INDUSTRY BIOSECURITY PLAN

FOR THE NURSERY & GARDEN INDUSTRY

Threat Specific Contingency Plan

Whitefly transmitted viruses

Specific examples detailed in this plan:

Tomato yellow leaf curl virus

Tomato leaf curl virus

Lettuce infectious yellows virus

Diodia vein chlorosis virus

Plant Health Australia

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1 Purpose and background of this contingency plan

This contingency plan provides background information on the pest biology and available control measures to assist with preparedness for an incursion into Australia of a range of viruses that are transmitted by Whitefly vectors (*Bemisia tabaci, Trialeurodes vaporariorum and T. abutilonia*). In this contingency plan viruses have been used as examples of those considered to be of greatest economic impact and risk to the Nursery Industry. It should be noted that the viruses of most economic impact in this group, are already recorded in Australia and examples were therefore provided for two pests currently with limited distribution but with enormous economic impact should they spread outside these production regions and into new production regions.

A list of Whitefly transmitted viruses is provided in Appendix 1.

It provides guidelines and options for steps to be undertaken and considered when developing a Response Plan for incursion of the virus pests. The control and management will specifically be for the Whitefly vectors. Any Response Plan developed using information in whole or in part from this Contingency Plan must follow procedures as set out in PLANTPLAN and be endorsed by the National Management Group prior to implementation.

This contingency plan was developed for the Nursery and Industry Australia (NGIA), and therefore is focused on production nurseries covered by this association. In the event of an incursion, operations that are not covered by the NGIA or another Emergency Plant Pest Response Deed (EPPRD) signatory (e.g. retail nurseries), will not be represented or have a decision making say in any arrangements for emergency response.

The information for this plan has been primarily obtained from documents as cited in the reference section. For each virus, information on background, life cycle, host range, distribution and symptoms is given, with the emphasis of this document on the management and control of the Whitefly vector.

2 Australian nursery industry

The Australian nursery industry is a significant horticultural sector with a combined supply chain (production to retail/grower) valued at more than $6 billion dollars annually. The industry employs approximately 45,000 people spread over more than 20,000 small to medium sized businesses including production nurseries and retail outlets. The industry is located predominantly along the Australian coastline and in major inland regions servicing urban and production horticulture.

Nursery production is a highly diverse primary industry servicing the broader $14 billion horticultural sector within Australia (Table 1).

Table 1. *Nursery production supply sectors within Australian horticulture*

Production Nursery	Horticultural markets	Economic value
Container stock[1]	Ornamental/urban horticulture	$2 billion retail value
Foliage plants[1]	Interior-scapes	$87 million industry
Seedling stock[2]	Vegetable growers	$3.3 billion industry
Forestry stock[3]	Plantation timber	$1.7 billion industry
Fruit and nut tree stock[2]	Orchardists (citrus, mango, etc)	$5.2 billion industry
Landscape stock[1]	Domestic & commercial projects	$2 billion industry
Plug and tube stock[4]	Cut flower	$319 million industry
Revegetation stock[1]	Farmers, government, landcare	$109 million industry
Mine revegetation	Mine site rehabilitation	Value unknown
	Total horticultural market value	**$14.5 billion**

3 Eradication or containment decision matrix

The decision to eradicate should be based on the potential economic impact of host damage resulting from Whitefly transmitted virus infestation, the cost of eradication and on technical feasibility. Eradication costs must factor in long term surveys to prove the success of the eradication program. A minimum of two years with no detections of the virus may be necessary to confirm that no Whitefly transmitted virus infestations remain before pest free status can be declared. The timeframe needs to be considered on a case by case basis, based both on the size of the infection, the degree and distribution of the pest with the final decision determined by the National Management Group.

No specific eradication matrix has been determined for Whitefly transmitted viruses; however the general decision process as outlined in Figure 1 and Table 2 should be followed in determining if an incursion of this pest will be eradicated or managed/contained. The final decision between eradication and management will be made through the National Management Group.

[1] Data sourced from Market Monitor

[2] Data sourced from Horticultural Handbook 2004

[3] Data sourced from ABARE 2005

[4] Data sourced from industry

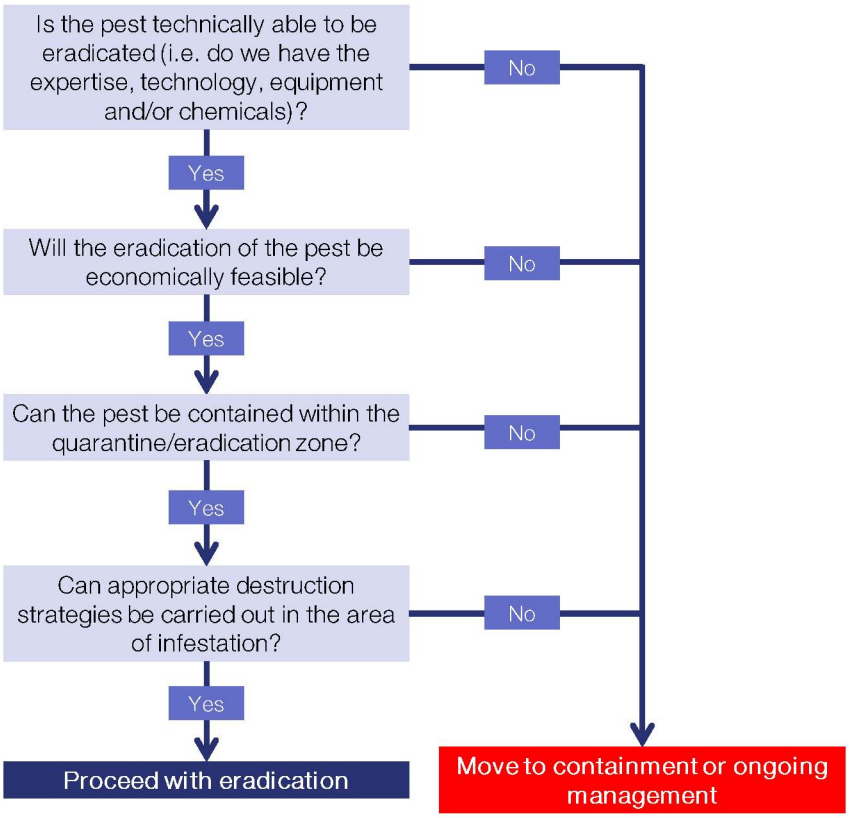

Figure 1. *Decision outline for the response to an exotic pest incursion*

Table 2. *Factors considered in determining whether eradication or alternative action will be taken for an EPP Incident (taken from Appendix 12 of PLANTPLAN)*

Factors favouring eradication	Factors favouring alternative action
• Cost/benefit analysis shows significant economic or amenity loss to industry or the community if the organism establishes. • Physical barriers and/or discontinuity of hosts between production districts. • Cost effective control difficult to achieve (e.g. limited availability of protectant or curative treatments). • The generation time, population dynamics and dispersal of the organism favour more restricted spread and distribution. • Pest biocontrol agents not known or recorded in Australia. • Vectors discontinuous and can be effectively controlled. • Outbreak(s) few and confined. • Trace back information indicates few opportunities for secondary spread. • Weather records show unfavourable conditions for pest development. • Ease of access to outbreak site and location of alternate hosts.	• Cost/benefit analysis shows relatively low economic or environmental impact if the organism establishes. • Major areas of continuous production of host plants. • Cost effective control strategies available. • Short generation times, potential for rapid population growth and long distance dispersal lead to rapid establishment and spread. • Widespread populations of known pest biocontrol agents present in Australia. • Vectors unknown, continuous or difficult to control. • Outbreaks numerous and widely dispersed. • Trace back information indicates extensive opportunities for secondary spread. • Weather records show optimum conditions for pest development. • Terrain difficult and/or problems accessing and locating host plants.

4 Pest information/status

4.1 Pest details

In this contingency plan specific pest information and status will be given for the Silverleaf whitefly (*Bemisia tabaci*) vector, as well as an example of a virus species from each of the major virus genera that are transmitted by whiteflies. The viruses have been chosen in consultation with the Nursery and Garden Industry Australia (NGIA) due to their economic importance and potential relevance to the Australian nursery industry. The two *Begomovirus* examples (Tomato yellow leaf curl virus and tomato leaf curl virus) have been selected as although they are already present in Australia, they currently have a restricted geographic distribution and would be a much larger problem should they expand into major tomato production regions.

One hundred and fourteen virus species are transmitted by whiteflies (family Aleyrodidae) with *Bemisia tabaci* transmitting 111 of these species and *Trialeurodes vaporariorum* and *T. abutilonia* transmitting three species each (Jones, 2003). The focus of this contingency plan is exotic viruses transmitted by the whiteflies; however, many measures outlined involve control of the endemic whiteflies that would be vectors of the viruses in an incursion. Where economically important exotic examples could not be found for a particular genus, non exotic examples were used. Of the whitefly transmitted virus species, 90% belong to the *Begomovirus* genus, 6% to the *Crinivirus* genus and the remaining 4% are in the *Closterovirus*, *Ipomovirus* or *Carlavirus* genera.

5 Pest information/status – the whitefly vector

5.1 Pest details

Taxonomic position: Kingdom, Animalia; Phylum, Arthropoda; Class, Insecta; Order, Hemiptera; Family, Aleyrodidae (Table 3)

Table 3. *Whitefly vectors of exotic virus threats to the Nursery Industry*

Scientific name	Synonyms	Common names
Bemisia tabaci (Gennadius, 1889)	*Bemisia argentifolii* Bellows, Perring, Gill and Hendrick, 1994	Silverleaf whitefly; Poinsettia whitefly; Tobacco Whitefly, B biotype
Trialeurodes vaporariorum		Glasshouse or greenhouse whitefly
T. abutilonia		Banded winged whitefly

5.1.1 Background

Whiteflies are insects belonging to the family Aleyrodidae. They occur in warm climates where they are pests of herbaceous plants and in temperate climates they are usually pests in protected environments such as greenhouses. Whiteflies typically feed on the underside of plant leaves (see Figure 2 for populations on plant leaves) damaging plants directly by sucking sap from leaves, and inducing physiological disorders.

Figure 2. *Silverleaf whitefly adult population found on the underside of a leaf. Image obtained from Division of Plant Industry Archive, Florida Department of Agriculture and Consumer Services, Bugwood.org.*

Whitefly instar nymphs and adults feed by inserting their proboscises into the leaf, penetrating the phloem and withdrawing sap. It is during this process that plant viruses are acquired. Adult whiteflies may disperse and transmit the virus to new plants while feeding (Jones, 2003).

Over 1300 whitefly species in over 120 genera have been described with only the *Bemisia* and *Trialeurodes* genera being virus vectors (Mound and Halsey, 1978). In the genus *Bemisia*, only *B. tabaci* has been shown to be a virus vector. The whitefly and the viruses it transmits are now responsible for significant crop losses in many regions and climates. Because *B. tabaci* transmits around 95% of Whitefly transmitted viruses, the information in this contingency plan focuses primarily on this species.

Within *B. tabaci,* as well as genetic variation, there is considerable phenotypic variability in ability to transmit begomoviruses, the rate of development, ability to utilise different hosts and the ability to induce physiological changes in some hosts (Bedford *et al.*, 1994a; Brown and Bird, 1995).

The *B. tabaci* species complex is represented in Australia by three distinct biotypes: Australian Native (AN), and the silverleaf whitefly (SLW) B biotype and Q biotype. These morphologically identical biotypes can only be separated using chemical (enzyme) or molecular (DNA) techniques.

B. tabaci has been of increasing importance as a pest and vector of virus diseases of food, fibre and foliage plants since the early 1980s, mainly due to the emergence of the B biotype and its rapid expansion in geographic distribution and host range. Since the initial outbreaks in Israel and southern USA invasions have occurred on all continents except Antarctica (De Barro, 1995). The *B. tabaci* responsible for the Israel and USA outbreaks have also demonstrated high levels of insecticide resistance and have transmitted previously unknown begomoviruses.

