked by *M. chitwoodi* are carrots, cereals, maize, peas (*Pisum sativum*), *Phaseolus vulgaris*, potatoes, *Scorzonera hispanica*, sugarbeet and tomatoes.
Distribution	Argentina, Belgium, Mexico, Netherlands (CABI/EPPO 2000), North-western United States (potato growing regions of California, Colorado, Idaho, Nevada, southern Oregon, Utah, Virginia, Washington, Wyoming (Santo *et al*. 1980; Nyczepir *et al*. 1982; Pinkerton and McIntyre 1987; CABI/EPPO 2000) and South Africa (CABI/EPPO 2000; Fourie *et al*. 2002).
Quarantine pest	*Nacobbus aberrans* (Thorne, 1935) Thorne & Allen, 1944
Synonyms	*Anguillulina aberrans* Thorne, *Nacobbus batatiformis* Thorne & Schuster, *Nacobbus bolivianus* Lordello, Zamith & Boock, 1961, *Pratylenchus aberrans* (Thorne) Filipjev
Common name(s)	False root-knot nematode or Potato rosary nematode
Main hosts	The false root-knot nematode reproduces on the following agronomic and vegetable crops: *Brassica nigra*, *Brassica oleracea*, *Brassica rapa*, *Capsicum annuum*, *Cucumis sativus*, *Cucurbita maxima*, *Cucurbita pepo*, *Daucus carota*, *Ipomea batata*, *Lactuca sativa*, *Lycopersicon esculentum*, *Pisum sativum* var. *arvense*, *Solanum melogena*, *Solanum tuberosum*, *Spinacia oleracea* and *Tropaeolum tuberosum* (Evans *et al*. 1993; CABI 2007).
Distribution	Highland Andean regions of Argentina, Bolivia, Chile, and Peru, as well as Guadeloupe, Martinique, Mexico, Puerto Rico, Trinidad, Tobago, Venezuela (Polston and Anderson 1997).

Glossary

Term or abbreviation	Definition
Additional declaration	A statement that is required by an importing country to be entered on a Phytosanitary Certificate and which provides specific additional information on a consignment in relation to regulated pests (FAO 2009).
Appropriate level of protection	The level of protection deemed appropriate by the Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory (WTO 1995).
Area	An officially defined country, part of a country or all or parts of several countries (FAO 2009).
Certificate	An official document which attests to the phytosanitary status of any consignment affected by phytosanitary regulations (FAO 2009).
Consignment	A quantity of plants, plant products and/or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities or lots) (FAO 2009).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2009).
Department of Agriculture, Fisheries and Forestry	A prescribed agency, within the Australian Government, responsible for recommendations for the development of Australia's biosecurity policy.
Endangered area	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss (FAO 2009).
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 (FAO 2009).
Equivalence	Importing contracting parties should recognize alternative phytosanitary measures proposed by the exporting contracting parties as equivalent when those measures are demonstrated to achieve the appropriate level of protection determined by the importing contracting party (FAO 2006).
Establishment	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2009).
Fruits and vegetables	A commodity class for fresh parts of plants intended for consumption or processing and not for planting (FAO 2009).
Host range	Species capable, under natural conditions, of sustaining a specific pest or other organism (FAO 2009).
Import Permit	Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2009).
Import Risk Analysis	An administrative process through which quarantine policy is developed or reviewed, incorporating risk assessment, risk management and risk communication.
Infestation (of a commodity)	Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection (FAO 2009).
Inspection	Official visual examination of plants, plant products or other regulated articles to determine if pests are present and/or to determine compliance with phytosanitary regulations (FAO 2009).
Intended use	Declared purpose for which plants, plant products, or other regulated articles are imported, produced, or used (FAO 2009).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2009).
International Standard for Phytosanitary Measures	An international standard adopted by the Conference of FAO [Food and Agriculture Organization], the Interim Commission on phytosanitary measures or the Commission on phytosanitary measures, established under the IPPC (FAO 2009).
Introduction	The entry of a pest resulting in its establishment (FAO 2009).
National Plant Protection Organisation	Official service established by a government to discharge the functions specified by the IPPC (FAO 2009).

Term or abbreviation	Definition
Official control	The active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests or for the management of regulated non-quarantine pests (FAO 2006).
Pathway	Any means that allows the entry or spread of a pest (FAO 2009).
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2009).
Pest categorisation	The process for determining whether a pest has or has not the characteristics of a quarantine pest or those of a regulated non-quarantine pest (FAO 2009).
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 (FAO 2009).
Pest free place of production	Place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained for a defined period (FAO 2009).
Pest free production site	A defined portion of a place of production in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this conditions is begin officially maintained for a defined period and that is managed as a separate unit in the same way as a pest free place of production (FAO 2009).
Pest Risk Analysis (agreed interpretation)	The process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it (FAO 2009).
Pest risk assessment (for quarantine pests)	Evaluation of the probability of the introduction and spread of a pest and the magnitude of the associated potential economic consequences (FAO 2009).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2009).
Phytosanitary Certificate	Certificate patterned after the model certificates of the IPPC (FAO 2009).
Phytosanitary measure (agreed interpretation)	Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO 2009).
Phytosanitary regulation	Official rule to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests, including establishment of procedures for phytosanitary certification (FAO 2009).
Polyphagous	Feeding on a relatively large number of host plants from different plant families.
PRA area	Area in relation to which a Pest Risk Analysis is conducted (FAO 2009).
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 (FAO 2009).
Regulated article	Any plant, plant product, storage place, packaging, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved (FAO 2009).
Restricted risk	Risk estimate with phytosanitary measure(s) applied.
Rhizomes	A horizontal plant stem with shoots above and roots below serving as a reproductive structure. Rhizomes may also be referred to as creeping rootstalks, or rootstocks
Spread	Expansion of the geographical distribution of a pest within an area (FAO 2009).
Stakeholders	Government agencies, individuals, community or industry groups or organisations, whether in Australia or overseas, including the proponent/applicant for a specific proposal, who have an interest in the policy issues.
Unrestricted risk	Unrestricted risk estimates apply in the absence of risk management measures.

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