The best known of the biotypes is the B biotype which is placed in the B subgroup within the Mediterranean/Asia Minor/Africa group determined using mitochondrial CO1 and ribosomal ITS1 which divides *B. tabaci* into six major races (De Barro *et al.*, 2005).

Differences in plant virus-transmission capabilities between biotypes have been recognised with populations of the B biotype having a greater capacity to transmit begomoviruses.

The global spread of the polyphagous *B. tabaci* biotype B as a 'hitch-hiker' on traded plant material is a major factor in the world wide increase in whitefly transmitted diseases (Jones, 2003). Other reasons for *B. tabaci* and its associated viruses becoming major problems have been the increase in resistance to insecticides and changes in agronomic practices (De Barro, 1995).

The Q biotype is a sister to B and sits in the Mediterranean subgroup within the Mediterranean/Asia Minor/Africa group. In 2009, Q biotype was identified in vegetables in parts of the Burdekin and Bowen areas and also in cotton in southern Queensland (Goondiwindi) and northern New South Wales (Wee Waa). However; recent ongoing monitoring has failed to detect any further Q biotype from these production regions. (**http://www.dpi.qld.gov.au/26_13528.htm**).

The Q biotype can be found from Spain across North Africa into Egypt and parts of the Middle East and has since spread via the ornamental nursery trade to China, France, Italy, Japan, the Netherlands and the USA (Zhang *et al.*, 2005; Liu and Anciso, 2005) and has a host range of more than 500 species.

5.1.2 Life cycle

The adult females lay fertilised eggs which develop into females and unfertilised eggs which develop into males. Eggs are usually laid in circular groups on the underside of leaves. Eggs are whitish in colour when first laid, but gradually turn brown. Hatching occurs after 5-9 days at 30℃ but this depends very much on host species, temperature and humidity. Eggs are pear-shaped with a pedicel spike at the base, approximately 0.2 mm long.

After the egg hatches there are four nymphal stages. On hatching, the first instar, or 'crawler', is flat, oval and scale-like in shape. The first instar is the only larval stage of this whitefly which is mobile. It

moves from the egg site to a suitable feeding location on the lower surface of the leaf, after which its legs are lost in the next moult and the larva becomes sessile. It does not move again throughout the remaining nymphal stages. The first three nymphal stages take 2-4 days each depending on the temperature. The fourth instar stage is from a feeding state to non-feeding pupal stage. Puparium are a flat, irregular oval shape, about 0.7 mm long, with an elongate, triangular vasiform orifice. On a smooth leaf the puparium lacks enlarged dorsal setae, but if the leaf is hairy, 2-8 long dorsal setae are present. The adult emerges from the 4th instar and is able to start reproducing in about 12 hours. Adults are approximately 1 mm long, the male slightly smaller than the female. The body and both pairs of wings are covered with a powdery, waxy secretion, white to slightly yellowish in colour.

The relative rates for development between biotypes B and Q have been reported by Pascual & Callejas (2004) and Muniz & Nombela (2001) using different host plants. In Muniz & Nombela (2001) biotype Q developed faster than B at temperatures across the range of 17^{o}-33^{o}C whereas in Pascual & Callejas (2004) biotype B completed development in 25-27 days and Q in 26-28 days. This later study also reported that biotype Q was less fecund than B, with Q producing half the number of eggs as biotype B. Horowitz *et al.* (2005) found that B was able to displace Q under conditions of no insecticide use, but that biotype Q replaced B when the insect growth regulator pyriproxyfen or the neonicatinoids, acetamiprid or thiamethoxam were used as Q possesses higher levels of resistance to these insecticides. In Spain, Q is the dominant biotype in areas where insecticide use (particularly use of neonicatinoids) is dominant.

The adult (Figure 3) emerges through a 'T'-shaped rupture in the skin of the puparium and spreads its wings for several minutes before beginning to powder itself with a waxy secretion from glands on the abdomen. The life span of the female can be up to 60 days with the male between 9 and 17 days. Each female can oviposit over 300 eggs during her life time with eleven to fifteen generations occurring in a year.

Figure 3. *Adult Silverleaf whitefly on leaf surface. Image obtained from Jeffrey W. Lotz, Florida Department of Agriculture and Consumer Services, Bugwood.org.*

5.1.3 Dispersal

Whiteflies do not fly very efficiently, but once airborne, can be transported long distances by wind or by convection. Transportation in ornamentals is the major means of spread over long distances with all life stages likely to be transported within the international trade of ornamental plants and cut flowers.

As with other species of whitefly and biotypes of *B. tabaci*, the B biotype can easily disperse naturally over short distances. This dispersal can occur in vast numbers when host plants become heavily infested and begin to senesce. Large 'clouds' comprising many millions of individuals have been recorded leaving a dying host crop. Dispersal is almost certainly assisted by wind.

Agricultural practices and physical movement of infested plants, whether it be through plant care, harvesting or spraying, can result in adult *B. tabaci* B biotype dispersal from an infested plant.

Movement or trade of any susceptible plant or crop where leafy material is produced for distribution and export can act as a means of dispersing the B biotype. Seasonal plants such as poinsettia, bedding plants, grafted crop plants and cut flowers are all potential means for B biotype distribution and usually the dispersal of whitefly larvae and pupae rather than adults (CAB International 2007).

Plant parts liable to carry the pest in trade/transport are:

- Flowers/Inflorescences/Cones/Calyx: Pupae, Adults; borne externally; visible to naked eye.
- Leaves: Pupae, Adults; borne externally; visible to naked eye.
- Seedlings/Micropropagated Plants: Eggs, Larvae; borne externally; visible under light microscope.
- Stems (above Ground)/Shoots/Trunks/Branches: Pupae, Adults; borne externally; visible to naked eye.

Plant parts not known to carry the pest in trade/transport are:

- Bark; Bulbs/Tubers/Corms/Rhizomes; Fruits (inc. Pods); Growing Medium Accompanying Plants; Roots; True Seeds (inc. Grain); Wood.

5.2 Affected hosts

5.2.1 Host range

Whiteflies have a large host range (Table 4, Table 5 and Table 6).

Table 4. *Whiteflies major host list as listed on the CAB Compendium (CAB International 2007)*

Family	Species	Family	Species
Brassica oleracea var. botrytis	Cauliflower	*Capsicum annuum*	Bell pepper
Carica papaya	Pawpaw	Cucurbita	Pumpkin
Euphorbia pulcherrima	Poinsettia	Fabaceae	Legume crops
Gossypium hirsutum	Bourbon cotton	Lactuca sativa	Lettuce
Lycopersicon esculentum	Tomato	Nicotiana tabacum	Tobacco
Solanum melongena	Egg plant		

Table 5. *Whiteflies minor wild host list (CAB International 2007)*

Family	Species	Family	Species
Abelmoschus esculentus	Okra	*Acer*	Maples
Amaranthus	Grain amaranth	Brassicaceae	cruciferous crops
Manihot esculenta	Cassava	*Mentha*	Mints
Members of the *Bombacaceae, Fagaceae, Geraniaceae, Lauraceae, Myrtaceae, Oleaceae, Passifloraceae, Rosaceae, Rubiaceae, Solanaceae* families			

Table 6. *Whiteflies wild host list (CAB International 2007)*

Family	Species	Family	Species
Aristolochia	Dutchman's pipe	Asclepias	Silkweed
Menispermum	Moonseed	Oxalis	Wood sorrels
Verbena	Vervain		
Members of the *Anacardiaceae, Annona, Araceae, Asteraceae, Balsaminaceae, Bignonia, Bixa, Boraginaceae, Cannabidaceae, Capparales, Caprifoliaceae, Caryophyllaceae, Chenopodiaceae, Cistaceae, Clusiaceae, Commelinaceae, Convolvulaceae, Ericaceae, Euphorbiaceae, Flacourtiaceae, Grossulariaceae, Lamiaceae, Malvaceae, Nyctaginaceae, Pedaliaceae, Plantaginaceae, Polygonaceae, Portulacaceae, Proteaceae, Punicaceae, Ranunculaceae, Rhamnaceae, Rutaceae, Salicaceae, Scrophulariales, Sphenocleaceae, Thymelaeaceae, Tiliaceae, Umbelliferae, Violaceae* families			

5.2.2 Current geographic distribution

The *B. tabaci* biotype B was first reported as an invasive species within the USA in the mid 1980s (Costa and Brown, 1991). It has since spread throughout most of the southern states of the USA, to Central America, the Caribbean, South America, Japan, South Africa, southern Europe, the Middle East (Perring *et al.*, 1993; Bedford *et al.*, 1992, 1993, 1994b) and Australasia (De Barro, 1995). It was also being reported as interceptions and sporadic appearances within glasshouses in northern Europe and the UK (Bedford *et al.*, 1993). In 2000 the B biotype appeared for the first time within South-East Asia (Simon *et al.*, 2003; Rekha *et al.*, 2005).

The Q biotype of the *B. tabaci* complex was identified in Australia in late 2008 and early 2009 from collections from vegetable crops in the Bowen/Burdekin region and cotton at Wee Waa in New South Wales and Goondiwindi in Queensland. Recent monitoring has failed to detect any Q biotype from these production areas. While Q biotype may be present in Australia, it does not pose a management risk at this stage (**http://www.dpi.qld.gov.au/26_13528.htm**) but this may change because the Q biotype has the ability to develop resistance quickly to some insecticides especially if they are used repeatedly.

5.2.3 Symptoms

Chlorotic spots caused by larval feeding and disfiguration by honeydew and associated sooty moulds may be the first symptoms observed. Other symptoms like leaf curling, yellowing, mosaics or yellow-veining may indicate the presence of whitefly-transmitted viruses. These symptoms are also observed in *B. tabaci* infestations, however phytotoxic responses such as a severe silvering of courgette and melon leaves, mis-ripening of tomato fruits, stem whitening of brassicae and yellow veining of some solanaceous plants are only caused by the B biotype (Costa *et al.*, 1993**;** Secker *et al.*, 1998).

The feeding of adults and nymphs causes chlorotic spots to appear on the surface of the leaves. Depending on the level of infestation, these spots may coalesce turning the leaf yellow resulting in the shedding of leaves.

The honeydew produced by the feeding of the nymphs can also disfigure flowers. Phytotoxic responses caused by larval feeding may include silvering of leaves, white stems in pumpkin, white streaking in leafy *Brassica* crops, uneven ripening of tomato fruits, reduced growth, yellowing and stem blanching in lettuce and kai choy (*Brassica campestris*) and yellow veining in carrots and honeysuckle (Bedford *et al.*, 1994a & b).

5.3 Diagnostic information

Morphologically none of the biotypes of *B. tabaci* can be distinguished from each other. The biotypes of *B. tabaci* can only be distinguished using molecular approaches (De Barro and Driver, 1997).

5.4 Pathogen risk ratings and potential impacts

Even though *B. tabaci* biotype B is present in Australia, it can have a serious impact on the production of certain field crops as well as a wide range of protected horticultural crops. The appearance of new viruses in areas colonised by the B biotypes is thought to be due to the fast development and broad host range of the biotypes. In the majority of cases, this is due to viruses transmitted by the whitefly.

The B biotype is also able to induce a phytotoxic response from a number of plant species that could cause yield loss or reduced quality of produce (Bedford *et al.*, 1994b; Costa and Brown, 1991; Costa *et al.*, 1993; Maynard and Cantliffe, 1989) with the B biotype alone causing an estimated $500 million loss to the 1991 winter harvest in California, USA, mainly through virus damage (CAB International 2007).

The appearance of *B. tabaci* biotype B within new areas is often the result of movement of infested plant material. The movement and establishment of biotype B populations in new areas bring with it the possibility of insecticide resistance genes. This invariably leads to an increase in the use of insecticides as whitefly control become more difficult, which in turn increases the levels of insecticide resistance and insecticide use.

6 Pest information/status – *Begomoviruses*

6.1 Pest details – example: Tomato yellow leaf curl virus

Common names:	Tomato yellow leaf curl virus
Scientific name:	*Tomato yellow leaf curl virus*
Synonyms:	Tomato leaf curl virus, yellow leaf curl, leaf curl, tobacco leaf curl virus (CABI 2007)
Taxonomic position:	Group: virus; Family: Geminiviridae; Genus: Begomovirus

6.1.1 Background

Begomoviruses are the most important of the Begomovirus, Crinivirus, Closterovirus, Ipomovirus or Carlavirus genera agriculturally that are transmitted by whiteflies (see Appendix 1), causing yield losses to crops of between 20 and 100% (Brown and Bird, 1992). *Begomoviruses* cause a range of different symptoms which include yellow mosaics, yellow veining, leaf curling, stunting and vein thickening. Mansoor *et al.* (1993) reported that 1 million hectares of cotton were decimated in Pakistan by Cotton leaf curl virus (CLCuV).

The main crops affected by begomoviruses in Latin America for example have been common bean, tomato and *Capsicum* spp with high economic losses reported for tomatoes. Tomato crops throughout the world are particularly susceptible to many different begomoviruses, and in most cases exhibit yellow leaf curl symptoms. This has caused their initial characterisation as *Tomato yellow leaf curl virus* (TYLCV) with many different species now recorded from within both the New World and Old World where B biotype *B.tabaci* occur (Jones, 2003). The B biotype has also been associated with transmission of Tomato mottle virus (EPPO, 1996), *Tobacco leaf curl virus* (TLCV), *Sida golden mosaic virus* (SiGMV), *Squash leaf curl virus* (SLCV), *Cotton leaf crumple virus* (CLCV), *Bean golden mosaic virus* (BGMV) and *Cotton leaf curl virus* (Simon *et al*., 2003), some of which cause heavy yield losses in their respective hosts.

Begomoviruses can cause large losses in a variety of crops worldwide including tomato, potato, tobacco, cotton and cassava (Morales and Anderson, 2001; Varma and Malathi, 2003). One prominent pest in this group is Tomato leaf curl virus (TLCV), a name given to a complex of closely as well as distantly related Begomoviruses that affect tomato worldwide (Nakhla and Maxwell, 1998). Whilst degrees of resistance to the virus have been identified in tomato germplasm, the virus has been known to cause losses up to 100% in glasshouse crops in Europe and field crops in Africa.

The economic importance and distribution of tomato begomoviruses can be described by examining its spread in Brazil as an example. The occurrence and spread was very limited until the mid 1990s when geminivirus-like diseases were reported in different parts of the country causing significant economic losses (Faria *et al*., 2000). These reports were associated with the presence of the B. biotype of *B. tabaci* and its spread to neighbouring regions (Haji et al 2004). The spread of the tomato viruses could be linked to the spread of the whitefly vector with losses in production of 40 - 100% depending on the cultivar and age of the plant when infection was initiated (Faria *et al*., 2000).

Tomatoes may be the most common host from which New World (North and South Americas) begomoviruses have been isolated (Varma and Malathi, 2003) and with the current rate of new begomoviruses species being discovered it is highly likely that more species will be found. To date four begomoviruses and eight tentative begomovirus species have been reported as infecting tomatoes in Brazil (Ribeiro *et al*., 2003; Faria *et al*., 1997; Zerbini *et al*., 2005).

From Appendix 1, the *Begomovirus* group was found to be a large genus with 115 species. To determine the identity and economic importance, each species was checked on the Australian Plant Pest Database (APPD), CABI and using web searches. The only economically important viruses found to be of significance to the Nursery Industry were found to be Tomato leaf curl virus and Tomato yellow leaf curl virus both of which have been previously detected in Australia.

In Australia, Tomato leaf curl virus (TLCV) was first reported in 1970 in the Northern Territory (Behjatnia *et al.*, 1996) causing severe to complete loss of tomato crops (Stoner *et al.*, 2003). It appears to be restricted to northern parts of Queensland and the Northern Territory (**http://www2.dpi.qld.gov.au/horticulture/18522.html)**

The first record of Tomato yellow leaf curl virus (TYLCV) in Australia was in early 2006 and is distinct from TLCV. Previously an exotic pest to Australia, TYLCV was detected in south east and south west regions of Brisbane and in Bundaberg in both commercial and home garden tomatoes. The introduction of TYLCV has had significant economical impact on tomato production, with disease incidence in some areas reaching 100%.

Figure 4. *Tomato plants showing TYLCV symptoms. Image courtesy of PaDIL (John Thomas, DEEDI)*

6.1.2 Life cycle

B. tabaci biotype B acquires TYLCV within 30 minutes of feeding on affected hosts and transmits the virus after 15-30 minutes of feeding on new plants (although the efficiency of transmission increases with time of feeding). The begomovirus can persist in the vector for 10-12 days and throughout the life of the insect (Czosnek *et al*., 2001). In the plant, the virus develops within the phloem inducing cytological changes with symptoms appearing only 15 days after inoculation (Ber *et al*., 1990).

6.1.3 Dispersal

The virus is spread from plant to plant by *B. tabaci* biotype B and is not transmitted in seed, soil or from plant to plant by handling.

6.2 Affected hosts

6.2.1 Host range

Tomato (*Lycopersicon esculentum*) is the major host of TYLCV with the following hosts also affected; common bean (*Phaseolus vulgaris*), petunia (*Petunia hybrida*), zinnia (*Zinnia elegans*), eggplant (*Solanum melongena*), tobacco (*Nicotiana tabacum*) and weeds such as common thornapple (*Datura stramonium*) and *Cynanchum acutum*. Other symptomless hosts include wild tomato relatives and marshmallow (*Malva parviflora*).

6.2.2 Current geographic distribution

TYLCV is found in Europe, Africa, Asia and North and Central America. One strain (Tomato leaf curl Australia virus (TLCV)) has been present in Australia (Northern Territory and parts of north Queensland) for a number of years. In 2006 an exotic strain of TYLCV was also found in Brisbane and has since been found in other regions in Queensland including Bundaberg, a major tomato growing region (Thomas and Persley 2007).

6.2.3 Potential distribution in Australia

Whilst TYLCV is currently only found in Queensland, the virus has the potential to spread to all other states and territories where *B. tabaci* biotype B is present.

6.2.4 Symptoms

Symptoms can be confused with other tomato viruses and disorders like tomato big bud, tomato yellow top, and physiological leaf roll and phosphate and magnesium deficiency.

The disease can be easily recognised when tomato plants are infected at the seedling stage with symptoms developing on inoculated seedlings 2 to 3 weeks after insect feeding, but can also vary depending on soil type, growth conditions and climate.

TYLCV infected seedlings show severe stunting of young leaves and shoots, leading to bushy growth. Affected plants show marginal leaf yellowing, upward or downward leaf cupping (particularly in

emerging leaves), reduced leaf size and marked stunting. The virus reduces fruit set and if fruit is produced it will be small. When infection takes place before the flowering stage, it can cause abortion of flowers and/or fruit. There are no noticeable symptoms on fruits derived from infected plants (Thongrit *et al.*, 1986).

In summary, the leaves can show abnormal colours, patterns and shapes, abnormal stem growth and overall dwarfing of plant.

6.3 Diagnostic information

Serological tests are non-specific and do not differentiate individual leaf curl viruses and hence, analysis of DNA sequences has become the tool of choice. The most accurate diagnoses rely on virus-specific DNA probes and PCR primers. TYLCV can be detected in tissues of infected plants as well as in *B. tabaci*. PCR is widely used for the diagnosis of geminiviral diseases, allowing the detection of very small amounts of the disease agent in the infected plant and vectors, and also the cloning of genomic fragments of the pathogen (protocol details can be found in Navot *et al.*, 1992). Southern blot hybridization (for methods see Taylor and Powell, 1982 and Zeidan and Czosnek, 1991) and squash-blot (tissue print hybridisation) techniques (for methods see Navot *et al.*, 1989) can also discriminate between viruses and their strains.

6.4 Pathogen risk ratings and potential impacts

TYLCV is already found in and has become established in parts of Queensland with the potential to enter and spread to other states and territories where *B. tabaci* is already established. The economic impact of becoming established in another area is high with reports from overseas showing crop losses of up to 100%.

7 Pest information/status - *Crinivirus*

7.1 Pest details – example: Lettuce infectious yellows virus

Common names:	Lettuce infectious yellows virus (LIYV)
Scientific name:	*Lettuce infectious yellows virus* (LIYV)
Synonyms:	
Taxonomic position:	Family, Closteriviridae; Genus, Crinivirus

7.1.1 Background

Lettuce infectious yellows virus (LIYV) of lettuce, cucurbits and other vegetable crops was first recognised as a viral pathogen in the irrigated desert vegetable production areas of California, Arizona and Mexico in the early 1980's. The severe losses (20-75%) caused by LIYV were associated with unprecedented increases in populations of *B. tabaci* (Figure 3). Economic damage in several crops including Silverleaf disorder in squash, irregular ripening in tomatoes and geminiviruses associated with disease symptoms in tomatoes are a direct result of the recent increases in *B. tabaci* populations. In 1981 severe losses of up to 75% yield in lettuce and 30% in sugar beet were reported (EPPO 98/085).

Figure 5. *Leaf symptoms on cantaloupe of Lettuce infectious yellows virus. Images courtesy of J.K. Brown, University of Arizona, Bugwood.org.*

7.1.2 Life cycle

LIYV can be retained by whiteflies for several days in serial transfers on susceptible hosts (Cohen *et al*. 1992). The virus is considered to be transmitted in a semi-persistent manner because it may be acquired in less than one hour by the white fly vector, is transmitted within 6 hours and the virus can be retained in the insect for 3-4 days.

7.1.3 Dispersal

LIYV is transmitted by *B. tabaci*, which can spread it between field and glasshouses in infested areas. It is unlikely to be carried by plants of its main cultivated hosts as they are short lived vegetable crops not normally moved. Young seedlings may be a pathway but these are not usually moved through international trade and would only be an issue for domestic trade movement. Even so LIYV could still be introduced into Australia, with the main risk being the distribution of *B. tabaci* on other host plants (e.g. ornamentals) given the fact that the vector moves readily from one host to another and that the virus can persist in the vector for several weeks after acquisition (EPPO data sheet).

There is no evidence of seed or dodder transmission or transmission by mechanical inoculation.

7.2 Affected hosts

7.2.1 Host range

LIYV has a wide host range (45 species in 15 families). The most significant economic hosts in North America are beetroots (*Beta vulgaris*), lettuce (*Lactuca sativa*), marrows (*Curcurbita pepo*) and melons (*Cucumis melo*). Other hosts include carrots (*Daucus carota*), cucurbits (*Cucurbita foetidissima, C. maxima, C. moschate)* and watermelons (*Citrullus lanatus*). LIYV can also infect various weeds including *Helianthus* spp, Morning glory (*Ipomoea* spp), *Lactuca canadensis,* small flowered mallow *(Malva parviflora)* and *Physalis heterophylla*.

7.2.2 Current geographic distribution

The current distribution is unknown but LIYV has been reported in Mexico, USA (Arizona, California, Pennsylvania and Texas) in hydroponic culture, and at the time of this report LIYV was absent from the European Union (EPPO data sheet) (EPPO/CABI 1996). LIYV has not been recorded in Australia.

7.2.3 Symptoms

Characteristics of LIYV include interveinal yellowing and/or reddening of the leaves, together with stunting of affected plants on a wide range of commercial and weed hosts (Brown and Nelson, 1986; Duffus *et al*., 1986). Infected lettuce leaves exhibit interveinal chlorosis (that develops into a general yellowing) and become brittle. Infected plants are usually stunted with the lettuce head often failing to develop. Necrotic lesions may appear at or near margins of older leaves as the disease progresses.

In cucurbits, a splotchy mottle or interveinal chlorosis develops on mature leaves. This may be accompanied by vein-clearing, mild mosaic, subtle curling of the tips of young leaves, and a leathery texture in older leaves. Plants are stunted, exhibit poor fruit set and/or incomplete fruit development (Brown and Nelson, 1986). Symptoms may appear as early as 3 weeks after plants emerge or 10-12 days after inoculation.

7.3 Diagnostic information

Previous detection methods included the bioassays using B. *tabaci* to transmit the virus to indicator hosts (Brown and Nelson, 1986; Duffus *et al*., 1986) and an indirect ELISA (Brown and Poulos, 1989) with more recent studies using molecular approaches (Rubio *et al*., 1999).

7.4 Pathogen risk ratings and potential impacts

LIYV causes severe losses of marrows, melons and related cucurbits in California (Nameth *et al*., 1985) with lettuce yields being reduced up to 75% by infection. The disease has also caused serious losses in hydroponically grown lettuces in northern USA (Brown and Stanghellini, 1988).

8 Pest information/status - Closterovirus

8.1 Pest details – examples Beet pseudo-yellows virus and Dioda yellow vein virus

Common names:	Beet pseudo-yellows virus (BPYV)
Scientific name:	*Beet pseudo-yellows virus*
Synonyms:	Cucumber chlorotic spot virus; Cucumber yellows virus; Melon yellows virus
Taxonomic position:	Family, Closteroviridae; Genus, Closterovirus

Common names:	Diodia vein chlorosis virus
Scientific name:	*Diodia vein chlorosis virus*
Synonyms:	Diodia yellow vein virus
Taxonomic position:	Family, Closteroviridae; Genus, Closterovirus

8.1.1 Background

Many Closteroviruses are spread by aphids (e.g. Citrus tristeza closterovirus, Carnation necrotic fleck virus); however, only two are currently known to be spread by whiteflies though it is likely more will emerge in the future. These viruses are Beet pseudo-yellows virus (BPYV, transmitted by *Trialeurodes vaporariorum* and already present in Australia) and Diodia vein chlorosis virus (DVCV, transmitted by *Trialeurodes abutilonea*).

BPYV (also known as cucumber chlorotic spot virus, cucumber yellows virus and melon yellows virus) causes a variety of symptoms (depending on the host) including interveinal yellowing/reddening or chlorosis on leaves, downward curling of leaf margins, leaf thickening or general poor growth of infected plants. Known commercial crop hosts include cucumber (*Cucumis sativus*), strawberries (*Fragaria ananassa*), lettuce *(Lactuca sativa),* endive (*Cichorium endive)* and beetroot (*Beta vulgaris)*.

BPYV is already present in Australia and was first recorded in Tasmania in 1981 on dandelion (*Taraxacum officinale*) plants in and around Hobart (Duffus and Johnston, 1981). It is also present in Europe, North America, Japan and New Zealand and has caused severe economic yield losses in Europe and the USA. However, in the three decades since it was discovered in Tasmania there have been no reports of serious damage to nursery plants (including crops, trees and shrubs) in Australia.

DVCV (also known as Diodia yellow vein virus) is only present in the USA. The only known host is *Diodia virginiana*, in which the virus causes chlorosis and vein-clearing symptoms (Larsen *et al.*, 1991). Other than transmission by *T. abutilonea*, the virus can only be transmitted by grafting. The virus appears of little threat to Australian nursery industries.

9 Pest management

9.1 Response checklist

The following checklist (Table 7) provides a summary of generic requirements to be identified and implemented within a Response Plan.

Table 7. *Checklist of requirements to be identified in a Response Plan*

Checklist item	Further information
Destruction methods for plant material, soil and disposable items	Section 10.1.1, 10.1.2
Disposal procedures	Section 10.1.5
Quarantine restrictions and movement controls	Section 10.3
Decontamination and property cleanup procedures	Section 10.5
Diagnostic protocols and laboratories	Section 5.3
Trace back and trace forward procedures	Section 10.6
Protocols for delimiting, intensive and ongoing surveillance	Section 9.2
Zoning	Section 10.4
Reporting and communication strategy	Section 13.4

A range of specifically designed procedures for the emergency response to a pest incursion and a general communication strategy refer to PLANTPLAN (Plant Health Australia, 2010). Additional information is provided by Merriman and McKirdy (2005)[5] in the Technical Guidelines for Development of Pest Specific Response Plans.

[5] Available on the PHA website (**www.planthealthaustralia.com.au/go/phau/biosecurity/general-biosecurity-information**)

9.2 Surveys and epidemiology studies

Information provided in Section 9.2.1 to 9.2.3 provides a framework for the development of early detection and delimiting surveys for whitefly transmitted viruses.

Where Silverleaf whitefly (*B. tabaci*) is found in a production nursery that is in close proximity to potential host trees and shrubs, periodically inspect nearby hosts for signs of whitefly infestation by examining leaves closely. Infested sources within the production nursery may provide an opportunity for *B. tabaci* to spread to trees and shrubs outside the production nursery.

Numerous chlorotic spots develop on the leaves of affected plants, which may also be disfigured by honeydew and associated sooty moulds. Leaf curling, yellowing, mosaics or yellow veining could indicate the presence of whitefly-transmitted viruses, and phytotoxic responses such as a severe silvering of courgette and melon leaves indicate the presence of the B biotype, the immature stages being mainly responsible for this symptom (Costa *et al*., 1993). Other phytotoxic responses to the B biotype include mis-ripening of tomato fruits (Maynard and Cantliffe, 1989), white streaking of *Brassica* leaves (Brown *et al*., 1992) and yellow veining of some solanaceous plants (Bedford *et al*., 1998).

Close observation of the undersides of the leaves will show the tiny yellow/white larval scales and in severe infestations, when the plant is shaken, numerous small white adult whiteflies will flutter out and quickly resettle.

Personnel should avoid moving infested plant material between production nurseries. Shoes, tools and vehicle tyres should be thoroughly washed of soil and then sanitised with a registered disinfectant. Extra precaution should be taken when working in areas known to be infested, including disposable overboots that may be used and disposed of on-site.

9.2.1 Technical information for planning surveys

When developing surveys for presence and/or distribution of Silverleaf whitefly (and its potential as a virus vector), the following characteristics of the pest provide the basic biological knowledge that informs the survey strategy:

- Silverleaf whiteflies have a wide host range and as a virus vector share many of the same hosts with that of the virus.
- Endemic host species in Australia are likely to be numerous and widely dispersed.
- The risk of whitefly movement on machinery, equipment and personal effects is high.
- Production nursery greenhouses and significant proportions of Australia have favourable climatic conditions for Silverleaf whitefly spread and establishment.

9.2.2 Surveys for early detection of an incursion in a production nursery

The survey protocol used to monitor Silverleaf whitefly is based on the protocol developed by the Department of Agriculture and Food Western Australia to support their area freedom from Silverleaf whitefly within the horticultural regions of Western Australia. Of particular concern was the risk to the state's cotton, melon and tomato production as well as ornamental/urban horticultural industries (**agspsrv34.agric.wa.gov.au/ento/Surveillance/Silverleaf%20whitefly.html**).

Points to consider in effectively monitoring Silverleaf whitefly in commercial production nurseries are:

- The survey should consist of two parts: an initial survey using yellow sticky card traps to determine the species of whitefly present and then follow up for leaf samples.
- Silverleaf whitefly are small (1.5 mm approx.) and difficult to see.
- As the whiteflies (adult and larva) are small, detection is dependent on careful visual inspection, preferably supplemented by use of a hand lens magnifier.
- Yellow sticky card traps will determine the presence of whitefly and other insect species such as thrips and aphids. It is recommended that traps be placed at a density of 1 trap per 300 to 400 plants positioning the trap bottom at canopy height. The traps should remain in place for one week.
- If whitefly is detected, leaves infested with whitefly (nymphs and adults if possible) should be collected for identification of the species.
- Leaf-turn method for sampling Silverleaf whitefly in horticultural structures involves sampling the underside of the leaves, 3rd to 5th node down from the growing tip. Sample the plants 2 to 3 metres apart in a zigzag pattern, after sampling 10 plants move to a new site and continue until all areas within the glasshouse have been covered.
- The sampling method in outdoor crops uses the same approach for the position of leaves but samples the plants 5 to 10 metres apart in a zigzag pattern, sampling 10 plants before moving to a new site and continuing until all areas of the planting have been covered. It is recommended that for plantings up to 30 hectares a sample of 100 plants will be sufficient assessment for whitefly populations.

If an incursion of a Silverleaf whitefly transmitted virus is to be eradicated, it must be detected early, before the vector has had the opportunity to disperse very far. It is therefore necessary to consider pathways and plan surveys and/or sentinel plantings accordingly. The sentinel plants used should be clean material (ie. material that has been brought from a non infected region). Important points to consider when developing early detection surveys are:

- Awareness information should be targeted at people who are in regular close contact with potential hosts in high risk areas or movement vectors (e.g. production nursery operators).
- Systematic and careful inspection of nursery crops and propagative plant material is essential to prevent introduction of a Silverleaf whitefly transmitted virus and limit its spread within and from contaminated nurseries. Early detection of the vector, while at low levels, will provide the best chance of eradication.
- An inspector must be trained to recognise Silverleaf leaf whitefly and virus symptoms and other similar disorders for comparison (see Section 5.2.3). A nursery layout map that includes approximate locations of target species will be required to develop a strategy for surveys. A survey map should include species and cultivar names, locations, approximate quantity and sources of targeted plants within the area. During the survey walkthrough, record the date, observations, and sampling information directly onto the survey map. The recorded information should be reviewed and used to develop an efficient survey strategy each time the nursery is inspected.

9.2.3 Delimiting surveys in the event of an incursion

- In the event of an incursion, delimiting surveys are essential to inform the decision-making process
- The size of the survey area will depend on the size of the infected area and the severity of the infection, as well as prevailing winds and movement of plant material during the period prior to detection (Figure 6). Other considerations are for example, movement of people or plant material equipment as a result of trace-forward and trace-backs
- Silverleaf whiteflies can fly and can readily spread long distances by floating with the wind or being transported on infested plants. New introductions can pose serious threats and complicate identification of naturalised populations
- All potential host species (refer to Section 5.2) should be surveyed, with particular attention paid to the species in which the pest was initially detected
- In addition to inspection of possible host plants, material should be collected for diagnostic purposes (refer to Section 9.2.4)
- If the incursion is in a populated area, publication and distribution of information sheets and appeals for public assistance may be helpful

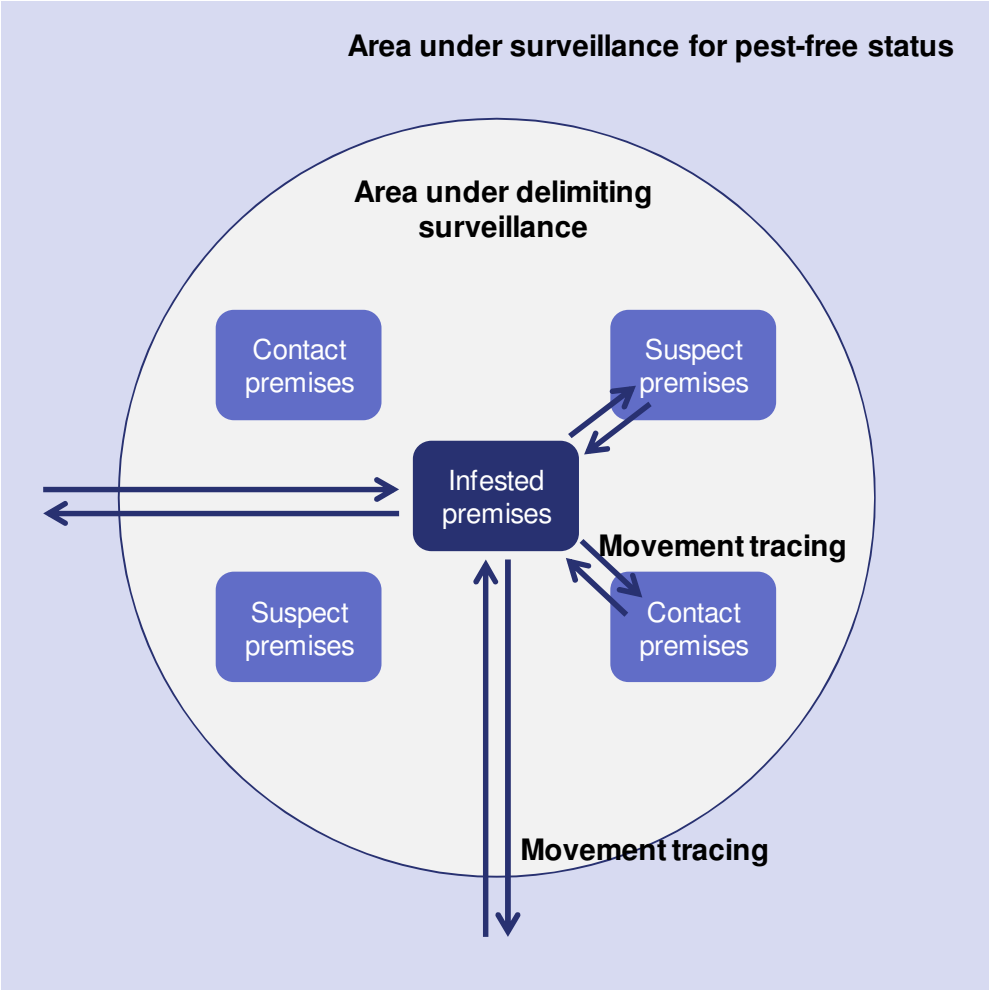

Figure 6. *Diagram of a delimiting survey showing surveillance activities from the infected premises*

9.2.4 Collection and treatment of Silverleaf whitefly samples

Protocols for the collection, transport and diagnosis of suspect Emergency Plant Pests (EPPs) must follow PLANTPLAN (Plant Health Australia, 2010). Any personnel collecting samples for assessment should notify the diagnostic laboratory prior to submitting samples to ensure expertise is available to undertake the diagnosis.

All sample containers should be clearly labelled with the name, address and contact phone number of both the sending and receiving officers. In addition containers should be clearly labelled in accordance with the requirements of PLANTPLAN (Plant Health Australia, 2010). Containers should be carefully sealed to prevent loss, contamination or tampering of samples. The Chief Plant Health Manager will select the preferred laboratory. Additional labelling includes the identification of plant species/parts affected, location of nursery and affected plant within the nursery (preferably with a GPS reading) as well as symptoms and an image if available.

Refer to PLANTPLAN for packing instructions under IATA 650.

9.2.4.1 COLLECTION OF SPECIMENS

Sampling procedures

Samples can be collected on leaf samples or on yellow sticky traps (see section 9.2). The leaves should contain most whitefly developmental stages.

Number of specimens to be collected

Where possible, collect multiple specimens representative of all life stages of the population available. Adult whiteflies are preferred, as the adult life stage is the easiest with which to confirm identification.

Record the identity of the host plant where the whiteflies were collected. Record the location, preferably as GPS co-ordinates, or alternatively, a map reference or distance and direction from a suitable landmark. If the land is privately owned, record the owner's details including contact telephone numbers.

How to collect and send plant samples with eggs, larvae or pupae

Leaf samples containing whitefly nymphs and if possible adults are to be placed in a specimen container and placed in a portable fridge of insulated container with cool packs to prevent the insect and leaf samples from drying out.

All sample containers should be clearly labelled with the name, address and contact phone number of both the sending and receiving officers. In addition containers should be clearly labelled in accordance with the requirements of PLANTPLAN (Plant Health Australia, 2010; Appendix 3). Containers should then be carefully sealed to prevent loss, contamination or tampering of samples. The Chief Plant Health Manager will select the preferred laboratory. Additional labelling includes the identification of plant species/parts affected, location of affected plant (where available include GPS reading) as well as symptoms and an image if available.

Refer to PLANTPLAN for packing instructions under IATA 650.

Precaution

Overheating or desiccation of samples prior to despatch should be prevented. Samples may be stored in a fridge (4-10℃) for a few days if necessary.

Receipt

On receipt of the samples the diagnostic laboratory should follow strict quarantine and processing guidelines. In keeping with ISO 17025 refer to PLANTPLAN (Plant Health Australia, 2010).

9.2.5 Collection and treatment of virus samples

Plants showing virus like symptoms or suspected symptoms should be sampled. Any personnel collecting samples for assessment should notify the diagnostic laboratory prior to submitting samples to ensure expertise is available to undertake the diagnosis. General protocols for collecting and dispatching samples are available within Appendix 3 PLANTPLAN (Plant Health Australia, 2010).

Number of specimens to be collected

Five to ten samples of symptomatic plants should be collected for initial identification. If a survey to determine the incidence of disease within a crop or geographic area is required, then a more formalised, statistical-based sampling strategy should be employed.

It is important to record the precise location of all samples collected, preferably using GPS, or if this is not available, map references including longitude and latitude and road names should be recorded. Property and owners names should also be included where possible.

How to collect plant samples

Samples should be treated in a manner that allows them to arrive at the laboratory in a fresh, well-preserved state. An esky with ice packs or portable fridge should be carried when sampling crops. Samples should be wrapped in absorbent paper towel or paper bags and place in rigid cardboard post boxes. The samples should be kept cool, out of direct sunlight and clearly labelled. Aim to keep the tissue at less than 10^{o}C. For appropriate labelling and packaging procedures for suspect emergency plant pests consult PLANTPLAN (Plant Health Australia, 2010).

Infected plant material is collected using sterilised scissors and wrapped in moist towelling.

How to preserve plant samples

Collected material can be stored at 2-5℃. Do not expose plant samples to direct sunlight. It is important to keep the sampled plant tissue below 10℃ where possible.

How to transport plant sample

Plant material should be mailed as a flat package. The samples should be either sent by a courier or by Express Post if overnight delivery to the diagnostic laboratory is guaranteed. The receiving laboratory must be notified before samples are sent.

9.2.6 Epidemiological study

The extent of infestation in a production nursery, on a property or within a region will depend on the initial population size and whether conditions have been favourable for the pest to spread from the initial location. Sampling should be based upon the origins of the initial suspect sample(s). Factors to consider will be:

- The proximity of other susceptible plants to the initial infestation source, including both current and previous crops. This will include crops in the production nursery or on the property with the initial detection and those on neighbouring properties.
- Machinery or vehicles that have been into the infested area or in close proximity to the infestation source.
- The extent of human movements into and around the infested area. A possible link to the recent importation of plant material from other regions should also be considered.
- The source of any production nursery stock propagation material.
- If any other crops have been propagated from the same source and/or distributed from the affected production nurseries.
- Depending on the temperature and environmental conditions Silverleaf whitefly can have multiple generations per year.

9.2.7 Models of spread potential

No models of spread potential have been developed for Silverleaf whitefly transmitted viruses.

9.2.8 Pest Free Area guidelines

Determination of Pest Free Areas (PFAs) should be completed in accordance with the International Standards for Phytosanitary Measures (ISPMs) 8 and 10 (IPPC 1998a, 1999).

General points to consider are:

- Design of a statistical delimiting survey for symptoms on host plants (see Section 9.2 for points to consider in the design)
- Plant sampling should be completed as described in the BioSecure *HACCP* manual (Nursery and Garden Industry Australia, 2008), including monitoring processes (summarised in Table 8 and Table 9), indicator plants and weed monitoring
- Surveys should also consider alternative hosts (see Section 5.2.1) and not be limited to the primary infected host
- Information (including absence of the pest) should be recorded

Table 8. *Summary of monitoring processes for protected production areas as described in BioSecure HACCP Guidelines*

Wear protective clothing when handling suspect samples
Walk at random through the area in a zigzag pattern
Take at least 10 minutes to inspect 10-20 plants or plug trays per 100 m^2 of production area
Inspect the tops and bottoms or leaves, looking for any direct evidence of insects
Inspect the entire plant if it has less than 6 leaves, or from larger plants select six leaves from all parts of the plant (upper, lower, middle) and examine them individually
Inspect the length of all stems and branches for insects and symptoms
During individual plant inspection, examine the underside of the foliage for the presence of whiteflies
If any plants show suspect symptoms or evidence of eggs or larvae (refer to Symptoms Section 5.2.3) take a sample (refer to Section 9.2.4) to be formally diagnosed
Check for a problem that have occurred regularly in the past, until you are certain it is not present
Record on the 'Crop Monitoring Record' sheet the presence or absence of the pest
Routinely inspect growing areas and remove alternate hosts and reservoirs of the pest, including weeds, crop residues and old plants that will not be marketed

Additional information is provided by the IPPC (1995) in Requirements for the Establishment of Pest Free Areas. This standard describes the requirements for the establishment and use of pest free areas as a risk management option for phytosanitary certification of plants and plant products. Establishment and maintenance of a PFA can vary according to the biology of the pest, pest survival potential, means of dispersal, availability of host plants, restrictions on movement of produce, as well as PFA characteristics (size, degree of isolation and ecological conditions).

Table 9. *Summary of monitoring processes for field production areas as described in BioSecure HACCP Guidelines*

Wear protective clothing when handling suspect samples
Pay particular attention to areas on the windward side, the sides bordering ditches, canals or other uncultivated areas and growing block centres
Place a flag or other marker at the entrance to the block or sampling area at the beginning of each inspection
Vary the entrance point in the sampling area (1 m to 3 m) for each subsequent sampling so that the same plants are not inspected each time
Walk at random through the area in a zigzag pattern
The scout should follow the same general pattern at each sampling
Make an effort to select those plants that appear less healthy for visual inspection
Take at least 10 minutes to inspect 10-20 plants or plug trays per 100 m^2 of production area
Inspect the tops and bottoms or leaves, looking for any direct evidence of insects
Inspect the entire plant if it has less than 6 leaves, or from larger plants select six leaves from all parts of the plant (upper, lower, middle) and examine them individually
Inspect the length of all stems and branches for insects and symptoms
During individual plant inspection, strike the foliage over a white sheet of paper, or a plastic or paper plate to dislodge small insects for easier viewing
If any plants show suspect symptoms or evidence of eggs or larvae (refer to Symptoms Section 5.2.3) take a sample (refer to Section 9.2.4) to be formally diagnosed
Check for a problem that have occurred regularly in the past, until you are certain it is not present
Record on the 'Crop Monitoring Record' sheet the presence or absence of the pest
Routinely inspect growing areas and remove alternate hosts and reservoirs of the pest, including weeds, crop residues and old plants that will not be marketed

9.3 Availability of control methods

9.3.1 General procedures for control

- Keep traffic out of affected areas and minimise movement in adjacent areas.
- Adopt best-practice property hygiene procedures to retard the spread of the pest between fields and adjacent properties.
- After surveys are completed, and permission has been obtained from the Chief Plant Health Manager or OCPPO, destruction of the infested plant material is an effective control.
- On-going surveillance of infected areas to ensure the pest is eradicated.
- Do not use any material from infected plants for propagation.

Controlling whitefly populations before they reach large numbers in crops is very important for successful management. If the adults occur in large numbers it becomes difficult to control the nymphal stages. Adults move between successive crops, so management approaches must be employed in all crops within the area.

To reduce early season populations, best management practices require consideration of several management approaches including the use of pest-free seedlings, weed management, chemical control and cleaning up of crop residue. Managing Silverleaf whitefly is based on protocols from the Queensland Government Department of Employment, Economic Development and Innovation website.

9.3.2 Pest free (clean) seedlings

Seedlings are potentially a major means of spreading whiteflies and whitefly transmitted viruses into new plantings. Young plants are more susceptible to damage from Silverleaf whitefly, so early infestations need to be avoided. Clean seedlings can be the first line of protection against the development of damaging populations.

Growers should check their suppliers to determine how the seedlings are grown and what measures are being used to protect against whitefly infestation. Inspect transplants carefully upon arrival for whitefly eggs, nymphs and adults.

9.3.3 Weed management

The availability of a continuous source of hosts, whether they are crops, weeds or abandoned crops, is the major contributing factor to a severe whitefly problem. Even a small area of a favoured host can maintain a significant whitefly population.

Minimising whitefly hosts is important in reducing the base population at the start of the cropping season. A smaller base population then will delay the time it takes for Silverleaf whitefly numbers to reach significant levels, reducing the number of sprays needed to control whitefly populations.

Common weed species that carry high numbers of whitefly include sow and milk thistle, bladder ketmia, bell vine, burr gherkin, native rosella and star burr. Control these weed species in farming areas and seedling nurseries to minimise a build-up in Silverleaf whitefly populations.

9.3.4 Chemical control

The following active ingredients have been reported as effective in controlling *B. tabaci* biotype B worldwide: bifenthrin, buprofezin, imidacloprid, fenpropathrin, endosulphan, cyfluthrin, amitraz, fenoxycarb, deltamethrin, azadirachtin, pymetrozine. The Australian Pesticides and Veterinary Medicines Authority (APVMA) must approve and register any chemical before it is legally allowed to be used to manage any plant pest.

The B biotype has been documented as being able to exhibit resistance to all groups of pesticide that have been developed for its control (Cahill *et al.*, 1995). Rotation of insecticides that offer no cross-resistance must therefore be used to control infestations.

A new group of environmentally safer insecticides that effectively kill whitefly by a physical mode of action are appearing on the market in many countries. These products do not have a specific active ingredient, but appear to utilise surfactant-like properties to overcome the protective waxes on whitefly larvae and adults.

Selecting the correct insecticides and applying them at the appropriate time is very important, both for achieving good Silverleaf whitefly management and minimising the development of resistance to the insecticides. A spray program should be based on the results of monitoring.

Insecticides vary in their efficacy on adult and immature Silverleaf whitefly. Select insecticides according to the growth stage of whitefly, the infestation level, the age of the crop and the type of crop. Information on how to select insecticides for controlling Silverleaf whitefly is provided in Table 10.

Good spray coverage, particularly of the underside of leaves, is very important when using foliar insecticide applications as Silverleaf whitefly adults, eggs and nymphs are found predominantly on the underside of leaves. Spray equipment should be correctly calibrated so that the correct amounts of insecticide are applied efficiently.

Imidacloprid is a systemic insecticide that can be applied to some crops as a foliar spray, or as a soil treatment through sub-surface drip irrigation tubing, as a furrow spray or as a plant hole drench. Soil applications are more efficient than foliar sprays and are made shortly before, at or shortly after planting. READ THE LABEL before use for crops, application directions, rates and timing.

Table 10. Chemical control options for whitefly control in nursery stock food crops and non-food crops.

Chemical group	Active ingredient	Product example	Food crops	Non-food crops
3A	Bifenthrin	Talstar, Procide 80SC		Roses, carnations and ornamentals
4A	Acetamiprid	Crown		Gerbera, fuchsia and other ornamentals
4A	Imidacloprid	Confidor Guard	Capsicum, cucurbits, eggplant, sweet potato, tomato, potato	
7C	Pyriproxyfen	Admiral	Food crops (cotton, rockmelon, capsicum, tomatoes)	
22A	Azadirachtin	AzaMax		Floriculture, ornamentals
	Potassium salts of fatty acids	Natrasop	Vegetables, fruit trees	Ornamentals, pot plants

Short residual contact insecticides (such as Talstar®) mainly control adults and are less effective against immature stages. Systemic insecticides (Confidor®) can control both adults and nymphs. Organophosphate insecticides used alone provide no control for Silverleaf whitefly. Other active ingredients (e.g. Pymetrozine) are registered for whitefly control oversees but the Australian labels do not include whitefly control.

Under the APVMA emergency permit system several chemicals have been approved against Silverleaf whitefly for use in a range of vegetable crops. A few chemicals are registered for Silverleaf whitefly control. Before use read the APVMA permit (click links in Table 11) and product label for directions. **Error! Reference source not found.** lists the chemicals registered or with APVMA permits at the time of publication.

All insecticides listed above are registered for use in Australia against other insect pests by the Australian Pesticides & Veterinary Medicines Authority (APVMA, PO Box E240, Kingston, ACT 2604; ph. 02 6272 5158; www.apvma.gov.au). If these Silverleaf whitefly transmitted viruses were detected in Australia, an additional permit would need to be required to enable the use of these chemicals for its management and/or destruction. Additional permits would be required from the Civil Aviation

Safety Authority (CASA, phone 131 757, www.casa.gov.au) if it was intended the pesticide be aerially applied.

Table 11. Chemical control permits for whitefly control in nursery stock food crops and non-food crops.

Chemical group	Active ingredient	Product example	Food crops	Non-food crops	States	Permit No. & expiry date
4A	Imidacloprid	Suscon Maxi		Seedlings/plugs, potted colour, trees and shrubs, foliage plants, palms, grasses, non-bearing fruit trees	WA, Vic, Tas, Qld, SA	PER11560 Exp. 31/01/13
7C	Pyriproxyfen	Admiral		Leafy and woody herbs	All states except Vic	PER8576 Exp. 30/08/12
7C	Pyriproxyfen	Admiral	Cucurbits, eggplant		Qld, WA, NT	PER10764 Exp. 30/09/12
9A	Pymetrozine	Chess		Seedlings/plugs, potted colour, trees and shrubs, foliage plants, palms, grasses, non-bearing fruit trees	All states except Vic	PER11973 Exp. 30/06/15
12B	Diafenthiuron	Pegasus		Nursery stock, non-bearing fruit trees	All states	PER11971 Exp. 31/05/15
17A	Buprofezin	Applaud		Nursery stock, non-bearing fruit trees	All states except Vic	PER11553 Exp. 30/11/14
	Potassium salts of fatty acids	Natrasop	Glasshouse and hydroponically grown capsicum, cucumbers and lettuce		All states except Vic	PER10184 Exp. 28/02/13
	Emulsifiable botanically oil	Eco-oil	Greenhouse and hydroponically grown capsicum, cucumbers and lettuce		All states except Vic	PER10311 Exp. 30/09/13

9.3.5 Clean-up crop residues

Movement of Silverleaf whitefly adults from older crops and crop residues is the main source of infestation for younger crops. Post-harvest destruction of heavily infested crops often causes mass migration of SLW adults into adjacent crops. Therefore it is important to control adult whiteflies before they move into young crops.

Clean-up strategies for old crops/crop residues:

- For moderate whitefly infestations, use an insecticide effective against adults.
- Use high spray volumes for better coverage as defined on the label.
- Remember that re-entry/withholding periods still apply and that entry into crops should be avoided and that produce should not be taken from the fields for consumption. Don't feed crop residues to livestock.
- Residues should be deep-buried or contained (sealed plastic bags) and disposed of via incineration.

9.3.6 Cultural Control

Intercropping practices using non-hosts have been used in many countries aiming to reduce numbers of whiteflies on specific crops. However, intercropping with susceptible crops can promote whitefly populations, by offering a greater leaf area for feeding.

Weed species can play an important role in harbouring whiteflies during and between crop plantings and attention should be paid to removing these in advance of planting susceptible crops. Weeds also can harbour whitefly-transmitted viruses (Bedford *et al.*, 1998) and may be a major source of crop virus epidemics, especially where *B. tabaci* biotype B is present, due to its polyphagous nature.

9.3.7 Host-Plant Resistance

The development of transgenic resistant plant and crop species through genetic engineering must be considered and accepted as a future method of control where whitefly-transmitted viruses are already endemic and causing severe crop losses (Wilson, 1993**;** Raman and Altman, 1994). Traditional sources of resistance have been used successfully for the control of other whitefly species.

9.3.8 Insect Pest Management

Compared with other biotypes of *B. tabaci*, the increased fecundity and polyphagous habit of the B biotype has exacerbated many control problems in field and glasshouse crops worldwide, compounded by insecticide resistance. It appears that no single control treatment can be used on a long-term basis against this pest, and that approaches should be integrated to achieve an effective level of control. (Further information is needed before comment can be made on the Q biotype).

If eradication is not feasible, IPM appears to offer the best option for controlling B biotype infestations without causing contamination of the environment. Beneficial insects are used alongside chemicals that offer a high level of selectivity, such as insect growth regulators. Plant and crop species that exhibit a high level of resistance to both vector and virus must also be considered when designing an IPM system.

9.3.9 Managing viruses

The two key points in managing the spread of Tomato leaf curl virus and Tomato yellow leaf curl virus are to:

- Prevent the movement of infected host plants, seedlings and Silverleaf whitefly infected plants.
- Control of Silverleaf whitefly on-farm, surrounding vegetation and seedling nurseries using good farm management and farm hygiene practices (Thomas and Persley, 2007).
- It is expected that these control strategies will also be effective for other whitefly transmitted viruses.

9.4 Phytosanitary Measures

In countries where *B. tabaci* biotype B is not present, the enforcement of strict phytosanitary regulations as required for *B. tabaci*, may help to reduce the risk of this whitefly becoming established.

Because of the difficulty of detecting low levels of infestation in consignments, it is best to ensure that the place of production is free from the pest (OEPP/EPPO, 1990). Particular attention is needed for consignments from countries where certain *B. tabaci*-listed viruses, now on the EPPO A1 or A2 quarantine lists, are present. These viruses are also transmitted by the B biotype.

10 Course of action

Additional information is provided by the IPPC (1998b) in Guidelines for Pest Eradication Programmes. This standard describes the components of a pest eradication programme which can lead to the establishment or re-establishment of pest absence in an area. A pest eradication programme may be developed as an emergency measure to prevent establishment and/or spread of a pest following its recent entry (re-establish a pest free area) or a measure to eliminate an established pest (establish a pest free area). The eradication process involves three main activities: surveillance, containment, and treatment and/or control measures.

10.1 Destruction strategy

10.1.1 Destruction protocols

- General protocols:
    - No plant material should be removed from the infested area unless part of the disposal procedure.
    - Disposable equipment, infested plant material or growing media/soil should be disposed of by autoclaving, high temperature incineration or deep burial.
    - Any equipment removed from the site for disposal should be double-bagged.
    - Machinery used in destruction processes need to be thoroughly washed, preferably using a detergent or farm degreaser.

10.1.2 Decontamination protocols

Machinery, equipment and vehicles in contact with infested plant material or growing media/soil, or present within the Quarantine Area, should be washed to remove plant material and growing media/soil using high pressure water or scrubbing with products such as a degreaser or a bleach solution (1% available chlorine) in a designated wash down area. When using high pressure water, care should be taken not to spread plant material. High pressure water should be used in wash down areas which meet the following guidelines:

- Located away from crops or sensitive vegetation.
- Readily accessible with clear signage.
- Access to fresh water and power.
- Mud free, including entry and exit points (e.g. gravel, concrete or rubber matting).
- Gently sloped to drain effluent away.
- Effluent must not enter water courses or water bodies.
- Allow adequate space to move larger vehicles.
- Away from hazards such as power lines.
- Waste water, growing media/soil or plant residues should be contained (see Appendix 18 of PLANTPLAN [Australia, 2010]).
- Disposable overalls and rubber boots should be worn when handling infested plant material or growing media/soil in the field. Boots, clothes and shoes in contact with infested plant material or growing media/soil should be disinfected at the site or double-bagged to remove for cleaning.
- Skin and hair in contact with infested plant material or growing media/soil should be washed.

Procedures for the sterilisation of plant containers and growing media are provided within the BioSecure *HACCP* Guidelines, however, in the event of a whitefly incursion, additional or modified procedures may be required for the destruction of the pest. Any sterilisation procedure must be approved for use in the endorsed Response Plan.

10.1.3 Priorities

- Confirm the presence of the pest.
- Limit movement or people and prevent movement of vehicles and equipment through affected areas.
- Stop the movement of any plant material that may be infested with the pest.
- Determine the strategy for the eradication/decontamination of the pest and infested host material.
- Determine the extent of infestation through survey and plant material trace back and trace forward which would be assessed on a case by case basis and included within the response plan.

10.1.4 Plants, by-products and waste processing

- Any growing media/soil or infected plant material removed from the infected site should be destroyed by (enclosed) high temperature incineration, autoclaving or deep burial.
- As whitefly transmitted viruses are easily spread, plant debris from the destruction zone must be carefully handled and transported.
- Infested areas or production nursery property should remain free of susceptible host plants until the area has been shown to be free from the pathogen.

10.1.5 Disposal issues

- Particular care must be taken to minimise the transfer of infected plant material from the area.
- Host material including leaf litter should be collected and incinerated or double bagged and deep buried in an approved site.

10.2 Containment strategies

For some exotic pest incursions where eradication is considered impractical, containment of the pest may be attempted to prevent or slow its spread and to limit its impact on other parts of the state or country. Containment is currently being considered for inclusion within the Emergency Plant Pest Response Deed (EPPRD). The decision on whether to eradicate or contain the pest will be made by the National Management Group, based on scientific and economic advice. Emergency interim containment measures are possible under EPPRD arrangements to gather information to determine if eradication is technically feasible.

10.3 Quarantine and movement controls

Consult PLANTPLAN (Plant Health Australia, 2010) for administrative details and procedures.

10.3.1 Quarantine priorities

- Plant material and growing media/soil at the site of infestation to be subject to movement restrictions.
- Machinery, equipment, vehicles and disposable equipment in contact with infested plant material or growing media/soil, or present in close proximity to the site of infestation to be subject to movement restrictions.

10.3.2 Movement controls

Movement controls need to be put in place to minimise the potential for transport of the pest, and this will apply to all plant material, growing media and other items within the quarantined area.

Movement of people, vehicles, equipment and plant material, from and to affected properties or areas, must be controlled to ensure that the pest is not moved off-property. Movement controls can be achieved through the following, however specific measures must be endorsed in the Response Plan:

- Signage to indicate quarantine area and restricted movement into and within these zones.
- Fenced, barricaded or locked entry to quarantine areas.
- Movement of equipment, machinery, plant material or growing media/soil by permit only. Therefore, all non-essential operations in the area or on the property should cease.
- Where no dwellings are located within these areas, strong movement controls should be enforced.
- Where dwellings and places of business are included within the Restricted and Control Areas movement restrictions are more difficult to enforce, however limitation of contact with infested plants should be enforced.
- If a production nursery is situated within the Restricted Area, all trading in host and no-host material must cease and no material should be removed from the site without permission, due to the high likelihood of pest spread. Movement restrictions would be imposed on both host and non-host material.
- Residents should be advised on measures to minimise the inadvertent transport of Silverleaf whitefly from the infested area to unaffected areas.
- Clothing and footwear worn at the infested site should either be double-bagged prior to removal for decontamination or should not leave the site until thoroughly disinfected, washed and cleaned.
- Plant material or plant products must not be removed from the site unless part of an approved disposal procedure.
- All machinery and equipment should be thoroughly cleaned down with a high pressure cleaner (see Section 10.1.2) or scrubbing with products such as a farm degreaser or a 1% bleach (available chlorine) solution, prior to leaving the affected area. Machinery should be inspected for the presence of insects and if found, treatment with insecticide may be required. The clean down procedure should be carried out on a hard surface, preferably a designated wash-down area, to avoid mud being re-collected from the affected site onto the machine. When using high pressure water, care should be taken to contain all plant material and mud dislodged during the cleaning process

10.4 Zoning

The size of each quarantine area will be determined by a number of factors, including the location of the incursion, biology of the pest, climatic conditions and the proximity of the infested property to other infested properties. This will be determined by the National Management Group during the production of the Response Plan. Further information on quarantine zones in an Emergency Plant Pest (EPP) incursion can be found in Appendix 10 of PLANTPLAN (Plant Health Australia, 2010). These zones are outlined below and in Figure 7.

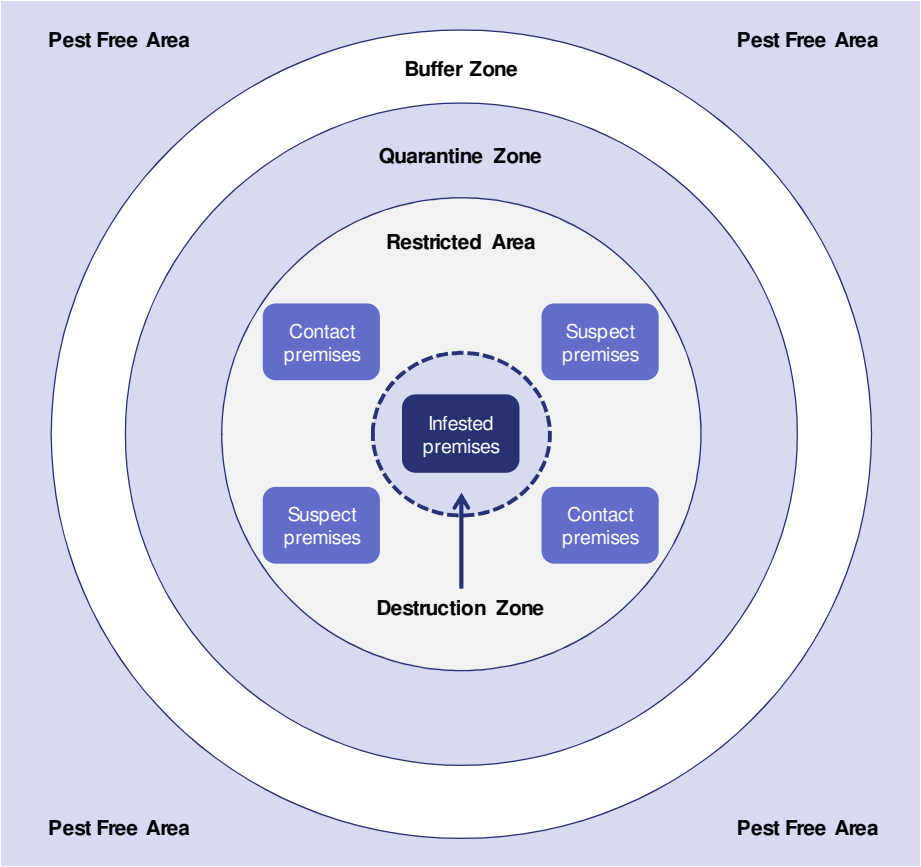

Figure 7. *Schematic diagram of quarantine zones used during an EPP incursion (not drawn to scale)*

10.4.1 Destruction Zone

The size of the destruction zone (i.e. zone in which the pest and all host material is destroyed) will depend on the ability of the pest to spread, distribution of the pest (as determined by delimiting surveys), time of season (and part of the pest life cycle being targeted) and factors which may contribute to the pest spreading.

All host plants should be destroyed after the level of infestation has been established. The delimiting survey will determine whether or not neighbouring plants are infested and need to be destroyed. Non-host plant material within this zone may be destroyed, based on recommendations in the Response Plan. The Destruction Zone may be defined as contiguous areas associated with the same management practices as, or in contact with, the infested area (i.e. the entire production nursery, property or area if spread could have occurred prior to the infection being identified).

Particular care needs to be taken to ensure that plant material (including non-hosts) is not moved into surrounding areas.

10.4.2 Quarantine Zone

The Quarantine Zone is defined as the area where voluntary or compulsory restraints are in place for the affected property or properties. These restraints may include restrictions or movement control for removal of plants, people, growing media/soil or contaminated equipment from an infected property.

10.4.3 Buffer Zone

A Buffer Zone may or may not be required depending on the incident. It is defined as the area in which the pest does not occur but where movement controls or restrictions for removal of plants, people, soil or equipment from this area are still deemed necessary. The Buffer Zone may enclose an infested area (and is therefore part of the Control Area) or may be adjacent to an infested area.

10.4.4 Restricted Area

The Restricted Area is defined as the zone immediately around the infected premises and suspected infected premises. The Restricted Area is established following initial surveys that confirm the presence of the pest. The Restricted Area will be subject to intense surveillance and movement control with movement out of the Restricted Area to be prohibited and movement into the Restricted Area to occur by permit only. Multiple Restricted Areas may be required within a Control Area.

10.4.5 Control Area

The Control Area is defined as all areas affected within the incursion. The Control Area comprises the Restricted Area, all infected premises and all suspected infected premises and will be defined as the minimum area necessary to prevent spread of the pest from the Quarantine Zone. The Control Area will also be used to regulate movement of all susceptible plant species to allow trace back, trace forward and epidemiological studies to be completed.

10.5 Decontamination and farm clean up

Decontaminant practices are aimed at eliminating the pathogen thus preventing its spread to other areas.

10.5.1 Decontamination procedures

General guidelines for decontamination and clean up:

- Refer to PLANTPLAN (Plant Health Australia, 2010) for further information.
- Keep traffic out of affected area and minimise it in adjacent areas.
- Adopt best-practice property hygiene procedures to retard the spread of the pest between growing areas/fields and adjacent properties.
- Machinery, equipment, vehicles in contact with infested plant material or growing media/soil present within the Quarantine Zone, should be washed to remove growing media/soil and plant material using high pressure water or scrubbing with products such as a degreaser or a bleach solution in a designated wash down area as described in Section 10.1.2.
- Only recommended materials are to be used when conducting decontamination procedures, and should be applied according to the product label.
- Infested plant material should be disposed of by autoclaving, high temperature (enclosed) incineration or deep burial.

10.5.2 General safety precautions

For any chemicals used in the decontamination, follow all safety procedures listed within each MSDS.

10.6 Surveillance and tracing

10.6.1 Surveillance

Detection and delimiting surveys are required to delimit the extent of the outbreak, ensuring areas free of the pest retain market access and appropriate quarantine zones are established.

Initial surveillance priorities include the following:

- Surveying all host growing properties and businesses in the pest quarantine area
- Surveying all properties and businesses identified in trace-forward or trace-back analysis as being at risk
- Surveying all host growing properties and businesses that are reliant on trade with interstate or international markets which may be sensitive to pathogen presence
- Surveying production nurseries selling at risk host plants
- Surveying other host growing properties and backyards

10.6.2 Survey regions

Establish survey regions around the surveillance priorities identified above. These regions will be generated based on the zoning requirements (see Section 10.4), and prioritised based on their potential likelihood to currently have or receive an incursion of this pest. Surveillance activities within these regions will either allow for the area to be declared pest free and maintain market access requirements or establish the impact and spread of the incursion to allow for effective control and containment measures to be carried out. Detailed information regarding surveys for Silverleaf whitefly have been outlined elsewhere in this plan (refer to Section 9.2).

Steps outlined in Table 12 form a basis for a survey plan. Although categorised in stages, some stages may be undertaken concurrently based on available skill sets, resources and priorities.

Table 12. *Phases to be covered in a survey plan*

Phase 1	Identify properties that fall within the buffer zone around the infested premise Complete preliminary surveillance to determine ownership, property details, production dynamics and tracings information (this may be an ongoing action)
Phase 2	Preliminary survey of host crops in properties in buffer zone establishing points of pest detection
Phase 3	Surveillance of an intensive nature, to support control and containment activities around points of pest detection
Phase 4	Surveillance of contact premises. A contact premise is a property containing susceptible host plants, which are known to have been in direct or indirect contact with an infested premises or infected plants. Contact premises may be determined through tracking movement of materials from the property that may provide a viable pathway for spread of the disease. Pathways to be considered are: • Movement of plant material and growing media/soil from controlled and restricted areas • Items of equipment and machinery which have been shared between properties including bins, containers, irrigation lines, vehicles and equipment • The producer and retailer of infected material if this is suspected to be the source of the outbreak • Labour and other personnel that have moved from infected, contact and suspect premises to unaffected properties (other growers, tradesmen, visitors, salesmen, crop scouts, harvesters and possibly beekeepers) • Storm and rain events and the direction of prevailing winds that result in air-borne dispersal of the pathogen during these weather events
Phase 5	Surveillance of production and greenlife retailers, including garden centres, hardware outlets and supermarkets, as well as gardens and public land where plants known to be hosts of pathogen are being grown
Phase 6	Agreed area freedom maintenance, post control and containment

10.6.3 Post-eradication surveillance

The period of pest freedom sufficient to indicate that eradication of the pest has been achieved will be determined by a number of factors, including growth conditions, the previous level of infection, the control measures applied and the pest biology.

Specific methods to confirm eradication of Silverleaf whitefly transmitted viruses may include:

- Monitoring of sentinel plants
- Sentinel plants are to be grown in containers or small plots at the affected site. Plants are to be grown *in situ* under quarantine conditions and monitored for symptoms of infection
- If symptoms are detected, samples are to be collected and stored and plants destroyed
- Surveys comprising host plant sampling for *the vector* and the virus should be undertaken for a minimum of three years after eradication has been achieved
- Alternate non-host crops should be grown on the site and any self-sown plants sprayed out with a selective herbicide

11 Technical debrief and analysis for stand down

Refer to PLANTPLAN (Plant Health Australia, 2010) for further details

The emergency response is considered to be ended when either:

- Eradication has been deemed successful by the lead agency, with agreement by the Consultative Committee on Emergency Plant Pests and the Domestic Quarantine and Market Access Working Group.
- Eradication has been deemed impractical and procedures for long-term management of the disease risk have been implemented.

A final report should be completed by the lead agency and the handling of the incident reviewed.

Eradication will be deemed impractical if, at any stage, the results of the delimiting surveys lead to a decision to move to containment/control.

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12.1 Related Websites

CABI 2007 **www.cabicompendium.org/cpc/home.asp**

EPPO archives **archives.eppo.org/EPPOReporting/1998/Rse-9805.pdf**

EPPO website **www.eppo.org/QUARANTINE/virus/Cucurbit_yellow_stunting_disorder/DS_cucurbit_yellow_stunting.pdf**

IPPC website **www.ippc.int**

Lettuce infectious yellows **www.doacs.state.fl.us/pi/enpp/pathology/pathcirc/pp335.pdf**

PHD tomato begamoviruses **library.wur.nl/wda/dissertations/dis4078.pdf**

Table – “A guide to choosing insecticides for Silverleaf whitefly control in vegetables” (2007) **www2.dpi.qld.gov.au/extra/pdf/health/tlcv_table1.pdf**

Table – “Insecticides for Silverleaf whitefly control in vegetables in Queensland’ (2007) **www2.dpi.qld.gov.au/extra/pdf/health/tlcv_table2.pdf**

Tomato leaf curl virus **www2.dpi.qld.gov.au/health/4250.html**

Tomato yellow lead curl virus **www2dpi.qld.gov.au/horticulture/18522.html**

13 Appendices

13.1 Appendix 1: List of whitefly transmitted viruses (modification Jones 2003)

	Primary host group			
Virus name	**Broadacre**	**Nursery**	**Vegetable**	**Other/Unknown**
Begomovirus				
Abutilon mosaic virus				
Acalypha yellow mosaic virus				
African cassava mosaic virus				
Ageratum enation virus				
Ageratum yellow vein virus				
Asystasia golden mosaic virus				
Bean calico mosaic virus				
Bean distortion dwarf virus				
Bean dwarf mosaic virus				
Bean golden mosaic virus				
Bean golden yellow mosaic virus				
Bhendi yellow vein mosaic virus				
Cabbage leaf curl virus				
Calopogonium golden mosaic virus				
Chayote mosaic virus				
Chilli leaf curl virus				
Chino del tomate virus				
Cotton leaf crumple virus				
Cotton leaf curl virus				
Cotton yellow mosaic virus				
Cowpea golden mosaic virus				
Croton yellow vein mosaic virus				
Cucurbit leaf curl virus				
Dicliptera yellow mottle virus				
Dolichos yellow mosaic virus				
East African cassava mosaic virus				
Eclipta yellow vein virus				
Eggplant yellow mosaic virus				

	Primary host group			
Virus name	**Broadacre**	**Nursery**	**Vegetable**	**Other/Unknown**
Begomovirus				
Eupatorium yellow vein virus				
Euphorbia mosaic virus				
Hollyhock leaf crumple virus				
Honeysuckle yellow vein mosaic virus				
Horsegram yellow mosaic virus				
Indian cassava mosaic virus				
Ipomoea crinkle leaf curl virus				
Ipomoea yellow vein virus				
Jatropha mosaic virus				
Kenaf infecting virus				
Leonurus mosaic virus				
Limabean golden mosaic virus				
Lupin leaf curl virus				
Macroptilium golden mosaic virus				
Macroptilium yellow mosaic virus				
Macrotyloma mosaic virus				
Malva infecting virus				
Malvaceous chlorosis virus				
Malvastrum yellow vein virus				
Melon chlorotic leaf curl virus				
Melon leaf curl virus				
Merremia mosaic virus				
Mungbean yellow mosaic virus				
Okra leaf curl virus				
Okra mosaic virus				
Okra yellow vein mosaic virus				
Papaya leaf curl virus				
Papaya mosaic virus				
Passiflora leaf mottle virus				
Pepper golden mosaic virus				
Pepper hausteco yellow vein virus				
Pepper leaf curl virus				
Pepper mild tigr´e virus				
Pepper yellow leaf curl virus				

	Primary host group			
Virus name	**Broadacre**	**Nursery**	**Vegetable**	**Other/Unknown**
Begomovirus				
Poinsettia leaf curl virus				
Potato deforming mosaic virus				
Potato yellow mosaic virus				
Pseuderanthemum yellow vein virus				
Rhynchosia golden mosaic virus				
Rhynchosia mosaic virus				
Sida golden mosaic virus				
Sida golden yellow vein virus				
Sida infecting virus				
Sida mottle virus				
Sida yellow mosaic virus				
Sida yellow vein virus				
Solanum apical leaf curl virus				
South African cassava mosaic virus				
Soybean crinkle leaf virus				
Soybean golden mosaic virus				
Squash leaf curl virus				
Squash mild leaf curl virus				
Squash yellow mild mottle virus				
Sri Lankan cassava mosaic virus				
Stachytarpheta leaf curl virus				
Sweet potato leaf curl virus				
Tobacco apical stunt virus				
Tobacco curly shoot virus				
Tobacco leaf curl virus				
Tobacco leaf rugose virus				
Tomato chlorotic mottle virus				
Tomato chlorotic vein virus				
Tomato crinkle virus				
Tomato curly stunt virus				
Tomato dwarf leaf curl virus				
Tomato golden mosaic virus				
Tomato golden mottle virus				
Tomato leaf curl virus				

	Primary host group			
Virus name	**Broadacre**	**Nursery**	**Vegetable**	**Other/Unknown**
Begomovirus				
Tomato yellow mild mottle virus				
Tomato yellow mosaic virus				
Tomato yellow mottle virus				
Tomato yellow vein streak virus				
Triumffeta yellow vein virus				
Watermelon chlorotic stunt virus				
Watermelon curly mottle virus				
Wissadula golden mosaic virus				
Zinnia leaf curl virus				
Carlavirus				
Cassava brown streak virus				
Cowpea mild mottle virus				
Cucumber vein yellowing virus				
Frenchbean crinkle stunt virus				
Oxalis leaf curl virus				
Pumpkin yellow vein mosaic virus				
Squash yellow leaf curl virus				
Sweet potato mild mottle virus				
Sweet potato yellow dwarf virus				
Closterovirus				
Beet pseudoyellows virus				
Diodia vein chlorosis virus				
Crinivirus				
Abutilon yellows virus				
Cucurbit yellow stunting disorder virus				
Lettuce chlorosis virus				
Lettuce infectious yellows virus				
Potato yellow vein virus				
Sweet potato chlorotic stunt virus				
Sweet potato chlorotic stunt virus				
Tomato chlorosis virus				
Tomato chlorosis virus				
Tomato infectious chlorosis virus				

13.2 Appendix 2: Standard diagnostic protocols

For a range of specifically designed procedures for the emergency response to a pest incursion refer to Plant Health Australia's PLANTPLAN (**www.planthealthaustralia.com.au/plantplan**).

13.3 Appendix 3: Resources and facilities

Table 13 provides a list of diagnostic facilities for use in professional diagnosis and advisory services in the case of an incursion.

Table 13. *Diagnostic service facilities in Australia*

Facility	State	Details
DPI Victoria – Knoxfield Centre	Vic	621 Burwood Highway Knoxfield VIC 3684 Ph: (03) 9210 9222; Fax: (03) 9800 3521
DPI Victoria – Horsham Centre	Vic	Natimuk Rd Horsham VIC 3400 Ph: (03) 5362 2111; Fax: (03) 5362 2187
DPI New South Wales – Elizabeth Macarthur Agricultural Institute	NSW	Woodbridge Road Menangle NSW 2568 PMB 8 Camden NSW 2570 Ph: (02) 4640 6327; Fax: (02) 4640 6428
DPI New South Wales – Tamworth Agricultural Institute	NSW	4 Marsden Park Road Calala NSW 2340 Ph: (02) 6763 1100; Fax: (02) 6763 1222
DPI New South Wales – Wagga Wagga Agricultural Institute	NSW	PMB Wagga Wagga NSW 2650 Ph: (02) 6938 1999; Fax: (02) 6938 1809
SARDI Plant Research Centre – Waite Main Building, Waite Research Precinct	SA	Hartley Grove Urrbrae SA 5064 Ph: (08) 8303 9400; Fax: (08) 8303 9403
Grow Help Australia	QLD	Entomology Building 80 Meiers Road Indooroopilly QLD 4068 Ph: (07) 3896 9668; Fax: (07) 3896 9446
Department of Agriculture and Food, Western Australia (AGWEST) Plant Laboratories	WA	3 Baron-Hay Court South Perth WA 6151 Ph: (08) 9368 3721; Fax: (08) 9474 2658

13.4 Appendix 4: Communications strategy

A general Communications Strategy is provided in Appendix 6 of PLANTPLAN (Plant Health Australia, 2010).

13.5 Appendix 5: Market access impacts

Within the AQIS PHYTO database (**www.aqis.gov.au/phyto**) export of some material may require an additional declaration regarding freedom from the virus. Should Silverleaf whitefly transmitted viruses be detected or become established in Australia, some countries may require specific declaration. Latest information can be found within PHYTO, using an Advanced search “Search all text” for the particular virus.